# Climate Change and Buildings in Nigeria: A Search for Mitigation and Adaptation framework for Residential Design Guide.

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## ABSTRACT

*A sustainable design guide has a huge potential to enhance the sustainability of the built environment. This thesis investigates the potentials of a sustainable residential design guide and develops a framework for its actualization in the three climatic regions in Nigeria. These regions are; Highland Climate Region (HCR), Tropical Savannah (TSC) and the Tropical Rainforest Climate Region (TRC). Given that Nigeria is the seventh most populous country in the world, and most populous in Africa, makes any statistical findings from Nigeria relevant to the rest of the world. This sub-Saharan country is also faced with a huge yearly housing shortage of over ten million units and yet little is known on the efforts and actions taken by Nigeria to ensure that expected new buildings are sustainably designed in line with the global concerns. A concurrent embedded strategy was used in the investigation processes which provided both primary and secondary data sources for this research. Tools for the investigation were; literature review, pilot study, questionnaires and interviews. A Cronbach's Alpha coefficient value of 0.96 was achieved from the survey instrument used. The questionnaire had 283 participants and a total of 30 interviewees were interviewed. The quantitative data from the questionnaire survey were analysed using SPSS 20 software and the NVivo 10 software was used for the qualitative analysis. Findings suggested that the impacts of climate change are evident and significant across all three regions. However, temperature increase recorded a significant value of more than 0.000 significance (p) level at 0.88 across the three regions, an indication that temperature increase is common to all three climatic regions. On the other hand, flooding, desertification/drought and erosion are more prevalent in the HCR, TSC and TRC respectively. This research's contributions to knowledge includes; identifying the climatic design parameters for each region and the development of a conceptual framework. Hence, this research is a pioneer study in the subject of climate change and buildings in Nigeria. The thesis concludes that, the framework would promote the production of sustainable residential buildings in Nigeria. Also, areas of future research were suggested to include; the use of New technologies, effective collaborations, policy formulation and testing of the framework.*

**Keywords:** *climate change, design guide, framework, sustainability, Nigeria.*

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## DEDICATION

With a heart full of gratitude and lips full of praises I dedicate this thesis to **The Lord JesusChrist**, my Saviour, who is the **Alfa** and **Omega** in all things. To **HIM** who remains a **constant** at all times, ever **faithful** and my **anchor** in all situations. **His grace** has been **sufficient** and **evermore** shall be. **Amen!**

Evelyn L. A. Allu. 2014

## DECLARATION

This thesis is submitted to De Montfort University, Leicester - UK, in accordance with the University's rules and regulations.

I hereby, declarethat this work or any part has not previously been presented in any form except the published papers arising from this research as listed in the appendix. I have also acknowledged the works of other studies and therefore, all contents of this thesis are as a result of my own efforts.

Signature ------------------------------------------------

Date ------------------------------------------------------

**Evelyn Lami Ashelo Allu**

**Approval page**

This PhD Thesis has been examined, approved and submitted to the Graduate School Office (GSO), De Montfort University Leicester, England UK.

…………………………………………………………………………………………………

Signature and stamp

Date……………………………………………………………………………………..

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**LIST OF ACRONYMS**

AGW Anthropogenic Global Warming

CABE Commission for Architects and the Built Environment

CIBSE Chartered Institute of Building Services Engineers

CO2 Carbon dioxide

EUA European Union Agency

IPCC Intergovernmental Panel on Climate Change

DEFRA Department for Environment, Food and Rural Affairs

DESAUnited Nations Department of Economic and Social Affairs,

DETR Department for Environment, Transport and the Regions

DFID Department of International Development

HM Treasury Her Majesty Treasury

NASANational Aeronautics and Space Administration

NOAA National Oceanic and Atmospheric Administration

RCEF Royal Commission on Environmental Pollution

TCPA Town and Country Planning Association

SLR Sea Level Rise

UKCIP United Kingdom Climate Impacts Programme

UNEP United Nations Environmental Programme

UNFCCC United Nations Framework Convention on Climate Change

UNDP United Nation Developmental Programme

| | |
|---|---|
| USGBC | U.S. Green Building Council |
| WCED | World Commission on the Environment and Development |
| WMO | World Meteorological Organization |

# CHAPTER ONE

## 1.0 INTRODUCTION

### 1.1 Introduction.

This chapter gives insights into the contents, focus and expectations of this research, thus serving as a pathway leading into the background information and general understanding on what this thesis entails. The chapter is divided into sections in the following order; section 1.1 gives an overview of the research background closely linking the key words from the abstract into a discussion to serve as a background. Sections 1.2, 1.3 and 1.4 highlight the Statement of Research Problem, Unit of analysis and the Research Statement of Intent respectively; the Motivation for the research is discussed in section 1.5. The Research Aim and objectives are briefly crystallized on in sections 1.6 and 1.7 provides the Research questions. Other sections cover the Research Limitation and Scope (1.8), Research Rationale and Relevance (1.9) and Research Methodology (1.10). The reasons for the choice of the study area are argued in section 1.11. In section 1.12 the expected contribution to knowledge is presented. Finally, the structure of the thesis is outlined and the work plan which shows the processes that led to the completion of the thesis is attached as **Appendix 1.**

### 1. 2 RESEARCH BACKGROUND

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. In response to this, most national governments have pointedly domesticated environmentally friendly laws. 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, 2009; 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, 2009; 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. 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. 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. 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 (see climate change impacts on the built environment 2.4).

Generally, buildings have great impact and influences on the natural environment. 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, 2011). 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, 2011).

It is therefore, necessary to minimise problems that occupants may face in terms of comfort and climatic risks. 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; Simoni 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.

Although buildings may contribute to climate change, obviously buildings themselves are equally vulnerable to the impacts of climate change themselves. 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, 2007; 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) 2010; De Wilde and Coley, 2012). Thus, any action taken to render buildings sustainable now will prove effective for today and for the future.

The ability to make buildings sustainable means that the buildings are able to mitigate and adapt to climatic changes. 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.

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 (discussed in chapter four). 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.

The importance of sustainable building design solutions is widely acknowledged. Hence, the general arguments suggest that potential capacities for curbing climate change should be sustainable (Commission for Architects and the Built Environment (CABE), 2005; 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. 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. 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.

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 (human-induced) 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. 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. 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.

**1.3 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. 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.

Furthermore, the challenges of climate change are likely to accumulate based on two reasons. 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.

Figure 1.1 shows the rising trend of C02 emission in the developing countries and these emissions are mainly from residential buildings. 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.


Figure 1.1 **C02 Emissions in Developed and Developing Countries**

Source: UNEP, (2007; pp.2).

Figure 1.1 shows C02 emissions trends for developed and developing countries. Unfortunately, this Figure suggest that developing countries has progressively accounted for a much higher proportion of global $CO_2$ emissions since 2000 and has presently surpass the Kyoto commitment level. 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.

Firstly, at the early design stage of buildings it is important that the right decisions are taken. Bogenstätter (2000) had noted that 20% of any design decision at the early phase of design has 80% consequences on the overall design. As such, early 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 "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 yearsdue to their rapid population.Arif et al. (2009) further observed that, increased constructionactivities 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.

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. Furthermore, Attia (2012) noted that architects are constantly in search of decision tools that would aid and promote design decisions.

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. 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.

### 1.4 WHY NIGERIA?

The evidence of climate change is overwhelming globally and chapter three of this thesis provides evidence for the Nigerian context. 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 (See figure 1.2). This also accounts for the differences in the magnitude of the impacts of climate change across the three regions in Nigeria. 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, 2003; World Bank, 2010c; Ogbo et al, 2013). Hence, increasing poverty levels and exposing its citizens to vulnerability to climate change impacts.

These differences associated with the magnitude and impacts across the different climatic regions have not been adequately established. 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.


**Figure 1.2 Map of Nigeria Showing Location of Latitudes and Longitudes**

**Source: http://www.infoplease.com/atlas/country/nigeria.html (Accessed 2/3/2012).**

The housing sector is very important to climate change studies because of the role buildings play in the activities that lead to climatic change. 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. This leads to the presentation of the next paragraph.

A National Climate Change Commission for Nigeria was approved by its Senate in November, 2010. 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. 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). This delay once again shows the lack of seriousness and the slow pace at which an important issue such as the challenges of climate change are being handled by the Nigerian government.

Therefore, researchers must stress to Nigeria government, the urgent need to step up its climate change initiatives and implementations. 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.

This thesis is therefore, mainly an exploratory research that looks at the residential design practices in the three climate 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. 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 thesis 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. 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.

## 1.5 UNIT OF ANALYSIS

The findings from this thesis are derived from the built environment professionals and Nigeria as the units of analysis. Unit of analysis is described as the main unit or entity of research analysis (Trochim, 2006). Sometimes, the unit of analysis is simply the 'what' and 'who' to be analysed (The Pell Institute, 2013). This main entity or unit of analysis includes; Individuals, Groups, Organizations, Metropolitan areas and geographical areas (Trochim, 2006; Rubin and Babbie, 2008). The example of units of analysis and their variables are listed in Table 1.1 for easy understanding.

**Table 1.1 Examples of Units of Analysis and Variables**

| | Unit of Analysis | Variables |
|---|---|---|
| 1 | Objects | Characteristics of objects which vary |
| 2 | Individuals (old & young people) | Individual income, age, gender, attitude , patterns etc |
| 3 | Groups or social interactions (family, small groups, associations and gangs) | Group income size (number of people), poverty rate, divorce<br>group cohesion/criminal activities |
| 4 | Organizations (company, college, mental hospitals) | Size, structure, gender composition, routine |
| 5 | Metropolitan areas | Population, percent of ethnicity,<br>number of jobs in different sectors,<br>proportion of population who are college graduates |
| 6 | Geographic areas(nations, states, regions) | Census tracts, economic development<br>Percent of population with access to; electricity, jobs etc<br>system of government, birth rate |

Source: Adopted from (Trochim, 2006; Rubin and Babbie, 2008; The Pell Institute, 2013)

Nigeria is the geographical area that has been chosen for this study, while the three different climatic regions will serve as main variables. The extensive literature review has a global theoretical underpinning which is aimed to focus various discussions and arguments. It will also help to give the research findings necessary academic grounding without necessarily attempting to re-invent the wheel and broaden the scope of discussion. This is demonstrated in the Figure 1.3.

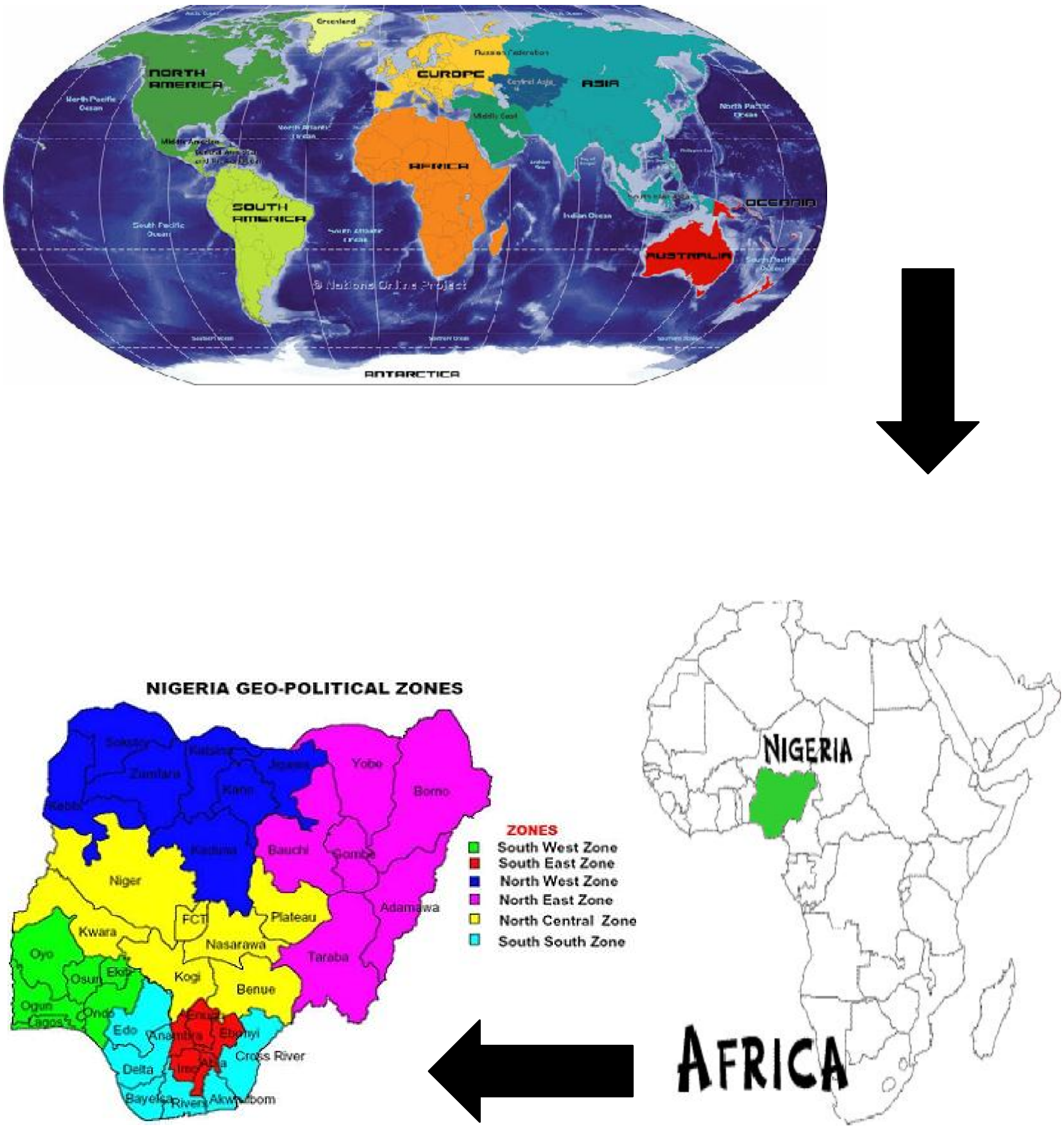



**Figure 1.3 Global Location of Nigeria**

Source: Author's arrangement

Nigerian climate has been variously classified, as reflected in Table 1.2 below. Like stated earlier however, this thesis adopts Tropical rainforest or monsoon, tropical savannah and the alpine for reason of distinction as climate types. This decision was arrived at after the pilot survey, where participants seem unsure of the specific distinction especially as to where boundaries lay between areas with nearly same climatic characteristics across geographical regions.

**Table 1.2 Nigeria's Different Climate Classifications**

| source | Suggested climate types | locations | remarks |
|---|---|---|---|
| **Agboola (2011) pp.18-19**<br>**Soneye, A.S.O. (2012).**<br>**Motherland Nigeria (2013)** | Warm Humid Zones of Southern Nigeria | Calabar, Port Harcourt, Warri, Lagos, Ikeja, Ondo, Benin, Ibadan, Osogbo, Lokoja, Ilorin, Enugu and Makurdi | Agboola noted that there are transitional regions |
| | Hot Savannah zone of the Middle Belt and the Northern Nigeria | Abuja, Minna, Zaria, Yola, Maiduguri, Kano, Sokoto, Yelwa, Kaduna, Katsina, Nguru and other mountainous regions | |
| **National Universities Commission (1977).** | Northern (hot dry, warm humid and cold dry) | Covering all northern states | The transitional areas were not considered |
| | Southern (warm humid) | Covering all Southern states | |
| ***www.climate-zone.com › Africa***<br>**http://en.wikipedia.org/wiki/Geography_of_Nigeria**<br>**http://www.nationsencyclopedia.com/Africa/Nigeria-CLIMATE.html** | Arid or tropical dry climate (Sahel) | Northern Nigeria | Only three distinct climate were identified |
| | Equatorial or tropical rainforest | Southern Nigeria | |
| | Tropical | Central Nigeria | |
| **Olaniran and Sumner (1989)**<br>**Online Nigeria (2013)** | Humid sub-equatorial | Southern lowlands | This classification included the transitional areas (highlands) |
| | Hot tropical | Far north | |
| | Moderate sub-temperate | Highlands and plateaus | |
| | Hot wet tropical | Central Nigeria | |
| **Ogunsote and Ogunsote (2002)** | Coastal Zone | | These authors had their classification as zones which seem to have been derived from |
| | Forest Zone | | |
| | Transitional Zone | | |
| | Savannah Zone | | |
| | Highland Zone | | |
| | Semi-Desert Zone. | | |

Source: Compiled by the Researcher, 2012

Table 1.2 above basically shows three climate types in Nigeria. These are the southern monsoon or tropical rainforest, tropical savannah and the highland (alpine) which has been referred to as a sub- temperate climate region. These three climate regions represent the variables within the geographical area (context) from where empirical data will be collected for the research study.

**1.6 RESEARCH AIM AND OBJECTIVES.**

**Aim:**

The main aim of this research isto develop a framework for its actualization in order to promote the design of sustainable buildings in Nigeria.

**Objectives:**

This research is specifically focused on achieving the following five objectives:

a) To conduct a critical literature review and identify research gaps in the area of Climate Change and buildings.
b) To establish the extent to which residential buildings have been impacted by climate change in Nigeria and globally.
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.
d) To ascertain how the knowledge and information available to design professionals are reflected in their design practices.
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. And
f) To ascertain the usefulness of a design guide as tool for design guidelines.

## 1.7 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 discussed in chapter five. These questions are;

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

## 1.8 SCOPE OF THE RESEARCH.

Basically, the research scope covers the three climatic regions in Nigeria with the key purpose of proposing a potentially sustainable residential design guide for the built environment in the country. 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. This scope is quite consistent with the detailed work plan designed as research guide towards achievable targets vice-a-vice time scales presented at the commencement of this research work. See **Appendix 1** attached.

## 1.9 RESEARCH LIMITATION

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. 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. This will help broaden secondary sources of data which will give this research the necessary academic underpinning it requires.

Another limitation is the difficulty in identifying and accessing relevant practicing design professionals in Nigeria who would be ready to participate in the interview and questionnaire surveys, in an attempt to gather empirical data. The researcher was address the above limitation through early contacts, right from the start of the research, with practising professionals who will be ready to participate in the interviews. 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.

## 1.10 RESEARCHRATIONALE.

Quite clearly, 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. 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. 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. 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.

More so, this research is relevant because it will help gather much needed information that could validate findings as it concerns the Nigerian context. Also, is the lack of academic materials, including data on climate change, especially in relation to buildings in Africa (Conway, 2008; Laryea, 2011). 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. 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.

**1.11 RESEARCH METHODOLOGY.**

An extensive and critical literature review has been conducted on climate change and sustainability, with the main focus being the impact of climate change on buildings. On-going and current issues on the interface between climate change and buildings are identified and the current global agenda for sustainable development are critically examined.

Chapter four of this report drills down on research methodology which specifically details various research strategies that will be used gather information needed to answer the research question and also achieve the stated research objectives. And because the research cuts across different academic disciplines (i.e. geography, sociology, physical sciences and architecture) a mixed approach became very important, for instance, it included a combination of research surveys like questionnaire and semi-structured face-to-face interviews while using both quantitative and qualitative approaches to analyse the data collected in the process of validating the findings from the different sources. The quantitative research method employed the use of descriptive statistics published by relevant national and international agencies to gather data on climate change and its impact on built environment in Nigeria. The multi-dimensional approach gives the research a robust background and scientifically verifiable framework with which data were collected and subsequently analysed.

### 1.12 CONTRIBUTION TO KNOWLEDGE

Following the research methodology above, the researcher has succinctly outlined some contributions this research project has made to existing knowledge generally and climate change in particular. Hence, developing a clear conceptual framework that will articulate the strategies needed to produce a new design guide that will help professional practices across the three climate regions (HCR, TSC and TRC) in Nigeria. Secondly, the research substantially contributes data about the subject of climate change and buildings in Nigeria.

Furthermore, this research outcome serves as a possible source of data for Nigerian legislative arms and public policy makers, as it may concern climate change. It will aid Non-Governmental Organizations (NGOs) create awareness of the need for government and built environment professionals to synchronize and ensure that their building designs reflects necessary mitigations and adaptation strategies to control and perhaps contain the negative effects and impacts of climate change in Nigeria.

Also, some aspects of the research work has been published and therefore, contributed to the body of knowledge (see **appendix 11-14**). Finally, the professional regulatory bodies within the built environment in Nigeria could adopt the new framework as basis for ensuring informed monitoring and effective implementation.

## 1.13 STRUCTURE AND OUTLINE OF THESIS.

This thesis is presented in seven chapters with each of these chapters focusing on providing a sustainable residential design guide. Figure 1.4 shows how each chapter is structured and the titles of its contents. The chapters are summarised below;

Chapter one- Introduction: is an introduction which gives an insight into the entire proposed project as a background and concludes with a summary.

Chapter two- Literature review: presents a critical review of relevant literature previously undertaken in the subject area of this research and also serve as detailed background to the thesis.

Chapter three- The study area: is the context of this thesis and the chapter highlights the impacts of climate change on buildings in Nigeria, the current scenarios on practices and governmental efforts, as well as providing further background information as regards Nigeria and the subject matter of this thesis.

Chapter four- Research methodology and Field survey: this chapter presents a brief review on research methodology and discusses the importance of methodology and methods. The methods adopted were discussed identifying their relevance and possible limitations. The chapter also details the experiences during the field study whilst collecting data and information.

Chapter five- Data presentation and analysis: the primary data is presented and steps taken to effectively analyse and discuss the results in two main sections (i.e. 5.2 and 5.3), with each section sub-divided into seven sub-themes in accordance with the survey instruments.

Chapter six- Findings and Implications: the implications on the survey results are discussed and a proposed context based framework is developed for each of the climate type derived from the research findings

Chapter seven- conclusions and recommendations: The chapter draws out conclusions from its findings and offers recommendations to stakeholders, as well as identify and suggest areas of interest to other academics.

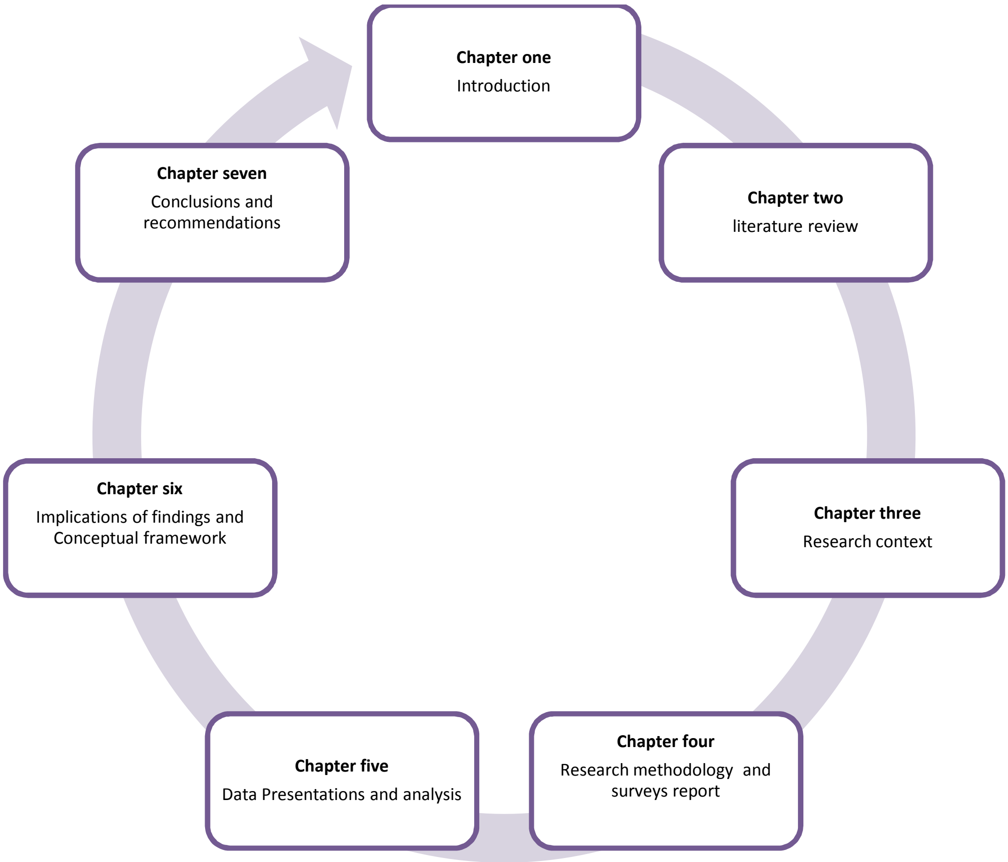



**Figure 1.4 Layout of thesis chapters and their titles**

## 1.14 CHAPTER SUMMARY AND CONCLUSION

Chapter one provided the research background and established the main aim and objectives of this research project. Overall, this chapter has undertaken a bird's eye view of the entire research work, with each section providing information leading to the research construct. It also identified some research contributions this research has made to existing academic knowledge as it concerns climate change in Nigeria. Finally, it closed with the structure and contents of each of the remaining chapters, thus serving as a compass to the entire thesis.

## CHAPTER TWO

## 2.0 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.

### 2.2 TERMINOLOGIES

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

**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. 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%). The commitment period spans from 2008 to 2012. 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 (Whole Building Design Guide WBDG, 2012).

**Uncertainty:** Is the futuristic degree or level to which the climate system is known for certain. It is dependent on information or the lack of information and what is known or knowable. 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. Presently, it has near-universal 195 countries membership. 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. 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'. 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). 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 0.2$^{o}$C 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, 2009; 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.

### 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. However, there are several arguments on the causes of climate change (Lowe et al, 2006; Lorenzo et al, 2007), which can be drilled down to four main strands.

The first argument suggests that climate change is a natural phenomenon. 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 (Gaye et al, 2000;

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. 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. 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.

Conversely, climate change is believed to have been induced by the activities of human beings. 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 ($N_20$), Methane ($ch_4$), Ozone ($O_3$) 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), 2009; Welch, 2010).

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 (American Society of Meteorology Society, 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. 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.

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

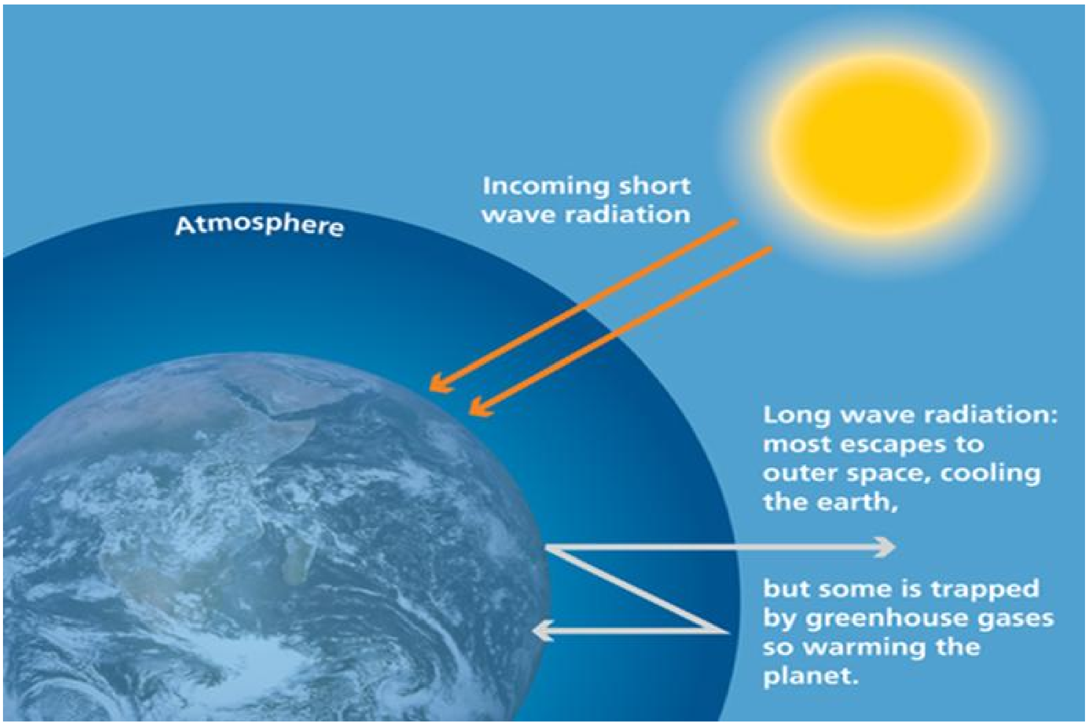



**Figure 2.1 Effects of Greenhouse gas emission.**
Source: UK Climate Change Impact Programme (UKCIP) 2011.

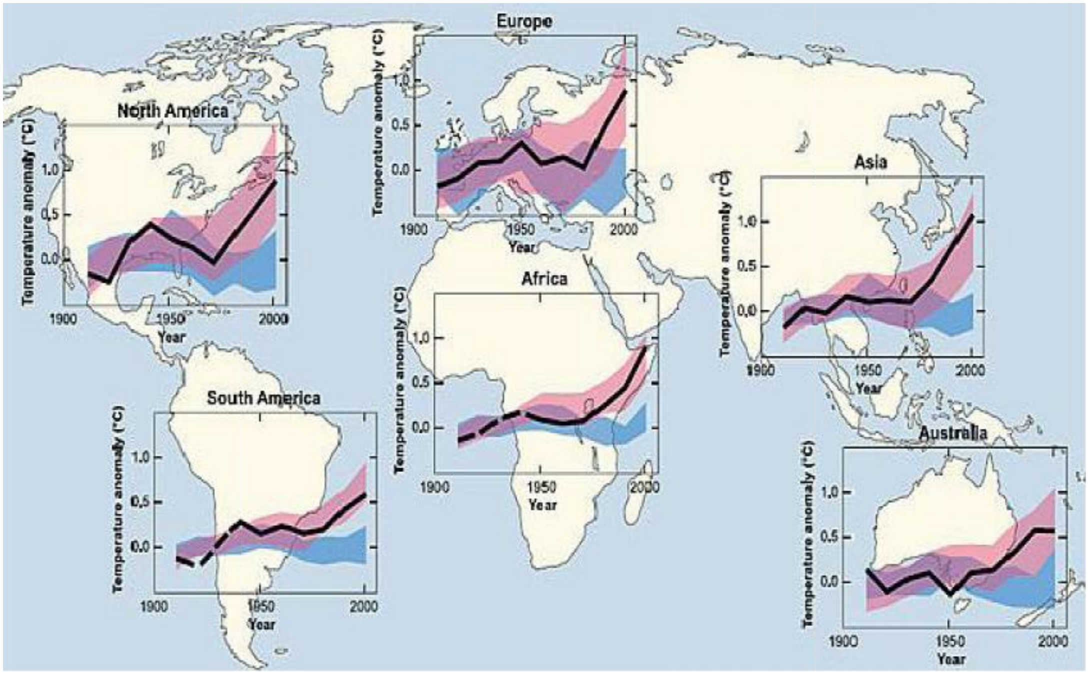



**Figure 2.2 Changes in temperatures during 1906-2005 per continent** (**Blue**: models using only natural forcings. **Red**: models using both natural and anthropogenic forcings -uncertainty margins. **Black**: Decadal averages of observations are shown for the period 1906-2005).
Source: Pachauri and 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. Basically, both combined elements are absorbed into the atmosphere apparently leading to global warming which is fundamentally responsible for Climate Change.

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. The relationship between climate change and buildings are discussed in sections 2.5 and 2.6 respectively.

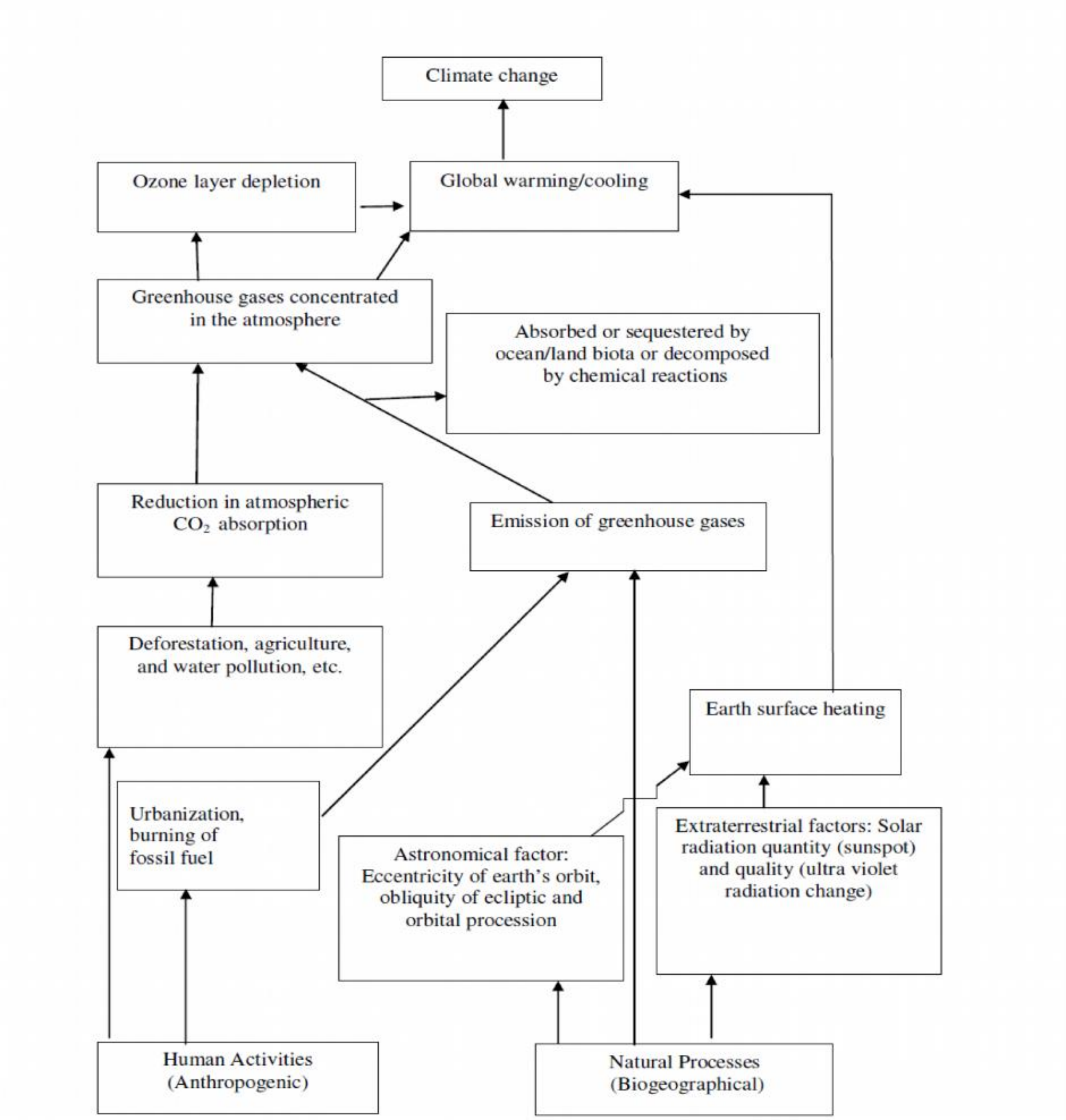



**Figure 2.3 Factors of climate change.**
Source: Odjubo, 2010, pp.143.

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. 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. 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. Thus, Carter (2007) also arguedthat 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, 2006a and Carter, 2006b) 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.

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. The study finally concludes that any targeted and tailored information to the UK public has implication on the reduction of Greenhouse Gas (GHG) emissions. 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.

Few, Brown and Tomkins (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. Thus, it is important to have professional and stakeholders' opinion on specific research goals and for eventual practical applications in relevant sectors.

According to Poortinga et al. (2003) the public are more inclined to believe professional findings because these reflect works by individuals and institutes who have developed professional and technically expertise over the years. In this research project the opinion and perceptions of architects and other relevant professionals in the built environment in Nigeria are sought with the aim of measuring their knowledge to ascertain their knowledge and awareness level and how these are applied to their design practices. The findings in this regard would address the fourth research objective; which is "To ascertain how the knowledge and information available to design professionals are reflected in their design practices".This is established in chapter five and the implications of the findings informed the recommendations in chapter seven.

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 (RCEF, 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.

## 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. 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.


**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 ($CO_2$), since the 1950s. 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. 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).

**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. The absorption of heat by the oceans precipitates vapour that evaporates into the stratosphere preventing heat loss, and warming the earth.

**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. 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.

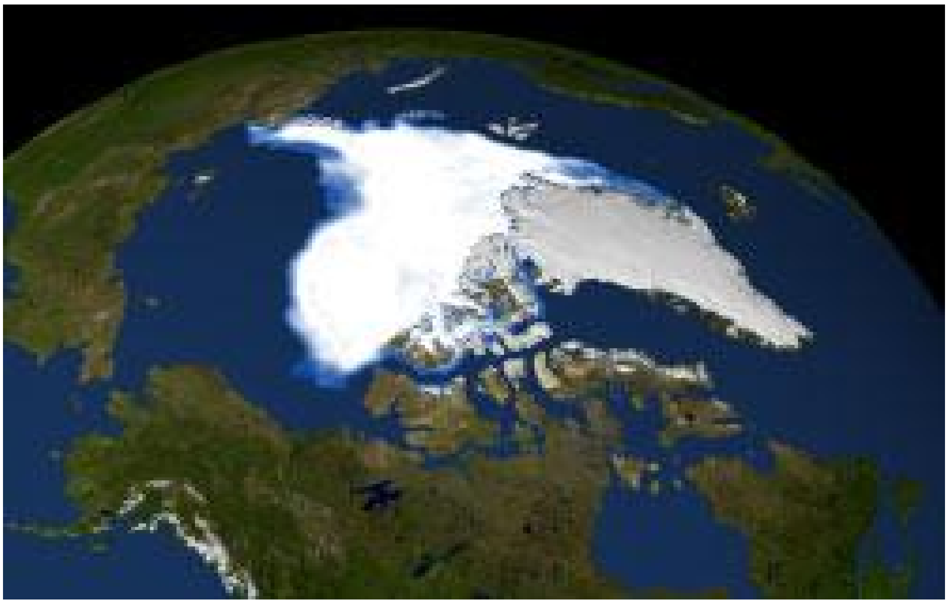


**Figure 2.9 Declining Arctic Sea level.**
Source: http://climate.nasa.gov/eveidence/ (Accessed 1/12/2011).

**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. Figure 2.11 shows how extremely low temperatures lead to extreme snow ice in temperate regions of the world.

**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 Rothrock, 2009; NASA, 2011; National Research Council (NRC), 2006; Tompkins and Adger, 2004). This evidence challenges any myth as to the existence of climate change.

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. 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.

## 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. 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,waterand 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 andmaintained to fulfil human purposes, which mediates the overall environment and has impacts on the environment. It also means that the transformation and transition of the natural environment into sustainable liveable setting by man for human activities (Aluko and Jolaosa, 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.

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.

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. The Table shows amongst others climate indicators, surface effect on the environment and the resultant impacts on the built environment.

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

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. Secondly, there is the need to regulate building locations through land-use planning tools and land management which will help curb the impacts of climate change on the built environment.

Thus, the importance and scope of this research is to provide a framework for the formulation of a sustainable residential design guide for Nigeria. 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.

## 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. 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), 2005; Trenberth, 2005; 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. This is reflected on the architectural practices and design choices from different of climatic regions globally.

Although several studies have suggested that buildings contribute to the causes of climate change (Wilby, 2007; Simoni 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, 2001; Ashley, 2005; Crawley, 2008; 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.

A number of studies seeking solutions have been carried out due to the global effects and impacts of climate change on buildings. 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 2.3) 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 $CO_2$ 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. Although, this advantage may not apply to all sectors they are characterized by a high degree of diversity or a large number of players.

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.

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. 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).

Secondly, possible limitations may arisedue 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.

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 2.3 below.

**Table 2.3 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.

Although, studies on the energy sector are relevant to buildings, however, it is the construction industry sector that is directly relevant to this research. 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. 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.

### 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. *"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. However, it is necessary to provide facts that support the summation from the above quotation.

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 per cent of global total GHG emissions, while Europe contributes

13.37 per cent (European Union Agency EUA, 2009). This shows that China contributes a larger and more significant percentage of global emissions as compared to Europe. This is consistent with the information trend of global emissions in Figure 1.1. 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. 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.

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. 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.

### 2.7 CLIMATE CHANGE AND SUSTAINABILITY

The acceptable process identified as preferred the way of growth is sustainable development. This has been adopted and accepted internationally as a global agendafor 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.

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. 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. Therefore, the historic relevance of sustainability is not within the scope of this research project.

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

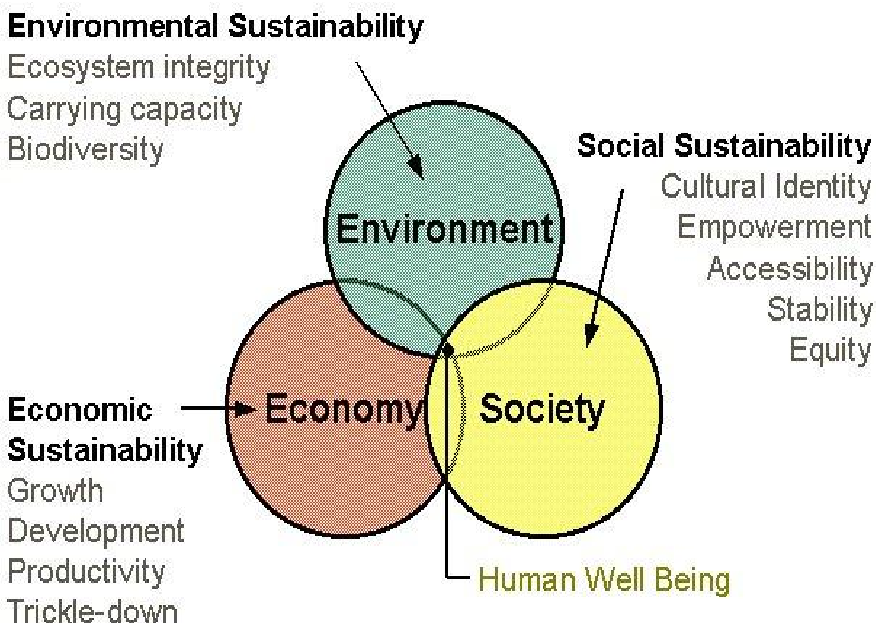



**Figure 2.13 Sustainable Development**

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. Hence, complex nature of sustainability and therefore, requiring sustainable actions that, would enhance holistic well-being in the society. 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 ofavailable 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.

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. 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, 2003; Doughty and Hammond, 2004; Bond, 2009). To maintain this status quo the developing countries do need to join this development trend by mainstreaming sustainability in all its Climate Change strategies. 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.

### 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. In the design of buildings the "…*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.

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, 2002; 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.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.

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.

**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**<br>1.1 Improved project delivery<br>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<br>and focus on developing client business |
| **Environmental sustainability** | **2.0 Effective protection of the environment**<br>2.1 Avoiding pollution<br>2.2 Protecting and enhancing biodiversity<br>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**<br>3.1 Improved energy efficiency<br>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**<br>4.1 Respect for staff<br>4.2 Working with local communities and road users<br>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.

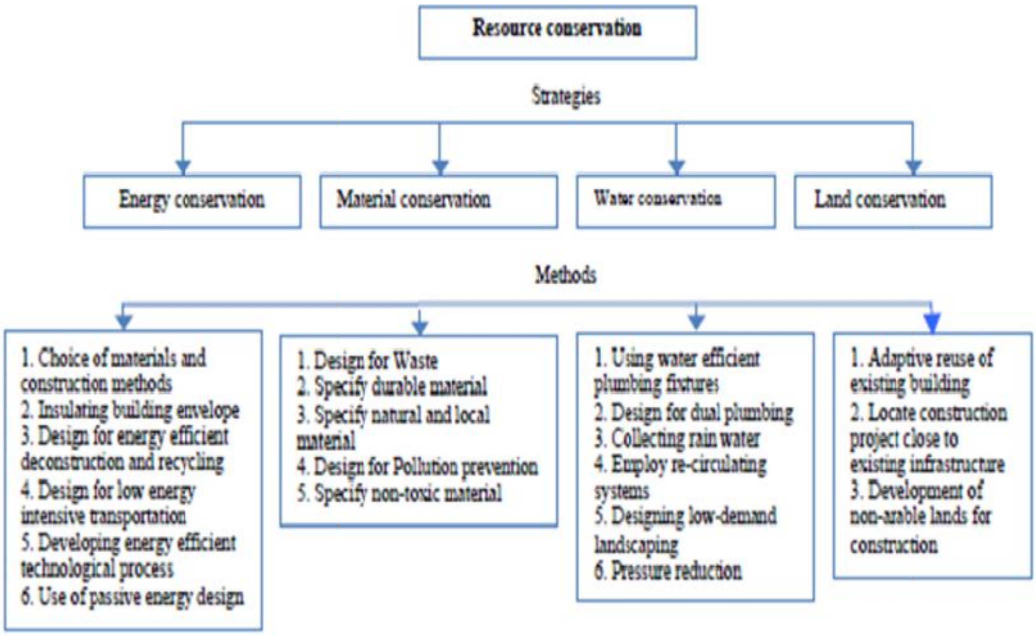



**Figure 2.14 Strategies and Methods to Achieve Resource Conservation.**
Source: Akadiri et al. (2012), pp.132.

Figure 2.14 highlights the strategies and methods for conserving non-renewable resources (energy, land,materials and water) used in the construction industry. 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-in-use and recovery cost as the methods to be used in checking economic balances.

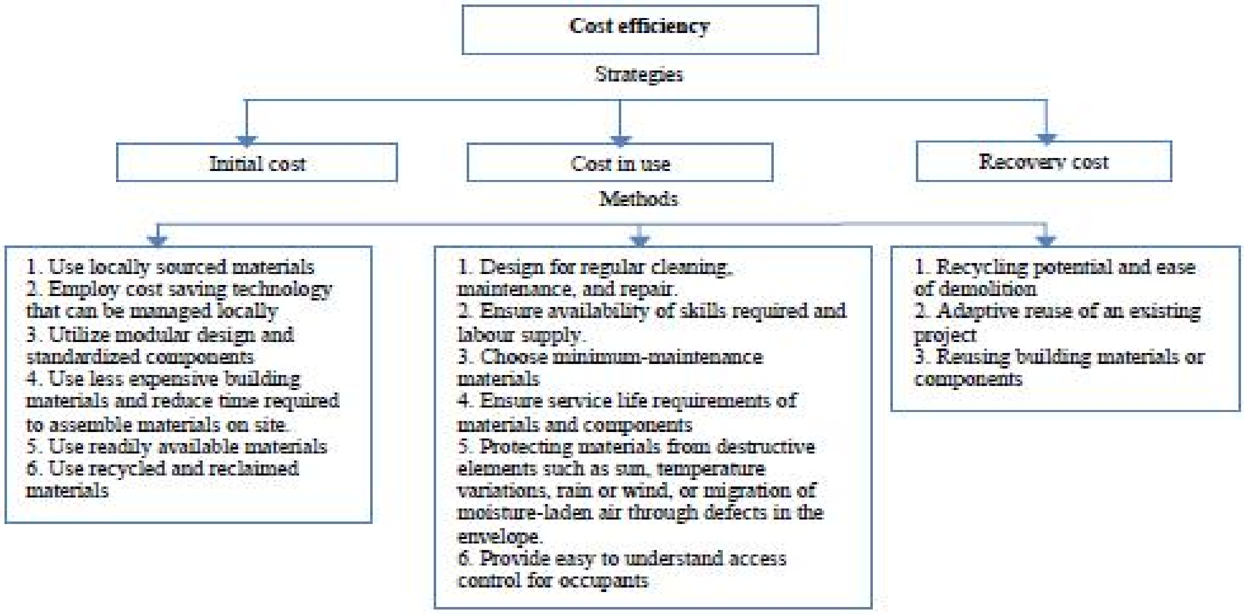



**Figure 2.15 Strategies and Methods to achieve cost efficiency.**
Source: Akadiri et al. (2012), pp. 140.

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. 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.

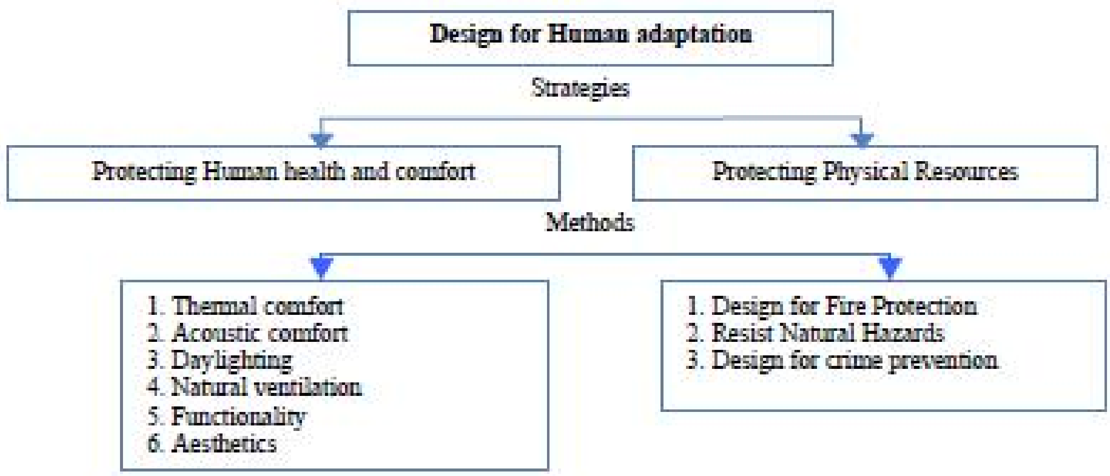



**Figure 2.16 Strategies and Methods to achieve human adaptation.**
Source: Akadiri et al. (2012), pp.143.

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. Again, professionals are required to employ different sustainable methods and strategies within their specialisation to enable sustainable design and construction. 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.

### 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. 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 Roodman and Lenssen 1995; Anink et al, 1996 (cited in United Nations Environmental Programme (UNEP), 2007).

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, Switzerlandand 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. Also, elaborate guidelines were listed for choosing building materials like:

1. Designing for long life and adaptability: use durable low maintenance materials
2. Ensure materials can be easily separated
3. Avoid a bigger house than you need to save materials used
4. Modify or refurbish instead of demolishing
5. Ensure the re-use or recycle of materials from demolished existing buildings and construction waste
6. Use locally sourced materials where possible (including materials salvaged from site) to reduce transportation
7. Select low energy where materials (which may include materials with high recycle content) preferably based on supplier-specific data
8. Avoid wasteful material use
9. Specify standard sizes and don’t use energy-intensive materials as fillers
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

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
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. 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. However, the opportunity is now present for practices in Nigeria to consider if they would like to adopt them for future practices.

**2.8 SUSTAINABLE DESIGN GUIDE**

A sustainable design guide offers built environment professionals the opportunity to consciously use sustainable principles for building designs. 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 positivelywith the various elements of their local environment. The result should bebuildings that use less energy and have less damaging environmentalimpacts over their whole life than equivalent buildings designed withoutregard to these factors. Buildings can be designed so as to respondintelligently to the existing topography and climate. For maximum effectand economy the aim should be for integration of appropriate design andtechnology into the overall building form and not simply to applytechnology as an afterthought or a 'clip-on'. This may cost more initiallybut the long term running costs should be lower, leading to overall cost savings.A climatically responsive approach to building design will eventually help togenerate a genuine local or regional architecture rather than a style* *of buildingimported from another place or time. However, this is not a building form or styleguide, but is intended to be a selection of medium to long term potential energyand resource saving ideas that can be easily integrated into the design of a newbuilding 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.

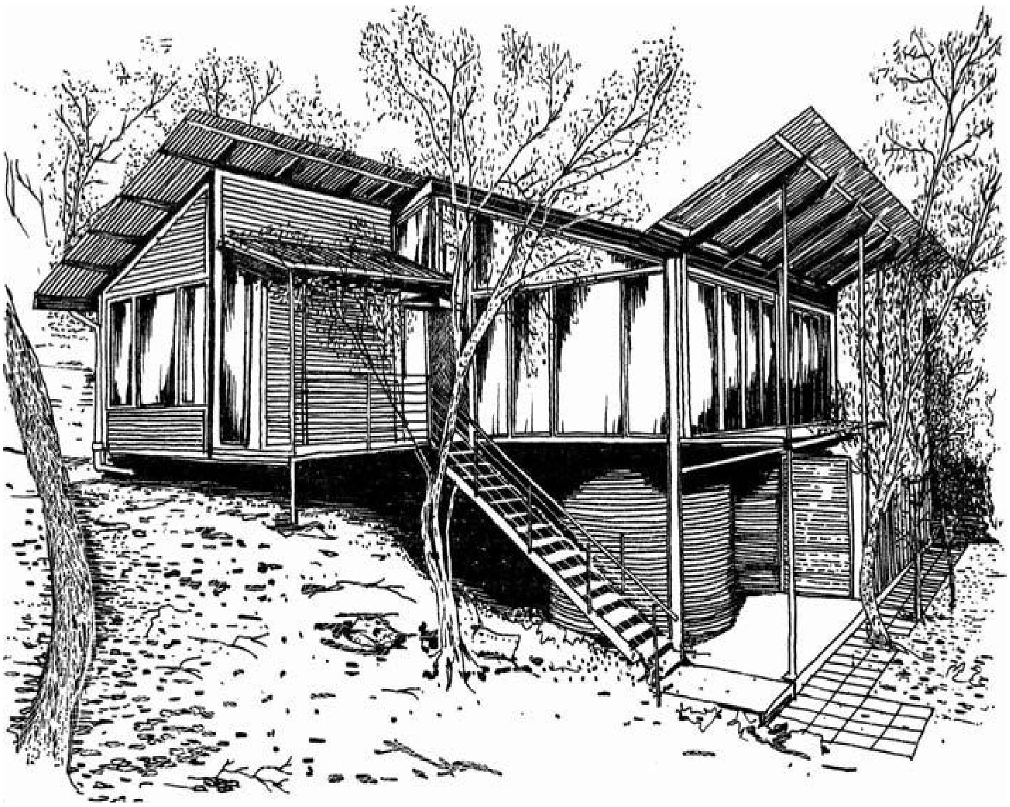


**Figure 2.17 Example of a House that Responds to the Local Climate and Topography**
Source: Smyth, B. and Schroder, J. (2004) pp.3

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 (see Appendix 2). 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:

1. Regulation of energy-efficient design principles;
2. Incentives to promote the continuation of traditional techniques, with regional resources and self-help strategies;
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;
4. Regulation of energy-efficient design principles;
5. Standards to discourage construction in ecologically inappropriate areas;
6. Cost and economies of scale
7. The restructuring of credit institutions to allow the poor to buy building materials and services;
8. International information exchange among architects and contractors, on all aspects of construction related to the environment, particularly about non-renewable resources;
9. Exploration of methods to encourage and facilitate the recycling and reuse of building materials, especially those requiring intensive energy consumption in their manufacture;
10. Financial penalties to discourage the use of materials that damage the environment;

11. Decentralization of the construction industry, through the encouragement of smaller firms;
12. Use of “clean technologies”

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. They concluded that …*“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.

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. 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.

The list of the different weighted guidelines, assessment tools and rating systems studied by Carmody et al. (2009) is attached in **Appendix 3**. Their conclusion provides a valid argument for sustainable design guide. 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.

### 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. This has been acknowledged in the following quote which states that, “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. 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.

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. The four guides were randomly selected, because they were easily accessible from their individual official websites. 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.

The councils selected are; London Borough of Barnet, Castle Point Borough, Highland Council and West Lothian Councils. The parameters for each of the guide give an insight into the relevant areas to be considered in this research. 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.

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. 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.

## 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<br>- Enclosure & Boundary Treatment<br>-Design Review | Buildings and their setting | Design and layout principle |
| **Internal space layout** | Internal Layout and Design | -Plot Size<br>-Corner Plots<br>-Detailing | Materials and traditional skills | -design and layout details<br>-Design Codes |
| **External space layout** | Outdoor Amenity Space | -Amenity Space<br>-Space Around Dwellings | The natural environment | Not considered |
| **Natural light** | Daylight, Privacy (minimum distance), Outlook and Light Pollution | -Building Lines<br>-Roof Development<br>- 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<br>-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<br>-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. As such, an effective framework should be a product of interactive professional contributions.

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.

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. 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.

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. 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.
2. Stakeholders and the public demands for development that is compliant with sustainability.
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.
4. Added value on quality and aesthetics to created spaces- This leads to higher returns on investments.
5. Saving time and money- where a strong sustainability strategy is adopted for every development
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).

## 2.9 STRATEGIES FOR CLIMATE CHANGE

This section discusses the two main strategies associated with tackling climate change; mitigation and adaptation. 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 Matthews and Caldeira, 2008 (cited in Ericksen et al, 2011; 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. 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.

### 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.

### 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. Thus, a great potential lies therein in tackling climate change. 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 $C0_2$ emissions from energy use in the world's buildings'. It is also one of the few studies that covered residential buildings. 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.

Further to the above, Urge-Vorsatz et al. (2007) in their conclusion suggested that, a huge reduction in $C0_2$ 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. 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.

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. Thus, making this research project necessary, relevant and bridging the gap in their study.

**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]<br>Economic: 12–25%[b]<br>Market: 15–37% | 1. Shell retrofit, including insulation, especially windows and walls<br>2. Space heating systems and standards for them<br>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<br>2. Water heating equipment<br>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]<br>Economic: 13–37%[d]<br>Market: 14% | 1. Pre- and post-insulation and replacement of building components, especially windows<br>2. Efficient lighting, especially shift to CFLs<br>3. Efficient appliances such as refrigerators and water heaters | 1. Efficient lighting and its controls<br>2. Water and space heating control systems<br>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]<br>Economic: 13–52%[f]<br>Market: 23% | 1. Efficient lights, especially shift to CFLs, light retrofit, and kerosene lamps<br>2. Various types of improved cook stoves, especially biomass stoves, followed by LPG and kerosene stoves<br>3. Efficient appliances such as air-conditioners and refrigerators | 1. Improved lights, especially shift to CFLs light retrofit, and efficient kerosene lamps<br>2. Various types of improved cook stoves, especially biomass based, followed by kerosene stoves<br>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 aresimple, effective and efficient.

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. Reactive adaptation refers to the spontaneous adaptation which is an action taken after an observed change that triggers an unconscious action. On the other hand, anticipatory adaptation is seen as the proactive plans put in place to potentially correct climatic impacts. 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. 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. 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. 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; Kovats and Akhtar 2008; 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, 2009; 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. 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. 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. 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. Table 2.10 gives a summary of the differences and areas of commonalities of mitigation and adaptation.

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
2. Provide no guarantee that resources are used in the most efficient manner when seeking to reduce climate risks
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).
4. The ability to create synergies is limited by the absence of a relevant knowledge base and of human, institutional and organisational capacity.
5. Increased spending on adaptation does not mean that less money is available for mitigation, or vice versa

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. Conversely, other barriers Klein et al. (2007) observed includethe 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.

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. Thus, the applicability of the synergy can be tested across the three climatic regions in Nigeria.

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. Their conclusions further shows that the synergies for mitigation and adaptation will allow for a faster implementation of climate change projects and sustainable development. 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. 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. Finally, all synergies are a demonstration of combined efforts to limit GHG emissions and reduce effects of climate change. 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.

### 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 (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.
2. The synergy allows for strategic complimentary application
3. It makes sustainable development easier to be achieved through the implementation of mitigation and adaptation policies in built environments, especially in developing countries.

4. It is “crucial” for the built environment due to long life span associated with infrastructures

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. Furthermore, a building designer may not be part of the actual construction team, maintenance and the deconstruction team which creates complexes for the industry.

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.

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.

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

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. 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. Secondly, open storm-water system: sinks carbon (using urban wetlands) and cools the environment through the use of open water surfaces.

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.

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. This is consistent with Egenhofer, (2008, pp. 59) *"We basically have three choices- mitigation, adaptationand suffering. We're going to do some of each".*

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. 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. This would be the main function expected from the design guide proposed in this study.

## 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.

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. It also highlights possibilities of drawing areas of common grounds and some of the findings could be applied to addressing Nigeria climate change challenges. 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.

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. This is also important because human beings spend most times of their lives inside houses as noted earlier in section 2.2.

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. 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.

## CHAPTER THREE

### 3.0 THE RESEARCH CONTEXT (THE STUDY AREA)

### 3.1 INTRODUCTION

Chapter three is an extension of the literature review from chapter two. This chapter discusses the research context – Nigeria, as the unit of research and thus, necessitated the creation of chapter three.

Furthermore, this chapter presents the contextualised motivation and rationale for the research project in the sections relating to the subject matter. A general overview of the country's profile and the climate change scenario are also presented to give a clearer understanding of the situation in Nigeria and answer some of the research questions; identifying the existing evidences on the impacts of climate change on residential buildings in Nigeria, which further addresses the second research objective of determining the extent to which climate change have impacted on residential buildings in Nigeria within the context of the climate peculiarities inherent across the three climatic regions.

### 3.2 NIGERIA: THE STUDY AREA

Nigeria lays about 3.0 meters above sea level, with a land mass area of 923,768km$^2$, a total coastline length of 850km and Atlantic Ocean bounders the southern coast of Nigeria (National Communication, 2003). The country is situated between 4$^o$N and 14$^o$N and between 3$^o$E and 15$^o$E. It is bordered on the north, east, and west by Niger, the Cameroon, and Benin Republic, respectively (National Communication, 2003; Nwilo et al, 2006; Oguntunde et al, 2011). See figure 3.1. In the decade up to 2011, Nigeria witnessed a sustained increase in its population growth (Taylor 2010; UNDP, 2010; World Bank, 2010), with the official population figures currently standing at 167 million, although, official population figures are often disputed by respective states (Federal Department of Agriculture (FDA) 2008; National Population Commission, 2012).

Nigeria's population growth has major implications for meeting its housing needs, its land use and the continuous loss of its natural environment to the built environment. It will therefore be catastrophic if necessary actions are not taken to reduce emissions and the effects of climate change in other to avert the continuous environmental degradation currently been witnessed across Nigeria (Pat-Mbano, 2012).The Nigeria's First National Communication (2003, pp. 2), sums up that 'Nigeria dense population makes it a high potential contributor to global warming.


**Figure 3.1 Location Map of Nigeria in Africa.**
Source: www.worldatlas (accessed 12/12/12)

Nigeria, which is a creation of colonial rule, is currently the most populous country in Africa (Nwaka, 2005; Federal Republic of Nigeria, 2007). The Federal Republic of Nigeria is divided into six geopolitical zones and made up of 36 states and the Federal Capital Territory (FCT). The official number of Local Government Areas (LGA's) of Nigeria currently stands at 774 (see Figures 3.2), however, there are isolated cases were some states like Lagos, without the Federal Government support, has gone on to create Local Council Development Areas (LCDA) which are not necessarily recognized or funded by the Federal government of Nigeria.

The history of the country dates back to 1914 when the colonial rulers merged the Southern and Northern protectorates together to create this present geographical entity. The country became independent in 1960, and became a sovereignty and republic in 1963. Although, it has its own written constitution, it chose to maintain its membership of the Commonwealth of Nations (Federal Republic of Nigeria, 2007).

Arguably, Nigeria is rich in both human and natural resources like crude oil and liquefied natural gas. Current statistics shows that it is Africa’s largest oil producer, although not due to a deliberate infrastructural innovation in the sector. Furthermore, current statistics also shows thatNigeria is thethird world exporter of crude oil, unfortunately however, the attendant benefits and proceeds of petro dollar does not resonate in the daily lives of its huge population (Nwaobi, 2003; Garba, 2006; Ojo, 2008), who are largely indigent nor used in the provision of social infrastructures, which is a paradox yet to be understood (Global Energy and Business, 2003; Okpe and Abu, 2009; World Bank, 2010).

Some scholars have argued that: “*developing countries ...typically directs considerable efforts to economical and industrial growth, with less focuses on the environment and natural resources” Abubakar et al. (2010; pp.708).* Further to the above and sadly,Nigeria currently ranks second in the world for gas flaring, which negatively affects the Ozone layer and further contribute to its depletion and global warming leading to climate change (World Bank, 1995; Sayne, 2011; Pat-Mbano and Alaka, 2012). The Nigerian government has consistently demonstrated its inability to effectively enforce its own policies on reduction of gas flaring, which has caused severe land degradation, especially in the Niger Delta states (BNRCC, 2008; Friends of the Earth International, 2009; Pat-Mbano and Alaka, 2012).


**3.2 Map of Nigeria Showing 36 States**
Source: www.google.co.uk.images (Accessed 3/4/2012)

### 3.3 BACKGROUND TO CLIMATE CHANGE IN NIGERIA

Current events have shown that West Africa, and Nigeria in particular, is not isolated from global climate change devastation being experienced across the world. It has been shown in section 1.1 that Africa is generally perceived to be extremely vulnerable to climate change, and arguably, West Africa is believed to be most vulnerable (Boko et al, 2007; Obioha, 2008). This is mainly evident in the astronomical rate of desertification ravaging the Northern part of Nigeria and a lack of state and Federal government readiness to empower relevant institutions who will empower, and educate the local population of the need to plant trees and build a natural green wall barriers, slow capacity to technological development and limited engagement with environmental and climate change research and implementations (Davidson et al, 2002; Karanja et al, 2004; IPCC, 2007; BNRCC, 2008). It is argued that 84 per cent of Nigeria's population currently lives below poverty level and do not enjoy a steady electricity supply (Adebanji, 2010; Olugbenga et al, 2013).

A study published by World Environmental Performance Index (EPI) focused on using performance indicators to assess good environmental practice, sadly ranked Nigeria 153 out of the 163 countries studied despite the lowered standard scale used to access the Sub-Saharan region (Areluba and Ajayi, 2011). This clearly shows that Nigeria has not come to terms with the realities of climate change despite evidence of land degradation observed across the country, which are mostly caused by flooding, wind and erosions associated with climate change (Ogunkunle, 2011).

Unexpectedly, Nigeria who is the largest and wealthiest country within the West African sub-region region, and often referred to as the power house of Africa, has failed to take effective leadership in terms of its engagement with environmental and climate change research activities and implementations.

Figure 3.3 clearly shows that Nigeria has different climatic zones and Africa's aridity cuts across Nigeria in this regard; Arid, Hyper arid, Semi-arid, Dry sub-humid, Moist sub-humid and humid (Paehler, 2007). Three climate types have been identified and adopted for this research within the six geo-political zones of Nigeria, they include Tropical rain forest, Savannah and the Highland or Alpine climate regions, which are the most affected areas at risk from the impact of climate change as shown in Figure 3.4, although, other parts of the country are also affected like discussed in section 3.5.

Figure 3.4 shows that the coastal areas of South-South and South West regions appears to be more at risk of rising sea levels leading to flooding, erosion and increased precipitations which could ultimately result in submerging of communities leaving along these coastal areas. But in the case of North East, North West and parts of North Central states unfortunately, they are already experiencing increasing impacts of climate change like drought, higher temperatures and flash flooding in recent times.

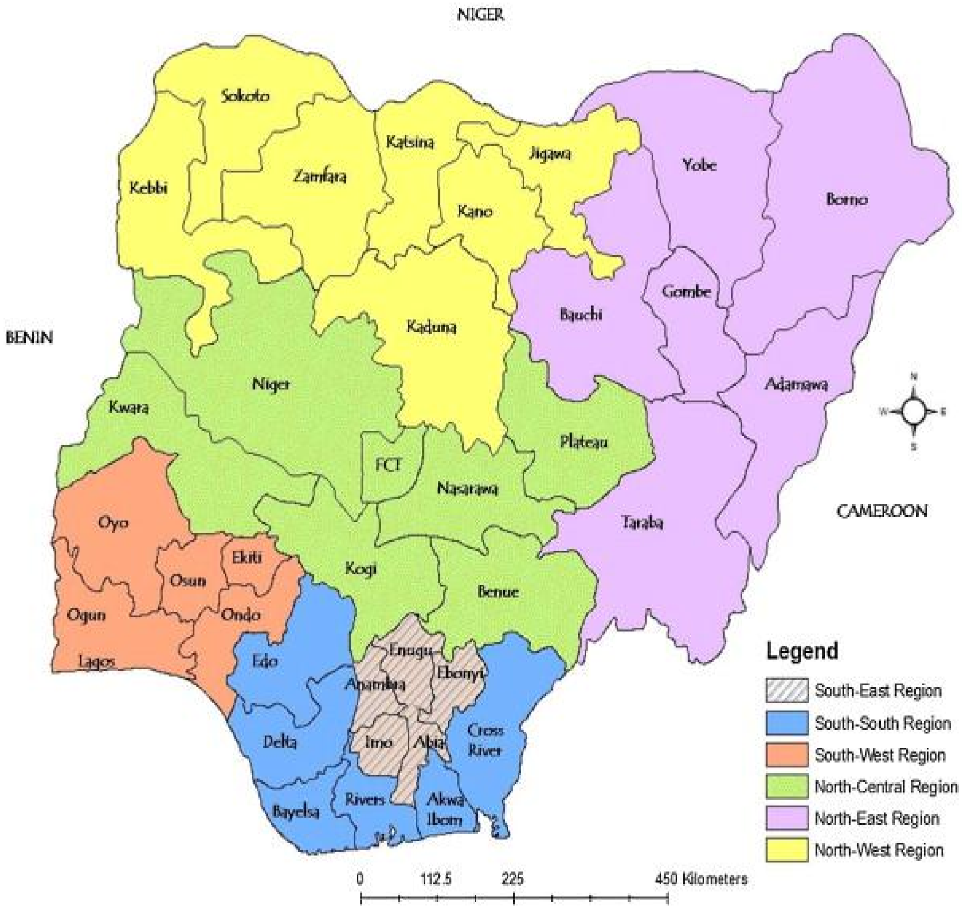
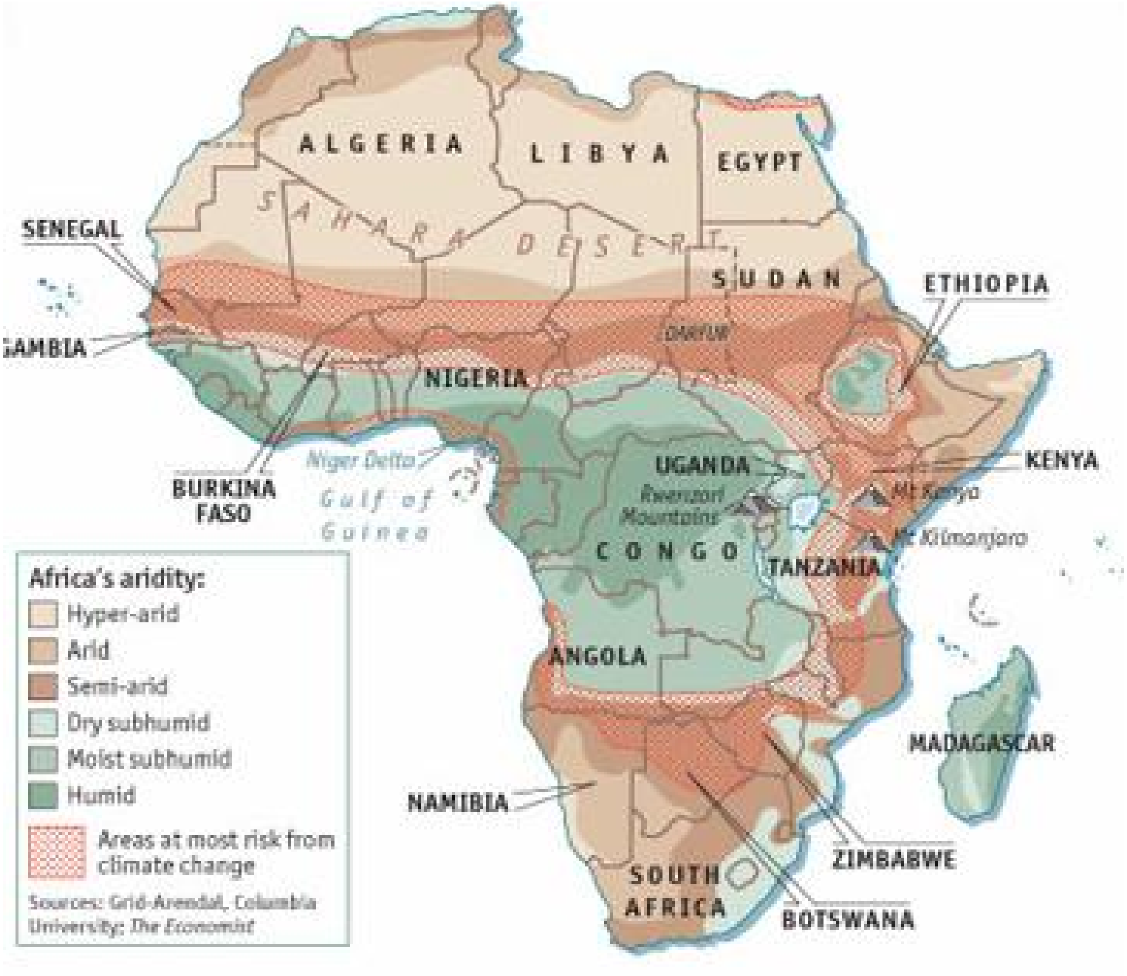



**Figure 3.3 Map of Nigeria showing the Geo-Political Regions (or zones).**
Source: www.google.co.uk.images (Accessed 3/4/2012)

However, there are no specific data on Nigeria, but there are related indicators which are discussed as a follow up to the research problem and the rationale for the choice of Nigeria. Broadly and of interest, sub-Saharan Africa's residential buildings are believed to consume about 96 percent of the total in the building sector (Earth Trends, 2005).




**3.4 Map of Africa's Aridity Showing Nigeria's Aridity and Areas of Most Risk from Climate Change**
Source: www.google.co.uk.images (Accessed 3/4/2012)

Mukhija (2004) argued that the Public housing programmes in developing countries have failed to provide quality and adequate housing that is affordable, while other research studies point to the fact these countries have made some efforts to address the problem of providing adequate, and affordable housing (Ibem and Amole, 2010).

The question remains whether concrete efforts was directed towards providing sustainable buildings and what evidence of research was employed to ascertain the suitability of potential buildings to climate type and regional requirement.

Like most parts of Africa, extensive data limitations exist in Nigeria. The lack of research activities and data availability especially in assessing climate change and long term forecast(scale and nature of impacts, climatic data, trends, basic baseline scenarios) presents a great challenge in Africa(Conway, 2008; Ademiluyi, 2010; Onyekuru and Marchant, 2012). In Nigeria, challenges for long term climate change forecast include, the impact of lack of research and data on policy formulation and implementation (Building Nigeria's Response to Climate Change (BNRCC) - 2011), thus affecting its ability to focus specific policies on the building (housing) sector.

Also, the lack of substantial policies is not the only issue, rather the inability to muster necessary political will to ensure effective implementation (DFID, 2009; Onyekuru and Marchant, 2012). Hence, the role of the built environment professionals, particularly the architects, in Nigeria should initiate actions that would persuade government to look closely at the industry and support the built environment professionals through the provision of housing policies for the sustainability of the built environment through the design of sustainable buildings.

**3.4 CLIMATIC CONDITIONS IN NIGERIA.**

Nigeria's climate scenario shows a better understanding to its adaptive capacity. Geographically, Nigeria is located within the lowland humid of the tropics and is generally characterized by a high temperature experienced continuously throughout the year (see Figure 3.5). However, there are clear differences in temperatures between the country's South and North. While the far south of the country has the mean maximum temperature of 32$^{o}$C, the North has a mean maximum temperature of 41$^{o}$C. Conversely, the mean minimum temperature in the northern region is under 13$^{o}$C, indicating a much higher annual range and the mean temperature for the southern region of Nigeria is 21$^{o}$C. 27$^{o}$C is the mean minimum temperature for the entire country in the absence of altitudinal variations (Nigeria's First Nigeria's First National Communication, 2003).

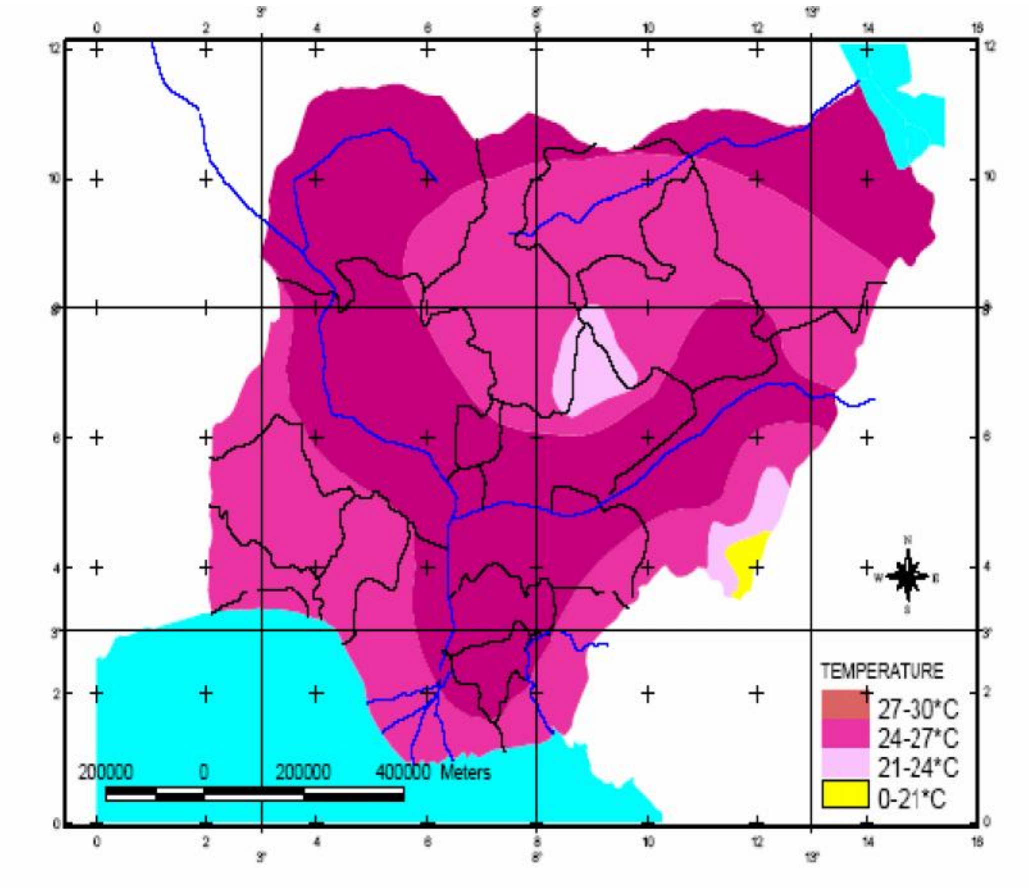
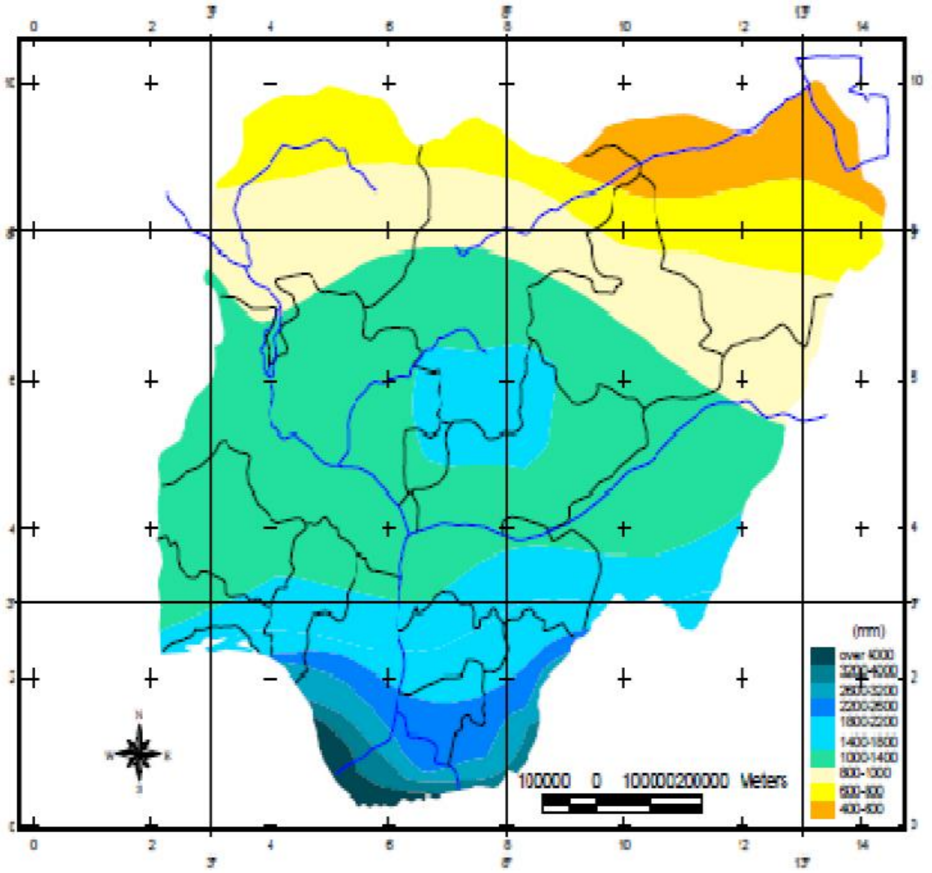



**Figure 3.5 Nigeria's Temperature Spread Map.**
Source: National Communication 2003, pp.16.www.unfccc.int/national reports/items/1408.pl (Accessed 02/03/2012)

In the last few decades,there has been a general climatic variationand these variations are reflected on weather patterns manifested throughout Nigeria as shown in Figures 3.6 to Figures 3.23. The country's climate varies from a very wet coastal area with annual rainfall greater than 3,500mm to the Sahel region in the northwest and north-eastern parts, with annual rainfall less than 600mm.

Figure 3.6 shows wide annual changes in the pattern of rainfall in Nigeria, particularly within the northern parts of the country. This often results in climatic vulnerability to hazards such as flash flooding and droughts, bringing a lot of suffering with devastating long term effects on food production and the nation's economy in general. Recent studies have also revealed declining trends in rainfall (Odjubo, 2010). Also, some northern states in Nigeria receive less than 75 per cent of annual rainfall and this is significant and calls for proactive actions (Nigeria's First National Communication on

Climate Change, 2003). It could be argued that, this trend is most likely than not, to get worse in the future as a result of climate change.




**3.6 Rainfall Distribution in Nigeria.**
Source: National Communication 2003, pp.16.
www.unfccc.int/nationa_reports/items/1408.pl (Accessed 02/03/2012)

According to the United Nation Development Programme UNDP (Report 2010), Nigeria is exposed to the dangers of climate change, like other countries globally. The danger poses serious threats to the environment which has huge implications for poverty alleviation. Given the strong link between climate change and development, Nigeria is currently at a high risk particularly in the area of food security, poverty alleviation, energy and most importantly, infrastructure and economic development. Therefore, Nigeria’s efforts and actions must be informed by the above realities. For example: the Sudan-Sahel area of Nigeria, between 89,297and 133,944 square kilometres of farm land would be at risk (UNDP, 2010). It has also been estimated that the capital value at risk stands at about US$6.4 billion at the present level of Nigeria's development (UNDP, 2010).

Vegetation: There are six commonly identified vegetation zones in Nigeria (see figure3.7). These are; Mangrove and Freshwater swamps along the coast, giving way northwards to Rain Forest, Guinea savannah, Sudan savannah, and Sahel savannah. It has been observed also, that, the actual vegetation cover all the vegetation zones have shown heavy imprint of centuries of human activities (National Adaptation Strategy and Plan of Action on Climate Change for Nigeria (NASPA-CCN), 2011).

It is also necessary to note that this observation from NASPA-CCN forms part of the report presented for review. This further suggests that there are significant human negative impacts on the environment within the Nigerian context and thus, affecting the vegetation spread as shown in Figure 3.7.

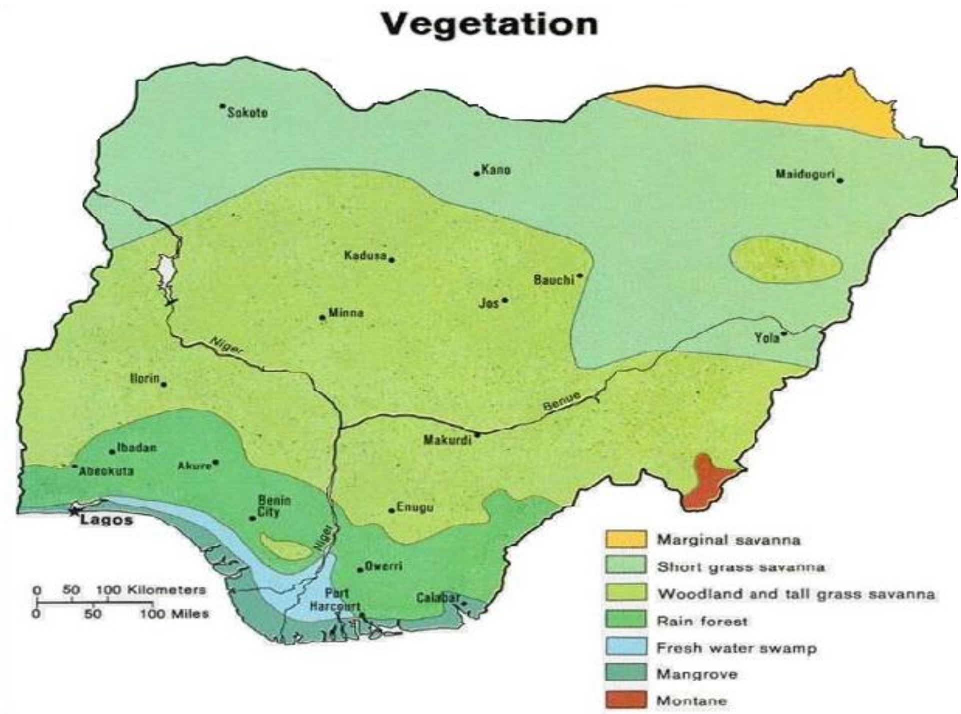



**Figure3.7 Nigeria Vegetation Cover.**
Source: National Adaptation Strategy and Plan of Action on Climate Change for Nigeria (NASPA-CCN), 2011, pp. 4.

### 3.5. EVIDENCE AND IMPACTS OF CLIMATE CHANGE IN NIGERIA.

Despite what could be viewed as denial tendencies on the impacts of climate change seemingly demonstrated by Nigeria, it is interesting to know one of the government agencies believes that, *"Climate change is already having an impact in Nigeria. Weather-related disasters have become more frequent in the past four decades and the trend continues"* (National Adaptation Strategy and Plan of Action on Climate Change for Nigeria (NASPA-CCN) 2012, p.1). There are lots of evidence observed across all climate regions in Nigeria that clearly points to the manifestations such as flash flooding and desertification in the North, gully erosions, increased precipitation and the rise in sea level to mention but a few in the South, that shows the effects and impacts of climate change in Nigeria. Unfortunately, these experiences are confirmation of earlier predictions about the potential risks and impact from climate change Nigeria might face, sadly, events have proved these predictions rights (Umoh, 2007; Odjubo, 2010; Onyekuru and Marchant, 2012).

Earlier studies were observed by Odjubo(2010) suggested that some indicators were used in assessing the evidence of climate change in the Nigerian region. These indicators include: increased temperature, increasing evaporation, decreasing rainfall amount in the regional interiors, increasing rainfall in the coastal regions, increasing disruption in climate patterns and increasing frequency and intensity of unusual or extreme weather related events such as; bush fires, droughts, constant loss of forest cover and biodiversity, drying up of rivers and lakes, floods, landslides, lightning, unpredictable rainfall patterns, rise in sea level, increase desertification and land degradation, thunderstorms and windstorms (Odjubo, 2010).

The indicators identified may not be common to all regions and at the same magnitude, but certainly they have become constant elements to consider in the measurement of the impact of climate change in Nigeria.

### 3.5.1 Increasing Temperature.

Some studies have suggested an increased temperature level across Nigeria regions (Nwafor, 2007; Umoh, 2007; Odjubo, 2010; Odjubo, 2011). Figure 3.8, Figure 3.9 and Figure 3.10 shows evidences of spatial and temporal variations in temperatures spanning from 1901 up to 2005 Odjubo (2010). The differences between the Figures (3.8, 3.9 and 3.10) are in the numbers of degree recorded at different periods.

The available climatic data from Nigeria was from a study conducted by Odjubo (2010), whose investigation was based on 30 out of the 36 weather stations in Nigeria. Those weather stations selected were spread across the various climatic regions of Nigeria and because they were regularly updated (Odjubo, 2010). Hence, suggesting a fair representation of all the climatic regions.

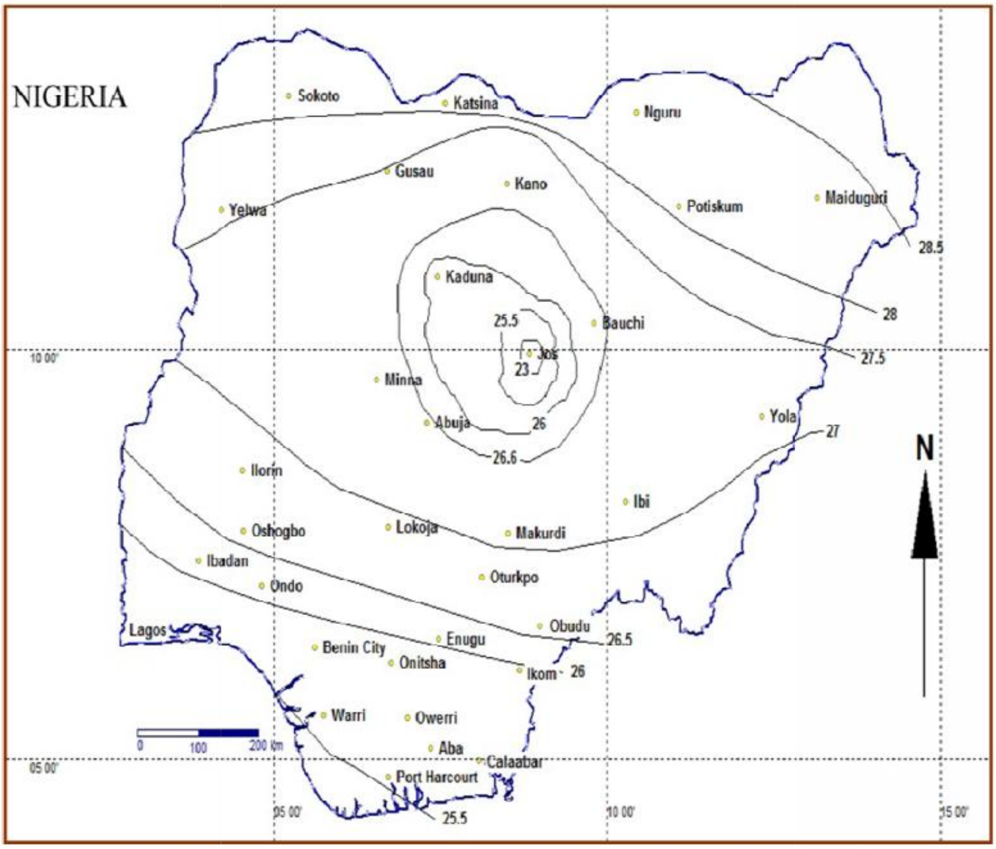



**Figure 3.8 Spatial pattern of air temperature in Nigeria (1901-1935)**
Source: Odjubo, 2010, pp.147.

In Figure 3.8 and Figure 3.9 the Spatial pattern of air temperature shows that between 1901 to 1935 and 1936 to 1970 the temperatures are virtually the same for all locations except for the pattern of spread as suggested by the contour lines. However, Figure 3.10 shows that from the 1970s there was temperature increase. For example in Figures 3.8 and 3.9 the temperatures for Jos, Lagos and Maiduguri areas are in the range of 22.5 -23$^{O}$C, 25.5 $^{O}$C and 28.5-29$^{O}$C respectively.

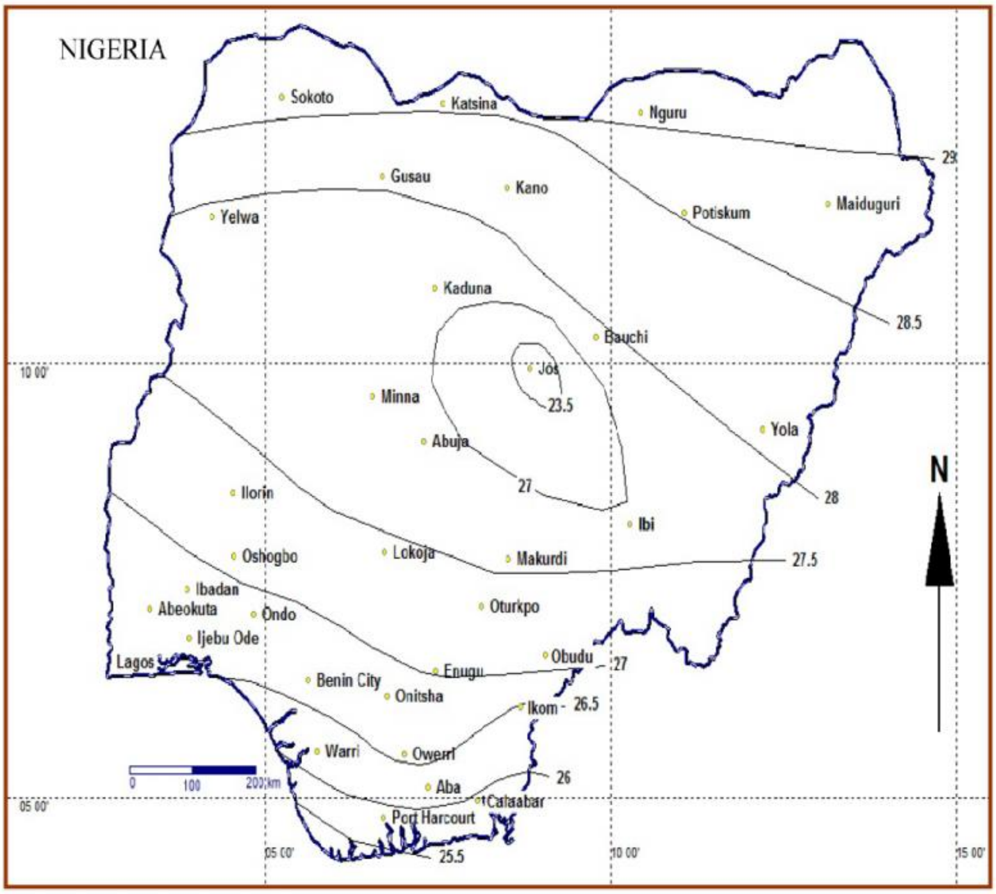



**Figure 3.9 Spatial pattern of air temperature rise in Nigeria (1936-1970)**
Source: Odjubo, (2010, pp. 148).

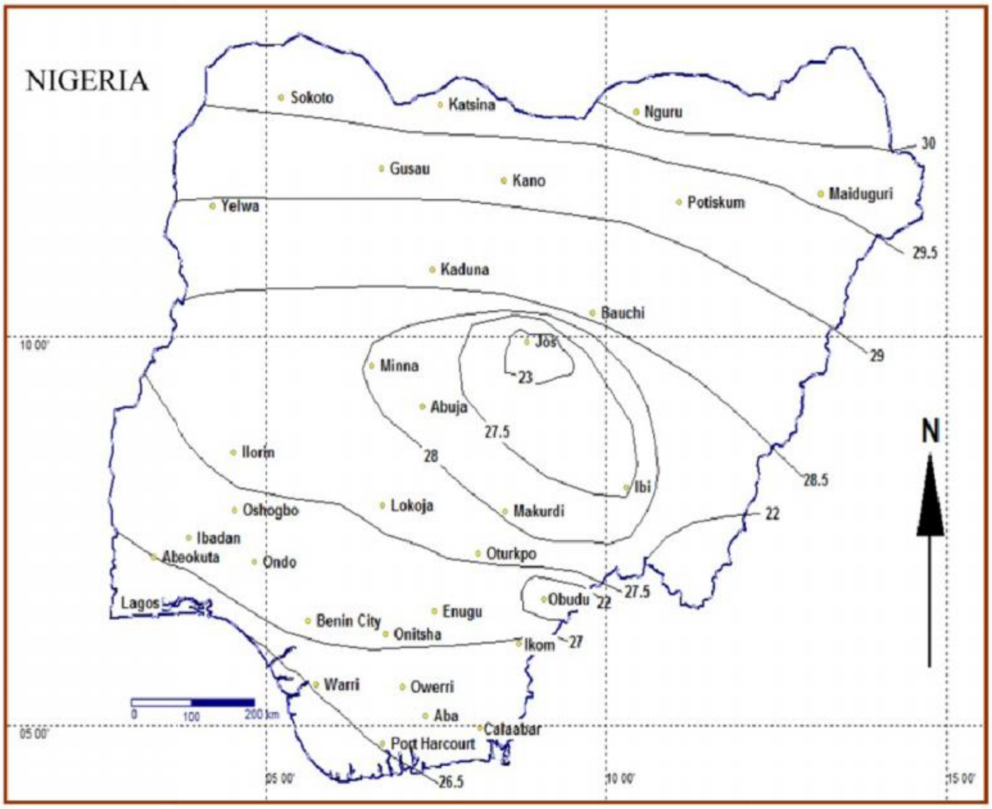



**Figure 3.10 Ambient temperature rises in Nigeria (1971-2005)**
Source: Odjubo, 2010, pp.147.

However, within the same locations there was temperature increase of 23 $^{O}$C, 26.5 $^{O}$C and 30 $^{O}$C.  Air temperature has witnessed a gradual increase since 1901 (see Figure 3.11) but has increased more rapidly since 1970. This suggests that the wide variations in temperature are clear and unequivocal indications that the evidence of global warming and the signals of climate change has indeed increased since the 1970s in Nigeria (Odjubo, 2010).The periods between 1941 to year 2000 shows a clear evidence of long-term temperature increase in most parts of Nigeria. The main exception was in the Jos area, where a slight cooling was recorded. The most significant increases were recorded in the northeast, northwest and the southwest extreme parts of the country, where average temperatures increased by 1.4$^{o}$C to 1.9$^{o}$C (Odjubo, 2010).

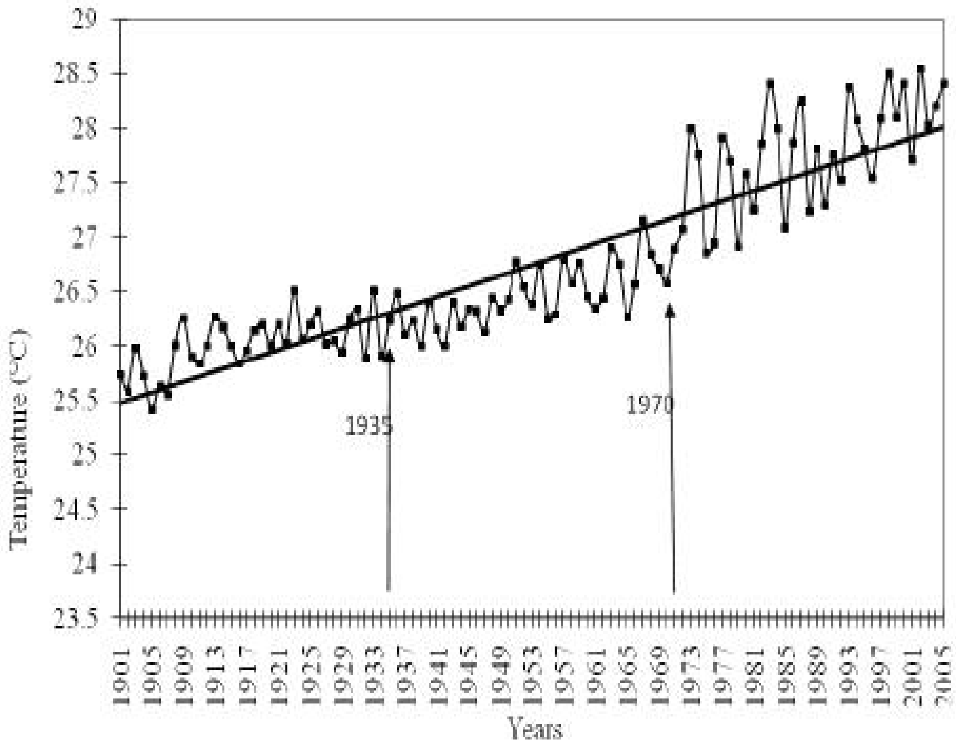



**Figure 3.11 Air Temperature Distributions in Nigeria 1901-2005**
Source: Odjubo, 2010, pp.145.

Sequel to the above and comparatively, it is clear that in the last 100 years the global average temperature increased by 0.74°C and the projection for the 21st century is within 2°C to 4°C (IIPC, 2007; IFRC, 2010). This means that temperature levels in the 21st century will have quite a catastrophic consequence on countries across the world which is evident in the recent Tsunamis witnessed in Asia. Quite succinctly therefore, Nigeria falls within the international bench mark (2°C to 4°C) (IFRC, 2010). From the data presented, the researcher observed that 1.9 °C recorded between 1901 and 1971, which is 34 years, as shown in figure 3.11 indicates that temperatures increased by 1.2°C in the coastal communities of the South-South region of Nigeria to 2°C in the far Northern states.

### 3.5.2. Extreme weather.

Extreme weather is commonly associated with the intensity or frequency of climate related elements of erratic rainfall leading to change in pattern, drought, floods, tropical storms, landslides and rise in sea-level (as discussed in section 2.4 and shown in Figures 3.11 to 3.14). These occurrences have effects on infrastructures, agriculture, human and environmental health, gender issues, conflict and human migration in Nigeria (Ayuba et al, 2007; Odjubo, 2007; USIP, 2011; CCAN, 2011; Onyekuru and Marchant, 2012). Hence buildings in Nigeria have been affected by the extreme weather occurrences.

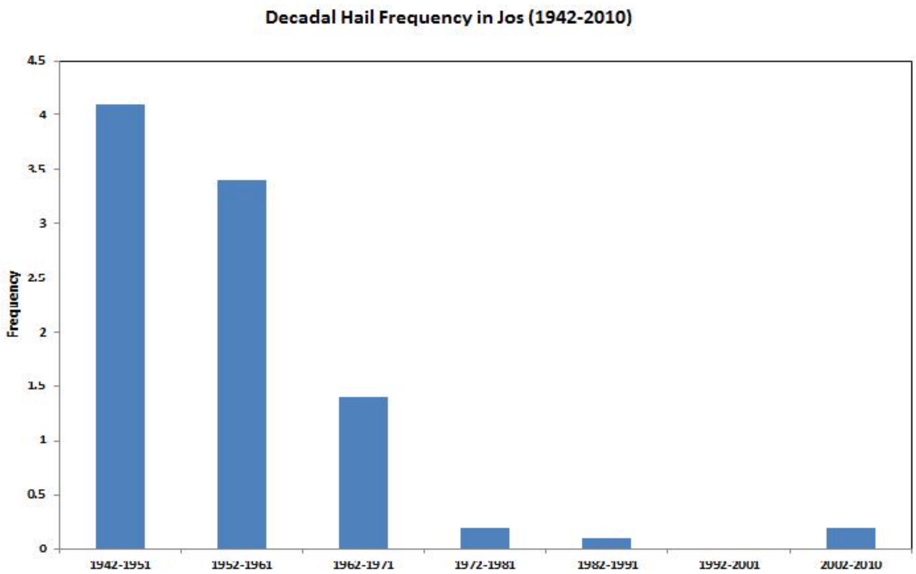



**Figure 3.12 Decadal Hail Frequencies in Jos, Nigeria (1942-2010).**

Source: NIMET 2008 and additional NIMET data (in Nigeria National Adaptation Strategy and Plan of Action on Climate Change for Nigeria (NASPA-CCN), 2011, pp.9).

### 3.5.3. Erratic rainfall

Furthermore, the decrease in rainfall induced by increased temperature has led to drought and desertification in Nigeria. This is mostly experienced in the semi-arid areas of Nigeria such as Katsina, Kano, Maiduguri, Nguru and Sokoto. Conversely, the experiences of increasing rainfall is causing flooding, erosion and rising sea level in the coastal communities and states located within the tropical rainforest climate region of Nigeria such as Lagos, Port Harcourt and Calabar areas (Chindo and Nyelong, 2005; NIMET 2008; Odjubo, 2010).

From the periods between 1971 and 2000 a combination of late onset and early cessation which shortened the length of the rainy season in the Northern parts of the country by 2-8 mm annually was observed. Although an increased annual rainfall was observed by 2-4 mm in some coastal areas like Port Harcourt, Lagos, Delta and Ondo within the same period of time (Odjubo 2009; NASPA-CCN, 2010).

The study by Onyekuru and Marchant (2012) reports that desert areas in Nigeria now covers about 35 per cent of country's land mass. Furthermore, desertification has been observed to be advancing at an estimated 0.6 km every year while deforestation is taking place at 3.5 percent every year (JAR, 2009).

JAR also noted that the desert belt shifted inwards from the Maiduguri-Kano axis to the Kebbi-Sokoto axis; covering a distance of about 1,200 km westward and about 800 to 900 km southwards, while the Savannah interface between desert and rainforest is observed to be now moving towards the Middle belt states of Makurdi- Kogi and the western states of Oyo, Osun,—about a 1,200 km shift to the south (see Figure 3.2 for locations). Hence, creating an environmentally unstable climate regime for Nigeria and thus, making the country substantially at risk, especially for its forests and water resources, and vulnerable to climate change.

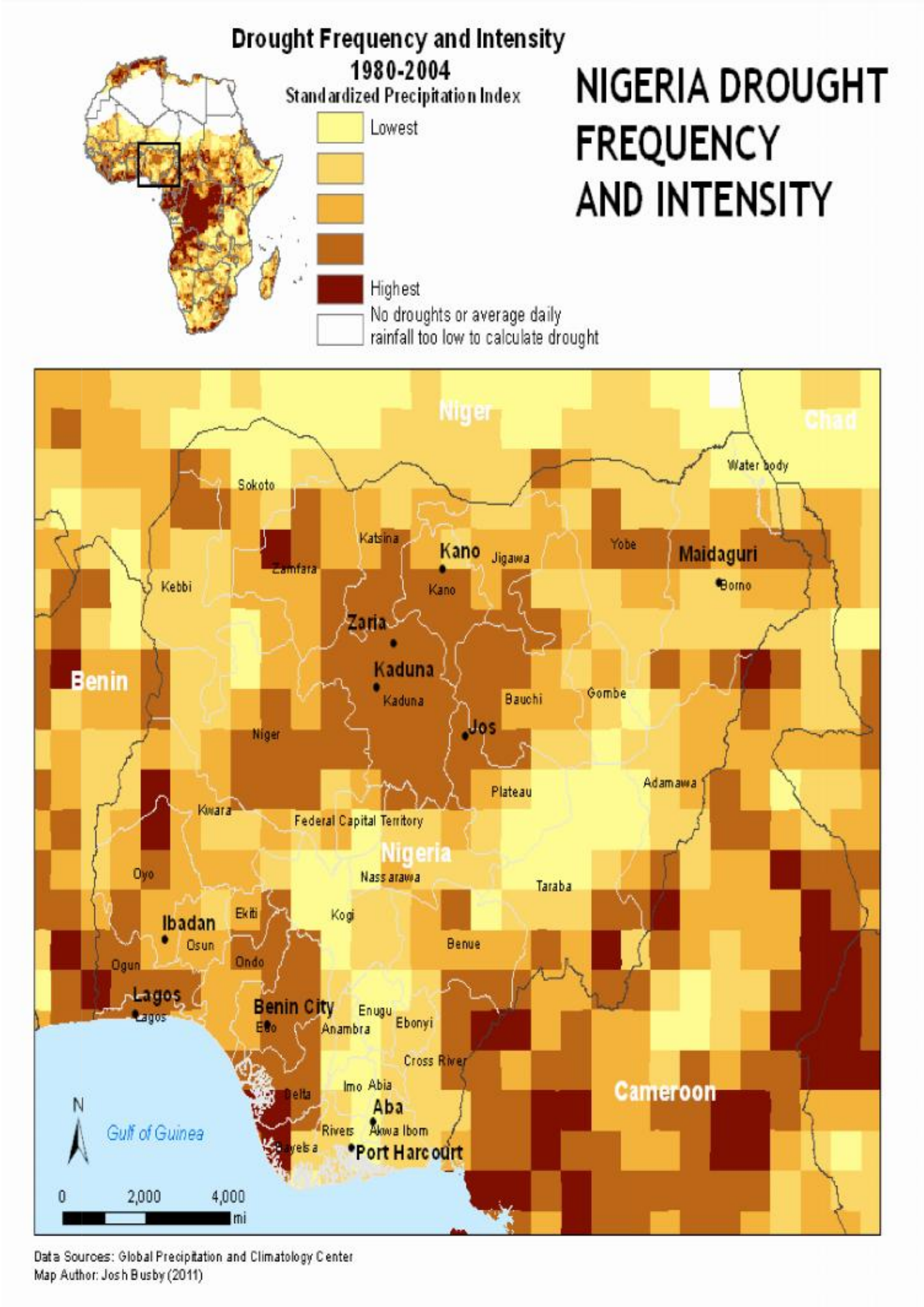



**Figure 3.13. Nigeria Drought Frequency and Intensity**
Source: climate change in Nigeria: key consideration for decision makers, 2011, pp.4. http://ccaps.strausscenter.org (Accessed 01/03/2012)

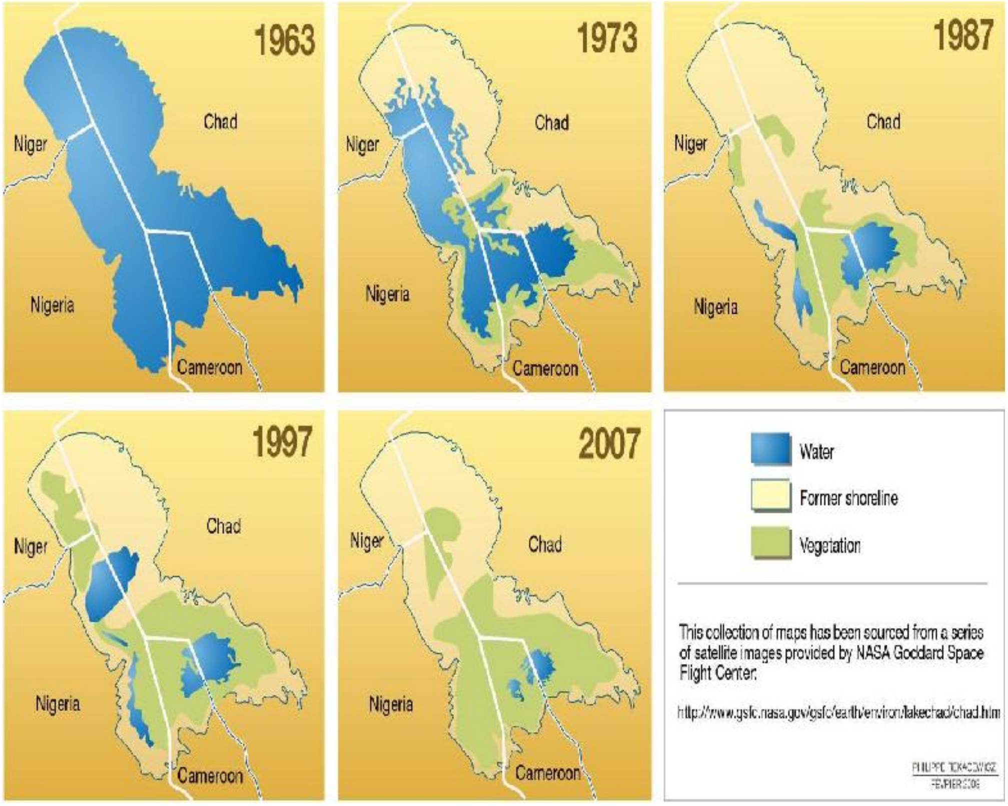


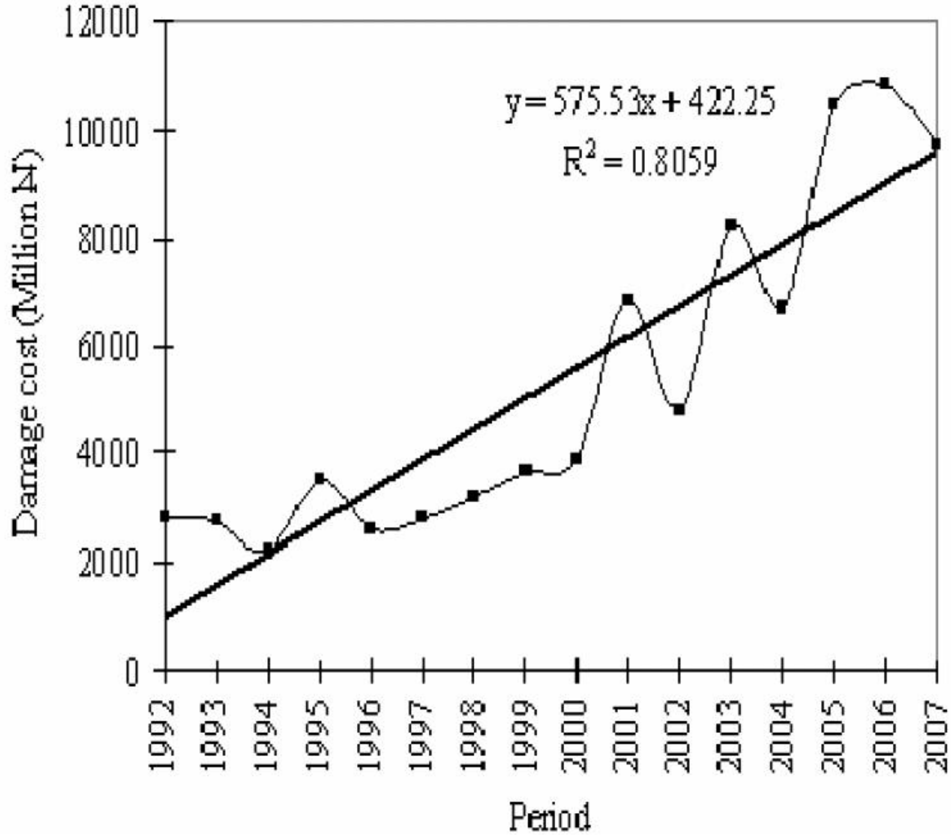

**Figure 3.14 Shrinking of Lake Chad due to Increase in Temperature and Decrease in Rainfall.**
Source: www.gstc.nasa/gstc/earth/environ/lakechad/chad.htm (Assessed 10/03/2012).

Figure 3.14, shows the shrinking images of the Lake Chad, the lake has receded significantly (see location in figure 3.2) which is one of the evidences of the manifestations of climate change impact underpinned by increasing temperature resulting into an increased evaporation on water surfaces like the Lake Chad located in the north eastern region of Nigeria.

### 3.5.4 Wind Action.

Basically, the wind action rate of destruction has steadily increased prior to year 2000 and since then it has become erratic (Figure 3.15 and 3.16) which explains the nature of the correlation between variations in wind and damage. This could be linked to the increasing rain and windstorms from the late 1990s and 2000s as rightly observed by

Dubu (2006) cited in Odjubo (2009). Therefore, two figures (that is 1990s and 2000s) compare the Tropical rainforest climatic zones Af (southern Nigeria) with the Savannah climatic zone Aw (Northern Nigeria). Odjubo (2005) also observed earlier that while rainstorms increased by 38 percent in Nigeria south of$8^{O}$N latitude, it was 6 percent between $8^{O}$N and $14^{O}$N latitudes. Again a later study carried out by Odjubo (2009, 2010) also confirmed the trends in climatic changes as shown in Figures 3.15 and 3.16.




**3.15 Temporal variation and storm damage in Nigeria.**
Source: Odjubo 2009, pp.97

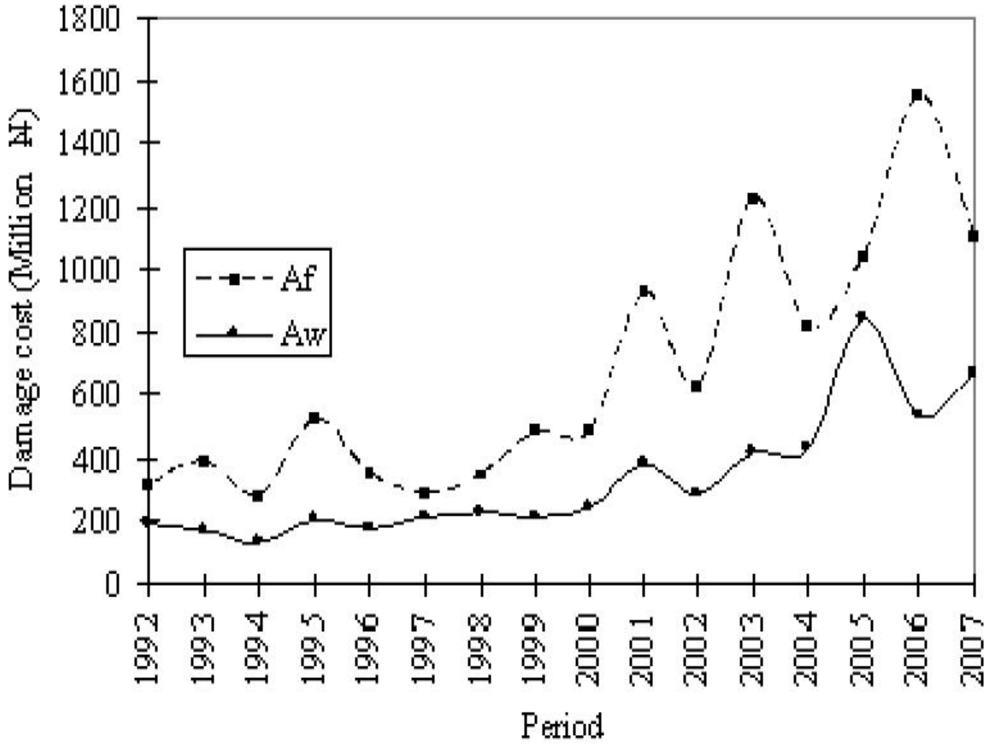



**Figure 3.16 Mean variation in damage (cost) between Tropical rainforest (Af) and Savannah climate (Aw) climatic types.**
Source: Odjubo 2009, pp.97

### 3.5.5 Rising Sea Levels

Africa's wetlands are predicted to experience a rise in sea levels, shore recessions and erosions (IPCC, 2001; National Communication, 2010). This prediction has become evident in Nigeria's wetlands which are the second largest in Africa (BNRCC, 2008). There has since been a visible rise in sea level along its coastal land areas of South West and South-South region which has decreased from 37,000km$^2$ to about 15000 km$^2$ within the span of fifty years, thereby displacing communities and causing loss of farmlands and buildings over the years (Nwafor, 2006 Labell et al, 2008; BNRCC, 2008; 2012).

### 3.5.6 Soil Salinity

Also, Nigeria has witnessed soil and water salinity in all its coastal areas, which has limited arable land and this has annually increased by 3 per cent, affecting residents and all fabrics of the society including infrastructures (UNDP, 2006; Ahaneku, 2010).

Figures 3.17 to 3.22 are pictures from the different regions of Nigeria showing evidence of the impacts of Climate Change.

**Figure 3.17 Evidence of flooding in South West region of Nigeria (Lagos).**
Source: Source: www.google.co.uk.images (Accessed 05/12/12).

Figure 3.17 further shows flooding of houses due to the increased rainfall being experienced in low lying coastal city of Lagos in South West Nigeria. Figure 18 and 19 shows flooding due to an over flow of river Makurdi and River Delimi in Jos, North Central Nigeria. In all cases residential buildings were affected.

**Figure 3.18 Evidence of Flooding North Central Region (Makurdi).**
Source: Source: www.google.co.uk.images (Accessed 05/12/12).

**Figure 3.19 Evidence of Flooding in North Central Nigeria (Jos in July 2012)**
Source: Source: www.google.co.uk.images (Accessed 05/12/12).

Also, Figures 3.20 and 3.21 show evidence of drought as a result of temperature increase and decrease in rainfall around the North West and North East regions of Nigeria. This affects agriculture, particularly farming and grazing, and with huge implications for hunger and malnutrition.

**Figure 3.20 Evidence of drought in Nigeria**
Source: Source: www.google.co.uk.images (Accessed 05/12/12).

Effects of lack of rainfall has clearly affected grazing and farmlands as shown in Figure 3.21.

**Figure 3.21 Evidence of Drought in North East Nigerian Region**
Source: Nigerian Vanguard Newspaper.
www.**vanguardngr.com**/2010/05/special-report-on(Accessed 09/12/2012) this shows the effects of lack of rain reflected on the draught been experienced on trees and vegetation in the North.


**Figure 3.22 Evidence of Gully Erosion in South East Region of Nigeria**
Source: Source: www.google.co.uk.images (Accessed 05/12/12).

Figure 3.22 shows on-going gully erosion taking place in South East region of Nigeria which suggest huge threats to buildings and Figure 3.23 shows the activities of gas flaring in Nigeria which affects the quality of building structures in the Niger Delta in South-South region of Nigeria.

**Figure 3.23 Gas flaring in South-South Nigeria**
Source: Source: www.google.co.uk.images (Accessed 05/12/12).

### 3.6 THE EFFORTS OF NIGERIAN GOVERNMENT ON CLIMATE CHANGE

As part of efforts to demonstrate Nigerian government readiness and capacity to effectively address the likely impacts of climate change, it set up the National Adaptation Strategy and Plan of Action on Climate Change for Nigeria (NASPA-CCN) vested with the principal responsibility to drive and coordinate as well as integrate all governmental efforts on climate change. The good news here is that, NASPA-CCN agrees with findings on impact of climate change in Nigeria as reflected that,

> "Climate change is the latest challenge to sustainable human development. The scientific evidence is clear: climate change is likely to have negative impacts on efforts to achieve Nigeria's development objectives, including the targets set out in Nigeria Vision 20:20:20 and the Millennium Development Goals (MDGs). In particular, climate change will impede efforts to reduce the poverty experienced by the majority of Nigerians…. Climate change is already having an impact in Nigeria. Weather-related disasters have become more frequent in the past four decades and the trend continues…."
>
> (NASPA-CCN, 2011, pp. iii)

It is expected therefore that, since NASPA-CCN has admitted to the fact of the obvious impacts of climate change in Nigeria, the body will focus its energy on providing solutions that could help drive government policies designed to ameliorate the rate of devastation currently been witnessed across the country. Of particular interest to this research work is the section on Human Settlement and Housing, even though the impacts from other sectors could be interrelated. The NASPA-CCN has also put in place proposed strategies, policies, programmes and measures for each of the thirteen sectors. However, they detailed the following strategies for human settlement and housing to include; development of climate change adaptation action plans for urban areas, particularly those at greatest risk, assist communities to reduce vulnerability through participatory planning of land use and housing and discourage building/urban encroachment into vulnerable areas, high risk zones and low lying areas. Other strategies include; discouraging housing and settlement practices that are maladaptive in the face of climate change and strengthen rural settlements in order to reduce migration(NASPA-CCN, 2011, pp. vii and viii).

Although these appear to be laudable plans, but because of the lack of readily available and accurate data on climate change and emission from buildings in Nigeria, it would be difficult to effectively implement these policies on climate change. Also, whether deliberately or not, NASPA-CCN document failed to acknowledge or capture the role of buildings in the emission of GHG gases causing climate change. This means they will pay less interest in issues concerning GHG emission by building into the environment, hence making the elaborate government efforts lobe sided. It could be argued that, they are picking and choosing what aspect of the global report on Nigeria they will implement. However, to make any meaningful headway, the government should ensure conscious efforts and work closely with building professionals in Nigeria, thereby coming up with an agreed role and strategies to help recalibrate sustainable building designs processes which will help reduce GHG emissions into the environment.

### 3.7 CHAPTER SUMMARY AND CONCLUSION

After a careful review of available data and discussions above, evidence clearly shows that Nigeria's population is constantly increasing therefore, the possibility of a near equal or rise in housing demand is certain. This will definitely increase the level of energy use and quite certainly expansion of the urban cities. Although climate change impacts is currently evident in droughts, flooding, rain storm, erosion, soil salinity, land degradation and loss of land, as well as extreme wind action on settlements and buildings, there is still a yearly housing deficit of 10 million. Thus, the climate change impacts currently been observed will form the bases on which to design the climatic parameters for the proposed design guide.

Furthermore, the role of the architect and building professionals is pivotal and quite vital to the adaptation of relevant strategies that could help provide solutions to the challenges posed by the various evidence of climate change observed so far in Nigeria.

The chapter two of this research work provides necessary theoretical underpinnings and applicable principles reflected in previous research findings which points at possible solutions through the use of sustainable design strategies suitable for Nigeria. The question now is how Nigeria architects can engage themselves in solving the challenges posed by climate change in residential buildings?

The evidence and obvious impacts of climate change in Nigeria is frightening. Therefore, the built environment is seriously in trouble as demonstrated in sections 3.5 and 3.6 respectively. However, despite the huge limitation of relevant data on climate change in Nigeria, the evidences from various research findings shown across this research has been able to provide strong facts about the it's reality in Nigeria and the expediency for the government to act fast. Finally, the inherent changing trends, current and potential social-economic problems associated with climate change like those discussed in section 3.3 underscores the choice of using Nigeria as the context of study for this research.

# CHAPTER FOUR

## 4.0 RESEARCH METHODOLOGY

### 4.1 Introduction

This chapter presents the research strategies that were employed to collect, collate, analyze and interpret the research findings. These are presented in 17 sections. Section 4.2 highlights the methodological framework and 4.3 discussed the research philosphies that underpins this research. 4.4 gives an overview of the research methodology and 4.5 examines the research strategy. While 4.6 highlights the unadopted research methods and in section 4.7 research sample and sampling methods are discussed. In sections 4.8 and 4.9 the reseracher discusses the pilot survey and the field survey report undertaken. Data sources and methods of data collection are examined in section 4.10. Also, surveys and scale of measurements for this resaerch are shown in sections 4.11 and 4.12 respectively. The satistical analysis and ethical considerations for the research are included in sections 4.13 and 4.14. In section 4.15 the researcher details the validity and reliability test. Furthermore, the methodolical limitations of adopted methods are highlighted in section 4.16.  Finally, the chapter closes with summary and conclusions in section 4.17.

### 4.2 RESEARCH METHODOLOGICAL FRAMEWORK

A conceptual framework in this research serves as the compass that outlines and offer explanations for the sequence of the methodology and the interelationship between the research methods employed. According to Miles and Huberman (1994, pp. 18), a methodological framework as a process that “explains either graphically, or in narrative form, the main things to be studied …the key factors, concepts or variables and the presumed relationship among them”.  Furthermore, Bell (2005) and Globio (2012) opined that methodological framework are the main focus or structure on which a research is carried out. The detailed structure and processes used in this research are discussed subsequently in sections 4.3, 4.4 and 4.5.

## 4.3 RESEARCH PHILOSOPHIES AND ASSUMPTIONS (PARADIGM)

Research philosophy deals with the development of knowledge, the nature of the knowledge and the assumptions on the way a researcher views the world (Saunders et al, 2007). According to Creswell (2007), research philosophies are grouped into three parts *ontology*, *epistemology* and *methodology.* On the other hand, Saunders et al. (2007) opined that the the three parts of research philosophies include; ontology, epistimology and axiology, whilst Scotland (2012) suggested a fourth paradigm as methods.

Ontology has been refered to as the philosophy concerned with the nature and form of what is known (Creswell, 2007). Carter and Little (2007) explained the term epistemology as the justification of the theory of knowledge whose methodology justifies the methods leading to the production of data and analyses. While axiology looks at the value the researcher puts into the research (Saxton, 2003). Quite interestingly and perhaps arguably, researchers often define the bases of their research knowldge using the epistomological concept because it justifies the theory of knowledge whose methods leads to the production of data and analysis which is apararently consistent with the arguments put forward by Carter and Little (2007).

Furthermore, methods includes tasks, actions or the practical activities of a research that includes; sampling, data collection,management, analysis, and reporting (Carter, and Little, 2007; Scotland,2012). Therefore, this research's ontology and epistomology positioning has an important bearing on the researcher's worldview. As such, it has been observed that the definitions of these concepts clearly suggests that epistomolgy has a longer influence on both methods and methodology of any research. This was rightly captured and further illustrated in figure 4.1. This argument is further supported by Easterby-Smith et al. (2008) who postulated that, the method a researcher employs during a research inquiry is justified by the epistemological assumptions adopted.

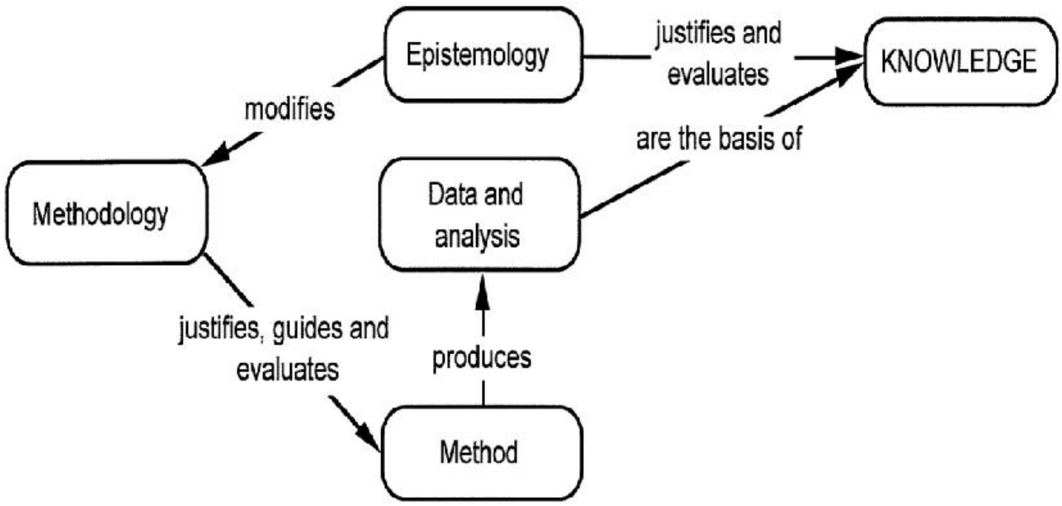



**Figure 4.1 Relationship Between Epistemology, Methodology, and Method.**
Source: Carter and Little (2007, pp. 1317).

Epistomological positioning ranges from *positivism* to *social constructivism* and in between them is the *post-positivism* and *pragmatism paradigm* (Creswell, 2007). Creswell (2007) further describe Positivismasa scientific research which is objective to reality, where the researcher engages in an impartial prior hypothetical testing, which is commonly associated with quantitative research methods. Secondly, Creswell (2007) decribed Social contructivism as a social research which is subjective in nature and context and commonly associated with qualitative research methds while Post-positivismstrikes a balance between the postivism and social constructivism, while its ideals are positivism its subjectivity is not absolute. Finally, Creswell (2007) argued that Pragmatismhas no leaning to any of the elements above, rather its technique is based on what a research sought to achieve and is guided by specific research questions.

The positivist researcher is primarily concerned with quantifying a precise knowledge using scientific methods to present findings emperically (Henning et al, 2004). In a natural setting the positivist empirical assumption is to assess research subjects through theories and models that are based on facts and observations using quantitative methods (Henning et al, 2004; Veal, 2006; Ayikoru, 2009).

Nevertheless, whichever method apply with regards to the epistomological positioning of the researcher remains an interesting debate (Bryman, 1984; Steinzetz, 2004). While

Polit and Beck (2008) argue that quantitative research is common with the natural sciences, Babbie (2007) on the other hand is of the opinion that social constructivism is more akin to social science researchers because it is subjective, based on how the researcher views an issue.

Johnson and Onwuegbuzie (2004) however, argued that these debates may be theoretical and argued that neither methods nor data collection are necessarily dependant on the epitemological belief and justification of the researher. However, a later opinion suggested that these belief directs the research tasks and the choice of methods for a particular research (Creswell, 2009; Nightingale, 2011). Although, an earlier suggestion by Tashakkori and Teddlie (1998) had concluded that there is no absolute knowledge on the reality of nature and hence, concluded that the combination of both quantitative and qualitative methods reduces or closes the gaps in the absoluteness of knowledge. A pragmatic stance is therefore adopted for this thesis to direct the methodology and the choice of methods in order to address the research questions and achieve the overall aim of this research.

## 4.4 AN OVERVIEW OF THE RESEARCH METHODOLOGY:

Research methodology refers to the theory and analysis of a research method. Research methods involves; procedures, tools and techniques involved in the research data generation and analysis (Schwandt, 2001). Any methods engaged by any research is expected to give credence to the project embarked upon and justify the appropriatness of the selected methods for that particular research (Fellows and Liu, 2003). Furthermore, the principles and logic driving any research investigation refers to research methodology used to solve research problems (Fellows and Liu, 1997; Kothari, 2007 and Sridhar 2009). Therefore, research methods and methodology are useful for the effective conduct of this research which addresses the set aim and achieve the stated objectives.

### 4.4.1 Types of research methods

Traditionally, research methods are basically qualitative and quantitative in nature (Onwuegbuzie and Leech, 2005). These involve the way data are collected, analysed and interpreted. Both methods are relevant and constantly used by researchers (Denzel and Lincoln 2005; Onwuegbuzie and Leech, 2005; Domegan and Fleming, 2007; Myers, 2009).

Qualitative methods explore and represent the interpretation of others with the aim of exploring issues of limited knowledge, which may be executed through, interviews or opinions, direct observations and documents which form data in words (Denzel and Lincoln 2005; Denzel and Lincoln 2006; Domegan and Fleming, 2007). In addition Denzel and Lincoln (2005) and Saunders (2009) also agreed and suggested that qualitative methods are inductive in nature; which do not require hypothesis and the researcher is the instrument of data collection and analysis. A qualitative approach gives details of the behaviour of the study subjects (Brannen, 1992).

Conversely, quantitative research approach is considered an empirical research which is deductive in nature (Hinchney, 2008; Saunders, 2009) and mainly for statistical findings from questionnaire surveys and experiments as tools to gather the numerical data for the statistical analysis (Myers, 2009). Furthermore, Myers (2009) posited that quantitative research interprets opinions, compares, and highlights the trends of events and causality or reasons of the events with a focus on the particular number of population involved. Also a quantitative research explores the attitudes rather than the behaviour of the research subjects in large-scale surveys (Brannen, 1992; Naoum, 1998) and includes experimental surveys and quasi-experiments (Social Justice Institute (SJI), 1999) and Table 4.1 compares these two approaches.

Generally, a qualitative research method gives in-depth and specificity to research findings while a quantitative research method provides a general understanding of the subject matter (Denzin and Lincoln 2005; Domegan and Fleming, 2007; Myers, 2009). However, the selection of methods should be tailored towards reaching successful reflective findings that address the research questions (Patel, 2006).

A third research method that seeks to combine both methods discussed above has also been explored by researchers. According to Johnson et al. (2007) and Hart et al. (2009) the third method is known as the mixed-methods research. The mixed-methods seek to integrate the two approaches with the aim of achieving accurate and detailed information that offers a triangulation (Maxwell, 2005; Canales, 2012). Mixed-methods research captures holistically the reflection of an inquiry and trends both in depth and participants' opinions in general (Creswell and Clark, 2007). Although, an earlier argument suggested that the mixed-methods allow for an analytical framework from literature review and investigative findings from individuals and groups (Brannen, 1992; McDougall and Beattice, 1998). These arguments suggest that the mixed methods offer a wider research inquiry from small to larger inquiries involving human subjects, hence, it has the mix-research method has been adopted for this research.

**Table 4.1 Differences between qualitative and quantitative research approaches**

| Approaches | Qualitative | Quantitative |
|---|---|---|
| **Research philosophy** | -Constructivist and Interpretative. | -Positivist and rationalistic |
| **Research Nature** | -Inductive and<br>-Subjective | -deductive<br>-experimental |
| **Research purpose** | -Towards understanding research subjects;<br>-gauge attitude, opinion and<br>-establish trends | -To quantify a sample data in order to draw out the general views and opinion of the research interest |
| **Research methods** | -Flexible<br>-dependant on data collected for design<br>-Hypothesis not required before research commences | -fixed procedures are established before commencement of research<br>-hypothesis required before research commences |
| **Sample size** | Usually small and to fulfil a given requirement | -Usually a large number Of the population of research subjects and interest. |
| **Data collection methods (types)** | -observations<br>-semi and unstructured interview<br>- Focus groups.<br>-case studies | -Structured interview<br>-questionnaires<br>-experiments<br>-content analysis / statistical analysis<br>-some case studies |
| **Data analysis** | -Non-statistical | -Statistical<br>-descriptive |
| **Research findings** | -May be either Exploratory, investigative or both.<br>-inconclusive (context based) and may not be generalised. | -conclusive and may be used for recommendation (universal context-based) |
| **Researcher's role** | -participatory | -non participatory only an objective observer |

Source: Adopted from various references in the preceding text

#### 4.4.2 Processes in mixed method research

The mixed methods have been recognised to have eight stages explained in Figure 4.2 which articulates the processes involved at each stage. It commences at the initial stage of making a choice to the final stage of report writing. Even though the stages were numbered it has been observed that researchers do have multiple directional movement between stages 4 to 7 as shown in Figure 4.2 below.

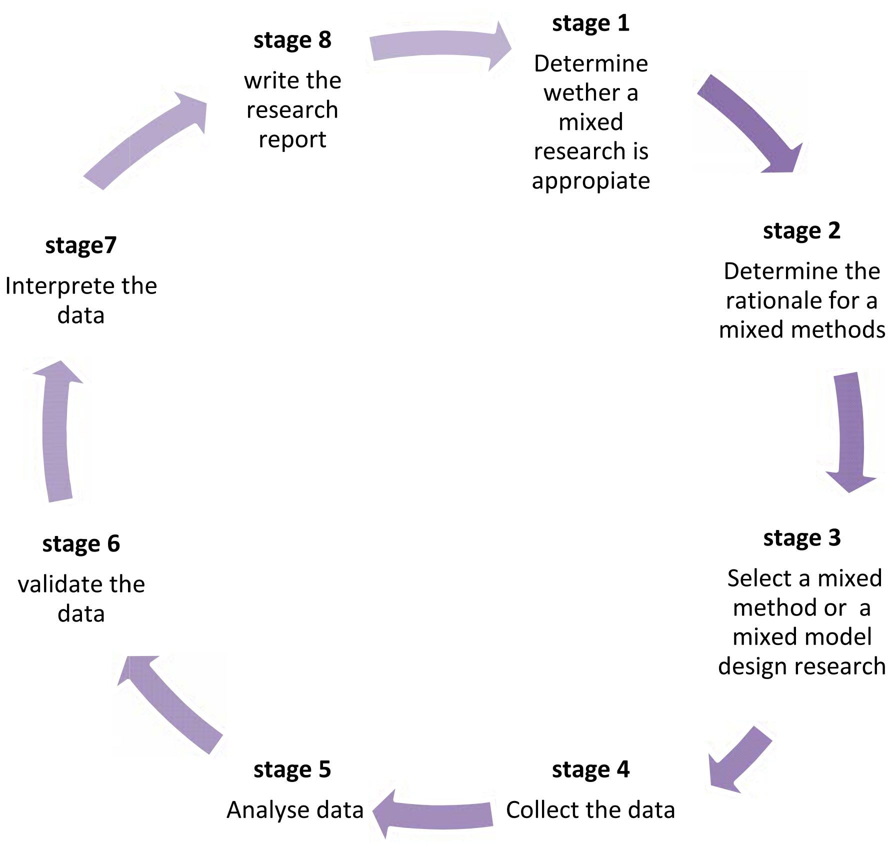



**Figure 4.2 stages in mixed methods research**

Source:http://www.southalabama.edu/coe/bset/johnson/lectures/lec14.htm(Accessed 05/06/2012)

## 4.5 RESEARCH STRATEGY

In the preceding sections the discussions on the research concepts, assumptions and the research approach has positioned this research project for a mixed methods researchstrategy.

### 4.5.1 Rationale for adopting mixed research methods

The mixed-method research brings together diverse views, meanings and their relationships in different perspectives. Johnson et al. (2007) explained that the mixed-methods of research is knowledge that integrates theories with practice as reflected by the quotation below

> "Today, the primary philosophy of mixed research is that of pragmatism. Mixed methods research is, generally speaking, an approach to knowledge (theory and practice) that attempts to consider multiple viewpoints, perspectives, positions, and standpoints (always including the standpoints of qualitative and quantitative research)".

(Johnson, Onwuebuzie and Turner, 2007 pp.113)

This research project adopts the mixed method for reasons of the diverse research questions that a single method may not be able to address effectively. Additionally, a mixed method offers the research finding validation from different information sources (stakeholders, professionals and users). Triangulation enables the collection of information in any particular research from different sources and the individual research subjects, thus, varying opinion on climate change and buildings in Nigeria can take advantages of triangulation.

The integration of qualitative and quantitative research provides a 'more accurate and comprehensive information' (Canales, 2012, pp.7). A quantitative approach checks the limitations of the qualitative approach and also the likely biasness in interpreting data as well as generalization of the research findings by the researcher (Creswell and Clark, 2007). Furthermore, the qualitative approach balances the researcher's subjective views along with those of smaller research groups (Creswell and Clark, 2007).

Furthermore, other advantages for mixed-methods includes accuracy, robust information that answers research questions as well as giving valuable knowledge to policy makers as well as educators, groups and individuals (Onwuebuzie and Leech, 2005; Hart et al, 2009; Canales, 2013). Furthermore, Asmar et al. (2012) in a recent study postulated mixed-research methods that could involve the participation of the stakeholder in the environment. More importantly, is that the combination of methods allows for triangulation which generally gives a credible research outcome (Maxwell, 2005; Bryman and Bell, 2011). This is because it uses quantitative scientific tools to drill down and crystallize on the subjective views of the researcher thereby sifting out any possible unverifiable data. The quest for a credible research underpinned by verifiable data makes the mixed-method a preferred choice for this research project. Table 4.2 highlights the rationale for adopting a mixed-method research adopted from Greene et al. (1987) and Bryman (2006).

Firstly, the questionnaire was used to collect necessary data from the research subject or participants (being the design professionals). The survey technique with underpinning quantitative method was adopted because it has been acknowledged as the most easily acceptable method within social science research circles (Adetunji, 2005) and suitable to quantify larger data. Qualitative research has also been argued to be best used in research involving humans who have developed subjective opinions on certain issues (Domengan and Fleming, 2007). The use of semi-structured interviews was adopted for interviewees (built environment professionals) in order to sample their views, opinions, feedback and to validate findings from the quantitative (questionnaire) surveys.

**Table 4.2 Rationale/purpose of mixed method research**

| Triangulation | Seeks to corroborate Seeks convergence, collaboration and correspondence of results from quantitative and qualitative data |
|---|---|
| Complimentarity | Seeks elaboration, enhancement, illustration, clarification of the result from one method to the other method |
| Process | quantitative provides outcomes while qualitative involves the processes |
| Offset | offset weaknesses of quantitative and qualitative and draw on strengths |
| Completeness | more detailed findings than either of quantitative or qualitative alone |
| Development | Seeks to use the result from one method to help develope or inform the other method, where development is broadly construed to include sampling and implementation, as well as measuerement decisions through the use of designed instruments |
| Initiation | Seeks the discovery of paradox and contradictions, new perspectives of frameworks, the recasting of questions or results from one another with questions or results from the other method |
| Questions | quantitative and qualitative answer different questions |
| Results | with the same focus quantitative can explain qualitative results or vice-versa |
| Expansion/Enhancement | Seeks to extend and build the breath and range of inquiry but using different form of data with the other |
| Outcome | surprising results from one (mostly from qualitative) explains or gives an explanation to the other |
| Sampling | one approach facilitates sampling from other approach |
| Findings and illustrations | Quantitative provides general while qualitative provides contextual and depth to quantitative data. |
| Confirm | quantitative seek to tests; qualitative may generate hypotheses |
| Credibility and Validity | both approaches enhance integrity of findings |
| Utility | more useful to practitioners (researchers) |
| Diversity of views | relationship and meaning; researcher/participant views |

Source: Adopted from Greene, Caracelli and Graham, 1989 and Bryman, 2006.

### 4.5.2 Types of mixed method research design

Four types of mixed methods design in research have been identified. These include; embedded explanatory, explanatory and triangulation designs (Morse, 1991, Creswell et al, 2003; Creswell, 2006). The four mixed methods are;

The embedded methodological design which is a set of data that normally complement each other, whilst using different methods to address different research questions (Morse, 1991; Morgan, 1998Creswell, 2006).

Secondly, the explanatory methodological design operates in two phases, where the qualitative data plays an explanatory role to the quantitative findings; especially where findings are at variance and contrast with previous research conclusions (Creswell et al, 2003; Creswell, 2006; Creswell, 2009).

Furthermore, the third mixed method research is the exploratory methodological design, which explores different emerging concepts and theories, especially where the first method is qualitative and requires a second method which is quantitative to further explore emerging phenomena, test instrument or variables, and for generalizing group results (Creswell et al, 2003; Creswell, 2006).

Finally, the triangulation methodological design is the most commonly used mixed method research design; this is because it allows the researcher to use both quantitative and qualitative methods sequentially or concurrently to obtain complementary data in a single research project (Creswell, 2009).

### 4.5.3 Types of triangulation mixed method

The triangulation mixed method is further divided into three research strategies. Creswell (2009) grouped the concurrent mixed methods into concurrent embedded strategy, concurrent triangulation strategy and concurrent transformative strategy. The study of Creswell (2009) further stressed that, even if all three strategies, that is, concurrent embedded, concurrent triangulation and concurrent transformative obtain quantitative and qualitative data, the concurrent embedded strategy would normally employ secondary data to support the primary data sources. This will add value to the total research as well as provide a wider perspective to the research findings. This research adopts the use of concurrent embeddded strategy to ensure that the findings are explicitly detailed, robust, grounded and well understood.

Some other research methods not adopted for data collection are; focus group or group interviews and direct observations. The focus group or group interviews are usually prearranged meetings of the target participants together and are considered a substitute to interviews (Kmeger and Cassey, 2000). However, the prearranged meeting nature of the group interviews was not used because of difficulty in getting the target participants in one venue at the same time from different locations. Secondly, high cost of moving these highly placed professionals, differences in their work schedules may prolong getting a suitable time for everyone and potentially high tendency for participants not to express their opinion in the open.

Conversely, observation is an approach that allows the researcher to observe and record information from people within or outside an environment, with or without their consent (Robson, 2002). Practically therefore, the observation method will not be effective enough for understanding the role, knowledge, perception and design practices in built environment in Nigeria. Hence, due to lack of applicability to the true intentions and focus of this research, the methods mentioned above were not adopted.

## 4.6 RESEARCH SAMPLE AND SAMPLING METHODS

It is an established fact that samples and population form a critical aspect of data collection in any research. A research involving people represents a targeted or a subset of a research population (Robson, 2002; Kelley et al, 2003) who are known as the research sample. The opinion of the targeted population is sought in order to gather the relevant information towards research findings (Bryman, 2004; Mugo, 2010). The target population for this research are professionals in built environment design across the three primary climatic regions (HCR, TSC and TRC) are chosen for this research purpose. The target population will enable the researcher understand the what built environment professionals consider when crafting new design for built environments, whose GHG emission levels has adversely impacted on climate change in Nigeria.

An important aspect of a research is the sampling consideration. Since this thesis is limited by time and funds considerations are based on what methods best suit the research. Sampling is a selection process that chooses a set or unit of a research population that help to produce a result that reflects a fair representation of the entire population being studied (Trochim, 2006). Basically, sampling is sub-divided into probability (random sampling) and non-probability (non-random) sampling (Trochim, 2006; Saunders et al, 2009), with each further divided into specific sampling units as shown in Table 4.3.

In the study carried out by Onwuegbuzie and Collins (2007) titled 'a topology of Mixed Methods Sampling Designs in Social Science Research', they argued that,both random and non-random sampling can be used in quantitative and qualitative studies (Onwuegbuzie and Collins 2007, p.282). Although this research agrees with their argument, it is most appropriate to use non-random purposive sampling methods, as this research is directed at specific professionals. A purposive non-random sampling was adopted for both surveys; expert sampling technique provided the quantitative data and for the qualitative data collection a snowballing technique was employed.

**Table 4.3 Examples of sampling methods**

| source | methods | types | character | selection |
|---|---|---|---|---|
| **Trochim, 2006; Saunders et al, 2009; Danika, 2010** | Random or probability sampling (common with quantitative data collection) | Simple Random Sampling | Everyone has the chance of being selected | Purposive expert sampling was selected for both quantitative and qualitative data. However, Snowball sampling was adopted in some cases for the qualitative survey. |
| | | Stratified Random Sampling (proportional or quota) | A specific group of a subset is selected | |
| | | Systematic Random Sampling | Selection is based on an equal interval of every nth element | |
| | | Cluster or area random sampling | Deals with very large samples e.g national surveys | |
| | | Multi-stage sampling | Used in studies that seek to obtain the maximised value of probabilistic sampling methods | |
| **Trochim, 2006; Saunders et al, 2009; Danika,2010** | Non-random or non- probability sampling | Accidental, Haphazard or Convenience Sampling | | |
| | | Purposive Sampling<br><br>-Modal Instance Sampling<br>- Expert Sampling<br>- Quota Sampling<br>-Heterogeneity Sampling<br>-Snowball Sampling | | |
| | | Convenience sampling | | |

Source: Compiled by the researcher, 2013

**Selected participants-** the selection of participants was based on the aim and objectives of this research that the researcher believes are potentially in the right position to answer the research questions. Their professional positions and years of experience was also a consideration for selecting any of the potential interviewee. The following considerations determined the choice of participants:

i) The individual participants are either design professionals in the built environment or are experienced housing providers, developers and housing agencies personnel.

ii) Participants may also be academics, private or public practitioners.

iii) Participants recommended by other participant(s).

iv) Mainly participants who have understood the research aim and objectives and have given their consent to participate.

As shown in **Appendix 6** and **7** respectively.

## 4.7 PILOT SURVEY

A pilot survey was undertaken on a randomly selected representation to draw out areas to be fine-tuned on the survey questions before the actual survey was undertaken. Three selected cities (Abuja, Jos and Uyo) were each chosen to represent the three climatic regions (HCR, TSC and TRC) of Nigeria. At the end of the pilot survey, some survey questions were dropped and or restructured. Generally, it is acceptable that a pilot survey ensures validity of research processes because it helps researchers avoid potentially biased tendencies. Thus, a pilot survey is considered a desirable test before administering questions for questionnaires and interviews (Bryman and Bell, 2011).

The option for online survey and the use of postal services were considered, unfortunately, this idea was dropped due to the erratic power supply in Nigeria and unreliability of the Nigerian Postal Services. Thus, the researcher considered physical administering of questionnaires as a more suitable option. Therefore, ruling out postal delays, inability to access the questionnaire online and the tendency to forget filling in the questionnaires or to return them electronically.

In the case of the face-to-face interviews, the initial interview questions were administered to three interviewees, one from each climatic region, in order to know if the questions were easy to understand and convey their intentions. After this exercise a few questions were re-worded. Generally, this pilot survey was adopted to boost the limited data in the research of climate change and buildings in the sub-Saharan African region and Nigeria in particular. The pilot study lasted for three weeks while the final field surveys spanned between May to September, 2013. Furthermore, 28 completed questionnaires were returned (n=28) and these helped to provide adequateinformation and clarifications that shaped the final survey, which enhanced the validity of the survey instruments employed.

## 4.8 FIELD SURVEY REPORT

### 4.8.1 An overview

The field surveys were conducted in order to measure ascertain and evaluate the perceptions and attitude of the built environment professionals across the three climatic regions of Nigeria (tropical savannah, tropical rainforest and the highland climate). A qualitative survey involving a large number of design professionals (architects), who are key to the production of sustainable buildings was conducted. This was carried out through the use of a questionnaire which was administered amongst architects across the three climatic regions. At the same time interviews were carried out amongst selected built environment professionals from different practices within the same climate regions in Nigeria.

In April, 2013, the researcher had an opportunity of attending and presenting a conference paper at the annual 'Architects Colloquium' which was themed 'Sustainable Built Environment' that attracted a large number of built environment professionals within and outside Nigeria as well as the Ministers of the relevant ministries in Nigeria. At the colloquium, the researcher made personal contacts with some of the professionals and exchanged contact details with potential stakeholders like Heads of architecture in Universities, Principals/ Directors of private practices and representatives of various ministries targeted for this research participation. It was relatively easy to establish these contacts because the researcher had been a familiar face at national events of the Nigerian Institute of Architects (NIA) and was a past official of one of its state chapters (Plateau State Chapter). Additionally, the researcher's identity card, as a staff at the University of Jos made it quite easy to reach out to other academics present at the colloquium. These contacts were particularly useful as they served as channels for the distribution of the final survey questionnaires for this research project, as well as for their readiness to snow-ball other interviewees for the interview surveys.

After all the contacts were established, potential appointments were booked (open and flexible) in some states including Adamawa State which is in the north- eastern zone of Nigeria and is part of the fourteen states with the tropical savannah climate type. A state of emergency was declared in Adamawa, Borno and Yobe States by President Goodluck Jonathan of Nigeria as a result of the continuous bombings and killings of innocent citizens by the terrorist group known as 'Boko Haram' on 15th June, 2013. This meant there was a twenty-four hour curfew and ban on free movements across these three states. This was still the case at the end of the survey period (September, 2013). However, permissions were sometimes granted to bury the dead, by the Military Special Task Force whose duty was to take control of these States. It was during one of these 'special permissions' that the researcher was only able to distribute 5 questionnaires to Adamawa State before the crisis, 2 of which were retrieved through the same opening at a later date. Although these formed part of the data, the rest of the questionnaire meant for Adamawa State was later distributed in the neighbouring Taraba State which is located within the same climatic region.

Due to the ease of accessibility and quality of participants required, the questionnaire surveys were administered in the Federal capital and state capitals because of the high presence of both the built environment professionals and construction activities in these locations. Retrieving questionnaires from the different states of the country was equally tasking, due to long distances between the selected State capitals, and the poor postal system added further challenges. Furthermore, the researcher also bore the physical and financial expenses of retrieving the completed questionnaires. This was repeated due to the on-going strike action declared on 1st July, 2013 by the Academic Staff Union of Universities (ASUU) in Nigeria. This made it more difficult to retrieve the completed questionnaires because the participating academics were no longer going to work, due to the strike action, and sometimes when phone contacts was made, communication became difficult due to poor network services.

Eventually, other architects whom the researcher had earlier established contacts with, served as research assistants (mostly those the researcher went to the University with and/ or are NIA State contacts) and thus, became the researcher's collation liaisons in each of the State where the questionnaire survey was administered. This contributed towards the high return-rate of the questionnaires distributed despite the initial difficulties experienced.

The summary of the survey coverage area for the quantitative data is given in Table 4.4. Even though the questionnaire targeted the architects, during the pilot survey it was discovered that a few of the architects have multiple professions and so additional options were added to the final questionnaire as shown in Table 4.5. The collation visits in some cases were also used to conduct some of the interviews. This meant that the quantitative and qualitative surveys were conducted concurrently.

**Table 4.4 showing climate types, geo-political zones spread and survey coverage**

| Climate type regions | Climatic/geo-political zones | States | Survey locations |
|---|---|---|---|
| **Tropical savannah** | North-Central, | Benue, Federal Capital, Kogi, Kwara, Nasarawa, Niger, Plateau, | Federal Capital, Nasarawa, Plateau |
| | North-East | Adamawa, Borno, Bauchi, Gombe, Taraba and Yobe, | Taraba, Gombe, |
| | North-West | Jigawa, Kaduna, Kano, Katsina, Kebbi, Sokoto, Zamfara | Kano, Kaduna, |
| **Tropical rainforest (Monsoon)** | South-East | Abia, Akwa-Ibom, Anambra, Enugu, Imo, | Akwa-Ibom, Imo |
| | South-South | Bayelsa, , Delta, Ebonyi, Edo and Rivers | Cross-Rivers, Delta and Edo |
| | South-West | Ekiti, Lagos, Ogun, Ondo, Osun, Oyo | Lagos, and Ondo |
| **Highland climate (Alpine)** | No entire zone falls in this category | No entire state falls in this category (Taraba, Cross-Rivers and Plateau states) Except for the Jos Plateau the Mambila Plateau; Obudu Mountains have limited inhabitants and Construction activities. | -Jos Plateau, -Mambila Plateau areas |

Source: Compiled by the Researcher (field survey), 2013

**Table 4.5 Character information for the tropical rainforest questionnaire participants**

| Climate type | No. of participants | Profession (Architect) | Practice type (Academics=A, Private=P, Public=U) | | | Years of experience | Gender (Female=F, Male=M) | |
|---|---|---|---|---|---|---|---|---|
| **Tropical rainforest** | 92 | 92 | A<br>36 | P<br>38 | U<br>18 | 5min-60max | F<br>9 | M<br>83 |
| **Tropical savannah** | 89 | 89 | 20 | 17 | 57 | 5min-30+ | 2 | 87 |
| **Highland** | 102 | 102 | 24 | 30 | 57 | 5min-30+ | 8 | 94 |

Source: Compiled by the Researcher (field survey), 2013

## 4.9 DATA SOURCES AND METHODS OF COLLECTION

Basically, surveys are conducted to gather specific research information from a subset of a population (Aday and Cornelius, 2006). Hence, data collection involving people is normally used in surveys due to its wide range of collection techniques and channels like self-completion questionanires, internet, postal, telephone and personal contact (Bryman, 2004). There are three main techniques for collecting data from people which have five common attributes (Robson, 2002), these techniques have been enumerated along with their attributes in Table 4.6.

**Table 4.6 Techniques for collecting data from people**

| Technique | Technique sub-type | 1.interaction | 2. No of responses | 3. Data | 4. Channel | 5.Synchronization |
|---|---|---|---|---|---|---|
| **Survey** | Self-completion questionnaire | Single | 1 | Quantitative, Qualitative. | Physical | Asynchronous |
| | Survey by Internet | Single | 1 | Quantitative, Qualitative. | Internet | Asynchronous |
| | Structured interview by telephone | Single | 1 | Quantitative, [Qualitative] | Telephone | Synchronous |
| | Survey by structured interview | Single | 1 | Quantitative, [Qualitative] | Face-to-face | Synchronous |
| **One-to-one interview** | Face to face interview | Multiple | 1 | Quantitative, [Qualitative] | Face-to-face | Synchronous |
| | Telephone interview | Multiple | 1 | Qualitative [Quantitative] | Telephone | Synchronous |
| | Internet interview | Multiple | 1 | Qualitative [Quantitative] | Internet | Asynchronous [Synchronous] |
| **Group interview** | Focus group | Multiple | >1 | Qualitative [Quantitative] | Face-to-face | Synchronous |
| | Group interview by Internet | Multiple | >1 | Qualitative [Quantitative] | Internet | Asynchronous [Synchronous] |

Source: Robson (2002: pp.223)

**Table 4.7 Advantages and Disadvantages of Survey Methods**

| Types of Survey | Advantages | Disadvantages |
|---|---|---|
| **Mail survey** | •Cost is low compared to other methods<br>•High degree of respondents anonymity<br>• Wide geographical reach<br>•Relatively low cost of processing | • Low rates of response<br>• Require easily understood questions and instructions<br>• Lack of chance to probe for further or clarity of answers<br>• Greater respondents bias<br>•High possibility of uncompleted questions |
| **Personal survey** | • Allows high flexibility in the questioning process<br>• Interviewers have control of the interviewing situation<br>• High response rate<br>• Possibility of collecting supplementary information | •Higher cost than mail questionnaire<br>• Potential interviewers bias due to high flexibility<br>• Lack of anonymity; hesitant to disclose personal data<br>• Time consuming |
| **Telephone survey** | • Moderate cost<br>• Increase speed and time of data collection<br>• High response rate<br>• Increase quality of data | •Hesitancy to discuss sensitive data on phone<br>•High chance of respondents terminating interview earlier<br>•Less chance for supplementary information |
| **Internet survey (Skype)** | •Moderate cost<br>• Increase speed and time of data collection<br>• Allows high flexibility<br>•Allows observation<br>• High response rate<br>• Increase quality of data | • High changes of network/reception instability<br>• Takes longer time<br>•High chance of interruptions<br>• Lack of anonymity |

Source: Adopted from Adetunji, 2005, pp.37 (with modifications).

The use of both secondary and primary data were adopted in order to address the research questions and to validate the findings from the literature review. Secondary data was based on the non-emperical research which includes; a critical review of literature that relates to the subject of this research which served as the background, trends on current debates, evidences and terms. Such sources included; books, research publications, journal arcticles, reports, reports and other internet research publications.

## 4.10 THE SURVEYS

### 4.10.1. Quantitative survey

The Nigerian Institute of Architects (NIA) was established in 1960. Since it was established, it has registered only 3,052 members (NIA Register, 2013). These figures include deceased members, and from the practice addresses of registered members, 62.7 per cent are located within the Tropical rainforest (monsoon) climate region, leaving the other two climate regions with 37 per cent of registered architects. It was therefore necessary to balance the spread of questionnaire distribution by giving equal opportunity to other climate regions.

The total number of 3,052 eligible participants formed the total sample population from which the sample frame was derived. For each climate region a total of one hundred and five (105) questionnaires were administered. Each climatic zone was represented by seven states except the highland climatic region. Each selected state had fifteen (15) questionnaires in order to capture a wide spread of participants. In all, a total of three hundred and fifteen (315) questionnaires were administered. The Tropical rainforest recorded eighty seven per cent (87%) response rate, while the Tropical savannah had eighty four per cent (84%), and with the Highland climate region having ninety seven per cent (97%) response rates. The breakdown of overall response rate is detailed in Table 4.10.

The Participants were informed by the researcher that the outcome of the study would be readily accessible through state offices of their professional bodies and a research paper on the outcome of the research would be presented during the NIA Annual General Meeting (AGM). This information spurred the interest of participants and most likely responsible for the impressive response rate shown in Table 4.10. The questionnaire survey instrument is attached as **Appendix 6.**

Although the highland climate is found in the three different climatic regions (see Figure 4.3) the survey covered mainly the Jos Plateau that is currently habited and a hot bed for construction activities because of the striving temperate micro-climate compared to the Mambila Plateau and the Obudu Mountain ranches that basically serve as tourist sites.


**Figure 4.3 Map of Nigeria showing the three locations of highland climate** areas coloured brown (with over 1000 meters above sea level).
Source: www.mapsofworld.com Accessed 20/09/2013

**Table 4.8 Response rate for quantitative survey**

| Climate Type | Number of questionnaire distributed | Number of questionnaire returned | Percentage of response |
|---|---|---|---|
| Tropical rainforest | 105 | 92 | 87% |
| Tropical savannah | 105 | 89 | 84% |
| Highland | 105 | 103 | 97% |
| Total /Overall response rate | 315 | 283 | 89% |

Source: Compiled by the Researcher (field survey), 2013

### 4.11.2. The qualitative survey

An interview provides the avenue to gather information orally through the use of guided sets of questions. According to Saunders et al. (2009), interviews consist of structured, semi-structured and unstructured questions. In this research, the structured questions were mainly utilised to ascertain demographic information (section A) from participants. However, semi-structured questions (section B) were employed for the main interview. Semi-structured interview serves as a guide, allows the researcher to take advantage of its flexibility and to minimise omissions (Babbie, 2005; Teddie and Tashakkori, 2009).

This research sought to identify and understand the experiences of built environment professionals in the academia, public and private practices in Nigeria, whose views and experiences are key and relevant to the research investigations. The interview allows the measurement of their personal opinions on the interview questions in order to draw up appropriate recommendations at the end of the research. Additionally, the interview provides this thesis the opportunity to document data on the opinion of the built environment professionals in Nigeria.

A qualitative approach best suits the exploratory nature of this research and allows both the participants and researcher to draw from the experiences and the contextual peculiarity of limited documentation in Nigeria.

In an interview based qualitative research the sample size is usually smaller than those of quantitative research (Mason, 2010). Although there are situations where many participants are willing, it is better to engaged a focus group experienced with relevant experience who has been informed about the researcher's areas of inquiries and milestone to be achieved (Morse, 2000; Fossey et al, 2002; Adler and Adler, 2011). However the exact sample size varies based on the assertion by Brannen and Nilsen (2011) that a sample size is dependent on the quality and logic of the study being carried out. A good sample size (n) should be between twelve and sixty (12-60), which is demonstrated across similar research (Charmaz, 2006; Peak, 2010; Bryman, 2012). And an adequate interview number should be from twelve (12) and above according to Guest et al. (2006).

This research therefore, adopted 30 samples as a way of giving a fair representation; ten (10) interviewees were selected for each of the three climate types or climatic regions and the different professions being surveyed as shown in Table 4.11.

The interviews were conducted in their comfort zones (offices) and a few of the academics who were on industrial action were met at their homes– using their study rooms, except for two whose interviews were conducted at their back gardens. All interviews lasted within a sixty minute time frame. For the purpose of accuracy, a recorder was used during interviews and at the same time interview notes were taken.

The researcher had an added advantage by sending the interview questions to the interviewees ahead of the interview sessions. All the interviewees had written out their thoughts to most of the questions in readiness for the interviews and were kind enough to allow the researcher to have their written notes as well. This further gave the researcher an opportunity to have a deeper understanding of the thoughts of the respective interviewees and also keep the context of their thoughts intact. Table 4.11 below gives the interviewees' characteristics and the survey coverage.

**Table 4.9 interviewees' character and coverage across climate types and zones**

| Climate type | Num. of participants | Practice location Residence city-state | Profession Architects(A) Builders(B) Engineers(E) Planners (P) | Practice type (Academics=A, Private=P, Public=U) | | | Years of experience | Gender Female (F) and Male (M) | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | F | M |
| **Tropical rain forest** | 10 | Warri/Ughelli-Delta, Lagos-Lagos and Enugu-Enugu | A=4,B=3, E=3,P=3 | A=4 | P=2 | U=4 | 10-30 | 3=30% | 7=70% |
| **Tropical savannah** | 10 | Federal Capital (Abuja), Gombe-Gombe and kano-Kano | A=3,B=4, E=3,P=3 | A=3 | P=3 | U=4 | 10-30 | 1=10% | 9=90% |
| **Highland** | 10 | Jos-Plateau, Yola – Adamawa, Takum-Taraba-Adamawa and Calabar-Cross Rivers | A=3,B=3 E=3,P=4 | A=4 | P=3 | P=3 | 10-30 | 3=30% | 7=70% |

Source: Compiled by the Researcher, 2013

The interview, as much as possible followed the sequence of derived themes discussed in section 4.12. A formal atmosphere was maintained despite the comfortable environment of the interviewees in order to keep them relaxed and derive quality responses.

The recorded interviews were transcribed from oral information into text data with close attention to avoid losing meanings and context of the original intentions of the interviewee. The process of transcribing the interview took a longer time compared to conducting the actual interview. Selected verbatim emphases by the interviewees were retained for interpretations and qualitative analysis. In general, content and themes in the questionnaire survey guided the interview questions and Nvivo 10 software was used to analyse the responses from the interviewees and this is detailed in chapter five.

**4.12 SCALE OF MEASUREMENTS**

This research adopted the Likert scale format for its measurements to present the opinions of participants in response to the questions in the questionnaire for easy understanding. The Likert scale is the summation of all selected preferences by participants (Vanek, 2012). Vanek (2007) and High (2013) further suggested that a Likert scale ranges between a minimum of three (3) to seven (7) points scale, which is used to measure opinions and experiences in a particular subject, with the aim of achieving a standardised and comparable results, while avoiding unnecessary complexities for the researcher. In this research four measurements were adopted 1- strongly disagree, 2- disagree, 3-agree, and 4- strongly agree. Allen and Seaman (2007) opined that using a four measurement scale of this nature has an advantage of excluding the options of neutrality. Furthermore, Synodinos (2003) also assert that, any well-structured questionnaire should be explicit enough for participants to offer in-depth opinions rather than to opt for a '**no'** opinion option. The above arguments therefore informed the researcher's decision to opt for the four-point Likert scale as been suitable for this research.

The questionnaire instrument has seven sections, apart from section 'A' whose questions were mainly for demographic purposes, the other sections B to F are derived from themes closely related to the research objectives in section 1.7 as shown in the questionnaire (see **Appendix 7**).

The measurement scale includes questions (Q) 6 to 38; termed as variables (v) in the analysis and thus, a total of 32 variables (v6- v38) form the measurement scale items.

## 4.13 STATISTICAL ANALYSIS

Statistical analysis refers to all aspects of data collection from planning, organising and presentation in a research survey or experiment that are analysed using either descriptive or inferential analysis (Dodge, 2006).

Data obtained from ranked scale survey instruments are considered to be ordinal data and useful for high quality statistical analysis for quantitative data analysis (High, 2013). Ordinal data analysis uses non-parametric statistical methods like Mann-whitney, Wilcox, Kruskal-Wallis, Friedman and Spearman Rank Order Correlation (Marusteri and Bacarea, 2010). The Kruskal-Wallis has been suggested as most suitable for testing more than two independent groups (Bruckers and Molenberghs, 2011). Spearman Rank Correlation and Mann-Whitney tests analysis have been identified for this study as the two suitable methods to test relationships in non-parametric statistical analysis (see Decision chart for statistic tests Figure attached as **Appendix 8**).

Furthermore, correlation has been suggested to test strength of the relationship, regression is the mathematical expression that quantifies the relationship between variables mostly for predictions purposes (Bewick et al, 2003). However, O'Brien and Scott (2012) argued that if variables cannot be swapped between the X and Y axis and the variables are ranked, then Spearman Rank correlation should be used. Furthermore, Spearman Rank Order Correlation has also been noted as a statistical tests which provide results that show the strength and the direction of the relationship between selected variables (Marusteri and Bacarea, 2010; O'Brien and Scott, 2012). The Spearman Rank Correlation best suits this research because the variables are ranked and since each of the groups has different climatic conditions their values cannot be interchanged.

Generally, cross tabulation is a commonly used statistical analysis that offers the researcher analytical tabular information on the association or interaction between variables (Yin et al, 2013). In this research, some selected variables that are perceived to have some level of association are further tested using cross tabulation in order to ascertain their level of associations or interactions (as detailed in Table 4.12).

Furthermore, chi-square ($x^2$) test provided the primary statistical significance of the variables from the cross tabulation table to show statistical independence or association between variables (Diener-West, 2008). In Table 4.12 the selected variables are shown and the results obtained are presented in chapter five.

**Table 4.10 Data sources and analysis profile from survey**

| Questionnaire Themes /Variables (V1-V38) | Data source | Purpose/ underpinning literature | Rationale | | Non- Parametric Analysis and Test |
|---|---|---|---|---|---|
| | | | Research Objective (RO) | Research Question (RQ) | |
| Section A: Demographic information (v1-v5) | Questionnaire survey and interviews | Demographic data | - | - | -Descriptive Analysis |
| Section B: Assessing Perceptions on climate change &buildings (V6-V8) | Questionnaire survey, interviews and literature review | Testing level of knowledge, information& ability to apply. Washington et al, 2006; Lorenzo et al, 2007; Laryea, 2011; Emuzie et al, 2013 | b | i, and iii | -Descriptive Analysis -Spearman's Rank Correlation and Cross Tabulation |
| Section C: Evidence and impacts of climate change on residential buildings (v9-v13) | Questionnaire survey, interviews and literature review | Evidence of impacts for each region Obioha, 2008; Odjubo, 2010; Habitat, 2011 NASPA-CCN, 2012 | b | ii | Descriptive Analysis and Mann-Whitney |
| Section D: Assessing the Perceptions of participants on the potentials a sustainable design guide (v14-v16) | Questionnaire survey and interviews | Evaluating potentials of the proposed design guide Lowe, 2003; White, 2004 | c and e | iv | Descriptive Analysis |
| Section E: Evaluating the primary design parameters/considerations for residential buildings in the three climate regions in Nigeria (v17-v31) | Questionnaire survey and interviews | Identifying specific design parameters for each region Eromobor&Das, 2013 | c and d | v | Descriptive Analysis Cross Tabulation & Chi-Square Test |
| Section F: Evaluating the perception of participants on the level of involvement for professional bodies (v32&v33) | Questionnaire survey and interviews | Evaluating views on collaboration Larsson,2004 Sherman & Ford, 2013 | e | iii | Descriptive Analysis |
| Section G:Assessing perceptions of participants on Government involvement (v34-37) | Questionnaire survey and interviews | Evaluating views on roles of government on climate change and buildings related issues | e | vi | Descriptive Analysis Cross Tabulation with Practice variables |
| Selected variables from sections C&E | surveys | Association of climate change impacts and choice of design parameters | e, c and d | i, iii and v | Cross Tabulation with related variables from the two sections |

Selected variables showing some perceived level of association are tested using cross tabulation to ascertain their level of interactions

Source: Arranged by the Researcher, 2013

## 4.14 ETHICAL REPORT

Ethical approval was sought before the commencement of the surveys and approval was granted (see **Appendix 9**) by De Montfort University, through the Faculty of Art, Design and Humanities (AD&H) ethical committee in April, 2013. The surveys were mainly a 'self-reported data' the respondents were reassured of their anonymity. Although their confidentiality was assured, their opinions were analysed. Consent of participants was sought through a Consent Form (attached as **appendix 10**) which was provided by the researcher and each participant voluntarily and willingly signed, thereby, indicating interest to participate and to provide accurate information for the questionnaires and the interviews questions. Hence, information provided by the participants formed the data used for this research thesis.

## 4.15 VALIDITY AND RELIABILITY TEST

### 4.15.1 Validity and Reliability test

Validity and reliability are the recognised standards for evaluating the quality of any research project undertaken. Beling and Law (2000) noted that, validity and reliability ensures that systematic biases (validity) are avoided and random errors (reliability) are minimised when carrying out any research project. Validity has also been opined to be a prerequisite to reliability which a pilot study provides (Mitchell and Jolley, 2004; Sekajipo, 2010), this is because it is a measure that ensures that findings are a reflection of what was intended to be measured (Tashakkori and Teddllie, 1998). In this research, the pilot survey provided the validity check as discussed in section 4.7 and the validity potentials of mixed methods research in section 4.4.

Subsequently, a research reliability test was carried out, which referred to the quality and consistency of adopted methods and procedures for analysis that yields to acceptable research findings (Saunders et al, 2009). A reliability test for the 32 items that form the measurement scale was conducted using Cronbach's Alpha index with the aid of SPSS analytical software. Cronbach's Alpha statistical analysis has been identified as an index of reliability that test the survey variables or items of measurement and the internal consistency of the items (Santos, 1999; Pallant, 2007; Dunn et al, 2013). The general acceptable value for any Cronbach's Alpha (α)consistency test result is from 0.7 (Tavakol, 2011). The generally accepted coefficient value indicators for reliability have a range from 0 to 1. This range is equated to the internal consistence of data and is designated as:

i. Values of $\alpha \geq 0.9$ are considered excellent
ii. $0.9 > \alpha \geq 0.8$ = Good
iii. $0.8 > \alpha \geq 0.7$ = Acceptable
iv. $0.7 > \alpha \geq 0.6$ = Questionable
v. $0.6 > \alpha \geq 0.5$ = Poor and values between
vi. $0.5 > \alpha$ are not Unacceptable

Table 4.11 shows the case processing details of the administered questionnaires. In Table 4.12 the reliability statistical test for the 32 items in this research measurement scale is shown, the result shows that the measurement scale items in this research has excellent value of 0.963 and therefore acceptable. The result in Table 4.13 shows the statistical summary of the measurement scale items referred to in section 4.12.

**Table 4.11 SPSS Cronbach's Alpha Reliability Statistical Test**

**Reliability Statistics**

| Cronbach's Alpha | Cronbach's Alpha Based on Standardized Items | N of Items |
|---|---|---|
| .963 | .964 | 32 |

**Table 4.12Case Processing Summary**

**Case Processing Summary**

| | | N | % |
|---|---|---|---|
| Cases | Valid | 273 | 96.5 |
| | Excluded[a] | 10 | 3.5 |
| | Total | 283 | 100.0 |

a. List wise deletion based on all variables in the procedure.

**Table 4.13 Statistical Summary of the Measurement Scale**

**Summary Item Statistics**

| | Mean | Minimum | Maximum | Range | Maximum / Minimum | Variance | N of Items |
|---|---|---|---|---|---|---|---|
| Item Means | 3.072 | 1.777 | 3.934 | 2.158 | 2.214 | .343 | 32 |
| Item Variances | .458 | .062 | .754 | .692 | 12.191 | .029 | 32 |

**4.16 METHODOLOGICAL LIMITATIONS**

Given that the mixed- methods approach was adopted does not rule out completely the individual limitations of each method especially where some questions may not have overlapped in both the questionnaire and the interview questions. Secondly, there is the likelihood that some participants may not have given a truthful opinion to certain questions which the researcher has no way of knowing and therefore, collates and interpret such data as the true reflection of the research findings.

There are also the chances of human errors associated with misinterpretations, which may arise as a result of lack of full understanding of an opinion expressed by a respondent by the researcher. These are potentially the limitations that may have occurred during the conduct of this research project.

## 4.17 CHAPTER SUMMARY AND CONCLUSION

This chapter has presented the research methodology adopted for this research project. Philosophical assumptions were explained and reasons given as to why this research lean towards a pragmatic stance, and the adoption of a mixed-methods approach which was supported by the rationale behind the selection. Notable is the fact that, although knowledge is attainable, it is not absolute and therefore, requires more than a single method of inquiry.

Triangulation mixed-methods was vital to the methodological underpinning of the research (Maxwell, 2005) because it allowed this study to measure the knowledge of design professionals, assess their opinions, and ascertain their design practices and their views on the relevant design parameters applicable to the three climates in Nigeria using, qualitative and quantitative approaches to extract data. Thus, providing a justification for the approaches adopted to carry out this research.

The literature review provided a comprehensive source of secondary data and relevant background information required to adequately and contextually drill down on the research topic, and arrive at the appropriate and possible approaches and methods suitable for answering the research questions and achieving the stated aim and research objectives. Empirically, primary data were sourced through the use of quantitative and qualitative approaches using both self-administered questionnaires and face-to-face interviews as survey tools.

Thus, the choice of triangulation mixed methods and specifically, the use of concurrent embedded strategy were adopted for this research. Furthermore, the limitations of the research methodology that may arise and how the researcher addressed the ethical considerations in carrying out the research in conformity with the standards of De Montfort University were discussed.

Finally, the methodological limitations were discussed (see section 4.16) and also noted the importance of the contents and focus of the chapter which preludes chapters five, six and seven respectively.

## CHAPTER FIVE

## 5.0 RESEARCH DATA PRESENTATION AND ANALYSIS

### 5.1 INTRODUCTION

The preceding chapter presented the methodological theories, processes of the research design and discussed the methods and tools which were used to address the research objectives and questions, whilst focusing on the research aim. Chapter four also presented the field report from where the data for this research is obtained which forms the main content of this chapter.

This chapter therefore focuses on recording of collated data, their analysis and interpretations. Findings are presented in a sequential order consistent with the way the questions were asked; firstly, the descriptive data of each of the three climatic zones and followed by the statistical testing using; Mann-Whitney Test and Spearman's Rank Correlation Test to analyse relationships of selected questions that relate to the research questions as shown in Table 4.7 in section 4. The decision for these tests was adopted from the statistics decision chart for non-parametric tests (see **appendix 8** attached).

The Statistical Package for Social Sciences (SPSS) software was used to carry out the quantitative analysis and interpretive content analysis was adopted for the qualitative analysis using the Nvivo 10 software in order to answer the research questions in sections 1.7 and 1.8. The chapter is divided into five main sections with section 5.1 as introduction to the chapter. Section 5.2 presents descriptive analysis of the quantitative data, while section 5.3 discusses the qualitative data analysis. A Summary of Findings and their applicable parameters is presented in section 5.4. The relationship test for selected variables is presented in section 5.5. Also, the quantitative (questionnaire) analysis is deductive with a descriptive discourse, and on the other hand, the qualitative (interviews) explored an inductive analysis that has an interpretive discourse as explained in chapter four. This combination allows for triangulation and validation of findings and research questions which are further discussed in section 5.6. The chapter concludes with a summary in section 5.7.

## 5.2 QUANTITATIVE DESCRIPTIVE DATA ANALYSIS AND FINDINGS

All the analyses in section 5.2 are descriptive in order to observe the general trend of the data collected. Descriptive analysis according to O'Neil (2009) gives an overview and the profile of frequencies showing the number of responses for every question answered. In this research, descriptive frequencies are presented in Tables and their corresponding Bar Chats in some cases are also provided for easy understanding, while the frequencies are shown in percentages on the y-axis.

All Tables have a combined data from the Highland (Alpine) climate region (HCR), Tropical Savannah Climate Region (TSR) and Tropical Rainforest Climate Region (TRC). The questionnaire is divided into seven sections as themes and each of these sections has questions (Q), designed to provide answers to the research questions as designated on the titles for the Tables and Graphs. At the end of every section the results are statistically tested within each region, using the participants' practice type (academics, private and public) to ascertain whether their responses have a relationship with the type of practice the professionals are engaged with.

### 5.2.1 Analysis of number of questionnaires distributed

A total number of 102 completed questionnaires out of the 105 questionnaires distributed in the Highland Climate Region (HCR) were inputted into the SPSS software for a descriptive analysis and the frequency result is presented in Table 5.1. The results in the same Table show that the numbers of valid questionnaires are 97.1%. The seemingly high percentage of completed questionnaires returned was attributed to the large number of attendance of participants at the NIA Plateau Chapter meeting when the researcher addressed the meeting on the research focus.

In the Savannah Climate Region (Table 5.1) out of the 105 questionnaires distributed in the tropical Savannah Climate Region (TSC) a total of 89 correctly filled questionnaires were returned which represents 84.8%. This seemingly lower return rate, in comparism with HCR, despite the researcher's much efforts is due to the challenges encountered at the time of the field survey as discussed in section 4.12.

The response rate for the Tropical Rainforest Climate region (TRC) is 87.6% (92 out of 105). The total response rate from the three regions stands at 283 out of the total 315 questionnaires distributed, with An overall percentage response rate from the of 87%. According to Fincham (2008) in his investigation on the viewpoint of other researcher regarding what is the acceptable response rate in any research, he concluded that a good response rate is between 60 to 80 per cent and suggested that researchers should aim at achieving 80%. This assertion by Fincham (2008) therefore, suggests that the 87% response rate recorded in this research clearly exceeds the 80% threshold; hence, this research has a good response rate.

**Table 5.1 Response rate**

RESPONSE

| REGION | | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|---|
| Highland Climate | Valid | Filled | 102 | 97.1 | 97.1 | 97.1 |
| | | Not Filled | 3 | 2.9 | 2.9 | 100.0 |
| | | Total | 105 | 100.0 | 100.0 | |
| Tropical Savannah Climate | Valid | Filled | 89 | 84.8 | 84.8 | 84.8 |
| | | Not Filled | 16 | 15.2 | 15.2 | 100.0 |
| | | Total | 105 | 100.0 | 100.0 | |
| Tropical Rainforest Climate | Valid | Filled | 92 | 87.6 | 87.6 | 87.6 |
| | | Not Filled | 13 | 12.4 | 12.4 | 100.0 |
| | | Total | 105 | 100.0 | 100.0 | |

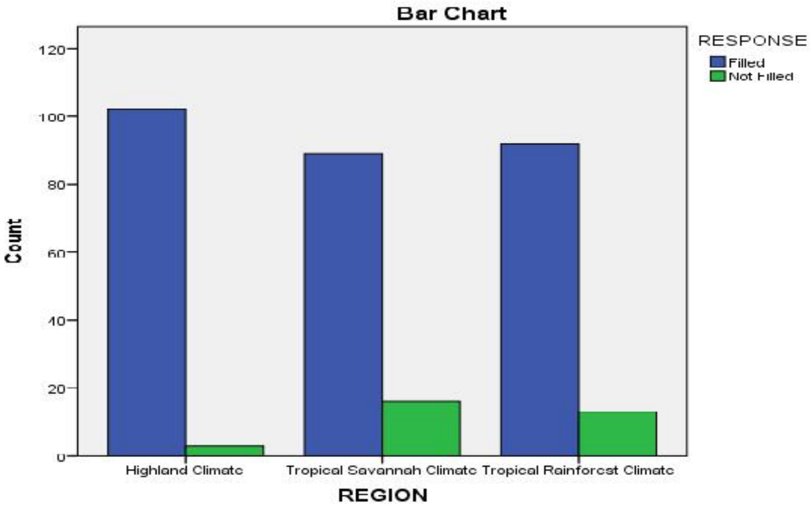



**Figure 5.1 Response rate**

### 5.2.2 Demographic sample characteristics

This section provides the basic information of the participants' in order to draw out their demographic characteristics including; gender, age, profession, level of education, and years of professional practice with the aim of establishing the participants' capacity to provide quality information for this research.

The demographic information is presented in order to have a general view of the character of the respondents from whom the research data was generated. Secondly, though all participants are architects, the specific details of the participants are also provided including; age group, gender, type of practice and the number of years spent in practice. This information is necessary because it offers the researcher the opportunity of making further observations, deductions, suggestions and to test (s) and make recommendations where applicable.

#### 5.2.2.1 Gender representation

The male participants out-numbered the female participants in this survey. This is typical of the architect profession in Nigeria and perhaps could be the case in other countries. This can also be linked to gender inequality and educational opportunities which are skewed in favour of men owing to religious and cultural beliefs and practices across countries, particularly in Nigeria.

In Table 5.2 the HCR female respondents were 7.8% (8) and males were 92.2% (94), TSC had 2.2% (2) females to the male respondents who represented 97.8% (87) and TRC shows the same pattern where the female respondent had 9.8% (9) and the male respondents had 90.2% (83) representation. While Table 5.2 gives a clearer picture of the gender differences across the regions in Bar charts.

**Table 5.2 Gender representation**

**Gender**

| REGION | | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|---|
| Highland (Alpine) | Valid | Male | 94 | 92.2 | 92.2 | 92.2 |
| | | Female | 8 | 7.8 | 7.8 | 100.0 |
| | | Total | 102 | 100.0 | 100.0 | |
| Tropical Savannah | Valid | Male | 87 | 97.8 | 97.8 | 97.8 |
| | | Female | 2 | 2.2 | 2.2 | 100.0 |
| | | Total | 89 | 100.0 | 100.0 | |
| Tropical Rainforest | Valid | Male | 83 | 90.2 | 90.2 | 90.2 |
| | | Female | 9 | 9.8 | 9.8 | 100.0 |
| | | Total | 92 | 100.0 | 100.0 | |

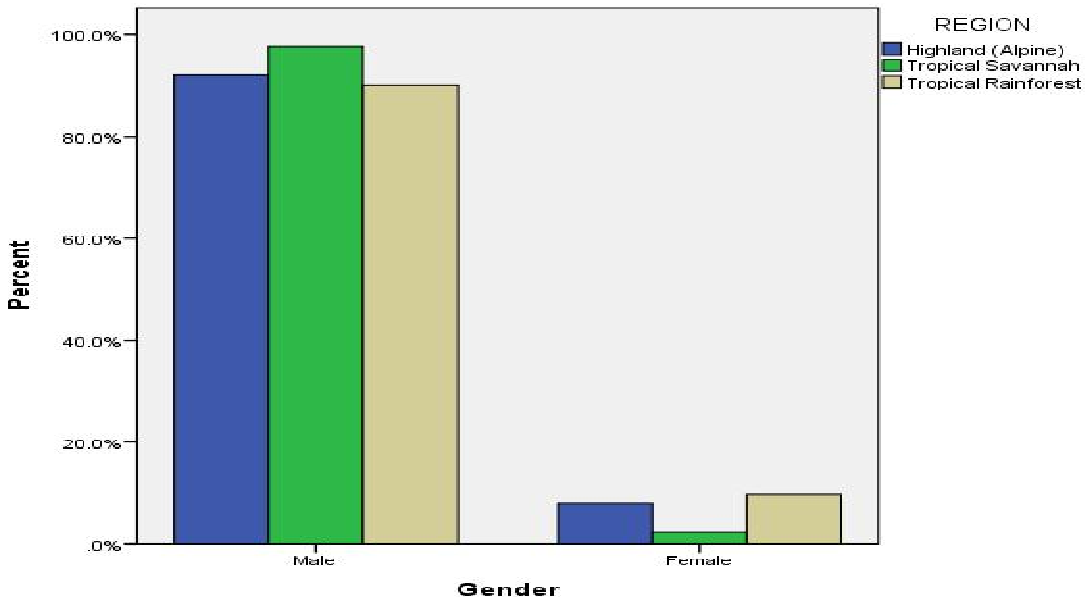



**Figure 5.2 Gender Distribution**

#### 5.2.2.2 Age group frequency distributions

All age groups deemed relevant were represented, starting from the earliest common graduate age. The five age groups were; 20s, 30s, 40s, 50s, and over 60 years. However, the result showed that the tropical rainforest had no representation on the 20s age group, and the age group frequency is shown in Table 5.3.

**Table 5.3 Age group frequency distributions**

**Age group**

| REGION | | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|---|
| Highland (Alpine) | Valid | 30s | 21 | 20.6 | 20.6 | 20.6 |
| | | 40s | 55 | 53.9 | 53.9 | 74.5 |
| | | 50s | 23 | 22.5 | 22.5 | 97.1 |
| | | 60+ | 3 | 2.9 | 2.9 | 100.0 |
| | | Total | 102 | 100.0 | 100.0 | |
| Tropical Savannah | Valid | 20s | 1 | 1.1 | 1.1 | 1.1 |
| | | 30s | 14 | 15.7 | 15.7 | 16.9 |
| | | 40s | 39 | 43.8 | 43.8 | 60.7 |
| | | 50s | 31 | 34.8 | 34.8 | 95.5 |
| | | 60+ | 4 | 4.5 | 4.5 | 100.0 |
| | | Total | 89 | 100.0 | 100.0 | |
| Tropical Rainforest | Valid | 30s | 14 | 15.2 | 15.2 | 15.2 |
| | | 40s | 56 | 60.9 | 60.9 | 76.1 |
| | | 50s | 13 | 14.1 | 14.1 | 90.2 |
| | | 60+ | 9 | 9.8 | 9.8 | 100.0 |
| | | Total | 92 | 100.0 | 100.0 | |

Figure 5.3 shows the Highland climate region (HCR) age group distribution Bar chart in percentages, with participants in their 30s, 40s, 50s, and 60s, represented as 21%, 54%, 22% and 3% respectively. This is an indication that most participants are in their active years with a concentrated spread between the 30s and 40s age group as shown in Figure 5.3. The respondents in Tropical savannah region (TSC) are mostly in their 40s with 61% (56), those in their 30s formed 16% (14), 60s with 4% (4) and the least was 20s representing 1% (1). Tropical rainforest region (TRC) data shows more age group concentration between 40 and 50 years represented by 44% (39) of total sample and

35% (31) for the Highland respondents, this shows a slight shift in the age group from the other two regions.

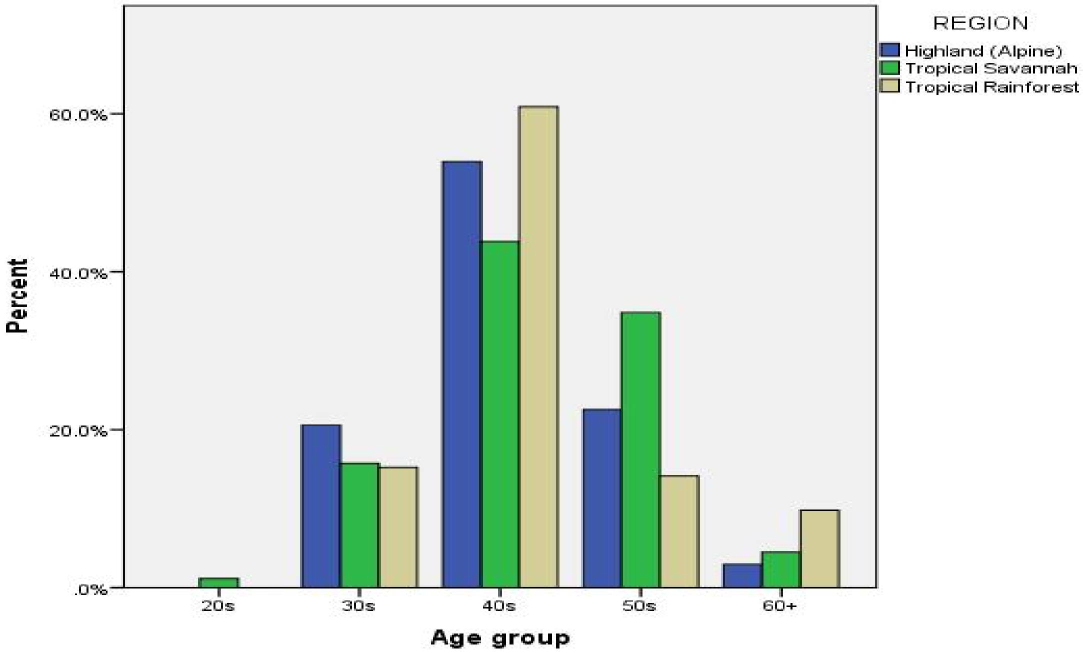



**Figure 5.3 Age group frequency distributions**

#### 5.2.2.3 Level of education frequency distributions for all three climate regions

Table 5.4 shows that all participants have post graduate qualifications representing 100% of the frequency. This is not surprising given that in Nigeria, all professionally registered architects must attain a graduate status to qualify for the professional practice examinations.

**Table 5.4 Level of education frequency distributions for all three climate regions**

**Level of education**

| REGION | | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|---|
| Highland (Alpine) | Valid | Post-Graduate | 102 | 100.0 | 100.0 | 100.0 |
| Tropical Savannah | Valid | Post-Graduate | 89 | 100.0 | 100.0 | 100.0 |
| Tropical Rainforest | Valid | Post-Graduate | 92 | 100.0 | 100.0 | 100.0 |

### 5.2.2.4 Practice Type

Table 5.6 and Figure 5.4 shows the frequencies and percentage distribution of the professions of respondents, these are; academic, private and the public practice identified as those in the services of all tiers of government. Results from Highland climate region revealed that participants in public practice are the majority with 51% and 21%, 30% for the academic, private and public practitioners respectively. The data from the respondents in the savannah climate region shows that more than half with 58% (52) of the respondents are in the public service, 23% (20) are in the academics and the least 19% (17) are into private practices.

These can be explained relative to the unemployment and income generating opportunities in these regions. For example, there are many states in Nigeria that are classed as 'civil service states', indicating their total dependence on government or public sector for employment and income. On the other hand, the practice data from the Tropical rainforest region reveals a different trend where the private sector are in majority with about 41% (38) of the total (92) respondents; academics are 39% (36) and about 20% (18) are in the public services.

**Table 5.5 Practice Type**

Practice Type

| REGION | | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|---|
| Highland (Alpine) | Valid | Academic | 21 | 20.6 | 20.6 | 20.6 |
| | | Private | 30 | 29.4 | 29.4 | 50.0 |
| | | Public | 51 | 50.0 | 50.0 | 100.0 |
| | | Total | 102 | 100.0 | 100.0 | |
| Tropical Savannah | Valid | Academic | 20 | 22.5 | 22.5 | 22.5 |
| | | Private | 17 | 19.1 | 19.1 | 41.6 |
| | | Public | 52 | 58.4 | 58.4 | 100.0 |
| | | Total | 89 | 100.0 | 100.0 | |
| Tropical Rainforest | Valid | Academic | 36 | 39.1 | 39.1 | 39.1 |
| | | Private | 38 | 41.3 | 41.3 | 80.4 |
| | | Public | 18 | 19.6 | 19.6 | 100.0 |
| | | Total | 92 | 100.0 | 100.0 | |

This distribution shows that the participants cut cross all sections of the sample population that are in a position to be well informed.

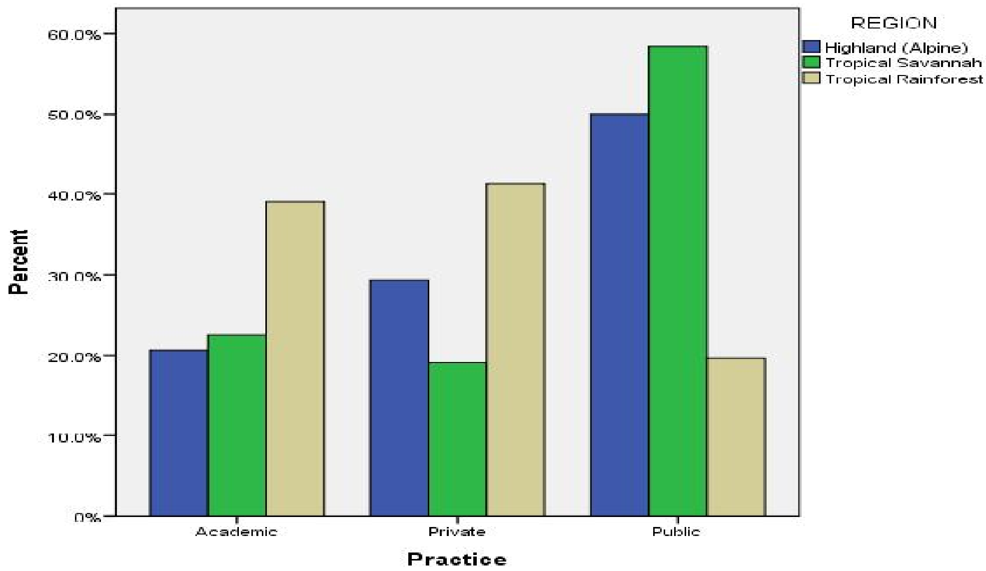



**Figure 5.4 Practice**

### 5.2.2.5 Number of years in practice

The result in Figure 5.6 shows distribution figures for the years of experience for the survey participants. From the Highland climate region the number of years of professional experience, ranges from 5 to 30 years with the mode being between 16 and 20 years. In the Tropical savannah climate region, therange of experience varies between 5 to 25 years with 47% of the respondents having between 16 to 30 years of professional experience. Indeed, about 5% of respondents have more than 30 years of professional experience. Data frequencies from the Tropical rainforest climate area show that, the distribution frequency is more on the 26 to 30 years range with 54%. Percentages of results from Table 5.4 are represented in Figure 5.5 in Bar charts.

**Table 5.6 Number of years in practice**

Years of practice?

| REGION | | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|---|
| Highland (Alpine) | Valid | 5-10 | 16 | 15.7 | 15.7 | 15.7 |
| | | 11-15 | 56 | 54.9 | 54.9 | 70.6 |
| | | 16-20 | 21 | 20.6 | 20.6 | 91.2 |
| | | 21-25 | 6 | 5.9 | 5.9 | 97.1 |
| | | 26-30 | 2 | 2.0 | 2.0 | 99.0 |
| | | 30+ | 1 | 1.0 | 1.0 | 100.0 |
| | | Total | 102 | 100.0 | 100.0 | |
| Tropical Savannah | Valid | 5-10 | 6 | 6.7 | 6.7 | 6.7 |
| | | 11-15 | 19 | 21.3 | 21.3 | 28.1 |
| | | 16-20 | 18 | 20.2 | 20.2 | 48.3 |
| | | 21-25 | 26 | 29.2 | 29.2 | 77.5 |
| | | 26-30 | 16 | 18.0 | 18.0 | 95.5 |
| | | 30+ | 4 | 4.5 | 4.5 | 100.0 |
| | | Total | 89 | 100.0 | 100.0 | |
| Tropical Rainforest | Valid | 5-10 | 2 | 2.2 | 2.2 | 2.2 |
| | | 11-15 | 12 | 13.0 | 13.0 | 15.2 |
| | | 16-20 | 50 | 54.3 | 54.3 | 69.6 |
| | | 21-25 | 8 | 8.7 | 8.7 | 78.3 |
| | | 26-30 | 6 | 6.5 | 6.5 | 84.8 |
| | | 30+ | 14 | 15.2 | 15.2 | 100.0 |
| | | Total | 92 | 100.0 | 100.0 | |

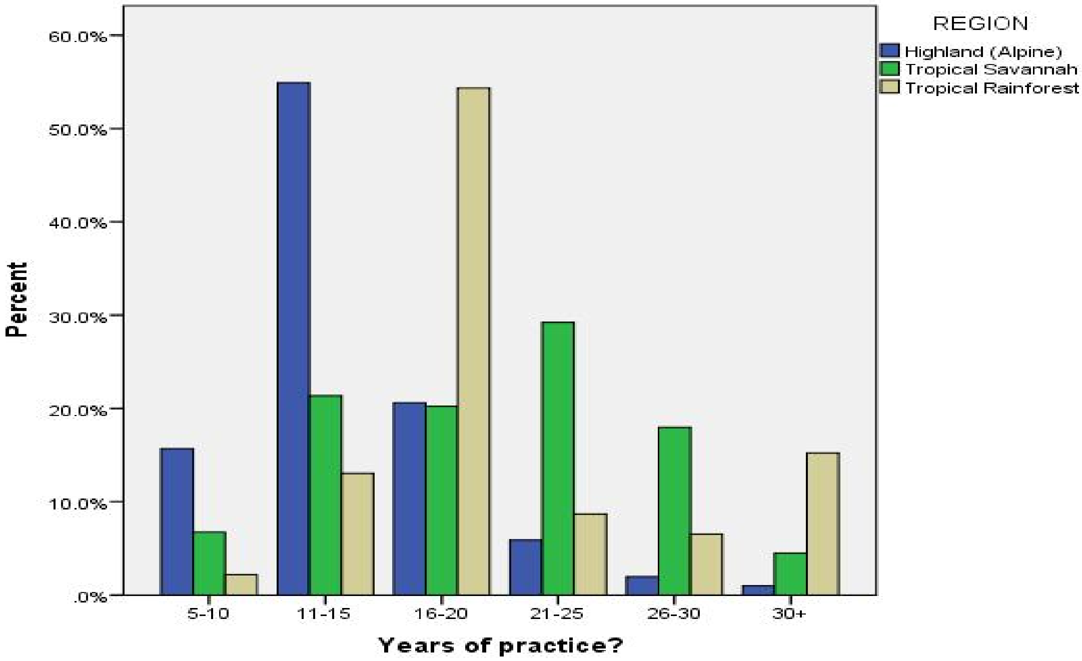



**Figure 5.5 Number of years in practice**

### 5.2.3 ASSESSING KNOWLEDGE AND OPINION OF PARTICIPANTS ON CLIMATE CHANGE AND BUILDINGS (VARIABLES 6-8)

The knowledge level of participants on climate change and buildings was sought in order to ascertain how their knowledge affects their design practices and their level of awareness of climate change, particularly the role of buildings as a major influence and possible solutions. Ascertaining the level of knowledge and awareness is fundamental to any mitigation and adaptation policies and measures for ameliorating climate change effects on buildings, and buildings on climate change. This section builds on the study carried out by Lorenzoni et al. (2007) which suggested that other studies on climate change should gauge the knowledge of participants on the subject in order to recognise and understand the knowledge gap therein. The section addresses parts of research objectives a, b and c as well as answers parts of research questions i and iii from sections 1.7 and 1.8 respectively.

### 5.2.3.1 Knowledge (v6)

This variable (knowledge) directly addresses the research 'objective **c**' in section 1.17 and research question **iii** in section 1.18. Results from Table 5.7 shows that in the Tropical rainforest region there was no participant who strongly disagrees with the statement but 71% disagree, 25% are in agreement, while about 4% strongly agreed. The results from Tropical savannah also revealed that 59% strongly disagree, 24% disagree, 12% agreed and 4% strongly agreed. Result presented from Highland climate region clearly shows that more than 88% of respondents are not knowledgeable on the relationship between climate change and buildings. Only a small 10% and 2.0% of the 102 respondents agreed and strongly agreed respectively that they are well knowledgeable on the relationship between climate change and buildings.

A total of 89% across the three regions do not agree that they are knowledgeable on the relationship between climate change and buildings. Figure 5.5 further shows how the different results are compared amongst the three regions.

**Table 5.7 knowledge (v6)**

I am well knowledgeable on the relationship between climate change and buildings

| REGION | | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|---|
| Highland (Alpine) | Valid | Strongly Disagree | 1 | 1.0 | 1.0 | 1.0 |
| | | Disagree | 89 | 87.3 | 87.3 | 88.2 |
| | | Agreed | 10 | 9.8 | 9.8 | 98.0 |
| | | Strongly Agreed | 2 | 2.0 | 2.0 | 100.0 |
| | | Total | 102 | 100.0 | 100.0 | |
| Tropical Savannah | Valid | Disagree | 63 | 70.8 | 70.8 | 70.8 |
| | | Agreed | 22 | 24.7 | 24.7 | 95.5 |
| | | Strongly Agreed | 4 | 4.5 | 4.5 | 100.0 |
| | | Total | 89 | 100.0 | 100.0 | |
| Tropical Rainforest | Valid | Strongly Disagree | 55 | 59.8 | 59.8 | 59.8 |
| | | Disagree | 22 | 23.9 | 23.9 | 83.7 |
| | | Agreed | 11 | 12.0 | 12.0 | 95.7 |
| | | Strongly Agreed | 4 | 4.3 | 4.3 | 100.0 |
| | | Total | 92 | 100.0 | 100.0 | |

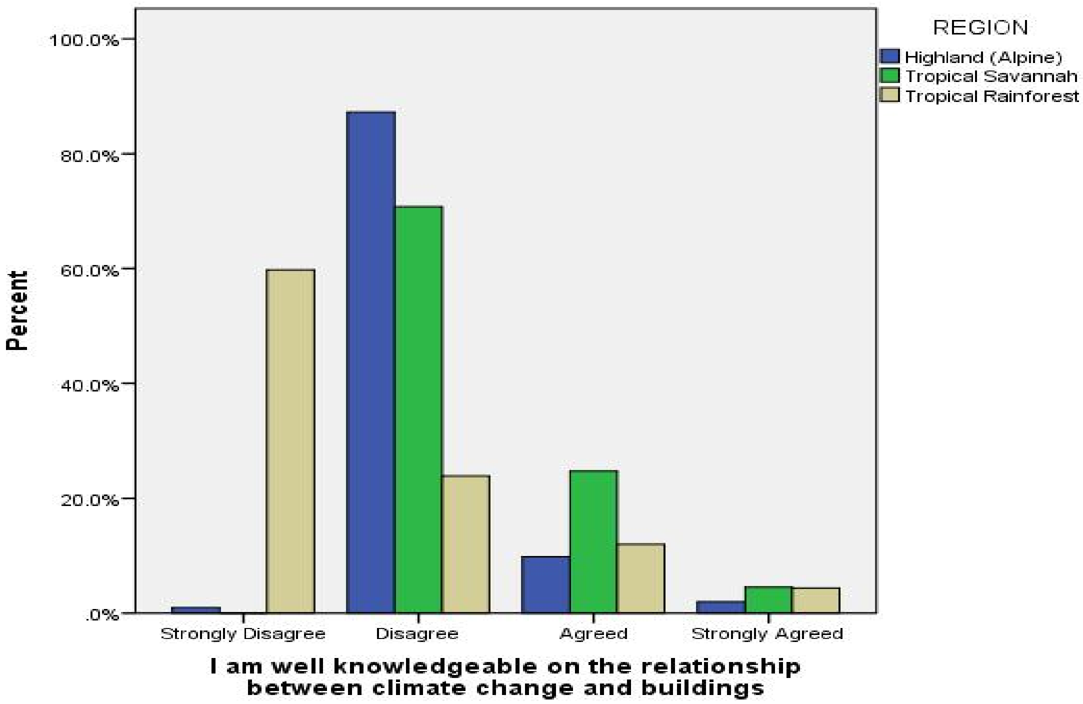



**Figure 5.6 Knowledge on relationship between climate and buildings**

#### 5.2.3.2 There is adequate information on climate change and buildings in Nigeria (v7)

Respondents have varied opinions according to Table 5.8 on the availability of climate change information in Nigeria. This data is further captured in Figure 5.8, showing that the majority (72%) of respondents in Highland climate region are in disagreement that adequate information is available on climate change. Only 29% agreed or strongly agree that adequate information is available. Results from Tropical savannah shows 78% are in agreement that adequate information exists on climate change and buildings, while 16% and 7% disagree and strongly disagree respectively.

Also the results from the Tropical rainforest respondents revealed that 38% strongly disagree, 28% disagree that there is adequate information on climate change and buildings. Others who agree that adequate information on climate change and buildings is available are; 12% agree and 22% strongly agree. In a nutshell, across the regions there is a general disagreement on the availability of adequate information on the statement, however, the results from Tropical rainforest region seem to have responses across all the agreement options.

**Table 5.8 Information (v7)**

**There is adequate information on climate change and buildings in Nigeria**

| REGION | | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|---|
| Highland (Alpine) | Valid | Strongly Disagree | 5 | 4.9 | 4.9 | 4.9 |
| | | Disagree | 68 | 66.7 | 66.7 | 71.6 |
| | | Agreed | 21 | 20.6 | 20.6 | 92.2 |
| | | Strongly Agreed | 8 | 7.8 | 7.8 | 100.0 |
| | | Total | 102 | 100.0 | 100.0 | |
| Tropical Savannah | Valid | Strongly Disagree | 7 | 7.9 | 7.9 | 7.9 |
| | | Disagree | 62 | 69.7 | 69.7 | 77.5 |
| | | Agreed | 14 | 15.7 | 15.7 | 93.3 |
| | | Strongly Agreed | 6 | 6.7 | 6.7 | 100.0 |
| | | Total | 89 | 100.0 | 100.0 | |
| Tropical Rainforest | Valid | Strongly Disagree | 35 | 38.0 | 38.0 | 38.0 |
| | | Disagree | 26 | 28.3 | 28.3 | 66.3 |
| | | Agreed | 11 | 12.0 | 12.0 | 78.3 |
| | | Strongly Agreed | 20 | 21.7 | 21.7 | 100.0 |
| | | Total | 92 | 100.0 | 100.0 | |

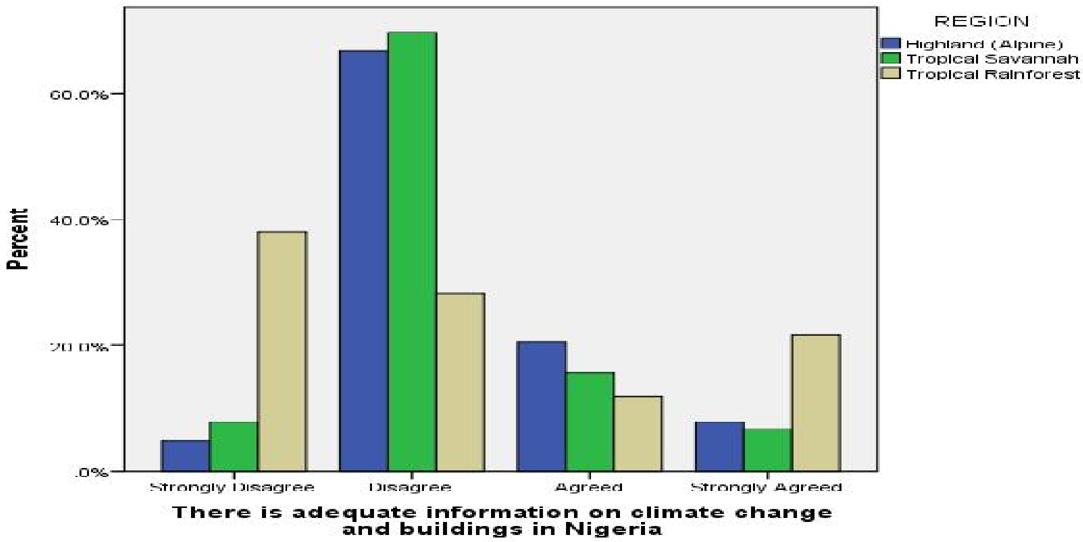



**Figure 5.7 Information**

#### 5.2.3.3 I am interested in knowing more about climate change and residential buildings (v8)

Table 5.9 and Figure 5.7 revealed a significant total number of the respondents are in agreement that they are interested in knowing more about climate change and residential buildings. The results show that the levels of agreement are: 97%, 90% and 94% from the Highland climate region, Tropical savannah and Tropical rainforest respectively. The total percentage of agreement across the three regions is 94% this leaves only 6% of respondents who are not interested in knowing more about climate change and residential buildings. The result from Tables 5.7 and 5.8 suggest that there is no adequate knowledge and information of climate change and buildings in Nigeria, hence the willingness of the respondents wanting to know more.

**Table 5.9 I am interested in knowing more about climate change and residential buildings**

**I am interested in knowing more about climate change and residential buildings**

| REGION | | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|---|
| Highland (Alpine) | Valid | Disagree | 3 | 2.9 | 2.9 | 2.9 |
| | | Agreed | 67 | 65.7 | 65.7 | 68.6 |
| | | Strongly Agreed | 32 | 31.4 | 31.4 | 100.0 |
| | | Total | 102 | 100.0 | 100.0 | |
| Tropical Savannah | Valid | Agreed | 48 | 53.9 | 53.9 | 53.9 |
| | | Strongly Agreed | 41 | 46.1 | 46.1 | 100.0 |
| | | Total | 89 | 100.0 | 100.0 | |
| Tropical Rainforest | Valid | Disagree | 2 | 2.2 | 2.2 | 2.2 |
| | | Agreed | 4 | 4.3 | 4.3 | 6.5 |
| | | Strongly Agreed | 86 | 93.5 | 93.5 | 100.0 |
| | | Total | 92 | 100.0 | 100.0 | |

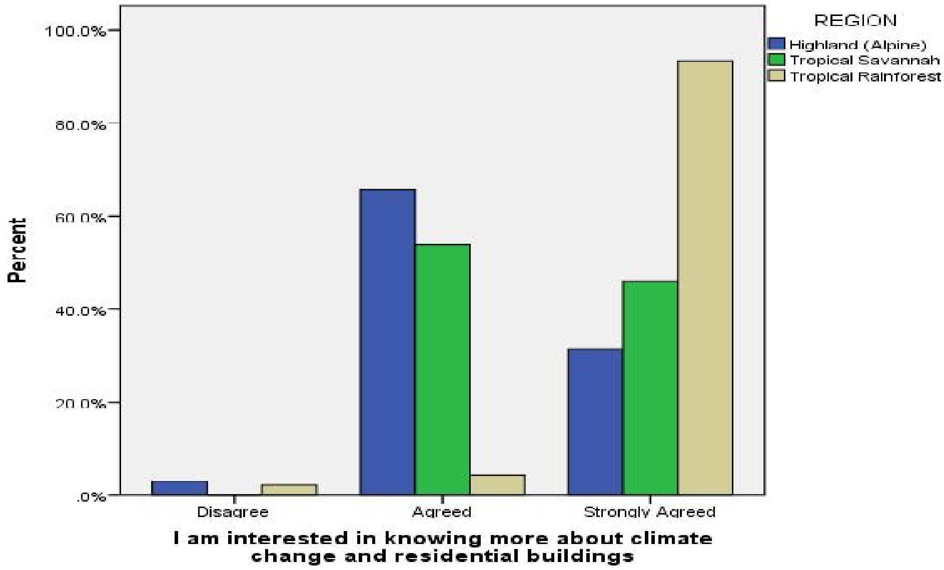



**Figure 5.8 I am interested in knowing more about climate change and residential buildings (v8)**

### 5.2.4 EVIDENCE AND IMPACTS OF CLIMATE CHANGE ON RESIDENTIAL BUILDINGS IN THE DIFFERENT CLIMATE REGIONS/ZONES IN NIGERIA

Firstly, this section presents the participants' perceptions on what impacts climate change has on residential buildings in each region, such understanding will enable the validation of the global theoretical findings in sections 2.4 and 2.6, that there are evidences of climate change and that residential buildings are the most carbon emitters in the building sector.

Secondly, the impacts of climate change across Nigeria were identified in section 3.5 to include; erosion, droughts/desertification, flooding, windstorm and temperature increase. Respondents from the three climate regions were asked their opinion on which of these impacts are more threatening to their region. Tables 5.10 to 5.14 relate the survey data.

Thirdly, this section is also directed at addressing objectives **b** 'to establish the extent to which climate change has impacted on residential buildings in Nigeria…'and **c**' to further identify potential design parameters that could possibly promote the development of a sustainable residential building design guide for the three different climatic regions in Nigeria' as well as to answer research questions **i**' What relationship exists between climate change, buildings and the built environment?' and **iii,** 'What level of knowledge exists amongst design professionals and how do they reflect such knowledge in their design practices?'

**5.2.4.1 Erosion is the most threatening impact in my region (v9)**

Highland climate region respondents results from Table 5.10 shows that 61% of the respondents disagree that erosion is the most threatening impact in the region, 32% (33) agreed and 7% (7) strongly agreed with the statement. Tropical savannah region results showed that the opinion of the respondents varies across the options; 23% disagree, 44% agreed and 34% (30) strongly agreed. The variations on the opinion of the respondents on erosion being the most threatening impact in their region, has bearings with the earlier discussions in sections 3.4 and shown in Figure 3.2, showing the differences of climatic conditions, and the latitudinal and longitudinal variations within the same region.

Data from Tropical rainforest region shows a shift from the other two regions with; 97% (89) strongly agreed and 3% (3) agreed. This result from Tropical rainforest region reveals that respondents were 100% in agreement that erosion is the most threatening impact on the region. Erosion is therefore, having a significant impact in all areas of this climatic region.

**Table 5.10 Erosion (V9)**

**Erosion is the most threatening impact of climate change in my region**

| REGION | | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|---|
| Highland (Alpine) | Valid | Disagree | 62 | 60.8 | 60.8 | 60.8 |
| | | Agreed | 33 | 32.4 | 32.4 | 93.1 |
| | | Strongly Agreed | 7 | 6.9 | 6.9 | 100.0 |
| | | Total | 102 | 100.0 | 100.0 | |
| Tropical Savannah | Valid | Disagree | 20 | 22.5 | 22.5 | 22.5 |
| | | Agreed | 39 | 43.8 | 43.8 | 66.3 |
| | | Strongly Agreed | 30 | 33.7 | 33.7 | 100.0 |
| | | Total | 89 | 100.0 | 100.0 | |
| Tropical Rainforest | Valid | Agreed | 3 | 3.3 | 3.3 | 3.3 |
| | | Strongly Agreed | 89 | 96.7 | 96.7 | 100.0 |
| | | Total | 92 | 100.0 | 100.0 | |

### 5.2.4.2 Drought/desertification

Table 5.11 shows the result from Highland climate region (HCR), where 97% of the respondents who either, strongly agree or disagree that, drought/desertification are the most threatening impact in their region, living only 3% of the respondents who agreed. Also result from Tropical savannah (TSC) shows that 46% of the respondents have disagreed and 54% agreed or strongly agreed that erosion is a major threat in their region. This results from the TSC spring surprises, given the shrinking grazing land across the region (see Figure 3.20) and the fast encroachment of desertification which has covered about 35% Nigeria's landmass (Onyekuru and Marchant, 2012).

While in the tropical rainforest region (TRC) results show that; 99% strongly disagree that desertification is a major threat in their region and 1% disagree with the statement. The researcher observed that although no respondent agree or strongly agree with the statement, it is not surprising because most of the region is located around major water bodies and their major climate change impacts are water related as indicated in the results on Table 5.10.

**Table 5.11 Drought/desertification**

Drought/desertification is the most threatening impact of climate change in my region

| REGION | | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|---|
| Highland (Alpine) | Valid | Strongly Disagree | 8 | 7.8 | 7.8 | 7.8 |
| | | Disagree | 91 | 89.2 | 89.2 | 97.1 |
| | | Agreed | 3 | 2.9 | 2.9 | 100.0 |
| | | Total | 102 | 100.0 | 100.0 | |
| Tropical Savannah | Valid | Disagree | 41 | 46.1 | 46.1 | 46.1 |
| | | Agreed | 27 | 30.3 | 30.3 | 76.4 |
| | | Strongly Agreed | 21 | 23.6 | 23.6 | 100.0 |
| | | Total | 89 | 100.0 | 100.0 | |
| Tropical Rainforest | Valid | Strongly Disagree | 91 | 98.9 | 98.9 | 98.9 |
| | | Disagree | 1 | 1.1 | 1.1 | 100.0 |
| | | Total | 92 | 100.0 | 100.0 | |

### 5.2.4.3 Flooding

In the HCR (Table 5.12) 1% disagrees, 31% agree and 68% strongly agrees with the statement, this result shows that 99% of respondents opined that flooding is a major treat of climate change in their region. Result from TSC also revealed that about 14% of respondents disagree, 43% agree and 44% strongly agree, indicating that 87% are in agreement. The TSC region result is not very surprising because most of the drought/desertification prune areas are located within this region. The TRC region result reveals a similar trend with the result from the HCR region, with 1% disagreement and 99% agreement that flooding has been the most threatening impacts of climate change in the TRC region. However, flooding seems to be a general climatic change treat to all regions across Nigeria.

**Table 5.12 Flooding**

Flooding is the most threatening impact of climate change in my region

| REGION | | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|---|
| Highland (Alpine) | Valid | Disagree | 1 | 1.0 | 1.0 | 1.0 |
| | | Agreed | 32 | 31.4 | 31.4 | 32.4 |
| | | Strongly Agreed | 69 | 67.6 | 67.6 | 100.0 |
| | | Total | 102 | 100.0 | 100.0 | |
| Tropical Savannah | Valid | Disagree | 12 | 13.5 | 13.5 | 13.5 |
| | | Agreed | 38 | 42.7 | 42.7 | 56.2 |
| | | Strongly Agreed | 39 | 43.8 | 43.8 | 100.0 |
| | | Total | 89 | 100.0 | 100.0 | |
| Tropical Rainforest | Valid | Disagree | 1 | 1.1 | 1.1 | 1.1 |
| | | Agreed | 2 | 2.2 | 2.2 | 3.3 |
| | | Strongly Agreed | 89 | 96.7 | 96.7 | 100.0 |
| | | Total | 92 | 100.0 | 100.0 | |

#### 5.2.4.4 Windstorm

Findings from Table 5.13 for the Highland climate region (HCR) show that; 9% strongly disagree, 57% disagree, 23% agree and 12% strongly agree that windstorm is the most threatening climate change impact in their region. Tropical savannah (TSC) result: 5% strongly disagree, 27% disagree, 23% agree and 46% (41) strongly agree. While Tropical rainforest (TRC) respondents indicate the following; 1% strongly disagree, 65% disagree, 32% agree and 2% strongly agree. These results show that 46%, 69% and 34% of respondents are in agreement for the HCR, TSC and TRC respectively, with a total of 47% agreement that windstorm is a major threat across the three regions. These results suggest that all regions are affected by the impacts of windstorms. Therefore, windstorm is one of the parameters to be considered by all climatic regional design guides.

**Table 5.13 Windstorm**

Windstorm is the most threatening impact of climate change in my region

| REGION | | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|---|
| Highland (Alpine) | Valid | Strongly Disagree | 9 | 8.8 | 8.8 | 8.8 |
| | | Disagree | 58 | 56.9 | 56.9 | 65.7 |
| | | Agreed | 23 | 22.5 | 22.5 | 88.2 |
| | | Strongly Agreed | 12 | 11.8 | 11.8 | 100.0 |
| | | Total | 102 | 100.0 | 100.0 | |
| Tropical Savannah | Valid | Strongly Disagree | 4 | 4.5 | 4.5 | 4.5 |
| | | Disagree | 24 | 27.0 | 27.0 | 31.5 |
| | | Agreed | 20 | 22.5 | 22.5 | 53.9 |
| | | Strongly Agreed | 41 | 46.1 | 46.1 | 100.0 |
| | | Total | 89 | 100.0 | 100.0 | |
| Tropical Rainforest | Valid | Strongly Disagree | 1 | 1.1 | 1.1 | 1.1 |
| | | Disagree | 60 | 65.2 | 65.2 | 66.3 |
| | | Agreed | 29 | 31.5 | 31.5 | 97.8 |
| | | Strongly Agreed | 2 | 2.2 | 2.2 | 100.0 |
| | | Total | 92 | 100.0 | 100.0 | |

**5.2.4.4 Temperature increase (Q13)**

Table 5.14 have the following responses: from Highland climate region (HCR) 1% disagrees, 28% agree, 71% strongly agree and similarly in the Tropical savannah region (TSC) result reveals that, 1% disagrees, 29%agree, 70% strongly agree that temperature increase is one of the most threatening impacts of climate change in their region. In the Tropical rainforest region (TRC) result also reveals that 20% agree and 80% strongly agree. This indicates a 100% agreement in the tropical rainforest climate region and across the three regions a significant 99% agreement was recorded for temperature increase, which is a strong indicator of global-warming leading to climate change (IIPC, 2007). This further validates the theoretical construct in chapter two, with particular reference to sections 2.3 and 2.4.

**Table 5.14 Temperature increase**

Temperature increase is the most threatening impact of climate change in my region

| REGION | | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|---|
| Highland (Alpine) | Valid | Disagree | 1 | 1.0 | 1.0 | 1.0 |
| | | Agreed | 29 | 28.4 | 28.4 | 29.4 |
| | | Strongly Agreed | 72 | 70.6 | 70.6 | 100.0 |
| | | Total | 102 | 100.0 | 100.0 | |
| Tropical Savannah | Valid | Disagree | 1 | 1.1 | 1.1 | 1.1 |
| | | Agreed | 26 | 29.2 | 29.2 | 30.3 |
| | | Strongly Agreed | 62 | 69.7 | 69.7 | 100.0 |
| | | Total | 89 | 100.0 | 100.0 | |
| Tropical Rainforest | Valid | Agreed | 18 | 19.6 | 19.6 | 19.6 |
| | | Strongly Agreed | 74 | 80.4 | 80.4 | 100.0 |
| | | Total | 92 | 100.0 | 100.0 | |

The importance of this section has been presented in section 5.4 and it is also a section where the results obtained determines the design parameters, which building designers are engaged with. However, the researcher observed that some questions have varied responses within the same region. Therefore, the result were further analysed in subsequent section in order to ascertain if the respondents' practice type has some influence on the views expressed.

### 5.2.5 ASSESSING THE PERCEPTIONS OF PARTICIPANTS ON THE POTENTIALS OF SUSTAINABLE DESIGN GUIDE

Data from the variables 14 and 16 attempt to gauge how built environment design professionals perceived; design strategies, their roles and their willingness to use a design guide in order to forecast the acceptability of the design guide to these professionals in Nigeria. The three questions contribute to achieve objectives **c** and **e** and addresses research question **v**. Furthermore, these questions contribute to the overall implications on the research as discussed at the end of each section, in regards to theoretical findings and the validation of other theoretical underpinnings from sections 2.5 and 2.6.

#### 5.2.5.1 Design strategy

This question sought to find out the opinion of participants about the role of design in order to ascertain the level of importance they attached to design. Their responses would suggest whether to forecast their willingness in terms of promoting sustainability through their practices. The findings from Table 5.15 shows that the agreement level for the potentials of design strategies in minimising the impacts of climate change are; 98%, 94% and 92% for the Highland climate region, Tropical savannah region and the Tropical rainforest climate regions respectively. Thus, the results suggest that a significant percentage of the participants rated design as a strategy very high. This further suggests that there is a likelihood that adopting a regional design guide would be successful.

**Table 5.15 Design strategies**

Sustainable design strategies have the potential to reduce the impacts of climate change on residential buildings

| REGION | | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|---|
| Highland (Alpine) | Valid | Disagree | 2 | 2.0 | 2.0 | 2.0 |
| | | Agreed | 11 | 10.8 | 10.8 | 12.7 |
| | | Strongly Agreed | 89 | 87.3 | 87.3 | 100.0 |
| | | Total | 102 | 100.0 | 100.0 | |
| Tropical Savannah | Valid | Disagree | 5 | 5.6 | 5.6 | 5.6 |
| | | Agreed | 37 | 41.6 | 41.6 | 47.2 |
| | | Strongly Agreed | 47 | 52.8 | 52.8 | 100.0 |
| | | Total | 89 | 100.0 | 100.0 | |
| Tropical Rainforest | Valid | Agreed | 32 | 34.8 | 34.8 | 34.8 |
| | | Strongly Agreed | 60 | 65.2 | 65.2 | 100.0 |
| | | Total | 92 | 100.0 | 100.0 | |

### 5.2.5.2 Roles of architects

The following data was recorded in Table 5.16 with each of the regions and findings showing that; HCR has 1% who disagrees, 27% agree and 72% strongly agree, this is an indication that more than 90% are in agreement that architects have an important role of providing climate sensitive buildings. Findings from TSC are; 10% disagree, 54% agree and 36% strongly agree, showing a total of 89.9% agreement. Findings from TRC show a similar trend as follows; 1% disagrees, 1% strongly disagrees, 53% agree and 45% strongly agree. This result shows a significant 93% agreement across the three climatic regions that architects can play an important role towards ensuring that the buildings they produce are climate sensitive and in the long run mitigate and adapt to climatic changes. This validates the earlier studies that suggest that the decisions taken by architects at the design stage buildings are key factors to the outcomes of sustainable buildings (Bunz et al, 2006; Attia, 2012).

**Table 5.16 Architects have an important role of providing climate sensitive buildings**

**Architects have an important role of providing climate sensitive buildings**

| REGION | | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|---|
| Highland (Alpine) | Valid | Disagree | 1 | 1.0 | 1.0 | 1.0 |
| | | Agreed | 28 | 27.5 | 27.5 | 28.4 |
| | | Strongly Agreed | 73 | 71.6 | 71.6 | 100.0 |
| | | Total | 102 | 100.0 | 100.0 | |
| Tropical Savannah | Valid | Disagree | 9 | 10.1 | 10.1 | 10.1 |
| | | Agreed | 48 | 53.9 | 53.9 | 64.0 |
| | | Strongly Agreed | 32 | 36.0 | 36.0 | 100.0 |
| | | Total | 89 | 100.0 | 100.0 | |
| Tropical Rainforest | Valid | Strongly Disagree | 1 | 1.1 | 1.1 | 1.1 |
| | | Disagree | 1 | 1.1 | 1.1 | 2.2 |
| | | Agreed | 49 | 53.3 | 53.3 | 55.4 |
| | | Strongly Agreed | 41 | 44.6 | 44.6 | 100.0 |
| | | Total | 92 | 100.0 | 100.0 | |

### 5.2.5.3 I am interested in using a sustainable design guide in the future

In Table 5.17, results from HCR revealed that 2% disagree, 66% agreed, 32% strongly agreed. In the TSC region; 7% strongly disagree, 9% disagree, 62% agreed and 23% strongly agreed. Also the TRC result revealed that 1% disagrees, 58% agreed and 41% strongly agreed. This is an indication that the possibility for the design professionals to use a design guide is significantly high, given the response from survey participants.

**Table 5.17 I am interested in using a sustainable design guide in the future**

I am interested in using a sustainable design guide in the future

| REGION | | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|---|
| Highland (Alpine) | Valid | Disagree | 2 | 2.0 | 2.0 | 2.0 |
| | | Agreed | 67 | 65.7 | 65.7 | 67.6 |
| | | Strongly Agreed | 33 | 32.4 | 32.4 | 100.0 |
| | | Total | 102 | 100.0 | 100.0 | |
| Tropical Savannah | Valid | Strongly Disagree | 6 | 6.7 | 6.7 | 6.7 |
| | | Disagree | 8 | 9.0 | 9.0 | 15.7 |
| | | Agreed | 55 | 61.8 | 61.8 | 77.5 |
| | | Strongly Agreed | 20 | 22.5 | 22.5 | 100.0 |
| | | Total | 89 | 100.0 | 100.0 | |
| Tropical Rainforest | Valid | Disagree | 1 | 1.1 | 1.1 | 1.1 |
| | | Agreed | 53 | 57.6 | 57.6 | 58.7 |
| | | Strongly Agreed | 38 | 41.3 | 41.3 | 100.0 |
| | | Total | 92 | 100.0 | 100.0 | |

### 5.2.6 EVALUATING THE PRIMARY DESIGN PARAMETERS/CONSIDERATION FOR RESIDENTIAL BUILDINGS IN THE DIFFERENT CLIMATE REGIONS IN NIGERIA

This section sought to identify the specific sustainable design parameters for each climatic region. Some design parameters (see Table 2.5) from the selected examples of residential guides in the UK were used to assess their potentials and suitability for the Nigerian climate types. Also sections 2.8 and 2.9 particularly gave the theoretical underpinnings to questions 17 to 31. This section addresses; objective c -'To further identify potential design parameters that could possibly promote the development of a sustainable residential building design guide for the three different climatic regions in Nigeria' and d – 'To ascertain how practicing design professionals effectively utilize knowledge and information available to them in their design practices' and research question iv – 'What design parameters are required for the residential buildings in the different climate regions or zones in Nigeria?'

#### 5.2.6.1 Building accessibility and Flexibility (functionality)

The results in Table 5.18 show that in the HCR; about 66% of respondents are in disagreement that the ability of a building to be easily accessed and adaptable to other functions is not given consideration as a design parameter, while 34% agreed that it is a parameter to be considered. TRC respondents responded differently; 1% strongly disagrees, 23% disagree, 43% agreed and 34% strongly agree, this shows that 77% of the respondents agreed that accessibility and adaptability of a building are considered as design parameter. Also, results from TRC region showed that 2% strongly disagree, 20% disagree, 5% agree, 26% strongly agree and a total of 78% of architects in this region are in agreement that accessibility and the ability of a building to be flexible are strong parameters.

Therefore, the ability of buildings to be accessible by all users and the ability of the building to adapt to flexible functions are important to the participants across the three regions, with the following percentages 34%, 77% and 78%, for the HCR, TSR and TRC respectively. However, the HCR has a surprisingly much lower level of agreement compared to the other two regions. This may be due to the cooler nature of their climate type.

**Table 5.18 Building accessibility and adaptability**

Building accessibility & adaptability

| REGION | | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|---|
| Highland (Alpine) | Valid | Strongly Disagree | 5 | 4.9 | 4.9 | 4.9 |
| | | Disagree | 63 | 61.8 | 61.8 | 66.7 |
| | | Agreed | 21 | 20.6 | 20.6 | 87.3 |
| | | Strongly Agreed | 13 | 12.7 | 12.7 | 100.0 |
| | | Total | 102 | 100.0 | 100.0 | |
| Tropical Savannah | Valid | Strongly Disagree | 1 | 1.1 | 1.1 | 1.1 |
| | | Disagree | 20 | 22.5 | 22.5 | 23.6 |
| | | Agreed | 38 | 42.7 | 42.7 | 66.3 |
| | | Strongly Agreed | 30 | 33.7 | 33.7 | 100.0 |
| | | Total | 89 | 100.0 | 100.0 | |
| Tropical Rainforest | Valid | Strongly Disagree | 2 | 2.2 | 2.2 | 2.2 |
| | | Disagree | 18 | 19.6 | 19.6 | 21.7 |
| | | Agreed | 48 | 52.2 | 52.2 | 73.9 |
| | | Strongly Agreed | 24 | 26.1 | 26.1 | 100.0 |
| | | Total | 92 | 100.0 | 100.0 | |

### 5.2.6.2 Building form

Table 5.19 has the following results from the HCR respondents who responded; 10% strongly disagree, 65% disagree and 20% are in agreement that a building form is a parameter that should be considered in their region, while 5% of the respondents did not respond. The TSC region has the following results; 5% strongly disagree, 39% disagree 47% agreed and 9% strongly agree that the building form is a criteria for design in their region. While respondents in the TRC region has the following results; 9% disagree and 91% are in agreement. Observation of the result for the variable building forms suggest that, the respondents in the TRC seem to be more in agreement with the building form as a strong criterion for design consideration than those in the other two regions, this may be explained by the heavy rainfall and water logged areas common to this region as earlier discussed in chapter three.

**Table 5.19 Building form**

Building form

| REGION | | | Frequency | Percent | Valid Percent |
|---|---|---|---|---|---|
| Highland (Alpine) | Valid | Strongly Disagree | 10 | 9.8 | 10.3 |
| | | Disagree | 66 | 64.7 | 68.0 |
| | | Agreed | 18 | 17.6 | 18.6 |
| | | Strongly Agreed | 3 | 2.9 | 3.1 |
| | | Total | 97 | 95.1 | 100.0 |
| | Missing | System | 5 | 4.9 | |
| | Total | | 102 | 100.0 | |
| Tropical Savannah | Valid | Strongly Disagree | 4 | 4.5 | 4.5 |
| | | Disagree | 35 | 39.3 | 39.3 |
| | | Agreed | 42 | 47.2 | 47.2 |
| | | Strongly Agreed | 8 | 9.0 | 9.0 |
| | | Total | 89 | 100.0 | 100.0 |
| Tropical Rainforest | Valid | Disagree | 8 | 8.7 | 8.7 |
| | | Agreed | 82 | 89.1 | 89.1 |
| | | Strongly Agreed | 2 | 2.2 | 2.2 |
| | | Total | 92 | 100.0 | 100.0 |

**Table 5.19 continues (Building form)**

| REGION | | | Cumulative Percent |
|---|---|---|---|
| Highland (Alpine) | Valid | Strongly Disagree | 10.3 |
| | | Disagree | 78.4 |
| | | Agreed | 96.9 |
| | | Strongly Agreed | 100.0 |
| | | Total | |
| | Missing | System | |
| | Total | | |
| Tropical Savannah | Valid | Strongly Disagree | 4.5 |
| | | Disagree | 43.8 |
| | | Agreed | 91.0 |
| | | Strongly Agreed | 100.0 |
| | | Total | |
| Tropical Rainforest | Valid | Disagree | 8.7 |
| | | Agreed | 97.8 |
| | | Strongly Agreed | 100.0 |
| | | Total | |

### 5.2.6.3 Building orientation as a design parameter

Building orientation is significant in the design of residential buildings due to the way rooms are positioned in relation to the sun's orientation and wind direction. Table 5.20 results shows that for the HCR region 32% respondents are in disagree and a total of 68% are in agreement that building orientation is a design criterion for their region. TSC result shows that 29% disagree that building orientation is not a strong design criterion, while 65% agreed that it is. In the TRC region; 30% disagree and 70% respondents are in agreement that the building orientation is an important design parameter.

An average of 68% agreement is recorded across the three climate regions. This is an indication that the orientation of a building has some significant effects on the design of buildings across the three regions. This is likely to have some relationship with the sun and wind direction and the occurrences of windstorm common to all three regions as shown in the responses from Table 5.13. Also, Nigeria being a tropical country (close to the equator) hence, all parts of the country experiences the sun's east to west directional movement at the same time.

**Table 5.20 Building orientation**

Building orientation

| REGION | | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|---|
| Highland (Alpine) | Valid | Strongly Disagree | 3 | 2.9 | 2.9 | 2.9 |
| | | Disagree | 30 | 29.4 | 29.4 | 32.4 |
| | | Agreed | 61 | 59.8 | 59.8 | 92.2 |
| | | Strongly Agreed | 8 | 7.8 | 7.8 | 100.0 |
| | | Total | 102 | 100.0 | 100.0 | |
| Tropical Savannah | Valid | Strongly Disagree | 7 | 7.9 | 7.9 | 7.9 |
| | | Disagree | 19 | 21.3 | 21.3 | 29.2 |
| | | Agreed | 51 | 57.3 | 57.3 | 86.5 |
| | | Strongly Agreed | 12 | 13.5 | 13.5 | 100.0 |
| | | Total | 89 | 100.0 | 100.0 | |
| Tropical Rainforest | Valid | Strongly Disagree | 3 | 3.3 | 3.3 | 3.3 |
| | | Disagree | 25 | 27.2 | 27.2 | 30.4 |
| | | Agreed | 37 | 40.2 | 40.2 | 70.7 |
| | | Strongly Agreed | 27 | 29.3 | 29.3 | 100.0 |
| | | Total | 92 | 100.0 | 100.0 | |

### 5.2.6.4 Building materials

Following the discussions in section 2.7.2, the choice of building materials plays an important role at the design phase of buildings. As such, the wrong or lack of consideration for the choice of building materials would affect the ability of the building to mitigate and adapt to climatic changes.

The building materials as a parameter recorded the following result in Table 5.21: HCR; 5% strongly disagree, 28% disagree, 33% agree and 33% strongly agree, this result shows a 69% agreement in HCR. TSC results revealed that 66% agreed and 34% strongly agreed, showing a 100% agreement. Also TRC reveals that 3% strongly disagree, 23% disagree, 44% agree, and 30% strongly agree, the agreement response is 74%.

**Table 5.21 Building materials**

**Choice of building materials**

| REGION | | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|---|
| Highland (Alpine) | Valid | Strongly Disagree | 5 | 4.9 | 4.9 | 4.9 |
| | | Disagree | 29 | 28.4 | 28.4 | 33.3 |
| | | Agreed | 34 | 33.3 | 33.3 | 66.7 |
| | | Strongly Agreed | 34 | 33.3 | 33.3 | 100.0 |
| | | Total | 102 | 100.0 | 100.0 | |
| Tropical Savannah | Valid | Agreed | 59 | 66.3 | 66.3 | 66.3 |
| | | Strongly Agreed | 30 | 33.7 | 33.7 | 100.0 |
| | | Total | 89 | 100.0 | 100.0 | |
| Tropical Rainforest | Valid | Strongly Disagree | 3 | 3.3 | 3.3 | 3.3 |
| | | Disagree | 21 | 22.8 | 22.8 | 26.1 |
| | | Agreed | 40 | 43.5 | 43.5 | 69.6 |
| | | Strongly Agreed | 28 | 30.4 | 30.4 | 100.0 |
| | | Total | 92 | 100.0 | 100.0 | |

### 5.2.6.5 Site analysis

The following responses were recorded for v21 criterion in Table 5.22 for HCR; 3% strongly disagree, 29% disagree, 60% agreed, 8% strongly agreed and total agreement of 69%. TSC; records 6% strongly disagree, 58% agreed, and 25% strongly agree. TRC shows that 86% agreed and14% strongly agree, recording 100 per cent agreement for the regions. Thus, site analysis has been identified by the respondents as a very important parameter. Furthermore, this agrees with the theoretical construct in section 2.8 and validates the conclusion of Carmody et al. (2009) that measures be taken at every site in order to meet the sustainability challenge.

**Table 5.22 Site analysis**

**Climatic site analysis(Thermal insulation, Wind control)**

| REGION | | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|---|
| Highland (Alpine) | Valid | Strongly Disagree | 3 | 2.9 | 2.9 | 2.9 |
| | | Disagree | 30 | 29.4 | 29.4 | 32.4 |
| | | Agreed | 61 | 59.8 | 59.8 | 92.2 |
| | | Strongly Agreed | 8 | 7.8 | 7.8 | 100.0 |
| | | Total | 102 | 100.0 | 100.0 | |
| Tropical Savannah | Valid | Strongly Disagree | 6 | 6.7 | 6.7 | 6.7 |
| | | Agreed | 58 | 65.2 | 65.2 | 71.9 |
| | | Strongly Agreed | 25 | 28.1 | 28.1 | 100.0 |
| | | Total | 89 | 100.0 | 100.0 | |
| Tropical Rainforest | Valid | Agreed | 79 | 85.9 | 85.9 | 85.9 |
| | | Strongly Agreed | 13 | 14.1 | 14.1 | 100.0 |
| | | Total | 92 | 100.0 | 100.0 | |

### 5.2.6.6 Energy efficiency

The importance of energy efficiency in buildings has been widely acknowledged, however, it is not certain if the respondents for this research are in agreement. Table 5.23 presents the following result-HCR; 1% disagrees, 78% agreed, 21% strongly agreed, this shows 99% agreement that energy efficiency forms part of the primary design consideration during the design of residential buildings. TSC; 9% disagree, 54% agree, 37% strongly agree, representing 80% agreement. TRC; 33% disagree, 28% agree, 39% strongly agrees which shows 68% are in agreement.

Thus, the results suggest that, this parameter is an important design parameter which architects should consider during their design decisions across all regions. However, in the TRC 33% disagreed and their opinions are probably due to lack of knowledge and or the inability of the respondents to understand the applicability of their knowledge to their design practices as was opined by Emuzie et al. (2013).

**Table 5.23 Energy efficiency**

**Energy efficiency**

| REGION | | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|---|
| Highland (Alpine) | Valid | Disagree | 1 | 1.0 | 1.0 | 1.0 |
| | | Agreed | 80 | 78.4 | 78.4 | 79.4 |
| | | Strongly Agreed | 21 | 20.6 | 20.6 | 100.0 |
| | | Total | 102 | 100.0 | 100.0 | |
| Tropical Savannah | Valid | Disagree | 8 | 9.0 | 9.0 | 9.0 |
| | | Agreed | 48 | 53.9 | 53.9 | 62.9 |
| | | Strongly Agreed | 33 | 37.1 | 37.1 | 100.0 |
| | | Total | 89 | 100.0 | 100.0 | |
| Tropical Rainforest | Valid | Disagree | 30 | 32.6 | 32.6 | 32.6 |
| | | Agreed | 26 | 28.3 | 28.3 | 60.9 |
| | | Strongly Agreed | 36 | 39.1 | 39.1 | 100.0 |
| | | Total | 92 | 100.0 | 100.0 | |

### 5.2.6.7 External space layout

As a follow up to earlier theoretical reviews, Figure 2.17 and Table 2.4 show that, the external space layout of a building affect the building's ability to respond to its local climate and topography. This knowledge was also tested and the responses for this criterion for the three regions are presented in Table 5.24.

HCR; 5% strongly disagree, 26% disagree, 58% agree, 4% strongly agree and 8% no response, with a total agreement of 62% of the 92 who responded. TSC shows that; 1% strongly disagree, 33% disagree, 56% agree, 10% strongly agree and 66% total agreement for this region. TRC; 55% disagree, 23% agree, 22% strongly agree. Respondents in the TRC have the least agreement percentage of 45%. These results showed a significant difference across the regions, therefore requiring further investigation and thus a statistical test is carried out to test differences between and within groups across the regions.

**Table 5.24 External space layout**

**External space layout**

| REGION | | | Frequency | Percent | Valid Percent |
|---|---|---|---|---|---|
| Highland (Alpine) | Valid | Strongly Disagree | 5 | 4.9 | 5.3 |
| | | Disagree | 26 | 25.5 | 27.7 |
| | | Agreed | 59 | 57.8 | 62.8 |
| | | Strongly Agreed | 4 | 3.9 | 4.3 |
| | | Total | 94 | 92.2 | 100.0 |
| | Missing | System | 8 | 7.8 | |
| | Total | | 102 | 100.0 | |
| Tropical Savannah | Valid | Strongly Disagree | 1 | 1.1 | 1.1 |
| | | Disagree | 29 | 32.6 | 32.6 |
| | | Agreed | 50 | 56.2 | 56.2 |
| | | Strongly Agreed | 9 | 10.1 | 10.1 |
| | | Total | 89 | 100.0 | 100.0 |
| Tropical Rainforest | Valid | Disagree | 51 | 55.4 | 55.4 |
| | | Agreed | 21 | 22.8 | 22.8 |
| | | Strongly Agreed | 20 | 21.7 | 21.7 |
| | | Total | 92 | 100.0 | 100.0 |

### 5.2.6.8 Flooding Strategies

In Table 5.12 the results revealed that flooding was a common climate change impact felt across all three climate regions in Nigeria. It is therefore, necessary to ascertain from the respondents if during design they are mindful of flooding strategies and this was tested in Table 5.25.

Table 5.25 results show that in the HCR region; 1% disagree that flooding strategies play an important role in their design considerations and 99% are in agreement. 12% of respondents from the TSC region disagree and 88% are in agreement on the important role of flooding strategies. Also, the TRC results revealed a similar trend with the HCR responses, where only 1% disagreed and 99% noted the importance of designing flooding strategies as design parameter.

Furthermore, the results show that in the TRC region 97% of the respondents strongly agreed with the statement. These very high affirmations suggest that the level of flooding in the region validates evidences in section 3.5.5 and Figures 3.17 and 18.

**Table 5.25 Flooding strategies**

**Flooding strategies**

| REGION | | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|---|
| Highland (Alpine) | Valid | Disagree | 1 | 1.0 | 1.0 | 1.0 |
| | | Agreed | 32 | 31.4 | 31.4 | 32.4 |
| | | Strongly Agreed | 69 | 67.6 | 67.6 | 100.0 |
| | | Total | 102 | 100.0 | 100.0 | |
| Tropical Savannah | Valid | Disagree | 12 | 13.5 | 13.5 | 13.5 |
| | | Agreed | 38 | 42.7 | 42.7 | 56.2 |
| | | Strongly Agreed | 39 | 43.8 | 43.8 | 100.0 |
| | | Total | 89 | 100.0 | 100.0 | |
| Tropical Rainforest | Valid | Disagree | 1 | 1.1 | 1.1 | 1.1 |
| | | Agreed | 2 | 2.2 | 2.2 | 3.3 |
| | | Strongly Agreed | 89 | 96.7 | 96.7 | 100.0 |
| | | Total | 92 | 100.0 | 100.0 | |

### 5.2.6.9 Internal space layout

Given that the external space layout of buildings and the orientation of buildings have a relationship with the climate and the local environment; it is deducible to suggest that the internal space layout also have some effects on the ability of the building to function sustainably. The views of the respondents were recorded in Table 5.26.

Table 5.26 has the following results; for the HCR region; all the 102 respondents agreed that the internal space layout of residential buildings should be considered as a design parameter in their region, this shows a 100% agreement. However, in the TSC region there was a divide with; 1% strongly disagrees, 22% disagree, 42% agree 35% strongly agree and this result sums up the agreement level in this region to 77%. Table

5.26 also shows that the TRC results as; 2% disagree, 8% agree, 90% strongly agreed and 98% agreement was recorded in the TRC region. Overall agreement across the three regions is 97% as regards to internal space layout. Thus, it is a parameter that is relevant to all three regions.

**Table 5.26 Internal space layout**

| REGION | | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|---|
| Highland (Alpine) | Valid | Agreed | 34 | 33.3 | 33.3 | 33.3 |
| | | Strongly Agreed | 68 | 66.7 | 66.7 | 100.0 |
| | | Total | 102 | 100.0 | 100.0 | |
| Tropical Savannah | Valid | Strongly Disagree | 1 | 1.1 | 1.1 | 1.1 |
| | | Disagree | 20 | 22.5 | 22.5 | 23.6 |
| | | Agreed | 37 | 41.6 | 41.6 | 65.2 |
| | | Strongly Agreed | 31 | 34.8 | 34.8 | 100.0 |
| | | Total | 89 | 100.0 | 100.0 | |
| Tropical Rainforest | Valid | Disagree | 2 | 2.2 | 2.2 | 2.2 |
| | | Agreed | 7 | 7.6 | 7.6 | 9.8 |
| | | Strongly Agreed | 83 | 90.2 | 90.2 | 100.0 |
| | | Total | 92 | 100.0 | 100.0 | |

### 5.2.6.10 Pollution and air quality control

Table 5.27 shows the detailed findings from the three climate regions on the choice of pollution and quality air control as a design parameter, HCR; 8% strongly disagree, 37% disagree, 35% agree, 20% strongly agree and a total of 55% agreement. For the TSC; 19% disagree, 60% agree, 21% strongly agree and a total of 81% agreement is recorded. This is no surprise, because the TSC region experiences severe harmattan characterised by heavy dust particles in the atmosphere. Also the TRC has; 15% disagree, 52% agreed, 33% strongly agree. The total agreement for the TRC is 85% agreement, this is the region identified in the context of this study with the most gas flaring activity in the world. However, the respondents in the HCR may have responded based on the fact that there are no much pollution prone industries in their region. Secondly, there is a possibility that the respondents did not consider pollution and air quality control as a major design consideration, and a similar situation has been observed in some UK councils' design guide on Table 2.4.

**Table 5.27 Pollution and Quality control**

Pollution & Quality control(air & noise)

| REGION | | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|---|
| Highland (Alpine) | Valid | Strongly Disagree | 8 | 7.8 | 7.8 | 7.8 |
| | | Disagree | 38 | 37.3 | 37.3 | 45.1 |
| | | Agreed | 36 | 35.3 | 35.3 | 80.4 |
| | | Strongly Agreed | 20 | 19.6 | 19.6 | 100.0 |
| | | Total | 102 | 100.0 | 100.0 | |
| Tropical Savannah | Valid | Disagree | 17 | 19.1 | 19.1 | 19.1 |
| | | Agreed | 53 | 59.6 | 59.6 | 78.7 |
| | | Strongly Agreed | 19 | 21.3 | 21.3 | 100.0 |
| | | Total | 89 | 100.0 | 100.0 | |
| Tropical Rainforest | Valid | Disagree | 14 | 15.2 | 15.2 | 15.2 |
| | | Agreed | 48 | 52.2 | 52.2 | 67.4 |
| | | Strongly Agreed | 30 | 32.6 | 32.6 | 100.0 |
| | | Total | 92 | 100.0 | 100.0 | |

### 5.2.6.11 Relationship with surrounding environment

The relationship of buildings with their surrounding environment was discussed in section 2.6. Buildings are central to human and environmental development as well as serving the role of climate modifiers (Lam, 2005; Cam, 2012). Therefore, the ability of a residential building to mitigate and adapt is also dependent on the relationship it has with the surrounding environment.

The findings for relationship with surrounding environment as a design criterion is presented in Table 5.28 as follows: HCR; 1% strongly disagrees, 4% disagree, 21%

agree, 76% strongly agree indicating 94% agreement. TSC; 3% strongly disagree, 2% disagree, 37% agree and 57% strongly agreed, these figures sums up the agreement total to 94% for the TSC region. Respondents from the tropical rainforest climate region had the following result; 12% disagree, 17% agree, 71% strongly agree, with a total agreement of 88%. Although, earlier results showed that professionals' knowledge on the relationship between climate change and building is low, they are however, aware that there is a relationship between buildings and the surrounding environment. These results thus, validate theoretical findings in section 2.5.

**Table5.28 Relationship with surrounding environment**

**Relationship with surrounding environment**

| REGION | | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|---|
| Highland (Alpine) | Valid | Strongly Disagree | 1 | 1.0 | 1.0 | 1.0 |
| | | Disagree | 3 | 2.9 | 2.9 | 3.9 |
| | | Agreed | 21 | 20.6 | 20.6 | 24.5 |
| | | Strongly Agreed | 77 | 75.5 | 75.5 | 100.0 |
| | | Total | 102 | 100.0 | 100.0 | |
| Tropical Savannah | Valid | Strongly Disagree | 3 | 3.4 | 3.4 | 3.4 |
| | | Disagree | 2 | 2.2 | 2.2 | 5.6 |
| | | Agreed | 33 | 37.1 | 37.1 | 42.7 |
| | | Strongly Agreed | 51 | 57.3 | 57.3 | 100.0 |
| | | Total | 89 | 100.0 | 100.0 | |
| Tropical Rainforest | Valid | Disagree | 11 | 12.0 | 12.0 | 12.0 |
| | | Agreed | 16 | 17.4 | 17.4 | 29.3 |
| | | Strongly Agreed | 65 | 70.7 | 70.7 | 100.0 |
| | | Total | 92 | 100.0 | 100.0 | |

#### 5.2.6.12 Sunlight control

Given that Nigeria is located close to the equator means there is very little differences in the hours of sunlight and dark nights. However, the design of interior spaces and building orientation from earlier results shows slight variations. Furthermore, from the discussions in section 3.3 on the background to climate change in Nigeria, it is evident that day light and sunlight control is an essential design requirement, due to the current epileptic electricity supply in Nigeria. The inability of designers to consider this parameter would mean the continuous use of artificial lighting by the means of non-energy efficiency electricity generating plant.

Table 5.29 Shows that in the HCR there are 9% strongly disagree, 57% disagree, 25% agree, 10% strongly agree and in total a 34% agreement is recorded for the control of sunlight in this region. TSC; 2% strongly disagree, 5% disagree, 48% agree, 45% strongly agree, therefore a significantly high percentage of 93% control sunlight with their design. Also TRC result is as follows; 69% disagree, 25% agree and 7% strongly agree, a lower percentage of 32% is recorded for sunlight control as a design criterion. Therefore, it is deducible from this result to suggest that sunlight control is a strong design parameter for the TSC region and less for HCR region and almost non considerable element in the TRC region.

It is arguable to suggest that the result from the TSC region suggest that the respondents were probably considering the sun's intensity rather than the illumination from the sunlight, due to the fact that it is a common knowledge that the sun heat intensity is felt the most in this region.

#### 5.2.6.13 Building Design Specifications

Building design specifications ensures that all information required for workmanship, construction and the materials to use are written to serve as instructions even beyond the design phase of buildings, therefore, promoting Offsite Manufacturing (OSM). OSM is fast becoming the option for sustainable construction for quality and mass production of housing needs of developing countries like Nigeria (Kolo et al, 2014). Arif and Egbu (2010) and Arif et al. (2012a and 2012b) also supported the use of OSM because of the advantages to offers, which includes; reduction in site waste and construction time. It is therefore, important to know the views of these professionals. This would further help to ascertain the workability and application of guides in the promotion of sustainable design practices.

**Table 5.29 Sunlight control**

Sunlight control

| REGION | | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|---|
| Highland (Alpine) | Valid | Strongly Disagree | 9 | 8.8 | 8.8 | 8.8 |
| | | Disagree | 58 | 56.9 | 56.9 | 65.7 |
| | | Agreed | 25 | 24.5 | 24.5 | 90.2 |
| | | Strongly Agreed | 10 | 9.8 | 9.8 | 100.0 |
| | | Total | 102 | 100.0 | 100.0 | |
| Tropical Savannah | Valid | Strongly Disagree | 2 | 2.2 | 2.2 | 2.2 |
| | | Disagree | 4 | 4.5 | 4.5 | 6.7 |
| | | Agreed | 43 | 48.3 | 48.3 | 55.1 |
| | | Strongly Agreed | 40 | 44.9 | 44.9 | 100.0 |
| | | Total | 89 | 100.0 | 100.0 | |
| Tropical Rainforest | Valid | Disagree | 63 | 68.5 | 68.5 | 68.5 |
| | | Agreed | 23 | 25.0 | 25.0 | 93.5 |
| | | Strongly Agreed | 6 | 6.5 | 6.5 | 100.0 |
| | | Total | 92 | 100.0 | 100.0 | |

From Table 5.30 the results show that in the HCR region; 3% strongly disagree, 11% disagree, 17% agree, 60% strongly agree, while 10 respondents did not respond to this question, leaving a 92 responses with 77% of these in agreement that building design specification is an important design consideration. Also in the TSC region; 1% disagrees, 49% agree and 49% strongly agree with a high agreement response of about 99%. TSC; the result in this region has a complete 100% agreement with a divide of; 57% agree and 43% strongly agree. An overall 91% across these regions agreed that the use of specifications and designing to building specification is important. Thus, it is most likely that the use of a design guide would enjoy the same response.

**Table 5.30 Building Design Specifications**

Specifications

| REGION | | | Frequency | Percent | Valid Percent |
|---|---|---|---|---|---|
| Highland (Alpine) | Valid | Strongly Disagree | 3 | 2.9 | 3.3 |
| | | Disagree | 11 | 10.8 | 12.0 |
| | | Agreed | 17 | 16.7 | 18.5 |
| | | Strongly Agreed | 61 | 59.8 | 66.3 |
| | | Total | 92 | 90.2 | 100.0 |
| | Missing | System | 10 | 9.8 | |
| | Total | | 102 | 100.0 | |
| Tropical Savannah | Valid | Disagree | 1 | 1.1 | 1.1 |
| | | Agreed | 44 | 49.4 | 49.4 |
| | | Strongly Agreed | 44 | 49.4 | 49.4 |
| | | Total | 89 | 100.0 | 100.0 |
| Tropical Rainforest | Valid | Agreed | 52 | 56.5 | 56.5 |
| | | Strongly Agreed | 40 | 43.5 | 43.5 |
| | | Total | 92 | 100.0 | 100.0 |

### 5.2.6.14 Water efficiency

Promoting water efficiency for sustainability requires and entails the ability to make the most of water resources and avoiding water wastages (see Table 2.4). Participants' responses are shown in Table 5.31. For the HCR region the result shows that; 3% strongly disagree, 57% disagree, 38% agree, 2% strongly agree and total agreement for water efficiency design is 40%. The TSC region responses are similar with that of the HCR; 3% strongly disagree, 54% disagree, 34% agree, 9% strongly agree and total agreement recorded is 40%. However, the TRC region result reveals that; 4% disagree that water efficiency is a major design consideration for their region and a total of 96% are in agreement. This result is quite different from the other two regions.

An explanation is that, the respondents in the TRC are design conscious of water efficiency because their region experiences the most rainfall in Nigeria and also the region has many of its communities living in water logged areas. As such, it is arguable to suggest that the respondents may not necessarily be conscious of water efficiency but water related climate change impacts.

**Table 5.31 Water efficiency**

Water efficiency(usage & harvest)

| REGION | | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|---|
| Highland (Alpine) | Valid | Strongly Disagree | 3 | 2.9 | 2.9 | 2.9 |
| | | Disagree | 58 | 56.9 | 56.9 | 59.8 |
| | | Agreed | 39 | 38.2 | 38.2 | 98.0 |
| | | Strongly Agreed | 2 | 2.0 | 2.0 | 100.0 |
| | | Total | 102 | 100.0 | 100.0 | |
| Tropical Savannah | Valid | Strongly Disagree | 3 | 3.4 | 3.4 | 3.4 |
| | | Disagree | 48 | 53.9 | 53.9 | 57.3 |
| | | Agreed | 30 | 33.7 | 33.7 | 91.0 |
| | | Strongly Agreed | 8 | 9.0 | 9.0 | 100.0 |
| | | Total | 89 | 100.0 | 100.0 | |
| Tropical Rainforest | Valid | Disagree | 4 | 4.3 | 4.3 | 4.3 |
| | | Agreed | 49 | 53.3 | 53.3 | 57.6 |
| | | Strongly Agreed | 39 | 42.4 | 42.4 | 100.0 |
| | | Total | 92 | 100.0 | 100.0 | |

### 5.2.6.15 Waste control

As shown in Table 2.4 waste control or strategy involves the management of refuse, recycling, and construction waste impact on the environment. The respondents' opinions are presented in Table 5.32. Findings from the different regions are as follows: HCR region; 4% strongly disagree, 33% disagree, 28% agree and 35% strongly agree. Thus, a total of 64% are of the opinion that waste control is an important parameter in their design practices. In the TSC region; 9% strongly disagree, 24% disagree, 34% agree, 34% strongly agree and a total of 67% agreement was recorded. Also the TRC region result shows that; 30% disagree, 37% agree, 33% strongly agree and thus, a total of 68% respondents are in agreement for this region. Thus, over 60% respondents across the three regions are in agreement, this result therefore, suggests that waste control is one of the parameters architects are conscious about during their design practices.

**Table32 Waste control**

| REGION | | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|---|
| Highland (Alpine) | Valid | Strongly Disagree | 4 | 3.9 | 3.9 | 3.9 |
| | | Disagree | 34 | 33.3 | 33.3 | 37.3 |
| | | Agreed | 28 | 27.5 | 27.5 | 64.7 |
| | | Strongly Agreed | 36 | 35.3 | 35.3 | 100.0 |
| | | Total | 102 | 100.0 | 100.0 | |
| Tropical Savannah | Valid | Strongly Disagree | 8 | 9.0 | 9.0 | 9.0 |
| | | Disagree | 21 | 23.6 | 23.6 | 32.6 |
| | | Agreed | 30 | 33.7 | 33.7 | 66.3 |
| | | Strongly Agreed | 30 | 33.7 | 33.7 | 100.0 |
| | | Total | 89 | 100.0 | 100.0 | |
| Tropical Rainforest | Valid | Disagree | 28 | 30.4 | 30.4 | 30.4 |
| | | Agreed | 34 | 37.0 | 37.0 | 67.4 |
| | | Strongly Agreed | 30 | 32.6 | 32.6 | 100.0 |
| | | Total | 92 | 100.0 | 100.0 | |

### 5.2.7 EVALUATING THE PERCEPTION OF PARTICIPANTS ON INVOLVEMENT AND COLLABORATIONS

The variables in this section sought to gauge the perceptions of design professionals on collaboration in order to validate theoretical findings which suggested that, the building sector needs sector based strategies or actions which can only be successful with collaboration amongst the built environment professionals. The rationale for the inquiry tied is tied to research objective **e** which is **'**to evaluate the views of built environment professionals in Nigeria on the areas of collaborations between themselves, the use of design guide and the role government plays as it concerns issues of climate change and sustainability of built environment across the three climatic regions in the country'**.** As well as research question **iii** which is; 'What level of knowledge exists amongst design professionals and how do they reflect such knowledge in their design practices?'

### 5.2.7.1 Perceptions on professional body involvement on awareness

Findings are presented in Table 5.33 as follows: HCR; 1% disagrees, 18% agreed, 81% strongly agreed. While in the TSC; 8% agreed, 81% strongly agreed and also for the TRC; 1% agreed and 99% strongly agreed. The TSC and the TRC regions revealed a 100% agreement on the need for built environment professional bodies to be involved in raising the awareness of its members. Given the results from previous Tables, the results from Table 5.33 clearly shows that the professional bodies within the built environment do need to engage more with raising the awareness of its members on the application of sustainable design parameters for residential building designs across the three climatic regions in Nigeria.

**Table 5.33 Professional body involvement in awareness campaigns**

Professional bodies can be involved in the awareness of its members on climate change problems

| REGION | | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|---|
| Highland (Alpine) | Valid | Disagree | 1 | 1.0 | 1.0 | 1.0 |
| | | Agreed | 18 | 17.6 | 17.6 | 18.6 |
| | | Strongly Agreed | 83 | 81.4 | 81.4 | 100.0 |
| | | Total | 102 | 100.0 | 100.0 | |
| Tropical Savannah | Valid | Agreed | 8 | 9.0 | 9.0 | 9.0 |
| | | Strongly Agreed | 81 | 91.0 | 91.0 | 100.0 |
| | | Total | 89 | 100.0 | 100.0 | |
| Tropical Rainforest | Valid | Agreed | 1 | 1.1 | 1.1 | 1.1 |
| | | Strongly Agreed | 91 | 98.9 | 98.9 | 100.0 |
| | | Total | 92 | 100.0 | 100.0 | |

### 5.2.7.2 Perceptions on professional body Collaborations

Findings for the variable; collaborations amongst the built environment professionals is presented in Table 5.34: HCR; 1% disagree, 74% agree, 25% strongly agree with a total of 99% agreement. TSC follows a similar trend; 1% strongly disagrees, 9% disagree, 55% agree, 35% strongly agreed with a total agreement of 90%. Similarly TRC also has; 1% disagrees, 12% agree, 87% strongly agree with a total of 99% agreement in the TRC and a total of 94% agreement across the three regions. Collaboration is therefore perceived to be a very strong strategy for achieving sustainability according to the respondents'opinions.

**Table 5.34 Collaborations amongst the built environment professionals**

Collaborations amongst the built environment professionals is needed to ensure sustainability of the built environment

| REGION | | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|---|
| Highland (Alpine) | Valid | Disagree | 1 | 1.0 | 1.0 | 1.0 |
| | | Agreed | 75 | 73.5 | 73.5 | 74.5 |
| | | Strongly Agreed | 26 | 25.5 | 25.5 | 100.0 |
| | | Total | 102 | 100.0 | 100.0 | |
| Tropical Savannah | Valid | Strongly Disagree | 1 | 1.1 | 1.1 | 1.1 |
| | | Disagree | 8 | 9.0 | 9.0 | 10.1 |
| | | Agreed | 49 | 55.1 | 55.1 | 65.2 |
| | | Strongly Agreed | 31 | 34.8 | 34.8 | 100.0 |
| | | Total | 89 | 100.0 | 100.0 | |
| Tropical Rainforest | Valid | Disagree | 1 | 1.1 | 1.1 | 1.1 |
| | | Agreed | 11 | 12.0 | 12.0 | 13.0 |
| | | Strongly Agreed | 80 | 87.0 | 87.0 | 100.0 |
| | | Total | 92 | 100.0 | 100.0 | |

### 5.2.8 ASSESSING PERCEPTIONS ON GOVERNMENT INVOLVEMENT

The variables (34-37) in this section sought to know what role the government in Nigeria has played to ameliorate the challenges of climate change within the built environment in the opinion of the respondents. Their responses would either agree or disagrees with earlier discussions in the first three chapters, which suggest that the Nigerian government has contributed very little towards tackling climate change problems, particularly in regards to raising awareness, enabling policies, capacities and encouragement.

#### 5.2.8.1. Government involvement in awareness and sensitization in Nigeria

Results from the respondents showing their agreement with the statement above is presented in Table 5.35 and it reveals the following: HCR region; 6% strongly disagree, 58% disagree, 21% agree, showing a low percentage of 36% agreement for the region. TSC; 21% strongly disagree, 58% disagree, 9% agree, 11% strongly agree, and another low 20% agreement from the TSC region. Also the TRC region result reveals; 1% strongly disagrees, 76% disagree, 22% agree, 1% strongly agrees and a total of 23% agreement is recorded. The three regions have a sum total of 36% agreement that government has been involved adequately in the awareness and sensitization of climate change problems.

This is an indication that there is an overall perception of dissatisfaction with the role the Nigerian government has played so far in the awareness and sensitization on climate change related problems. Thus, this result validates the earlier arguments of Onyekuru and Marchant (2012), who opined that, the Nigerian government is lacking in its role to raise awareness and sensitization of citizens on the problems of climate change.

**Table 5.35 Government involvement in awareness and sensitization in Nigeria**

**Government has been involved adequately in the awareness and sensitization of climate change problems**

| REGION | | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|---|
| Highland (Alpine) | Valid | Strongly Disagree | 6 | 5.9 | 5.9 | 5.9 |
| | | Disagree | 59 | 57.8 | 57.8 | 63.7 |
| | | Agreed | 21 | 20.6 | 20.6 | 84.3 |
| | | Strongly Agreed | 16 | 15.7 | 15.7 | 100.0 |
| | | Total | 102 | 100.0 | 100.0 | |
| Tropical Savannah | Valid | Strongly Disagree | 19 | 21.3 | 21.3 | 21.3 |
| | | Disagree | 52 | 58.4 | 58.4 | 79.8 |
| | | Agreed | 8 | 9.0 | 9.0 | 88.8 |
| | | Strongly Agreed | 10 | 11.2 | 11.2 | 100.0 |
| | | Total | 89 | 100.0 | 100.0 | |
| Tropical Rainforest | Valid | Strongly Disagree | 1 | 1.1 | 1.1 | 1.1 |
| | | Disagree | 70 | 76.1 | 76.1 | 77.2 |
| | | Agreed | 20 | 21.7 | 21.7 | 98.9 |
| | | Strongly Agreed | 1 | 1.1 | 1.1 | 100.0 |
| | | Total | 92 | 100.0 | 100.0 | |

### 5.2.8.2 Government policies on climate change and buildings

The Nigerian government has a draft policy on climate change (National Environmental, Economic and Development Study (NEEDS) for climate Change in Nigeria, 2010). A preview of the document reveals that, although, the draft policy is a robust instrument, it failed to address the issue of buildings. The researcher sought validation from the respondents many of whom are part of government.

Furthermore, the responses from respondents are presented in Table 5.36 and the results were recorded as follows: HCR; 51% strongly disagree, 47% disagree, 2% strongly agree. Thus, a total of 98% respondents do not agree that the Nigerian government policy on climate change, specifically address residential buildings or buildings in general. Similarly, respondents from the TSC region have also 90% disagreement and 10% respondents agreed that government has such policy in place. Also respondents from the TRC region share a similar opinion with; 72% disagreement and 28% agreement. The sum total of agreement for the respondents across the three regions is 13%. The result is an indication that there is generally a low perception on the efforts of government;this suggests that, there are no policies and good efforts to stem climate change impacts on residential buildings in Nigeria.

**Table 5.36 Government policies**

Government has put in place policies and actions to stem climate change impacts on residential buildings

| REGION | | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|---|
| Highland (Alpine) | Valid | Strongly Disagree | 52 | 51.0 | 51.0 | 51.0 |
| | | Disagree | 48 | 47.1 | 47.1 | 98.0 |
| | | Strongly Agreed | 2 | 2.0 | 2.0 | 100.0 |
| | | Total | 102 | 100.0 | 100.0 | |
| Tropical Savannah | Valid | Strongly Disagree | 59 | 66.3 | 66.3 | 66.3 |
| | | Disagree | 21 | 23.6 | 23.6 | 89.9 |
| | | Agreed | 9 | 10.1 | 10.1 | 100.0 |
| | | Total | 89 | 100.0 | 100.0 | |
| Tropical Rainforest | Valid | Strongly Disagree | 4 | 4.3 | 4.3 | 4.3 |
| | | Disagree | 62 | 67.4 | 67.4 | 71.7 |
| | | Agreed | 21 | 22.8 | 22.8 | 94.6 |
| | | Strongly Agreed | 5 | 5.4 | 5.4 | 100.0 |
| | | Total | 92 | 100.0 | 100.0 | |

### 5.2.8.3 Government capabilities

Perceptions of the participants on government capabilities to enforce building standards are shown in Table 5.37. Evidently, while 28% of HCR respondents believe that the government has the capabilities to enforce housing standards, a massive 72% strongly agreed. Thus, if those who agreed are added to those who strongly agreed

(100%), it shows that all respondents believe that the government has the capabilities to enforce building standards and sustainable building design practices in Nigeria. This finding is very interesting and contrasts remarkably with the findings in the literature, and this will be pursued further in chapter 6.

Further, perceptions from the TSC shows a slightly lower agreement trend than the HCR, with 6% strongly disagree, 22% disagreed, 14% agreed and 58% strongly agreed. The total agreement adds up to 72% in the TSC region. Again, respondents from the TRC have a slightly higher agreement with the statement than respondents from TSC region with 11% disagree, 23% agreed and 66% strongly agreed. Thus, the total agreement for TRC region is 79%.

Overall agreement on the capabilities of government across the three regions is 83%. This is an indication that, although the respondents do think the government is not doing enough in tackling problems of climate change, they believe that the government has the potentials to do so. Earlier discussions also suggested that Nigeria has a lot of human, natural and material resources to turn things around for the better.

**Table 5.37 Government capabilities**

Government has the capabilities to ensure compliance of building standards and implementation

| REGION | | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|---|
| Highland (Alpine) | Valid | Agreed | 28 | 27.5 | 27.5 | 27.5 |
| | | Strongly Agreed | 74 | 72.5 | 72.5 | 100.0 |
| | | Total | 102 | 100.0 | 100.0 | |
| Tropical Savannah | Valid | Strongly Disagree | 5 | 5.6 | 5.6 | 5.6 |
| | | Disagree | 20 | 22.5 | 22.5 | 28.1 |
| | | Agreed | 12 | 13.5 | 13.5 | 41.6 |
| | | Strongly Agreed | 52 | 58.4 | 58.4 | 100.0 |
| | | Total | 89 | 100.0 | 100.0 | |
| Tropical Rainforest | Valid | Disagree | 10 | 10.9 | 10.9 | 10.9 |
| | | Agreed | 21 | 22.8 | 22.8 | 33.7 |
| | | Strongly Agreed | 61 | 66.3 | 66.3 | 100.0 |
| | | Total | 92 | 100.0 | 100.0 | |

#### 5.2.8.4 Government encouragement of sustainable design practices

Table 5.38: the responses for the variable on government enforcement of sustainable design practices had the following results. For the HCR; 14% agreed and 86% strongly agreed. This is an indication that 100% respondents believed that Nigerian government can enforce sustainable design practices for residential buildings. In the TSC the findings show a 1% disagreement, 55% agreement, 44% strongly agreed. Whereas, in the TRC the response there was a total agreement with 14% agreed and 86% strongly agreed. This is an indication that the respondents are of the opinion that government has the ability to enforce sustainable practices.

In this section, the overall perceptions suggest that, although the respondents are not pleased with the involvement of the Nigerian government in ameliorating climate change problems they are however, of the opinion that the government has the power to encourage design professionals to imbibe the culture of sustainable design in their practices.

**Table 5.38 Government encouragement of sustainable design practices**

Government should encourage all housing providers to imbibe sustainable design choices for residential buildings

| REGION | | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|---|
| Highland (Alpine) | Valid | Agreed | 14 | 13.7 | 13.7 | 13.7 |
| | | Strongly Agreed | 88 | 86.3 | 86.3 | 100.0 |
| | | Total | 102 | 100.0 | 100.0 | |
| Tropical Savannah | Valid | Disagree | 1 | 1.1 | 1.1 | 1.1 |
| | | Agreed | 49 | 55.1 | 55.1 | 56.2 |
| | | Strongly Agreed | 39 | 43.8 | 43.8 | 100.0 |
| | | Total | 89 | 100.0 | 100.0 | |
| Tropical Rainforest | Valid | Agreed | 13 | 14.1 | 14.1 | 14.1 |
| | | Strongly Agreed | 79 | 85.9 | 85.9 | 100.0 |
| | | Total | 92 | 100.0 | 100.0 | |

## 5.3 SUMMARY OF FINDINGS AND THEIR APPLICABLE PARAMETERS

This section summarises findings from the preceding sections on the regional evidence and impacts of climate change and the design parameters to be considered. The summary is presented in Table 5.39. The Table serves as a checklist document that would guide the framework professional interactions as discussed in chapter six of this thesis. However, the parameters are only suggestive as the relevant professional specialists and other professionals would provide the detailed specifications for each region. Again, some parameters such as; specifications, energy efficiency, choice of building materials, site analysis, internal and external space considerations apply to all regions. Thus, only few parameters were suggested to serve as examples on Table 5.39 below.

**Table 5.39Summary of Findings and their applicable parameters**

| Impacts of climate change | HCR REGION | TSC REGION | TRC REGION | REMARKS |
|---|---|---|---|---|
| | % Agreement | % Agreement | % Agreement | **Selected design strategies** |
| **Erosion** | 39% | 77% | 100% | Erosion control strategies |
| **Drought/ desertification** | 03% | 54% | 01% | Drought control strategies |
| **Flooding** | 99% | 87% | 99% | Flooding strategies andWater efficiency (usage & harvest) |
| **Windstorm** | 46% | 69% | 34% | Building orientation, Building form, |
| **Temperature increase** | 99% | 99% | 100% | Energy efficiency and passive ventilation mechanisms |

Source: Compiled by the Researcher

This concludes the quantitative descriptive analysis for the structured (closed) questions which has a total of 37 variables. The quantitative non-parametric statistical test analysis is presented in section 5.4 for selected variables. Statistical test analysis methods employed in section 5.4 are: Spearman's Rank Order Correlations, Man-Whitney U Test, Cross Tabulation and Chi-square Test.

## 5.4 STATISTICAL TEST ANALYSIS

Statistical test analysis offers the opportunity for the researcher to conduct further analysis between the variables to ascertain; their associations, differences and relationships. The tests analysis results also helps the researcher to gain deeper understanding of the results and to draw out their research implications as further discussed in chapter six. The SPSS software was used to carry out all the statistical tests conducted as discussed in chapter four.

### 5.4.1 Assessing Knowledge and opinion of participants on climate change (Relationship Test for variables v6-v8).

**Variables:** I am well knowledgeable on the relationship between climate change and buildings (v6). There is adequate information on climate change and buildings in Nigeria (v7). I am interested in knowing more about climate change and residential buildings (8).

The Spearman's Rank Order Correlation Test was adopted to test the relationship amongst the three variables because; it shows the strength and direction of relationship between variables. The findings from variables v6 to v8 are further test for relationship from participants within the same region. Decisions for all statistical tests are based on; 95% as the assumed degree of confidence, 0.05 level of confidence and 0.000 significance level (p).

The result of the Spearman's rho correlation test carried out for the Highland climate region (HCR) is shown on Table 5.39. The result suggests that, for the variables knowledge (v6) and information (v7), there is a positive but weak relationship at 0.12 significance (p) and correlation coefficient (r) at 0.249. Also, for the variables knowledge (v6) and interests (v8) are significant (p) at 0.000 and **r** = 0.463. While the variables information (v7) and interests (v8) are statistically significant at 0.000 and **r**= 0.690 or 69% in the sample population of the HCR region. The result from the HCR region suggests that there is a positive relationship between all three variables with the strongest relationship between information and interest in the HCR region.

The TSC region correlation result shows that the variables knowledge (v6) and information (v7) have a positive statistical significant relationship at p = 0.000 and r = 0.0789. While the results for variables v6 and v8 and variables v7 and v8 are; r = 0.690 at p = 0.000 and v= 0.599 respectively. This result also suggests a positive relationship between all three variable (v6-v8) in the TSR region.

In the TRC region the correlation coefficient obtained from Table 5.39 are; r = 0.862 with p at 0.000 for variables v6 verses v7, r = 0.209 with p at 0.000 for variable v6 versus v8, r = 0.297 with p at 0.004 for variable v7 and v8. This region's result also indicates a positive and significant level of relationship between the three variables.

The entire results obtained from Table 5.40 for the three regions are statistically significant and validates the theoretical assertions by Lorenzoni et al. (2007) on the importance of knowledge, information and raising awareness, in order to get the public interested in the subject of climate change generally. Also, other studies noted that there are problems of low level of research information on climate change and buildings in this sub-Saharan region (Laryae, 2011; De Wilde and Coley, 2012; Onyekuru and Merchant (2012).

Noting that the respondents who are also design professionals have shown interest in knowing more on climate change and buildings as shown in Table 5.9 and the results from Table 5.40, their level of knowledge and professional capabilities can be enhanced. This would effectively promote sustainable residential design in the future. Therefore, addressing objective **d** which is to ascertain how practicing design professionals effectively utilize knowledge and information available to them in their design practices.

**Table 5.40 shows the correlation for Variables v6- v8**

| REGION | | | | V6 | V7 | V8 |
|---|---|---|---|---|---|---|
| Highland (Alpine) | Spearman's rho | V6 | Correlation Coefficient | 1.000 | .249* | .463** |
| | | | Sig. (2-tailed) | . | .012 | .000 |
| | | | N | 102 | 102 | 102 |
| | | V7 | Correlation Coefficient | .249* | 1.000 | .630** |
| | | | Sig. (2-tailed) | .012 | . | .000 |
| | | | N | 102 | 102 | 102 |
| | | V8 | Correlation Coefficient | .463** | .630** | 1.000 |
| | | | Sig. (2-tailed) | .000 | .000 | . |
| | | | N | 102 | 102 | 102 |
| Tropical Savannah | Spearman's rho | V6 | Correlation Coefficient | 1.000 | .789** | .690** |
| | | | Sig. (2-tailed) | . | .000 | .000 |
| | | | N | 89 | 89 | 89 |
| | | V7 | Correlation Coefficient | .789** | 1.000 | .599** |
| | | | Sig. (2-tailed) | .000 | . | .000 |
| | | | N | 89 | 89 | 89 |
| | | V8 | Correlation Coefficient | .690** | .599** | 1.000 |
| | | | Sig. (2-tailed) | .000 | .000 | . |
| | | | N | 89 | 89 | 89 |
| Tropical Rainforest | Spearman's rho | V6 | Correlation Coefficient | 1.000 | .862** | .209* |
| | | | Sig. (2-tailed) | . | .000 | .045 |
| | | | N | 92 | 92 | 92 |
| | | V7 | Correlation Coefficient | .862** | 1.000 | .297** |
| | | | Sig. (2-tailed) | .000 | . | .004 |
| | | | N | 92 | 92 | 92 |
| | | V8 | Correlation Coefficient | .209* | .297** | 1.000 |
| | | | Sig. (2-tailed) | .045 | .004 | . |
| | | | N | 92 | 92 | 92 |

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

### 5.4.2 Evidence and impacts of climate change on residential buildings in Nigeria

Although the descriptive analysis for the evidence and impacts of climate change in Nigeria revealed that all regions are affected, the test analysis provides the statistical significant differences for the three regions. Table 5.41 shows the Mann-Whitney Rank Table and Table 5.42 shows the Mann-Whitney (U) statistical test result that compares variables v9 to v13 for the two regions; the Highland climate region and the Tropical Rainforest region.

**Variables:**
Erosion is the most threatening impact of climate change in my region (v9).

Drought/desertification is the most threatening impact of climate change in my region (v10).

Flooding is the most threatening impact of climate change in my region (v11).

Windstorm is the most threatening impact of climate change in my region (v12)

Temperature increase is the most threatening impact of climate change in my region (v13).

The U test reveals a significance difference for variables v9, with significant difference value of 0.000, v10 with significant value of 0.000 and v11 with value of 0.000 significant differences. The results at 0.000 significant differences show that locations and climatic conditions of these regions determine the level of impacts of climate change. Whereas the variables; v12 and v13 have significance differences values at 0.857 and 0.107 respectively.

The result therefore, suggest that for climate change impact variables; Erosions, Drought/desertification and flooding have higher significance differences, which means that these impacts have greater differences from one location to the order. On the other hand, the impacts of variables v12 and v13 (windstorm and increased temperature) have little significant differences value and hence, there is very little difference in their impacts across the three regions.

Overall, this result also validates the earlier discussions on the evidence of climate change in Nigeria and study conducted by Odjubo (2010) on the spatial temperature differences and trends across Nigeria.

**Table 5.41 Mann-Whitney Ranks for variables v9 to v13**

Ranks

| | REGION | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| V9 | Highland (Alpine) | 102 | 55.25 | 5635.00 |
| | Tropical Rainforest | 92 | 144.35 | 13280.00 |
| | Total | 194 | | |
| V10 | Highland (Alpine) | 102 | 139.41 | 14219.50 |
| | Tropical Rainforest | 92 | 51.04 | 4695.50 |
| | Total | 194 | | |
| V11 | Highland (Alpine) | 102 | 84.26 | 8595.00 |
| | Tropical Rainforest | 92 | 112.17 | 10320.00 |
| | Total | 194 | | |
| V12 | Highland (Alpine) | 102 | 96.90 | 9884.00 |
| | Tropical Rainforest | 92 | 98.16 | 9031.00 |
| | Total | 194 | | |
| V13 | Highland (Alpine) | 102 | 92.88 | 9474.00 |
| | Tropical Rainforest | 92 | 102.62 | 9441.00 |
| | Total | 194 | | |

**Table 5.42 Mann-Whitney Statistical test for HCR and TRC regions on the most threatening impacts of climate change**

**Test Statistics**[a]

| | V9 | V10 | V11 | V12 | V13 |
|---|---|---|---|---|---|
| Mann-Whitney U | 382.000 | 417.500 | 3342.000 | 4631.000 | 4221.000 |
| Wilcoxon W | 5635.000 | 4695.500 | 8595.000 | 9884.000 | 9474.000 |
| Z | -12.044 | -12.552 | -5.128 | -.180 | -1.612 |
| Asymp. Sig. (2-tailed) | .000 | .000 | .000 | .857 | .107 |

a. Grouping Variable: REGION

Tables 5.43 and 5.44 compare variables v9 to v13 for the Tropical savannah region and the tropical rainforest region. The statistical test result on Table 5.44 reveals a similar trend with Table 5.42. Although the Mann-Whitney test results in Table 5.43 had the variable v13 (temperatures increase) as the only variable that has significant value more than 0.000 at 0.88, the implication is that temperature increase is a climate change impact common to the three regions. Thus, location and climate type do not seem to make any difference to this variable as such; temperature is a parameter for all residential building designers in the regions to make conscious sustainable decisions for the framework and at the design guides stages.

**Table 5.43 Mann-Whitney rank tests for TSC and TRC regions on the most threatening impacts of climate change.**

**Ranks**

| | REGION | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| V9 | Tropical Savannah | 89 | 61.67 | 5488.50 |
| | Tropical Rainforest | 92 | 119.38 | 10982.50 |
| | Total | 181 | | |
| V10 | Tropical Savannah | 89 | 136.77 | 12172.50 |
| | Tropical Rainforest | 92 | 46.72 | 4298.50 |
| | Total | 181 | | |
| V11 | Tropical Savannah | 89 | 66.74 | 5939.50 |
| | Tropical Rainforest | 92 | 114.47 | 10531.50 |
| | Total | 181 | | |
| V12 | Tropical Savannah | 89 | 112.27 | 9992.00 |
| | Tropical Rainforest | 92 | 70.42 | 6479.00 |
| | Total | 181 | | |
| V13 | Tropical Savannah | 89 | 85.94 | 7649.00 |
| | Tropical Rainforest | 92 | 95.89 | 8822.00 |
| | Total | 181 | | |

***Table 5.44* Statistical test for TSC and TRC regions on the most threatening impacts of climate change**

**Test Statistics[a]**

| | V9 | V10 | V11 | V12 | V13 |
|---|---|---|---|---|---|
| Mann-Whitney U | 1483.500 | 20.500 | 1934.500 | 2201.000 | 3644.000 |
| Wilcoxon W | 5488.500 | 4298.500 | 5939.500 | 6479.000 | 7649.000 |
| Z | -8.841 | -12.497 | -7.689 | -5.770 | -1.704 |
| Asymp. Sig. (2-tailed) | .000 | .000 | .000 | .000 | .088 |

a. Grouping Variable: REGION

### 5.4.3 Evaluating the primary design parameters/considerations for residential buildings in the three climate regions in Nigeria

From the descriptive analysis in section 5.2 respondents from each region identified the most threatening climate change impacts and the design parameters they mostly considered during their design. However, in this section some selected climate change impacts and their corresponding parameters are compared, in order to evaluate how the participants' responses correspond to their capability to mitigate and adapt to climate change by making the right sustainable choices.

Earlier in section 1.3 (research problem) it was established that design parameters play a role on the ability of buildings to perform sustainably (Eromobor and Das, 2013). However, there are arguments that suggest that, the built environment professionals in the developing countries do not fully understand the sustainability concept and how best to apply these concepts into the design of buildings (Emuzie et al, 2013). In the light of this uncertainty, selected variables in section 'c' (most threatening impacts of climate change) and their perceived related variables in section 'e' (design parameters) are cross tabulated to ascertain the association between them in regards to the choice of options made by the respondents.

In carrying out the test, the cross tabulation analysis and chi-square test analysis were carried out in order to ascertain if the choice of parameters made by the design professionals are sustainable and associated to the most threatening climate change impact identified for each region. The result provides validation to the argument on whether the design professionals do apply the appropriate features in their residential designs in Nigeria.

#### 5.4.3.1 Cross tabulation of variables v9 and v30

Variable v9 and v30 are cross tabulated because both are water related and are perceived to have some level of association for design considerations. Where v9 = Erosion is the most threatening impact of climate change in my region and v30 = Water efficiency (usage & harvest). These variables are cross tabulated because if the region suffers the impact of erosion then designers are expected to consider water efficiency in their design by integrating strategies that include; rain water roof harvest, non-wasteful water usage and proper channelling of waste water.

From the analysis on Table 5.45 (v9 and v30) variables; there is variance in the degree of agreement across the three regions and within each region. In the Highland climate (HCR) region, 61% of the respondents disagree and 39% agreed that water efficiency is a parameter to be considered as a strategy for erosion. Also, 22% of respondents from the Tropical rainforest region (TSC) disagreed and 78% agreed. While the respondents from the Tropical rainforest (TRC) region had 3% who disagreed and 97% of respondents who agreed that water efficiency is a strategy in the design of buildings for erosion. The result from Table 5.45 further tested, using chi-square to ascertain the independence of the two variables in Table 5.46.

Table 5.46 shows the chi-square statistical test for the Highland region: the Chi-square ($\chi2$) values for v9 and v30 is 123.188 at degree of freedom (df) of 6, at significance (p) of 0.000 and the likelihood ratio of about 135 to the sample size of the population. In the case of the Tropical Rainforest region: result from the statistical Table 5.45 shows that the $\chi2$ value is 73.295 at degree of freedom (df) of 6 at significance of 0.000 and the likelihood ratio of 92 to the sample size of the population. While in the Tropical Savannah region the result from Table 5.45 reveals $\chi2$ value of 68.225 at df of 2 with a significance level of 0.000 and likelihood of 22 to the sample size of the TRC population. These results indicate that it is more likely for the responses in TRC to apply to design water efficiency than those from the other two regions.

Overall, the level of significance association from Table 4.46 are 67%, 50% and 67% for the HCR, TSC and TRC respectively, this reveals that the respondents in the TSC are less likely than the other two regions to design water efficiency; this is likely due to the drought/desertification being experienced in the region.

**Table 5.45 Cross Tabulation of variables v9 and v30**

V9 * V30 Cross tabulation

| REGION | | | V30 | | | | Total |
|---|---|---|---|---|---|---|---|
| | | | Strongly Disagree | Disagree | Agreed | Strongly Agreed | |
| Highland (Alpine) | V9 | Disagree | 3 | 58 | 1 | 0 | 62 |
| | | Agreed | 0 | 0 | 33 | 0 | 33 |
| | | Strongly Agreed | 0 | 0 | 5 | 2 | 7 |
| | Total | | 3 | 58 | 39 | 2 | 102 |
| Tropical Savannah | V9 | Disagree | 3 | 17 | 0 | 0 | 20 |
| | | Agreed | 0 | 31 | 8 | 0 | 39 |
| | | Strongly Agreed | 0 | 0 | 22 | 8 | 30 |
| | Total | | 3 | 48 | 30 | 8 | 89 |
| Tropical Rainforest | V9 | Agreed | | 3 | 0 | 0 | 3 |
| | | Strongly Agreed | | 1 | 49 | 39 | 89 |
| | Total | | | 4 | 49 | 39 | 92 |

**Table 5.46 chi-Square Test for v9 and v30**

Chi-Square Tests

| REGION | | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|---|
| Highland (Alpine) | Pearson Chi-Square | 123.188[a] | 6 | .000 |
| | Likelihood Ratio | 134.824 | 6 | .000 |
| | Linear-by-Linear Association | 79.357 | 1 | .000 |
| | N of Valid Cases | 102 | | |
| Tropical Savannah | Pearson Chi-Square | 73.295[b] | 6 | .000 |
| | Likelihood Ratio | 92.125 | 6 | .000 |
| | Linear-by-Linear Association | 53.257 | 1 | .000 |
| | N of Valid Cases | 89 | | |
| Tropical Rainforest | Pearson Chi-Square | 68.225[c] | 2 | .000 |
| | Likelihood Ratio | 21.941 | 2 | .000 |
| | Linear-by-Linear Association | 18.116 | 1 | .000 |
| | N of Valid Cases | 92 | | |

a. 8 cells (66.7%) have expected count less than 5. The minimum expected count is 14.

b. 6 cells (50.0%) have expected count less than 5. The minimum expected count is 67.

c. 4 cells (66.7%) have expected count less than 5. The minimum expected count is 13.

### 5.4.3.2 Cross tabulation of variables v11 and v24

The results for the variables Flooding (v11) and Flooding strategies (v24) are cross tabulated in Table 5.47 and the statistical test results are presented in Table 5.48 as follows:

Table 5.47 shows that for the variables v11 and v24 have the following degree of agreements: 99%, 87% and 99% in the Highland climate region (HCR), Tropical savannah (TSC), and Tropical rainforest climate (TRC) respectively. This leaves only 1%, 13% and 1% of respondents HCR, TSC and TRC who do not apply flooding strategies in their design considerations.

The chi square results in Table 5.48 show that in the HCR region the Chi-Square value is 97.555 at degree of freedom 2 at significant level of 0.000 with degree of confidence of 100%. Since the value of $p < 0.05$ it means there is a strong association between variables v11 and v24. Also in the TSC region the chi-square value is 102.163 at degree of freedom 6 at significant level of 0.000 with the degree of confidence of 100%. Again the result from the TRC region shows that the chi-square value is 74.665 at degree of freedom 4 at significant level of 0.000 at 100% degree confidence. Like the other two region there is a level of association between variables v11 and v24.

However, the chi-square statistical test results also shows that the level of association is stronger in the TRC with 77.8%, then the TSC region has 50% and with the lowest percentage of 33.3% for HCR region.

The results from the three regions show that the built environment professionals design to flood risk in TRC region more than in the other regions. This finding comes as no surprise given that the incessant flooding in the region in recent years, as can be seen in Figure 3.17 in chapter 3.

In the case of TSC flooding is becoming a common occurrence in parts of this region, this is evidenced by the two rivers of Benue and Niger breaking their banks owing to heavy rain falls to precipitate some of the worst flooding ever experienced in the region as shown in Figure 3.19.

The relative adherent or reference to flooding in design by the built environment professionals in the HCR region has to do with relative little encounter with flood in the region. However, flash flooding do occur during heavy rainfall more so, there is a problem of rapidly advancing desertification which consumes homes and farmlands to which built environment professionals need to be mindful.

**Table 5.47 cross tabulation of variables v11 and v 24**

V11 * V24 Cross tabulation

Count

| REGION | | | V24 | | | | Total |
|---|---|---|---|---|---|---|---|
| | | | Strongly Disagree | Disagree | Agreed | Strongly Agreed | |
| Highland (Alpine) | V11 | Disagree | | | 1 | 0 | 1 |
| | | Agreed | | | 32 | 0 | 32 |
| | | Strongly Agreed | | | 1 | 68 | 69 |
| | Total | | | | 34 | 68 | 102 |
| Tropical Savannah | V11 | Disagree | 0 | 12 | 0 | 0 | 12 |
| | | Agreed | 1 | 8 | 29 | 0 | 38 |
| | | Strongly Agreed | 0 | 0 | 8 | 31 | 39 |
| | Total | | 1 | 20 | 37 | 31 | 89 |
| Tropical Rainforest | V11 | Disagree | | 1 | 0 | 0 | 1 |
| | | Agreed | | 1 | 1 | 0 | 2 |
| | | Strongly Agreed | | 0 | 6 | 83 | 89 |
| | Total | | | 2 | 7 | 83 | 92 |

**Table 5.48 Chi-Square Test for variablesv11 and v24**

**Chi-Square Tests**

| REGION | | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|---|
| Highland (Alpine) | Pearson Chi-Square | 97.565[a] | 2 | .000 |
| | Likelihood Ratio | 119.395 | 2 | .000 |
| | Linear-by-Linear Association | 92.811 | 1 | .000 |
| | N of Valid Cases | 102 | | |
| Tropical Savannah | Pearson Chi-Square | 102.163[b] | 6 | .000 |
| | Likelihood Ratio | 111.571 | 6 | .000 |
| | Linear-by-Linear Association | 61.629 | 1 | .000 |
| | N of Valid Cases | 89 | | |
| Tropical Rainforest | Pearson Chi-Square | 74.685[c] | 4 | .000 |
| | Likelihood Ratio | 21.745 | 4 | .000 |
| | Linear-by-Linear Association | 48.546 | 1 | .000 |
| | N of Valid Cases | 92 | | |

a. 2 cells (33.3%) have expected count less than 5. The minimum expected count is 33.
b. 6 cells (50.0%) have expected count less than 5. The minimum expected count is 13.
c. 7 cells (77.8%) have expected count less than 5. The minimum expected count is 02.

#### 5.4.3.3 Cross tabulation of variables v13 and v22

Variable v13 (temperature increase) has been identified from the descriptive analysis on Table 5.14 as the most common impact of climate change across the three climatic region in Nigeria and also been selected as one of the variables for further analysis with variable v22. The cross tabulation is presented in Table 5.49, which shows the rank distribution and the result from the chi-square statistical test of independence is presented in Table 5.50.

According to Table 5.49 the total survey for the three regions shows that 33% disagreed that a rise in temperature requires energy efficiency consciousness in their design. This contradicts rationality, given that, in a country like Nigeria where power generation is intermittent one would expect that the built environment designers would pay attention to rising temperature and design sustainably, either by employing passive design - ventilation and cooling methods, to reduce the need for energy driven mechanical ventilating systems such as air conditioning.

However, this could be put down to the fact that Nigeria, being a rich oil exporter and the sixth largest natural gas producer in the world, does not charge international bench mark price for energy, hence they do not see the need to design energy efficiency residential buildings. This is significant for many reasons, but suffices to mention a few. What is been displayed here, is the ignorance of the effects of energy consumptions on the natural environment in that the environmental cost of energy consumption intensity is not considered, only the financial cost, which is relatively affordable and may have been considered by the respondents.

From Table 5.50 the result for the HCR has a chi-square value of 112.784, at degree of freedom of 4 at a significant level of 0.000, with linear-to-linear association of 15 and likelihood ratio of 27.576 in the HCR sample population. The result also reveals 56% level of association between the two variables. Also, the result for the TSC region has a chi-square test value of 41.356 at degree of freedom of 4 at a significant level of 0.000 with level of association at 45%. Also, the result for the TRC region has 46.249 as the chi-square value at degree of freedom 2. The statistical test for this region has weak level of association at 0%. However, it is noted that most of those who disagree come mainly from TRC region as shown in Table 5.50.

In general, the results for the three regions show that, the respondents are not very mindful of the need to design with energy efficiency as a parameter that can regulate the impact of temperature increase. Nigeria being a generally warm country requires design measures that regulate energy efficiency, especially in the design of residential buildings where occupants spend most of their lives. Perhaps this explains the lack of known specific data for energy consumptions for buildings from the reviews undertaken in chapters one to three of this thesis.

**Table 5.48 Cross Tabulation of Variable v13= Temperature increase and v22 = Energy efficiency**

V13 * V22 Cross tabulation

Count

| REGION | | | V22 | | | Total |
|---|---|---|---|---|---|---|
| | | | Disagree | Agreed | Strongly Agreed | |
| Highland (Alpine) | V13 | Disagree | 1 | 0 | 0 | 1 |
| | | Agreed | 0 | 29 | 0 | 29 |
| | | Strongly Agreed | 0 | 51 | 21 | 72 |
| | Total | | 1 | 80 | 21 | 102 |
| Tropical Savannah | V13 | Disagree | 1 | 0 | 0 | 1 |
| | | Agreed | 7 | 19 | 0 | 26 |
| | | Strongly Agreed | 0 | 29 | 33 | 62 |
| | Total | | 8 | 48 | 33 | 89 |
| Tropical Rainforest | V13 | Agreed | 18 | 0 | 0 | 18 |
| | | Strongly Agreed | 12 | 26 | 36 | 74 |
| | Total | | 30 | 26 | 36 | 92 |

**Table 5.49Chi-Square Test for Variable v13 = Temperature increase and v22 = Energy efficiency**

Chi-Square Tests

| REGION | | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|---|
| Highland (Alpine) | Pearson Chi-Square | 112.784[a] | 4 | .000 |
| | Likelihood Ratio | 27.576 | 4 | .000 |
| | Linear-by-Linear Association | 15.463 | 1 | .000 |
| | N of Valid Cases | 102 | | |
| Tropical Savannah | Pearson Chi-Square | 41.358[b] | 4 | .000 |
| | Likelihood Ratio | 47.320 | 4 | .000 |
| | Linear-by-Linear Association | 34.763 | 1 | .000 |
| | N of Valid Cases | 89 | | |
| Tropical Rainforest | Pearson Chi-Square | 46.249[c] | 2 | .000 |
| | Likelihood Ratio | 50.573 | 2 | .000 |
| | Linear-by-Linear Association | 35.220 | 1 | .000 |
| | N of Valid Cases | 92 | | |

a. 5 cells (55.6%) have expected count less than 5. The minimum expected count is 01.

b. 4 cells (44.4%) have expected count less than 5. The minimum expected count is 09.

c. 0 cells (0%) have expected count less than 5. The minimum expected count is 5.09.

Overall, all regions show some level of association between the selected variables which suggest that these participants do apply some level of sustainable application in the choice of related and appropriate parameters in their design practices. However, there is much room for improvement and where appropriate parameters are adopted, it is not clear if their actions are deliberate and consciously carried out. Hence, findings from the tests on this section show that there is some level of certainty on the part of the participants on what design parameters are applicable. Thus, not fully validating the assumptions raised by Emuzie et al. (2013), who argue that, the design professionals in developing countries do not apply sustainability concepts.

#### 5.4.3.4 PERCEPTIONS ON GOVERNMENT INVOLVEMENT

On the involvement of the Nigerian government on tackling climate change related problems, many studies suggested that the government involvement was below expectations (BNRCC, 2008; Friends of the Earth International, 2009; Onyekuru and Manchant, 2012). The descriptive analysis in section 5.2.8.1 shows a general dissatisfaction with the performance of government on tackling climate change problems and yet, a significant number of respondents agreed that the government is capable of performing better and to encourage sustainable practices in Nigeria. The views expressed by the respondents differ across their professional practice types. In this section the opinions expressed are further tested to ascertain if their type of practice is associated with the opinion expressed.

#### 5.4.3.5 Cross tabulation of v4 and v34

In order to evaluate the categories of the respondents and opinion expressed, a further test analysis were carried out with Variable v5 (practice types); academic, private and public. The practice types (v5) are cross tabulated with variables v34 to v37.

These variables are; Government has been involved adequately in the awareness and sensitization of climate change problems (v34), Government has put in place policies and actions to stem climate change impacts on residential buildings (v35), Government has the capabilities to ensure compliance of building standards and implementation (v36) and Government should ensure all housing providers imbibe sustainable design choices for residential buildings (v37). The exercises in Tables 5.51 to 5.58 are to ascertain any correlation between respondents' opinion and the nature and type of practice they are engaged in. It can be seen from Table 5.51 that across the three regions there are 27% of the respondents in academics, 30% in private practice, and 43% practice their profession in the public sector.

While the details for the Highland climate region (HCR) in Table 5.51 show that; there are 21%, 29% and 50% of respondents in the academics, private and public sectors respectively. Results from this Table also reveal that, all those (6) who strongly disagreed that government has been involved adequately in the awareness and sensitization of climate change problems are the public sector practitioners. Furthermore, 76% of those who disagree are also from the public sector. On the other hand, a significant majority (76%) of those who also agreed come from the private sector. While no practitioner in the private sector strongly agreed that government has been involved adequately in awareness and sensitization of climate change problems. A sizeable number of practitioners in private practice (16 or 100%) nevertheless agreed with the statement in the HCR.

Result from the Tropical savannah TSC (TSC) region has shown that, there are 39%, 41% and 20% respondents who are engaged in the academics, private and public sectors respectively. Practitioners' responses show that all respondents who strongly disagree that government has been involved adequately in awareness and sensitization of climate change problems are from the public sector and of the 52 respondents who disagree 63% are also from the public sector. Similarly all those who agreed to the statement are academic practitioners.

Respondents from the Tropical rainforest climate have the following statistics from Table 5.20 as follows; 22% are academics, 29% are in the private practice and 50% are public sector practitioners. The only respondent who strongly disagrees with the statement is public sector practitioner, 24% of those who disagree are also from the public sector and a significant majority (54%) of others who disagreed with the statement are in private practice. While only 1 respondent from academics in the TRC agreed that government has been adequately involved with the awareness and sensitization on climate change problems.

The details in Table 5.51 Suggest that opinions expressed by the participants have some association with their practice types for all three regions. Table 5.52 gives the degree of association based on the chi-square statistical analysis at 100% degree of confidence and the results are presented as follows:

From the Highland climate region (HCR); chi-square value is 114.883 at degree of freedom 6 and significance at 0.000. While in the TSC region has chi-square value of 88.902 at degree of freedom 6 and significant at 0.000. Also, in the TRC region the chi-square value is 46.037 at degree of freedom 6 and significant at 0.000. All results from the three regions show significant at 0.000, indicating association between practice types and variable v34. The statistical test results show there are some levels of significant association as presented in Table 5.52 as: 50%, 58% and 58% degree of association between variables v5 and v34 in the HCR, TSC and TRC regions respectively.

These results suggest that practice types have some level of influence on the opinion expressed by practitioners and it could be argued based on the results obtained that the opinion expressed by the public practitioners may also have bearing with their job dissatisfaction and or with their salaries which has create many disagreements in the public service.

On the other hand, it could also be explained as seen from the results in Table 5.51 a significant number of academic practitioners are in agreement that, government has been adequately involved with the awareness and sensitization on climate change problems. Also, another explanation could be that, the academic practitioners may be more factual in their opinion because as researchers they are more likely to be better informed on government activities.

**Table 5.51 Cross Tabulation for variables v5 and variable 34**

| REGION | | | Practice | | | Total |
|---|---|---|---|---|---|---|
| | | | Academic | Private | Public | |
| Highland (Alpine) | V34 | Strongly Disagree | 0 | 0 | 6 | 6 |
| | | Disagree | 0 | 14 | 45 | 59 |
| | | Agreed | 5 | 16 | 0 | 21 |
| | | Strongly Agreed | 16 | 0 | 0 | 16 |
| | Total | | 21 | 30 | 51 | 102 |
| Tropical Savannah | V34 | Strongly Disagree | 0 | 0 | 19 | 19 |
| | | Disagree | 2 | 17 | 33 | 52 |
| | | Agreed | 8 | 0 | 0 | 8 |
| | | Strongly Agreed | 10 | 0 | 0 | 10 |
| | Total | | 20 | 17 | 52 | 89 |
| Tropical Rainforest | V34 | Strongly Disagree | 0 | 0 | 1 | 1 |
| | | Disagree | 15 | 38 | 17 | 70 |
| | | Agreed | 20 | 0 | 0 | 20 |
| | | Strongly Agreed | 1 | 0 | 0 | 1 |
| | Total | | 36 | 38 | 18 | 92 |

**Table 5.52 Chi-square Test for variables v5 and variable 34**

Chi-Square Tests

| REGION | | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|---|
| Highland (Alpine) | Pearson Chi-Square | 114.883[a] | 6 | .000 |
| | Likelihood Ratio | 122.798 | 6 | .000 |
| | Linear-by-Linear Association | 74.442 | 1 | .000 |
| | N of Valid Cases | 102 | | |
| Tropical Savannah | Pearson Chi-Square | 88.901[b] | 6 | .000 |
| | Likelihood Ratio | 90.831 | 6 | .000 |
| | Linear-by-Linear Association | 55.547 | 1 | .000 |
| | N of Valid Cases | 89 | | |
| Tropical Rainforest | Pearson Chi-Square | 46.037[c] | 6 | .000 |
| | Likelihood Ratio | 52.724 | 6 | .000 |
| | Linear-by-Linear Association | 31.840 | 1 | .000 |
| | N of Valid Cases | 92 | | |

a. 6 cells (50.0%) have expected count less than 5. The minimum expected count is 1.24.

b. 7 cells (58.3%) have expected count less than 5. The minimum expected count is 1.53.

c. 7 cells (58.3%) have expected count less than 5. The minimum expected count is .20.

#### 5.4.3.6 Cross tabulation of v4 and v35

**Variables**: Practice type - academic, private and public (v5) and Government has put in place policies and actions to stem climate change impacts on residential buildings (v35)

Variables v5 and variable v35 are also cross tabulated for significance and association; Table 5.53 shows the detailed distribution count frequencies and Table 5.54 shows the chi-square statistical analysis and degree of association. The following results were obtained in the three regions:

In the Highland climate region (HCR) the distribution frequency count on Table 5.53 shows that a significant percentage (98%) of the 52 public practitioners strongly disagree that government has put in place policies and actions to stem climate change impacts on residential buildings. Also 60% of the practitioners who disagree with the statement are from the private section and 40% from the academic. This result also shows that a significant majority (98%) of all the HCR region practitioners do not agree that government has put in place policies and actions to stem climate change impacts on residential buildings.

For the Tropical climate region (TSC) and the Tropical rainforest climate (TRC) region their results show similar trend as the HCR region. 90% and 95% of the respondents, from the TSC and TRC respectively, are of the opinion that the government has not put in place policies and actions to stem climate change impacts on residential buildings. Again 50% and 88% of these respondents who strongly disagree are from the public sector in these two regions.

The correlation results from Table 5.54 show that in the HCR region the chi square (r)= value is 103.919 at degree of freedom (df) 4 and significant at 0.000, while for the TSC region, the r value is 84.409 at 4 df and significance at 0.000 and also the TRC results show r value as 71.556 at df 4 and p at 0.000. The results from Table 5.53 further reveal that all results from the three regions are statistically significant at 33%, 44% and 58% levels of degree of association for the sample population in the HCR, TSC and TRC regions respectively.

**Table 5.53 Cross Tabulation for variables v5 and variable 35**

Crosstab Count

| REGION | | | Practice | | | Total |
|---|---|---|---|---|---|---|
| | | | Academic | Private | Public | |
| Highland (Alpine) | V35 | Strongly Disagree | 0 | 1 | 51 | 52 |
| | | Disagree | 19 | 29 | 0 | 48 |
| | | Strongly Agreed | 2 | 0 | 0 | 2 |
| | Total | | 21 | 30 | 51 | 102 |
| Tropical Savannah | V35 | Strongly Disagree | 0 | 7 | 52 | 59 |
| | | Disagree | 11 | 10 | 0 | 21 |
| | | Agreed | 9 | 0 | 0 | 9 |
| | Total | | 20 | 17 | 52 | 89 |
| Tropical Rainforest | V35 | Strongly Disagree | 0 | 0 | 4 | 4 |
| | | Disagree | 10 | 38 | 14 | 62 |
| | | Agreed | 21 | 0 | 0 | 21 |
| | | Strongly Agreed | 5 | 0 | 0 | 5 |
| | Total | | 36 | 38 | 18 | 92 |

**Table 5.54 Chi-Square Test for variables v5 and variable 35**

Chi-Square Tests

| REGION | | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|---|
| Highland (Alpine) | Pearson Chi-Square | 103.919[a] | 4 | .000 |
| | Likelihood Ratio | 136.180 | 4 | .000 |
| | Linear-by-Linear Association | 71.422 | 1 | .000 |
| | N of Valid Cases | 102 | | |
| Tropical Savannah | Pearson Chi-Square | 84.409[b] | 4 | .000 |
| | Likelihood Ratio | 99.848 | 4 | .000 |
| | Linear-by-Linear Association | 67.465 | 1 | .000 |
| | N of Valid Cases | 89 | | |
| Tropical Rainforest | Pearson Chi-Square | 71.556[c] | 6 | .000 |
| | Likelihood Ratio | 78.123 | 6 | .000 |
| | Linear-by-Linear Association | 42.940 | 1 | .000 |
| | N of Valid Cases | 92 | | |

a. 3 cells (33.3%) have expected count less than 5. The minimum expected count is .41.

b. 4 cells (44.4%) have expected count less than 5. The minimum expected count is 1.72.

c. 7 cells (58.3%) have expected count less than 5. The minimum expected count is .78.

#### 5.4.3.7 Cross Tabulation for variables v5 and v36

**Variables:** Practice type - academic, private and public (v5) and Government has the capabilities to ensure compliance of building standards and implementation (v36).

Also the variables v5 and v36 were statistically tested, the cross tabulation are presented in Table 5.55 and its corresponding correlation results are presented in Table 5.56 below.

Table 5.55 results indicated that all respondents (102 or 100%) are in agreement that Government has the capabilities to ensure compliance of building standards and implementation. This result for the HCR region further revealed that 73% practitioners from all three sectors strongly agreed with the statement and 27% public practitioner who agreed.

Table 5.55 also shows that in the Tropical savannah climate (TSC) region 6% of the public practitioners strongly disagree and 22% disagree that Government has the capabilities to ensure compliance of building standards and implementation. While 38%, 33% and 29% strongly agreed with the statement from the academic, private and public sectors practitioners respectively.

Result for the TRC on Table 5.55 shows that, 20 public practitioners of 11% disagree that Government has the capabilities to ensure compliance of building standards and implementation. While a significant majority with 23% and 66% of the practitioners agree and strongly agreed with the statement.

All the cross tabulation results from Table 5.55 and tested for correlation between opinions and the nature of practices are tested in Table 5.56. The results are presented thus: HCR region result shows r value = 38.595, df = 2 and p = 0.000. TSC has r value of 45.060, df at 6 and pat 0.000. Also, the TRC has r value of 73.276 at df of 4 and p at 0.000.

These results suggest that, in the HCR region there is no significant association between variables v5 and v36. However, the results from TSC and TRC regions suggest that there are statistical significance of association at 58% and 44% respectively between variable v5 and v36 of the sample populations.

**Table 5.55 Cross Tabulation for variables v5 and v36**

Cross tab Count

| REGION | | | Practice | | | Total |
|---|---|---|---|---|---|---|
| | | | Academic | Private | Public | |
| Highland (Alpine) | V36 | Agreed | 0 | 0 | 28 | 28 |
| | | Strongly Agreed | 21 | 30 | 23 | 74 |
| | Total | | 21 | 30 | 51 | 102 |
| Tropical Savannah | V36 | Strongly Disagree | 0 | 0 | 5 | 5 |
| | | Disagree | 0 | 0 | 20 | 20 |
| | | Agreed | 0 | 0 | 12 | 12 |
| | | Strongly Agreed | 20 | 17 | 15 | 52 |
| | Total | | 20 | 17 | 52 | 89 |
| Tropical Rainforest | V36 | Disagree | 0 | 0 | 10 | 10 |
| | | Agreed | 0 | 13 | 8 | 21 |
| | | Strongly Agreed | 36 | 25 | 0 | 61 |
| | Total | | 36 | 38 | 18 | 92 |

**Table 5.56 Chi-square Test for variable v5 and variable v36**

**Chi-Square Tests**

| REGION | | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|---|
| Highland (Alpine) | Pearson Chi-Square | 38.595[a] | 2 | .000 |
| | Likelihood Ratio | 49.679 | 2 | .000 |
| | Linear-by-Linear Association | 30.744 | 1 | .000 |
| | N of Valid Cases | 102 | | |
| Tropical Savannah | Pearson Chi-Square | 45.060[b] | 6 | .000 |
| | Likelihood Ratio | 58.360 | 6 | .000 |
| | Linear-by-Linear Association | 30.943 | 1 | .000 |
| | N of Valid Cases | 89 | | |
| Tropical Rainforest | Pearson Chi-Square | 73.272[c] | 4 | .000 |
| | Likelihood Ratio | 83.006 | 4 | .000 |
| | Linear-by-Linear Association | 54.746 | 1 | .000 |
| | N of Valid Cases | 92 | | |

a. 0 cells (0%) have expected count less than 5. The minimum expected count is 5.76.

b. 7 cells (58.3%) have expected count less than 5. The minimum expected count is .96.

c. 4 cells (44.4%) have expected count less than 5. The minimum expected count is 1.96.

### 5.4.3.8 Cross Tabulation for variables v5 and v37

**Variables:** Practice type academic, private and public (v5) and Government should enforce all housing providers to imbibe sustainable design choices for residential buildings (v37).

Variables v5 and v37 are also statistically tested for each of the three regions. The cross-tabulation count is presented in Table 5.57 and the chi-square test analysis results are presented in Table 5.58.

Table 5.57 presents the cross tabulation count results for the variables v5 and v37. HCR region: Result shows that, although, all practitioners strongly agreed that Government should ensure all housing providers to imbibe sustainable design choices for residential buildings. A significant 13% out of the 20% of public practitioners agreed to the statement.

TSC region: Table 5.57 also revealed that 55% of the public practitioners agreed that Government should ensure all housing providers to imbibe sustainable design choices

for residential buildings. While in the overall as significant majority strongly agreed that the Government should ensure all housing providers to imbibe sustainable design choices for residential buildings.
TSC region: 14% of the public practitioners agreed that, the Government should ensure that all housing providers imbibe sustainable design choices for residential buildings. Furthermore, the results show that 46%, 48% and 6% of the academic, private and public practitioners strongly agreed with the statement.

Test of the degree of association between variables v5 and v37 in Table 5.58 shows that, for the HCR region the chi-square value of 16.227 is obtained, at degree of freedom 2, and significant at 0.000. While the TSC has chi-square value of 81.188, degree of freedom at 4 and significant at 0.000 and the TRC has chi-square value of 39.017 at degree of freedom 2 and significant at 0.000.

Again each region's results indicate a statistical significance values for between variables v5 and v37 at 33%, 33% and 17% for the HCR, TSC and TRC sample populations respectively. This suggests that, although there are statistical significant association between variables, it is less than average noting that the highest percentage is 33%. Hence, strength of association for variable v37 and the respondents practice type v5 is less than average.

## Table 5.57 Cross Tabulation of variables v5 and v37

Cross tab Count

| REGION | | | Practice | | | Total |
|---|---|---|---|---|---|---|
| | | | Academic | Private | Public | |
| Highland (Alpine) | V37 | Agreed | 0 | 0 | 14 | 14 |
| | | Strongly Agreed | 21 | 30 | 37 | 88 |
| | Total | | 21 | 30 | 51 | 102 |
| Tropical Savannah | V37 | Disagree | 0 | 0 | 1 | 1 |
| | | Agreed | 0 | 0 | 49 | 49 |
| | | Strongly Agreed | 20 | 17 | 2 | 39 |
| | Total | | 20 | 17 | 52 | 89 |
| Tropical Rainforest | V37 | Agreed | 0 | 0 | 13 | 13 |
| | | Strongly Agreed | 36 | 38 | 5 | 79 |
| | Total | | 36 | 38 | 18 | 92 |

## Table 5.58 Chi-Square Test for variables v5 and v37

**Chi-Square Tests**

| REGION | | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|---|
| Highland (Alpine) | Pearson Chi-Square | 16.227[a] | 2 | .000 |
| | Likelihood Ratio | 21.645 | 2 | .000 |
| | Linear-by-Linear Association | 12.926 | 1 | .000 |
| | N of Valid Cases | 102 | | |
| Tropical Savannah | Pearson Chi-Square | 81.188[b] | 4 | .000 |
| | Likelihood Ratio | 105.063 | 4 | .000 |
| | Linear-by-Linear Association | 65.276 | 1 | .000 |
| | N of Valid Cases | 89 | | |
| Tropical Rainforest | Pearson Chi-Square | 62.239[c] | 2 | .000 |
| | Likelihood Ratio | 53.677 | 2 | .000 |
| | Linear-by-Linear Association | 39.017 | 1 | .000 |
| | N of Valid Cases | 92 | | |

a. 2 cells (33.3%) have expected count less than 5. The minimum expected count is 2.88.

b. 3 cells (33.3%) have expected count less than 5. The minimum expected count is .19.

c.1 cells (16.7%) have expected count less than 5. The minimum expected count is 2.54.

Overall, findings revealed that the government is not adequately participating on climate change related problems in Nigeria. This validates and agrees with the arguments of Ademiluyi (2010) and Onyekuru and Merchants (2012) although, government has done very little to ameliorate climate change problem and slow in adopting a climate change policy, it has the potentials to do better and encourage sustainable practices in the country. Findings also revealed that respondents have confidence that the government is capable of improving on its actions towards tackling the challenges of climate change in Nigeria.

## 5.5 OPEN ENDED QUESTIONS

The last variable (v38) asked the respondents to comment freely on any section of the questionnaire in order to add to the robustness of the investigations and to also cover relevant areas that the researcher may have overlooked. The researcher noted that most of the comments made by the respondents were mainly to show appreciation for the opportunity to participate in the survey.

However, there are three relevant comments on the research subject from the highland climate region, five from the tropical rainforest and none from the tropical savannah climate regions. The researcher observed that all the additional comments were only relevant to two sections; professional collaborations and government participation. These comments are provided below:

### 5.5.1 Professional collaborations;

- Professional bodies should standardize and provide an approved checklist document for the sustainability of buildings
- To ensure sustainability of residential buildings in Nigeria the built environment professionals need to think sustainably rather than for monetary rewards only.
- Professionals should separate politics from professional ethical issues.
- Professional bodies should engage their members on joint monitoring strategies to ensure adherence to the proposed design guide for residential buildings.

- Professionals should collaborate and build prototype sustainable compliant residential buildings in every state of the country to make the general public and other members appreciate the benefits of sustainability.

The itemised comments and concern shown by these respondents further validates the importance of professional collaborations amongst the built environment in Nigeria in order that the sector would move beyond the current challenges. This could be attainable where sustainable practices are encouraged, monitored and guided by supporting policies.

### 5.5.2 Government participation;

- Government should be more proactive in its actions to stem the challenges of climate change in Nigeria.
- Policy documents on climate change should be drafted in conjunction with the built environment professionals.
- Government should ensure that the National Building Research Institute (NBRI) should include sustainability of the built environment in its vision and research outlook.

Again the contribution by the respondents in the comments above further agrees with the results on Tables 5.57 and 5.58 which demonstrate the confidence on the part of the respondents that the Nigerian government has the capabilities to ensure sustainable compliance, monitoring and enforcement.

## 5.6 QUALITATIVE DATA ANALYSIS AND FINDINGS

This section presents the qualitative data with the intent to; Firstly address the research questions secondly, to gain more insights into both theoretical and quantitative findings and thirdly, to further validate these findings using the inductive approach. The appropriateness of the approach and method has been discussed in chapter four. Furthermore, an earlier study by Kvale (1996) has noted that inductive interpretation of qualitative data allows the researcher to draw out in-depth meanings which may not ordinarily be obtainable otherwise.

### 5.6.1 The interviews

A total of 30 face to face interviews were conducted amongst the built environment professionals in Nigeria. Each of the three climate type (HCR, TSC and TRC) region was represented by 10 interviewees. The processes for the interview data included; recording, translations, transcribing, coding and using Nvivo 10 software for the analysis. Each interviewee was assigned an identification label to reflect the interview region and number.

A typical identification are; HCRE1, TSCE1 and TRCE1- which represents the opinion of interviewee 1 opinion from the Highland region, Tropical Savannah region and Tropical rainforest climate regions respectively. This identification label is carried out in order to maintain the anonymity of the interviewees in compliance with DMU research ethical approval requirements and to adhere to the agreement between the interviewees and the researcher on the consent form (attached as Appendix **10**). The interview instrument has two parts; section 'A' is the structured questions mainly conducted for demographic purposes and participants' profile has been presented in section 4.10.2 and Table 4.11 in chapter four of this thesis.

The demographic character of the interviewees as shown in Table 4.11 is more heterogeneous than the character of the participants for the quantitative data. The explanation is simply because the qualitative data represents opinions from allied professions within the built environment.

Section B of the interview questions consist of 9 semi-structured questions as shown on the interview instrument (see Appendix **7**) and the questions were closely related to the themes in the quantitative inquiry. The difference between the two investigations is the ability of the interviewer to ask for further clarifications. In order to gain more insights into the 'why' and the 'how', these are common with follow-up questions.

Selected interviewees' responses from each region are quoted in order to give emphasis to findings and to provide basis for further discussions in the next chapters.

### 5.6.2 Analysis and discussions on the interviewees' views on knowledge and information

This section analysis is presented in two parts as; information and knowledge in 5.5.2.1 and 5.3.2.2 respectively. From the earlier assumptions in chapters one and two, lack of adequate Knowledge and information has been noted to contribute to the inability of developing countries to tackle effectively the challenges of climate change (Leary et al, 2008; Thrabrew and Ries, 2009; Ford et al, 2013).

Therefore, to ascertain these assumptions, the interviewees opinions were sought in order to; validate earlier findings from the theoretical reviews and compare with the quantitative findings in the preceding sections of this chapter, which suggest a low level of knowledge and understanding on the relationship between climate change and buildings. The overall intention for this section is to address research *Objective* ***d*** *-to ascertain how practicing design professionals effectively utilize knowledge and information available to them in their design practices*, and *research question* ***iii*** *- What level of knowledge exists amongst design professionals and how do they reflect such knowledge in their design practices?*

This is intended with a view to provide insight for further discussions, on the research implications in chapter six and to form the basis for recommendations in chapter seven.

#### 5.6.2.1 Knowledge

**Question 1: Do you think the built environment professionals in Nigeria have adequate knowledge on climate change and buildings?**

All interviewees did not respond in favour to the inquiry in all the three regions. This is not surprising because, the opinion expressed by the interviewees confirms the results obtained from the quantitative surveys. Furthermore, studies by Laryea (2011) and De Wilde and Coley (2012) noted the limited studies on climate change and buildings in the West African region. It is also arguable to suggest that, perhaps, this limited knowledge on climate change and buildings have contributed to the scarcity of studies and data availability from this region. Although, all of the interviewees' responses were similar, the Nvivo software is able to identify responses that have close association using nodes. A set of three responses, one each from the three regions are used as examples and for discussions.

TSCE 3: *"Good question, but I do not think our professionals are knowledgeable on the issues of climate change, let alone on climate change and buildings…"*

This prompted a follow up question, thus;

**'What is your suggestion on ways to increase awareness and knowledge of climate change to the built environment professionals?'**

The following itemised ways to raise awareness were suggested by the respondents as the ways to improve the knowledge of the built environment professionals across the climatic regions to include:

- Professional and sector based training, Seminars and workshops on related subject
- Integration of climate change and buildings courses or modules into universities curricula
- Increased media dissemination of information on climate change related information
- Sponsored awareness jingles for both the public and professionals practices
- Creation of discussion platforms
- Professional newsletters publications

Looking at the itemised suggestions by the respondents, the researcher is able to deduce that these professionals are interested in enhancing their knowledge level on the relationship between climate change and buildings.

These responses led to the question to ascertain and revalidate findings from the quantitative data on the relationship between knowledge and information on climate change and buildings in Nigeria. Findings from the interviewees are discussed in section 5.6.2.2.

#### 5.6.2.2 Information

In this section of the interview, the interviewees were asked of their views on the availability of information.The researcher observed that there is generally a low perception on the availability of information. Typical responses are quoted verbatim as follows:

**Question 2: Do you think there is enough information on climate and buildings and are you aware that research findings have shown that climate change and buildings are interrelated and have impact on each other. Briefly comment on this information based on your observations and experience please.**

HCRE1

- *"I am truly not sure of the relationship between climate and buildings but I do know that the climate is part of the environmental considerations for design and construction...the constant lack of electricity has also made it difficult for one to really search for detailed information on the relationship between climate change and building."*

TSCE3

- *"Climate change science is still an area I am not too familiar with and so therefore, I cannot say I am well informed about the relationship between climate change and buildings"*

TRCE1

- *"There may be some information. During my school days climate change was not an issue and now the west is always talking about climate change challenges and since I do not believe them I do not listen or read about what they want us to believe. In short, I do not have much information on the relationship between climate and buildings. Although, I have observed that the* *rise in sea level and the rivers in our state have caused severe flooding which affected many buildings, it is as a result of force majeure which no one can stop."*

The obvious inductions from these quotations above, is that the interviewees are either not well informed or that their views were formed out of ignorance and or lack of interest in the subject and not necessarily that information is not available. This explains why only 6 out the 30 interviewees (17%) of the interviewees are well informed on the relationship between climate change and buildings. Furthermore, this also validates the quantitative data analysis in section 5.2.3 above, which also reveals a low level of knowledge and information on climate change and buildings amongst the built environment professionals in Nigeria. However, there is an interesting response that is worth noting as quoted below:

**TSCE10:** "*I doubt if there is adequate information or rather if professionals are open to new information. New information may require them (professionals) to consider re-training in order to be updated. Which ideally is good, but knowing who we are... It is difficult to accept ignorance. At the end, it is all status issues. "*

This response speaks volume, as this may probably be a case of 'claiming ignorance' on the part of the professionals. It is therefore, necessary for the professional bodies to sensitise their members on the availability of information, if only it is sought for. Also respondent TSE10 may have expressed his personal views rather than giving a general opinion as he suggested and so his claim could be refuted.

#### 5.6.2.3 Application of Knowledge and information

The ability of the built environment professionals and especially the design professionals in the developing countries to apply knowledge acquired has been questioned in section 1.3. Findings from this section would offer the research the basis for the discussions about the ability of the professional to accept and apply knowledge acquired and the research implication in chapter six.

**Question 3: Research findings in developed and a few developing countries suggest that the integration at the design stage of buildings the synergy of mitigation and adaptation are achievable and promotes the production of sustainable buildings. In your opinion can this be applicable to Nigeria?**

All interviewees answered 'yes' to application of research findings on the synergy of mitigation and adaptation, but their views and opinions expressed seemed divergent in words but all have the same depth in contents. However, two different views from each of the three regions; HCR, TSC and TRC are presented below as follows:

*HCRE*2. *"Yes, but we have to develop specific findings for Nigeria's local climate and environmental conditions.... on the other hand, research findings from other regions may not be necessarily applicable here in Nigeria but could serve as case studies to be improved upon ."*

HCRE5. *"Yes, borrowing from others is not a bad idea. However, we should work with the advantage and minimise as much as possible any negative outcome that the synergy may have."*

*TSCE2. "The world is a global village, so research from one part of the world is applicable to Nigeria since we are not from different planet with other countries. My only concern is to make sure such application is adaptable to the Nigerian environmental conditions."*

TSCE7. "Research findings cannot be disputed, so I believe countries with similar climatic conditions would have solutions and strategies that are applicable to Nigeria."

*TRCE1. "If it is working in the developed countries then it should work in Nigeria. The major problem would be that of political opinion, if a political class is not holding such an opinion then a good strategy or plan may not be allowed to succeed."*

*TRCE3. "It can be applicable but we need our own researchers to make an input on the discussions..."*

Findings from these interviewees suggest the willingness of professionals to adapt and apply strategies relevant to the Nigerian context and peculiarity. This is a positive outlook towards ensuring the workability of design strategies.

### 5.6.3 Evidence and impacts of climate change in Nigeria

Chapters one, two and three have earlier noted the evidences of climate change globally (IPCC, 2007; Reid and Huq, 2007; Ogbo et al, 2013) and in Nigeria (Obioha, 2008; Odjuibo, 2010; Ogbo, 2013). Earlier studies have also emphasised the increasing frequencies and impacts of climate change globally (Boko et al, 2007; Karl et al, 2009; NASA, 2011). Also this section attempts to answer *research question **ii*** from section 1.8. Findings from the quantitative analysis in sections 5.2.4, 5.3.2 are validated from the quantitative data analysis obtained from participants. Presented below are list of impacts as suggested by the interviewees according to their climatic regions.

**Question 4: What in your opinion are the main impacts of climate change on residential buildings in your climate region?**

**List of identified climate change impacts from the HCR interviewees**

- Increased temperature
- Increased rainfall
- Flooding
- Windstorm

**List of identified main climate change impacts from the TSC interviewees**

- Increased temperature
- Drought/ desertification
- Erosion

**List of identified main climate change impacts from the TRC interviewees**

- Increased temperature
- Flooding (Raising sea level and loss of coastal communities)
- Erosion

- Windstorm

The list for each region is arranged according to most mentioned impact and all interviewees mentioned increased temperature as an impact they have observed to be the most common in their regions. This suggests that strategies and design parameters that will reduce the effects of increased temperature for residential buildings should be the most sought design consideration for all three regions**.** The views expressed are also captured verbatim as:

**HCRE4.** ***"...****It is the increasing rainfall being experienced these days that is causing much of the flooding in this part of Nigeria....."*

**TSCE5**. "*We here have been experiencing increased flooding occurrences in some communities of Gombe State and desert encroachment in the Borno and Yobe States areas although we are all within the same savannah region of Nigeria."*

**TRCE9**. *"…Increasingly, heavy rainfall and flooding have caused a lot of dampness on the wall of many residential building which was not a common sight some years back."*

These responses do not only validate earlier findings that the impacts of climate change are evident but also further validate earlier review that noted the increasing occurrences of the impacts of climate change in recent times across all climatic regions in Nigeria. The interviewee from the TSC region went further by observing that even within the same climatic region, differences do occur. Therefore, it is inductive to suggest that specific strategies may be required for particular locations with different peculiarities within the same region. A typical example in the TSC region is that there are flooding occurrences in the southern parts of the region, while the north eastern part of the region is experiencing drought. This has been captured in Figures 3.17 and 3.20 showing flooding and desertification within the same region.

### 5.6.4 Design parameters

It is important to consider the local environmental conditions for the design of every building. Eromobor and Das (2013) noted that identifying design parameters is a design prerequisite that is necessary for; maximising the potentials and performance of sustainable buildings. This section's main focus is to address *objective* ***c***, which is'To further identify potential design parameters that could possibly promote the development of a sustainable residential building design guide for the three different climatic regions in Nigeria.'and*research question* ***iv;*** 'What design parameters are required for the residential buildings in the different climate regions or zones in Nigeria?' and to compare with the enumerated design parameters suggested in Section E of the questionnaire.

Thus, this chapter presents the design parameters identified by the interviewees. The qualitative analysis and findings suggested the parameters to be considered by designers at the design stage for residential building designs across the three climatic regions based on **question 5** from the interviews carried out.

**Question 5: Based on your experience, what are the sustainable climatic design parameters for residential buildings that you considered are relevant to your climate type?**

In each region two of the responses that include most of the common parameters were selected in order to reflect all the qualitative findings. Responses from interviewees HRCE1 and HRCE4 are therefore, quoted below:

**HRCE1: "***It actually takes a lot of design considerations for any design to achieve its purpose but I think the following are essential;*

- *The use of climatic data to determine ratio of volumes and openings, although this is not strictly the case in practice today.*

**Why is that?**

*"Oh, it is because climatic data are not easily accessible and sometimes the data are not available."*

- *Accurate set –backs and distances from plains likely to flood*
- *Design against storms*
- *Site analysis especially soil analysis (types, absorption capacity)*
- *Effects of sun*
- Flooding strategies
- Other parameters that can make houses comfortable for occupants"

**What about materials?**

*"You are an Architect, so you know that it is only in traditional architecture that materials maters. Here we think of what materials the client can afford because the basic building materials are the same cement, sand and sand screed block across the country."*

**HRCE4: "***Most of the time, over the years I find myself always using the same basic design parameters; Building form, specifications, building orientation and site analysis."*

Findings from the interviews conducted in the HCR suggest the key parameters as follows;

- Choice of building materials
- Climatic data/consideration
- Flooding strategies
- Set backs
- Human comfort
- Site analysis
- Storm control (wind control) and
- Sun control

The researcher has also observed that, although human comfort and set-back were not listed in the list of parameters in the questionnaire, during the interviews three of the interviewees expressed concerns for the two items. Again, there are diverse views on building materials as a key parameter for consideration during design. However, the interview responses are presented below to include:

**TSCE2**: "*For me, I think a proper roof design, choice of high density and quality roof covering materials are the most important design parameters irrespective of location and the type of building.*"

**TSCE8**: ..."*All weather elements are relevant for the choice of design parameters such as; wind and sun control, temperature control, size of openings, site analysis and location. I am also looking forward to your research findings so that one may understand what parameters are most suitable these days with the changes taking place in our environment.*"

Responses amongst the interviewees from TSC have noted the following parameters as necessary to include;

- Building materials
- External and internal spaces (openings)
- Environmental consideration (location)
- Roof design
- Site analysis
- Temperature control
- Sun and wind orientation and
- Water control

While the interviews from the TRC have the following views:

**TRCE2: "***Choice of building materials, flooding strategies, building form, climatic site analysis, specification and to ensure that all professional bodies are engaged in any project implementation. In the long run, parameters should not be chosen for building performance but for occupants comfort as well.*"

**TRCE6: "***Thank you, to be specific, the flooding challenges we are experiencing here, it is very important to use the original damp proof materials and have raised foundations. Designs that allow for easy roofs water run-offs and drainages are necessary. Building orientation and site analysis are also important. I may not be able to name them all but I think these are the important ones..."*

Also findings from the TRC interviewees show that their considerations during design include the following design parameters;

- Building materials
- Building form
- Flooding strategies
- Human comfort
- Dampness control
- Orientation of building
- Site analysis and
- Specifications

Professional involvement was also mentioned as a parameter by one of the interviewees, although it was not captured as one of the parameters, it is however, an aspect of the collaboration. Furthermore, the interactive nature of the framework developed in chapter six has created a forum for professional involvement.

### 5.6.5 Potentials for a design guide in Nigeria

Another qualitative inquiry directed at the interviewees was to ascertain the workability of using a design guide and the challenges therein. Additionally, this section is intended to address *objective* ***e- '***To evaluate the views of built environment professionals in Nigeria on the areas of collaborations between themselves, use of design guide and the role government plays as it concerns issues of climate change and sustainability of built environment across the three climatic regions in the country.' and *research question* ***v-*** *'What are the prospects that the proposed sustainable* *residential design guide will result in sustainable building designs in Nigeria?*' It is necessary to ascertain the potentials of the proposed design guide because, if it has no potentials then this research project is likely to become only an academic exercise with no practical application potentials and benefits.

**QUESTION 6: Would a design guide for residential buildings in Nigeria be an effective tool for the production of sustainable buildings? What are the prospects and challenges? Please explain with reasons.**

Again some selected verbatim responses are presented in order to understand and evaluate the findings therein and for further discussions in subsequent chapters.

**HCER1:**"*The prospect is high because no designer designs to fail. The challenges would include the ability to produce a good and simple design guide, with government backing and the ability to circulate it.*"

**HCRE6: "***YES, a specific sustainable design guide is a welcome idea and most likely it will be readily acceptable by the professional bodies. The challenges would depend on the ease to which the guide can be used; its application, simplicity and its ability to address regional specifics. I think before it is adopted, there is the need to educate members of every professional body, approval boards and or agencies on how to use the guide. Another likely problem is its acceptability by all agencies at the same time. Otherwise, I suggest that the guide be given a national connotation. That way it becomes easier to be accepted and approved at a national level.*"

**HCRE10: "***Oh yes! A design guide would be an effective tool because the only guide or standard available to us now is the National Building Code which lacks sustainable consideration. I am also sure that a design guide will help us to reduce the cost of building maintenance and probably improve energy use in residential buildings. As an architect using a design guide would save me time spent during design and gives my client more value for their money and comfort.... My only fear would be that it may take a long time for it to be operational like the National Building Code...*"

**TSCE1: "***Absolutely yes, because a design guide will help to maintain a uniform sustainable standards for every designer. Well...the only likely problem is the inability to enforce compliance, especially in some local government councils who do not have designated or qualified staff to ensure compliance*."

**TSCE6:"***Yes, because designers will become more conscious of what is expected of them. The challenge I think will come when the document is seen as a document for the architect alone... a design guide should be accessible to everyone; the architect, allied professionals, clients, authorising or approval bodies and even the general public. I also think that students and those in academia be given the opportunity to use it for training and for regular update."*

**TRCE2:***"Yes, with legal backing and good governance that eschews corrupt practices that may give the design guide the relevance it deserves."*

**TRCE10:***"Very effective I believe, except if it is not design to address the issues it is supposed to address. The main challenge would be if it is complicated to understand and too cumbersome. My advice is to produce a very simply, easy to understand design guide of not more than 10 pages."*

There is an overwhelming support for the use of a design guide, although there are also some challenges that were observed by the interviewees. These challenges are summarised below to include:

- Availability and accessibility to the guide
- Enforcement
- Delays
- Corruption
- Governance support
- Keeping it simple
- Enforcement and compliance
- Professional rivalry
- Monitoring mechanism

### 5.6.6 Views on professional collaborations

The focus for this section is to address objective **e** and to evaluate the views of interviewees on collaborations. Collaborations amongst professionals within the built environment are deemed to be an effective way to promote sustainable strategies within the building and construction sector. Some selected responses confirm this conclusion from earlier review in chapter two.

**QUESTION 7: Overall, what are your views about collaborations amongst built environment professionals in Nigeria?**

**HCRE4:“***I agree collaborations are very important although, collaboration amongst professional bodies has been very weak due to power tussles and political ambitions, but if these are overcome every agreed action and decision taken as a group is bound to be successful. Therefore, more collaboration should be encouraged especially in the areas of research and joint communiqué (or positions) presentations to government on sustainable or any issues that would promote our industry.”*

**HCRE10: “***We do need to collaborate more in order to advance our profession and the industry.”*

**TSCE3:** *“I do agree that collaboration amongst professionals is good and it should be encouraged and such professional collaborations should be directed or targeted at achieving meaningful projects or vision that would affect the general public positively.”*

**TSCE9:***“My views on professional collaboration is to have all the professionals come together not just to improve their monitory gains like seeking government approvals on the increase of professional fees but to improve the services we render to the society.”*

**TRCE1: “***Collaborations are good and effective for achieving industry based initiatives.”*

**TRCE4: “***Collaborations within our industry have been on-going but so far, it is a mare association of politically minded professionals with no real direction or agenda due to power tussles amongst the professions. Although, within each profession there is good* *collaboration, it is also good to have collaboration across the professions for a better and effective productive development."*

**TRCE10:*"****Nigerian professionals in the building and construction industry do have an association (I think it is called Association of Professional Bodies of Nigeria) and I also do know that those in the academics have research collaborations. However, there is room for more collaboration that is not mere social clubs for the elites in the society but geared towards professional and industry advancement."*

These views expressed above were selected because these views represent the views of other interviewees across all the three regions and no single region had a view that was not expressed in the same manner with the other as above.

**5.6.7 Views on the roles of government**

Earlier review has suggested that the government in Nigeria has done very little or has been too slow in its action and intervention to tackle climate change problems. These perceptions have prompted the researcher to ask the interviewees their views as stated in question 8 and some selected responses are captured thereafter.

**Question 8: What are your views on the roles of the Nigerian government in term of policies formulation, raising awareness and strategic actions towards tackling climate change and buildings, with emphasis on residential buildings?**

**HCRE8:**"*Government has sincerely not done enough despite the fact that it has the human and intellectual capacity to carry out its duties in regards to climate change and buildings. Even the legislative arm has also not lived up to my expectation looking at the calibre of the legislators we have both at the lower and the upper houses of legislation.'*

**TSCE3: "***Government and its agencies should be more serious at checking residential or any building designs before approvals are given, especially now that we are faced with the negative impacts of climate in Nigeria."*

**TSCE5: "***Effective commitment by government is necessary for actualising any strategy for buildings in regards to the changing climate. About government policies; I have heard that there is a policy document but I have no personal knowledge. Also, I do strongly believe that the political climate we find ourselves in this country does not do us any good for any healthy development."*

**How?**

*"Well, because politicians think more of themselves and their political party loyalty than what is good for the progress and development of Nigeria as a country. At this period and the challenges of climate change, should we still be wondering on what government is planning to do? No! We should be assessing our score cards on; policies, strategies, implementation and evaluation."*

**TSCE10:** *"Government and governance in Nigeria has always been a slow train, this is because issues that are very important never really get the attention of government, except where Politicians have personal interest. For instance, the Federal Government in 1999 established the Federal Ministry of Environment which has five Parastatals; Environment Health Officers Registration Council, Forestry Research Institute, National Park Services, National Oil Spill Detection Response Agency and National Environmental Standards and Regulations Enforcement Agency of which climate change is only a unit. If you ask me, climate change should be a Ministry, going by what we see happening in other countries. So I think our government can do better."*

**TRCE5:** ***"****Government has only shown interest in the agricultural related climate change issues so far, even at that, not much has been achieved. Yes, I am aware that Nigeria has a very good policy proposal document on climate change, which is yet to be available to the general public and so I may not be able to comment on its efforts on climate change and buildings."*

Again the views expressed on the role of government are also common to views expressed by other interviewees from each of the three regions and are summarised thus:

- Government participation is key to achieving successes with climate change interventions and implementations
- Government needs to raise awareness on the subject matter
- Federal Government should engage other levels of governance for effective implementation
- Government has the capabilities to do better
- Focused and well-articulated strategic plan and actions are necessary
- Government should fund and promote climate change related research
- Increase capacity for agencies
- Create a Federal Ministry to coordinate climate change programme
- Policy adaptation and accessibility is necessary
- Government should set up climate change information units across the 36 states
- Government at all levels should not politicize climate change issues
- Government should direct schools at all levels to integrate climate change studies
- It is important for government to develop monitoring and evaluation processes and modalities across all the regions of the country.

### 5.6.8 Other comments

Only about 37% (11) of the interviewees had further comments after the interviews were concluded and opinions expressed are presented below:

**HCRE10: "***Firstly, I just want to let you know I was at the Architects' Colloquium in Abuja and I listened to your presentation and I hope we shall see more of your presentation on your research findings in the near future. Secondly, I feel you should also suggest to Architects' Registration Council of Nigeria and the Nigerian Institute of Architect to organise a platform to have architects discuss on how your proposals can form part of the training sessions at any of the Continuous Development Professional Practice Workshops. Good luck on your research."*

**TSCE6:** *"Just to note that it is good to have a simple design guide so that even the non-professionals at the local government councils unit can use it as a reference for approvals. The advantage is that it will bring some sanity in such areas where buildings are being erected on a daily basis without any form of control."*

**TRCE9: "***I feel this research is timely especially for the geographical location of Nigeria and the scanty research in our country. After completing your studies do keep in touch so that we can invite you to our chapter to share with us the findings from your research."*

Like most of the interviewees who had very little comments to make at the end of the interview the next interviewee simply said:

**TSCE1**: *"Not much really, but to thank you for this opportunity to be part of your research."*

The general findings from this chapter suggest that there are problems especially in the areas of; approvals, collaborations and government participation. Also the researcher observed that, even though the interviewees are no new comers to the profession, there seem to be hesitations in answering questions they are not too sure of the answers. However, it is possible to develop a framework for a design guide that has very high workable and acceptable potentials. Thus, based on the research participants' responses, the proposed sustainable design guide would provide the guide required as a tool for early design intervention for residential buildings in Nigeria.

### 5.7 CHAPTER SUMMARY AND CONCLUSION

This chapter presented analysis from the mixed methods research investigations. The section starts with the descriptive analysis of all variables from the questionnaire survey which had its themes derived from the underpinning reviews. Secondly, selected variables were statistically analysed to establish significant or insignificant relationships amongst the variables tested. The results obtained from the statistical analysis have a significant excellent research value due to the excellent Cronbach's

Alpha value of 0.96 (see Tables 4.13 and 4.13) achieved with the measurement scale. Thus, the data provided and the analysis achieved suggest have acceptable research value.

Thirdly, the face-to-face interviews inductive analysis provided the explanations and further insights on the views expressed by participants across the three climatic regions. Together this concurrent embedded strategy provided triangulation and the validation of findings.

The findings revealed the following summaries:

- There is a statistical significantly low level of understanding and information on climate change and buildings amongst the built environment professionals across the three climatic regions in Nigeria.
- The evidences and impacts of climate change are significantly different for the three regions except for temperature increase which is statistically insignificant across the three climatic regions.
- Statistically, a significant degree of associations exist between climate change impacts and their corresponding parameter variables.
- Results from selected variables between practice types and opinions expressed on the role of government on tackling climate change problem also revealed significant differences.
- Furthermore, limiting factors and the overall potentials of the proposed residential design guide framework were expressed.

In conclusion, the methodological framework from chapter three and analytical findings from this chapter provided the underpins for the rationale in developing the framework for the proposed design guide as an early design decision tool for achieving sustainable residential buildings in Nigeria. The next chapter (6) discusses the implications of findings from this chapter and the development of the proposed sustainable residential building design framework.

CHAPTER SIX

# 6.0 DISCUSSIONS ON IMPLICATIONS OF FINDINGS

## 6.1 Introduction

The main focus of this research is to investigate the potentials of a design guide and to develop a framework for a sustainable residential design guide in order to promote the design of sustainable buildings in Nigeria. This chapter is a corollary to chapters four and five. Chapter four discussed the methodological study and establishes the processes as a methodological framework. Chapter five presented the research data, analyses undertaken and findings were established.

In this chapter the implications for six major research findings are discussed in sections in order to avoid duplications, to provide clarity, and to maintain some level of sequential arguments. These sections are arranged in sequence that allows for easy flow of arguments as follows:

Knowledge and information (section 6.2)

i. Evidence and impacts of climate change in Nigeria (section 6.3)
ii. Design parameters (section 6.4)
iii. Professional collaborations (section 6.5)
iv. Potentials for a design guide in Nigeria (section 6.6)
v. Role of governance and policy implications (section 6.7)

Following the discussions on the implications of the research findings, there are three other sections which are included in this chapter as follows:

vi. Development of a conceptual framework (section 6.8)
vii. Attributes of the conceptual framework (section 6.9)
viii. The potentials of the proposed framework (section 6.10)
ix. General summary and conclusion (section 6.11)

## 6.2 KNOWLEDGE AND INFORMATION

Knowledge acquisition and relevant information are important to the decisions made during the design of buildings. Reports from IPCC (2007) and World Bank, (2009) noted that climate change information and knowledge are the key factors to understanding and tackling climate change problems. Other propositions from literature suggest a low level of information and knowledge amongst the built environment professionals in the West African region on climate change problems (Ademiluyi, 2010; Laryea, 2011; Onyekuru and Marchant, 2012). Leary et al. (2008); Thrabrew and Ries (2009) and Ford et al. (2013) noted that twin problems are the reason for the inability of the sub-Saharan region to tackle climate change problems.

Consequently therefore, this research investigation confirms the assertions above on the low level of knowledge and information in Nigeria. By implication this suggests that the built environment professionals are not likely to apply the most appropriate features for the production of sustainable buildings. Furthermore, this research's investigation revealed that a significant number (over 90%) of the participants are willing to improve their status in this regards.  Hence, this section addresses research questions (i) which is; what relationship exists between climate change, buildings and the built environment? and (iii) which is; what level of knowledge exists amongst design professionals and how do they reflect such knowledge in their design practices?

## 6.3 EVIDENCE AND IMPACTS OF CLIMATE CHANGE IN NIGERIA

Evidence and impacts of climate change in Nigeria is not debatable. Many studies have observed that evidences of climate change abound in Nigeria (Obioha, 2008; Odjubo, 2010, Ogbonna and Allu, 2011; NASPA-CCN, 2012). Other similar studies also acknowledged that the impacts of climate change have regional differences (Boko et al, 2007; Habitat, 2011, VijiyavenkataRaman et al, 2012). Furthermore, an earlier study by Liso, (2003) also noted that climate change impacts and the design of buildings are interrelated. Findings from the three climatic regions investigated in Nigeria have validated these acknowledgements the different evidences of climate change above, which are further discussed in the next paragraph.

Findings also identified some threatening impacts in one climatic region (such as erosion and flooding) are not the same in other climatic regions. These climate change impacts were further tested to ascertain the level of their inherent peculiarities resulting in the differences observed across the three regions. It therefore means that, no single design tool can be adopted for use across these regions. Further discussions on the implication of impacts on design are discussed in sections 6.4 and 6.8 below.

## 6.4 CLIMATIC DESIGN PARAMETERS

Eromobor and Das (2013) opined that the ability to identify design parameters aid the production and performance of sustainable buildings. Decisions for sustainable climatic design parameters are dependent on their locations, climatic peculiarities and the application of sustainable design features (Allu and Ebohon, 2014). As such, the specific design parameters for each climatic region were investigated and analysed (see 5.2.6), the results validate the earlier opinion of Eromobor and Das (2013). These parameters are considered as part of the major design decisions required for any early design strategy.

The variations observed on the choice of parameters reflect statistical significant association and these were revealed by the test analysis result presented in section 5.2.9. Therefore, only regions with the same type of climate change impact would consider the same sustainable design parameters for its residential building design guide. It is important to determine the specific parameters for each climatic region before the commencement of the design processes for residential buildings.

## 6.5 PROFESSIONAL COLLABORATION

Lack of collaborations and the divergent views on interests amongst the built environment professionals is noted to be the major impediment to achieving the sustainability of the built environment (Larson 2004; Shaw et al, 2007; Ebohon, Taki and Allu, 2013). Yet similar researchers opined that the effective way the sector can tackle the challenges of climate change is through the effective collaborations by these professionals (Schmidt et al, 2008; Sherman and Ford, 2013).

Other researchers have observed that the building sector professionals have the capacity to collaborate effectively and lead the sustainable agenda through its decisive actions (Sev, 2009, Janda, 2011; Akadiri et al, 2012). Furthermore, Sherman and Ford (2013) also observed that effective collaborations are achievable when participants' are: well knowledgeable, are interested in the subject and know that their views will be voiced. In other to ascertain these arguments, the views of the participants with regards challenges for effective collaborations were sought.

Findings suggest that participants may not be highly knowledgeable as discussed in section 6.2 but are interested in the subject and went further to suggest factors that would serve as impediments towards effective collaborations amongst the professions in the built environment sector (see section 5.3.4 to avoid duplications). The findings are quite similar to those in the theoretical findings and most especially with the assertion that the lack of coordination in the sector is largely due to professional differences (Ayers and Huq, 2009; Klein, 2007; Laukkonen et al, 2009).

Hence, the way forward is an ideological integration between the different professions focusing on the advancement of the built environment in ensuring sustainable practices, whilst considering suggestions like; fair professional representation and separation of politics from professional practices. Accordingly, these suggestions would help in addressing the impediments of lack of collaborations amongst professionals in order to promote sustainable design practices across the three climatic regions in Nigeria.

Furthermore, in order to provide effective coordination and collaborations amongst these professionals, the research advocates for government intervention as regards monitoring and evaluating machinery, institutionalized strategic structures and policies for climate change.

## 6.6 POTENTIALS FOR A DESIGN GUIDE IN NIGERIA

Research has shown that the lack of an early design strategy leads to unsustainable built environment (Loh et al, 2009; Allu et al, 2013). This is because the design stage of any building is the most crucial and about 20% of all decisions taken at this stage have a lasting influence of 80% on the design outcome (Bogenslatter, 2000; Bunz et al, 2006). Therefore, early sustainable decisions must not be compromised (Allu et al, 2013). However, it has been observed that it is also at the design stage that the design professionals become most uncertain, requiring the need for a design guide or design decision tools (Anthienitis, 2010; Marszal, 2011). This agrees with the focus of the research and address objective **f**.

Again, another study shows that design guides are widely accepted and used for the reasons of; design control, integrating mitigation and adaptation strategies, local variations, accommodating best methods and practices (Carmody et al, 2009). Bunz et al. (2006) and Laukkonen et al. (2009) further noted that; it is only when designers employ the use of a sustainable design guide that it becomes certain that sustainable features are drafted into a design. Laukkonen et al. (2009) further advocated that a guide as a design tool must be made simple.

Following the premises discussed above, the research investigations (see section 5.2.5 and 5.5.5) revealed that participants are willing to accept and use a residential design guide and reasons given was mainly to enhance their professional practices and for the promotion of sustainable practices.

However, the potential challenges presented in section 5.5.5 are; corruption, institutional delays, professional rivalry and accessibility to the proposed design guide. The researcher observed that the potential challenges were expressed not because there is an existing design guide in Nigeria but because the respondents are aware of the constraints in the country's National Building Code (NBC), see section1.3.

In order to ascertain the workability of a sustainable design guide for Nigeria and its implications, the researcher is able to infer that, the workability potentials are high from findings discussed in sections 2.7 and 2.8 which were further analysed in section 5.5.5.

These potentials include the following:

- Promotes global agenda for sustainability
- Allows for the mitigation and adaptation synergy
- Promotes and enhancement of sustainability of the built environment in general
- Production of sustainable buildings
- Promotes localised architecture
- Enhances building efficiencies (energy, waste, materials etc.)
- Enhances design decisions
- Cost effective decisions rather than cost affordability
- Addresses the quest for design tools for professionals
- Promotes regulations and standards for buildings
- Allows for collaborations amongst the built environment professionals
- Serves as a benchmark for local approval agencies or boards
- Provides a basis for specific comparative studies and adaptation with similar climate regions.

In their study, asdiscussed earlier, Carmody et al. (2009) concluded that, design guides are becoming more acceptable as design strategies for buildings to mitigate and adapt to the negative impacts of climate change.

Therefore, the purpose of providing a sustainable design guide includes the following:

- To make residential buildings mitigate and adapt to climatic changes
- To serve as standard for good practice and not as a standard in itself
- To serve as a back-up for policy formulation, monitoring and for evaluation purposes
- It is intended that the design guide would enhance flexibility, appropriateness of design and innovation that promotes sustainability of the Nigerian built environment.

It is also important and necessary to note that, although sustainable design guide for residential buildings in Nigeria is proposed, it is however, a framework that was developed by the research in order that each of these three climatic regions is able to adopt a specific guide for its own region. Secondly, a design guide cannot be fully functional without technical inputs from other professionals and a government policy to guide its operation. Details of the framework are discussed in section 6.8.

### 6.7 GOVERNANCE AND POLICY IMPLICATIONS

It has been suggested previously that, the activities of the Nigerian government on climate change related issues, have been lukewarm (Onyekuru and Marchant, 2012). BNRCC (2008); Ibem and Amole (2010); Sayne (2011) have also attested to the inability of the Nigeria government to tackle climate problems due to; weak institutional capacity, corruption, lack of foresight and political will amongst others. Findings (see section 5.2.8) from this research also confirmed the views expressed in the literature review.

The Chi-Square test analysis was carried out based on the practice types (see section 5.3.5) of the design professional in order to make a deduction as to whether the views expressed were based on practice or regional sentiments. The results from the test analysis suggested a significant weak relationship with the practice type and therefore not strong enough to ascribe their views to a particular practice type. Furthermore, results revealed that the government have the capacity to (re)strategize, institutionalize climate change initiatives and coordinate its activities through policies formulation.

Craft and Howlett (2012) described policy formulation as a combination of policy advice to decision makers, which contains components of government, local context and interactive elements for directing actions on administrative and technical purposes. This research agrees with Dantata (2011) who opined that it is necessary to direct these actions in order to achieve systematic adoption and effective implementation through a framework.

Thus, it is also important for the built environment professionals to collaborate with government in order to actualise a working structure for climate change action through policy formulation. The implication is therefore, to promote an interactive policy formulation through a framework. The interactive process that combines policy formulation and framework development is discussed in the next section.

## 6.8 CONCEPTUAL FRAMEWORK

### 6.8.1 Introduction

This section presents an overview of the conceptual framework for developing sustainable residential design guides for Nigeria. In order to produce a sustainable design guide for residential buildings, various inputs are required from all the different professions within the built environment (WBDG, 2012a). The professions suggested by WBDG (2012b) are: Architecture, Architectural Programming, Commissioning Authority, Quantity Survey and Engineering (Electrical,Fire, Plumbing, Structural, HVAC and Refrigerating). Others includes; Information Technologies, Interior Design, Landscape Architecture, Lighting Design and Planning (WBDG, 2012b). Thus, there is need for formulating a framework that would guide these professionals through the processes of producing a design guide for the three climatic regions in Nigeria. The following sections provide the details on the framework;

- Conceptual framework development (section 6.8.2)
- Attributes and uniqueness of the framework (section 6.8.3)
- Potentials for implementation (section 6.8.4)

### 6.8.2 Conceptual framework development

The conceptual framework was developed from the findings discussed in chapter five. A conceptual framework is derived from processes that are employed by the researcher to link or achieve the research goal or purpose (Nalzaro, 2012; Shields and Rangarjan 2013). In this research, such processes include; the underpinning literature, research questions, methodological framework and results of the data analysed. Adetunji et al. (2003), in their study on 'Trends in the Conceptualisation of Corporate Sustainability' concluded that, one of the key factors for slow progress on the application of sustainable concepts in the building and construction sectors is the lack of a concise framework. However, an earlier study by Parkins (2000) also argued that, in order to achieve a workable conceptual framework; the framework needs to address research questions and to be developed rather than to be taken from a blue print.

The summation to these arguments is to develop a framework based on processes that address the research questions. As such, this research noted the above arguments and as a result, the conceptual framework is developed from; methodological framework established in chapter four (sections 4.2, 4.3, 4.4 and 4.5) and findings from the analysis presented in chapter five. Hence, the development of the framework is discussed in the next paragraph.

The framework for this research is guided by Contextual Interaction Theory CIT as discussed in chapter two. Taking into consideration the advantages CIT offer especially with regards to the interactive nature of it operations. Other advantages include; ability to be adapted as an implementation tool, operational Consistency, potentials for future comparative studies, allows for applicable analyses, wide application and implementation opportunities, and easy to identify strengths and limitations (Owens and Brassers, 2013).

These advantages have made it suitable to be adopted for this research framework development. As such, the implication for this research is that the proposed design guide has an interactive function within the conceptual framework as shown in Figure 6.1. Thus, a framework that would promote the actualization and applicability of a sustainable guide for residential buildings in Nigeria was developed.

## 6.9 ATTRIBUTES AND UNIQUENESS OF THE FRAMEWORK

The conceptual framework has seven attributes (or structures), starting from its context identification to the application stage. Although these attributes are arranged sequentially through seven operational levels and the interactive nature of the framework also allows for multidirectional movements (interchangeable). The attributes include: the context, background, collaborations, assessment and decisions, selection of suitable parameters, awareness and education, policy actions, and output.

Details of each of the seven attributes are enumerated and the activities contained therein in the following sub-sections below.

### 6.9.1 Context

The context is mainly for identification purpose, particularly with reference to location, history and the identified climate types as discussed in chapter three.

### 6.9.2 Background

The background shows how the research was conducted and how the data were obtained. It also offers other researchers the opportunity to know the processes that led to the production of the framework. Thus, countries with similar scenario could either adopt the framework or modify it to suit their purpose following the same processes. However, for this stage is optional for those professionals who are adopting the framework for developing their regional design guides. Hence, it is shown in dotted lines.

### 6.9.3 Collaborations

All the design professionals come together to interact in order to harmonise the different professional requirement and to agree on minimum requirements. Professional collaboration would promote sectorial effective participation, usage of the joint project (design guide) and overall; the underpinning aim for promoting sustainable residential buildings for Nigeria, would be common to all the professions within the built environment. This resonates with the assertion made by WBDG (2012b) that any developmental project within the building sector that is based on result of integration of skills and ideas from collaborations are generally known to achieve holistic solutions.

### 6.9.4 Assessment and decisions

Given the existing differences on the impacts of climate change amongst the three climatic regions in Nigeria, it is necessary to assess regional peculiarities. As such, the assessment at this stage deals with identifying a specific climate region for which a design guide is to be produced. Decisions are taken by the professionals involved based on their assessment for each of the three climatic regions (HCR, TSC and TRC). These decisions determine what parameters are suitable and the minimum standard required in making residential buildings to mitigate and adapt to climate change for each region. This process leads to the formulation of regional sustainable design guides.

### 6.9.5 Awareness and education

Findings in chapter five, which validated the theoretical findings, suggested low level of knowledge and information as one of the problems associated with sustainable practices in Nigeria. Hence, the reason for integrating awareness and education as one of the operational level in the framework becomes relevant. The built environment design professionals, especially the participants who were engaged in the interactive assessment in the preceding section are encouraged to sensitise and raise the awareness of their members. Subsequently, each of the profession could further institute trainings and continuous development programmes for its members. Findings from this research also suggest that such trainings are possible through: awareness campaigns, workshops, documentaries films, colloquiums, and the addition of sustainable courses within the educational training of future professionals. Thus, this action would promote sustainable practices and capacity building within the built environment professions.

### 6.9.6 Policy actions

Adopting the use of a residential sustainable guide and its effective implementation and operation in Nigeria, would require a back-up policy to be developed by the government. This is because the policy would help to ensure; sustainable practice compliance, monitoring and evaluation. Furthermore, findings showed that 100% of the respondents believed that the government have the capacity to promote sustainable practices in Nigeria.

### 6.9.7 Output and implementation

The output is the production of a design guide produced from the processes of the framework and at this stage the application of the sustainable design commences for all three regions. It is also expected that copies of the design guide are made available to clients, professionals, and government agencies responsible for developments. Hence, it becomes necessary for professional teams (involved with the framework) to include strategies for periodic evaluation of such guide through feedback.

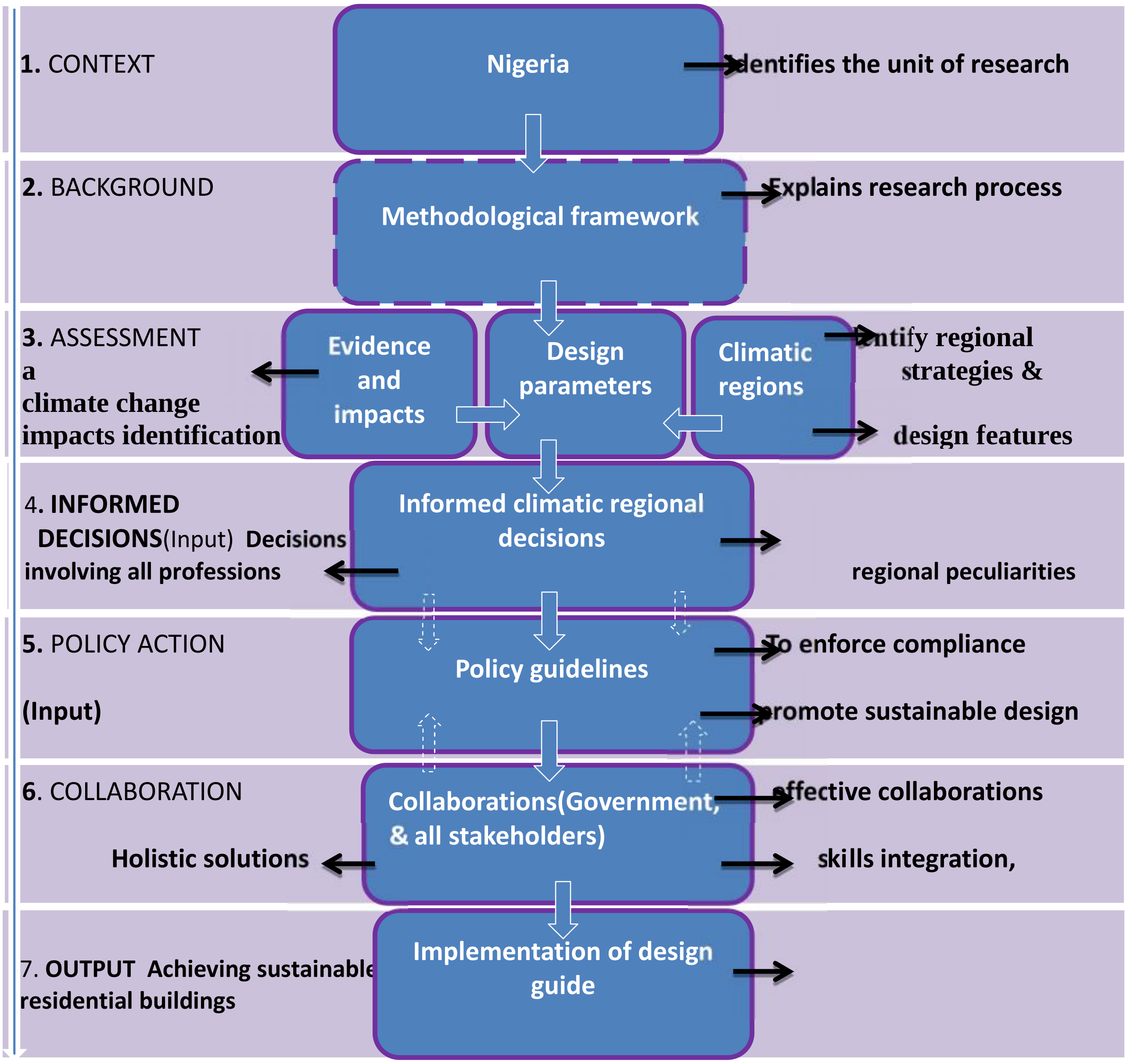



**Figure 6.1 Sustainable Residential Design Guides Framework**
Source: Researcher's design, 2014

### 6.9.8 Uniqueness of the framework

The uniqueness of the framework is that it is the outcome of this research findings and the contextual nature of decisions at the different operational levels makes it credible and thus, a novel contribution to knowledge. Consequently, other unique attributes of the framework are enumerated as follows:

- Developed from data generated from qualified professionals who were selected through purposive sampling and therefore, not from a probability results or elements of chance. Thus, a product of robust, reliable and validated results.
- The framework directs all the methodological processes and implementations.
- It can be easily adopted by other sectors and countries because the processes and operational levels are applicable.
- It is interactive and therefore allows for bridging of gaps between individual professional sustainable focus.
- Promotes best practices.
- Operational levels could be interchangeable.

The possible constrain the researcher is able to identified is that human errors are not unlikely.

## 6.10 POTENTIALS FOR FRAMEWORK IMPLEMENTATION

Every framework has its research purpose. The conceptual framework was designed to provide specific sustainable design guide for residential buildings in the three climate regions in Nigeria. The framework has the potential to provide the following key functions:

- To promote sustainable design practices (integrating mitigation and adaptation synergy)
- To serve as a design decision tool for building design professionals
- To promote conscious sustainable design decisions
- To promote interactive participation and collaboration amongst the built environment professionals

- To help professionals develop regional best practices and methods
- To ensure policy implementation
- To sensitize professionals towards sustainable professional development
- To promote efficiency in residential buildings and;
- To provide users a reference for feedback

**6.11 CHAPTER SUMMARY AND CONCLUSION**

This chapter has presented the major research findings and the overriding implications on the research in sections 6.2 to 6.8. The underpinning literature references were also highlighted in the course of the discussions. The discourse provided this research the premise on which the framework was developed. Also, the framework was necessitated because, the regional variations of climatic conditions, impacts of climate change and design parameters. As such, no single design guide would have provided specific design guide for the three climatic regions in Nigeria. Hence, a framework was developed, in order to serve as a decision tool and a means to achieving sustainable guide. In the next chapter a chronological summation of the entire thesis is presented leading to the research conclusions, recommendations and future studies.

## CHAPTER SEVEN

## 7.0 RESEARCH CONCLUSIONS, RECOMMENDATIONS AND FUTURE REASEARCH

### 7.1 INTRODUCTION

This chapter is the summation of the entire research thesis structured into sections. The main aim of this research is to develop a framework for its actualization in order to promote the design of sustainable buildings in Nigeria. The aim was supported with the following objectives:

a) To conduct a robust literature review and identify research gaps in the area of Climate Change and buildings.
b) To establish the extent to which residential buildings have been impacted by climate change in Nigeria and globally.
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.
d) To ascertain how the knowledge and information available to design professionals are reflected in their design practices.
e) To evaluate the perceptions of built environment professionals on the areas of; collaborations, the use of a design guide and the role of governance in the issues of climate change and sustainability of the built environment.

These objectives and the research processes were guarded by the research questions in order that the research remains within its focus. The research questions are as follows:

i. What relationship exists between climate change, buildings and the built environment?
ii. What evidence exists on the impacts of climate change on residential buildings in Nigeria?
iii. What level of knowledge exists amongst design professionals and how do they reflect such knowledge in their design practices?

iv. What design parameters are required for the residential buildings in the different climate regions or zones in Nigeria?

v. What are the prospects that the proposed sustainable residential design guide will result in sustainable building designs in Nigeria?

vi. What role has the Nigerian government played in the subject of climate change and buildings in Nigeria?

**7.2 SUMMARY OF CHAPTERS AND FINDINGS**

Chapter one presented an overview of the entire thesis and how the research intends to actualise its aim and objectives. In chapter one the background and the research problems were highlighted. This informed the direction of the literature review in chapters two and three (particularly in chapter two). Chapter two robustly discussed the global premise of climate change and buildings. Chapter three concerned itself with the context of research project- Nigeria as the unit of research. This was carried out in order to support the motivation and the reasons for the choice of Nigeria as the research context. These two chapters (2 and 3) provided the theoretical premise and the secondary data for the research undertaken. Hence, achieving the first two research objectives and addressing the first two research questions. The theoretical findings from the first three chapters include the followings:

- 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.
- There is very little research activities in the subject of climate and buildings in the sub-Saharan region of Africa.
- Sustainability has been acknowledged as a global strategy for tackling environment development due to the challenges of climate change.

- 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.
- Information, subject knowledge, location and stakeholders' collaboration have been identified as key to achieving sustainability in the built environment.
- There is no known data on the carbon emissions specifically from residential buildings in Nigeria.
- The twin strategies of mitigation and adaptation have huge potentials to reduce and minimise the impacts of climate change on buildings vice versa.
- 20% of design decisions has 80% influence on the entire design of buildings
- Design decision tools are limited globally and lacking in Nigeria.
- Divergence views and focus amongst the built environment professionals globally has slowed down the progress of achieving environmental sustainability.

Chapter four was built upon the construct from the two preceding chapters. The chapter begins with the methodological study, the underpinning of philosophical assumptions, the research processes and the adoption of the concurrent embedded strategy. Thus, the research methodological framework was developed. The framework provided the road map for the entire research project. Thus, chapter four serves as the engine room of the entire thesis as well as the pivot between the first three and the last three chapters of this thesis. It is also in this chapter that the validity and the reliability of the scale of measurement were established.

Chapter five presented the quantitative and qualitative data analysis and statistical tests. Findings from the analyses were interpreted and the research questions were addressed. This chapter clearly provided the structures for validation between the primary sources, the theoretical underpinnings and the sources of their references from chapters 1, 2 and 3. Findings from these chapter have:

- Established the research problem and thisresearch context
- Established the unit of analysis for this research project.

- That there exist a relationship (causal and effects) between climate change and buildings globally (objective 1 and research question 1)
- 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).
- 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).
- 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). These includes:
    - Time lapse; due to unnecessary institutional delays
    - Corrupt practices are found at the three tiers (Federal, state and local government) of governance
    - Weak or faulty institutional structures
    - Lack of information on the state of the proposed policy draft document on climate change and buildings
- 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:
    - Encourage effective collaborations amongst the built environment professionals by creating interactive fora.
    - Participants also suggested that environmental issues should not be politicised.
- 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).

The findings from this chapter addresses the objectives 3, 4 and 5 above and also answered the research questions 3, 4 and 5 as indicated in chapter five.

Chapter six discusses the implications for the research findings in six sections. The chapter also developed the conceptual framework for the proposed sustainable residential design guide (objective 6). The major underpinning construct that shaped the outcome of the framework and their chapters are itemised below as follows:

- Theoretical findings (chapters 2 and 3)
- Methodological framework and methods (chapter 4)
- Findings and their implications (chapter 5)
- The conceptual interactive theory CIT (chapter 6)

This present chapter is an overview of the thesis, consisting of the preceding two sections and the remaining sections. The next sections are discussed as follows: section 7.3 is the research recommendations, 7.4 contributions to knowledge, 7.5 research limitations and reflections on the study, 7.6 gives the overall conclusion of the research project. Section 7.7 suggests areas for future research.

**7.3 RECOMMENDATIONS**

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

- **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.
    - 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.
    - 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.

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

➢ **Recommendations for the built environment professionals**

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

### 7.4 RESEARCH OUTPUT

This thesis 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. Hence, the novelty in this research project. The research has contributed to the body of knowledge as follows:

- The framework: This would help facilitate design decisions tools.
- This research has added value to the body of knowledge and for Nigeria in particular with its data.
- Climatic design parameters for the HCR, TSC and TRC have been established.
- Findings would provide data and reference for future research and testing
- The study has helped raise awareness of climate change and buildings by various explanations given to participants during the field studies.
- 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.
- Research findings are relevant for academic purposes, public and private practices and for policy formulations.
- 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.
- The research instruments were developed mainly for the purpose of this research project.

## 7.5 LIMITATIONS

- The research context was limited to Nigeria and the subject of climate and building.
- Some participants who consented at the onset of the field survey could not be reached to retrieve their questionnaires. This was due to the 'Boko Haram' insurgents and the declaration of State of Emergency in three states of Adamawa, Borno and Yobe as was discussed in chapter four.
- Participants were selected through purposeful sampling based on the research methodological adoptions.
- The researcher has no way of knowing if the responses from the participants were the absolute truth.
- The PhD research programme duration would not allow for incorporating other areas this research project did not cover.
- Constrains of time and lack of financial resources did not afford the researcher the opportunity of travelling back to Nigeria to test the applicability of the framework. Furthermore, difficulty to assemble all representative of each profession within the built environment within a short period of time serve also as an impediment to testing the proposed framework.

## 7.6 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.

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.

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. Thus, the research aim is achieved with the formulation of a sustainable residential design framework. Also, all the research objectives and research questions were addressedas stated at different sections of this thesis.

**7.7 AREAS FOR FUTURE RESEARCH**

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

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

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**Zubairu, S. (2012)** The Importance of Evaluation and Sustainability in the Built Environment In: Laryea, S. Agyepong, S. Leiringer, R. and Hughes, W. (Eds)

Proceedings 4th West Africa Built Environment Research (WABER) Conference, 24-26 July 2012, Abuja, Nigeria, 9-13.

## APPENDIX 1: WORK PLAN

| No | Phase/duration | Task Description | Start date | Finish Date | Completion |
|---|---|---|---|---|---|
| 1 | Establishing background theory(6months) | Identifying field of interest | 0ct.2011 | Apr.2012 | YES |
| | | General literature review | Oct.2011 | Oct.2013 | ON-GOING |
| | | Registration | MAY 2012. | Jun 2012. | YES |
| 2 | Establishing research focus (6months) | Thesis proposal | JUL 2012. | NOV.2012. | YES |
| | | 1st year /Transfer Report | Dec-12 | MAR.2013 | YES |
| 3 | Design of Study (Field survey) | Evaluation and selection of methods | Jan.2013 | Feb 2013. | YES |
| | | Design of studies | Mar.2013 | Apr.2013. | YES |
| | | Validation of methods | Mar 2012. | Apr.2013. | YES |
| 4 | Data collection (6 Months) | Pilot Studies | May 2013. | May 2013. | YES |
| | | Field studies | Jun 2013. | Aug 2013. | YES |
| | | Publication based on Preliminary findings/ Second year report | Sept 2013 | Oct 2013. | YES |
| 5 | Data analysis (3 months) | Data collation | Oct.2013. | Oct-13 | YES |
| | | Data Analysis | Oct 2013. | Dec 2013. | YES |
| 6 | Writing up (6 months) | Publication based on results from analysis analysis | Jan 2014. | Jun 2014. | YES |
| 7 | Thesis submission | | Jun 2014. | Aug 2014. | YES |
| 8 | External Examination | viva | Aug 2014. | Sept2014. | AWAITING |

Source: Researcher's arrangement, 2011.

**APPENDIX2: INTERNATIONAL BUILDING GUIDELINES AND STANDARDS**

**Table 1.** International Building Sustainability Guidelines and Standards

| | North America | | Europe | | | Asia | | |
|---|---|---|---|---|---|---|---|---|
| Phase | United States | Canada | United Kingdom | Germany | Netherlands | Japan | Hong Kong | Korea |
| Programming phase | LEED ASHRAE GreenGuide | C-2000 IDP and CBIP GBTool | BREEAM | Guideline for sustainable building | | CASBEE | HK-BEAM | |
| Design phase | LEED ASHRAE GreenGuide | C-2000 IDP and CBIP GBTool | BREEAM | Guideline for sustainable building | GreenCalc | CASBEE | HK-BEAM | GBRS |
| Building construction | LEED ASHRAE GreenGuide | C-2000 IDP and CBIP GBTool | BREEAM | Guideline for sustainable building | | | HK-BEAM | GBRS |
| Building operation | LEED ASHRAE GreenGuide | C-2000 IDP and CBIP GBTool | BREEAM | Guideline for sustainable building | | CASBEE | HK-BEAM | GBRS |
| Building demolition | | C-2000 IDP and CBIP GBTool | | Guideline for sustainable building | | | | |

Note: LEED=USGBC (2002); GreenGuide=Grumman (2003); IDP=Larsson (2000); CBIP=Office of Energy Efficiency (2000); GBTool=Cole and Larsson (2002); BREEAM=BREEAM (2002, 2003); Guideline=Federal Office (2001); GreenCalc=Boon and Sunikka (2003), "GreenCalc" (2004); HK-BEAM=HK-BEAM Society (2003); and GBRS=*Green Building* (2004). See also Bobenhausen (1999), Dimson (1996), and Rousseau and Chen (2001).

Source: Bunz et al. (2006) page 35

**APPENDIX 3: LIST OF ASSESSMENT TOOLS**

List of weighted guidelines, assessment tools and rating systems used in the study conducted by Carmody et al. (2009) are:

| No. | Country | Name of tool |
|---|---|---|
| 1. | Japan | - CASBEE-Homes |
| 2. | Hong Kong | - HK-Beam |
| 3. | China | - GOBAS |
| 4. | Korea GBCS-MURB | |
| 5. | North America | - LEED for Neighborhood Development |
| 6. | North America | - LEED for Homes |
| 7. | North America | - Austin Energy Green Builder Program |
| 8. | North America | - Living Building Challenge |
| 9. | North America | - Minnesota Sustainable Building Guidelines (B3) |
| 10. | North America | - Green Communities |
| 11. | North America | - Green Globes (ANSI Standard 01-2008P) |
| 12. | North America | - Architecture 2030 |
| 13. | Canada | - SB Tool |
| 14. | Germany | - PassivHaus |
| 15. | United Kingdom | - Code for Sustainable Homes |
| 16. | Sweden | - EcoEffect |
| 17. | Australia | - NABERS-Homes |
| 18. | Australia | - NABERS-Office |
| 19. | South Africa | - SBAT Lite |

## APPENDIX 4: RESEARCH CONSENT FORM

Research Topic: Climate Change and Buildings in Nigeria: A Search for Mitigation and Adaptation strategies for Residential Design Guide.

I have read and understood the attached information sheet □

The aims and objectives of this research are clear to me □

I am aware that I can withdraw from participating in the survey □

I have consented for the use of information collected from me to be included in this thesis report □

Consent given by:

Name (optional): …………………………………………………………………………………….

Signature: ………………………………………………………………………………………………….

Date: ……………………………………………………………………………………………………….

Researcher:

Evelyn LamiAsheloAllu

P10559866

The Graduate School Office, John Whitehead.

De Montfort University,

The Gateway Leicester,

LE1 9BH England, United Kingdom.

E: evelyn.allu@myemail.dmu.ac.uk

## APPENDIX 5: COVER LETTER

Developing World Built Environment Research Unit
Leicester School of Architecture
De Montfort University
Leicester, LE1 9BH, United Kingdom.
evelyn.allu@myemail.dmu.ac.uk
May, 2013

Dear Research Participant,

**Research Information Sheet**

As part of my PhD studies at De Montfort University, I am required to undertake a research study titled:Climate Change and Buildings in Nigeria: A Search for Mitigation and Adaptation Residential Design Guidelines.

I am administering questionnaires surveys and conducting structured and semi structured interviews in line with my study to enable me gauge your perceptions and to understand your views on the subject area of my research.

The information being sought would form part of my university thesis, which would be read by academic staff at the university and an external examiner.

You may want to withdraw from the study two weeks after your participation (interview/ questionnaires surveys) without giving reasons.

I shall endeavour to keep all your information in confidence to avoid any form of recognition from my thesis. All data collected will be destroyed upon my completion and thesis submission to the university.

Thank you.

Evelyn LamiAsheloAllu
Student Number: P10559866.

**APPENDIX 6: QUESTIONNAIRE INSTRUMENT**

**PhD Research Instrument on:**

Climate Change and Buildings in Nigeria: A Search for Mitigation and Adaptation Strategies for Residential Design Guide

Homesteads perch precariously at gully's edge


**Evelyn Lami Ashelo Allu**
P10559866.

Developing World Built Environment Research Unit
Leicester School of Architecture
De Montfort University
Leicester, LE1 9BH, United Kingdom.
evelyn.allu@myemail.dmu.ac.uk and evelynallu28@yahoo.com


May, 2013.

**PHD RESEARCH QUESTIONNAIRE**

**(For architects only)**

**GENERAL INSTRUCTIONS**

Please answer all questions and follow the instructions relating to each question. All information given will be treated as strictly confidential and will only be used for the purposes of research. The questionnaire is used as a tool to generate information that would help in producing a sustainable design guide to designers for residential buildings in Nigeria.

The questionnaire would take about twenty minutes to complete and I shall collect same thereafter.

You may use my details on the cover page for further clarification if the need arises and thank you for your time.

**SECTION 1:** Please tick the appropriate box □

Climate type (Practice location)

i).Alpine climate or highland climate region (HCR) - Jos Plateau, Mambila Plateau and Obudu mountains□

ii). Tropical savannah climate or tropical wet and dry region (TSR) -North-Central, North-East and North-West □

iii). Tropical rainforest climate or the equatorial monsoon (TRC) - South-East, South-West and south-south regions□

**A: Basic information**

1. Gender? Female □ or Male □

2. Age group? 20s □30s □ 40s □ 50s□ 60+□

3. Level of education? Graduate □ Post graduate □

4. Practice? Academic □ Private □ Public □

5. Years of practice? 5-10 □ 11-15□ 16-20□ 21-25□ 26-30□ 30+ □

**B: Assessing Knowledge and opinion of participants on climate change and buildings**

Please tick appropriate box

| Please tick appropriate box in the table to rate your agreement to the following statements | (4) Strongly agreed | (3) Agreed | (2) Disagree | (1) Strongly disagree |
|---|---|---|---|---|
| 6.Iam well knowledgeable on the relationship between climate change and buildings | ☐ | ☐ | ☐ | ☐ |
| 7.There is adequate information on climate change and buildings in Nigeria | ☐ | ☐ | ☐ | ☐ |
| 8.I am interested in knowing more about climate change and residential buildings | ☐ | ☐ | ☐ | ☐ |

C: Evidence and impacts of climate change on residential buildings in the three climatic regions

| Please tick appropriate box in the table to rate your agreement to the following statements | (4) Strongly agreed | (3) Agreed | (2) Disagree | (1) Strongly disagree |
|---|---|---|---|---|
| 9.Erosion is the most threatening impact of climate change in my region | ☐ | ☐ | ☐ | ☐ |
| 10.Drought/desertification is the most threatening impact of climate change in my region | ☐ | ☐ | ☐ | ☐ |
| 11.Flooding is the most threatening impact of climate change in my region | ☐ | ☐ | ☐ | ☐ |
| 12.Windstorm is the most threatening impact of climate change in my region | ☐ | ☐ | ☐ | ☐ |
| 13.Temperature increase is the most threatening impact of climate change in my region | ☐ | ☐ | ☐ | ☐ |

D: Assessing the Perceptions of participants on the potentials of a sustainable design guide

| Please tick appropriate box in the table to rate your agreement to the following statements | (4) Strongly agreed | (3) Agreed | (2) Disagree | (1) Strongly disagree |
|---|---|---|---|---|
| 14.Sustainable design strategies has the potential to mitigate and adapt to the impacts of climate change on residential buildings | ☐ | ☐ | ☐ | ☐ |
| 15. Architects have an important role of providing climate sensitive buildings through good design practices | ☐ | ☐ | ☐ | ☐ |
| 16.I am interested in using a sustainable design guide in the future | ☐ | ☐ | ☐ | ☐ |

E: Evaluating the primary design parameters/considerations for residential buildings in the three climate regions in Nigeria

The main design considerations for residential buildings in my climatic region include the followings...

| Please tick appropriate box in the table to rate your agreement to the following statements | (4) Strongly agreed | (3) Agreed | (2) Disagree | (1) Strongly Disagree |
|---|---|---|---|---|
| 17.Building accessibility & adaptability | ☐ | ☐ | ☐ | ☐ |
| 18.Building form | ☐ | ☐ | ☐ | ☐ |
| 19.Building orientation | ☐ | ☐ | ☐ | ☐ |
| 20.Choice of building materials | ☐ | ☐ | ☐ | ☐ |
| 21.Climatic site analysis(Thermal insulation, Wind control) | ☐ | ☐ | ☐ | ☐ |
| 22.Energy efficiency | ☐ | ☐ | ☐ | ☐ |
| 23.External space layout | ☐ | ☐ | ☐ | ☐ |
| 24.Flooding strategies/control | ☐ | ☐ | ☐ | ☐ |
| 25.Internal space layout | ☐ | ☐ | ☐ | ☐ |
| 26.Pollution & Quality control(air & noise) | ☐ | ☐ | ☐ | ☐ |
| 27.Relationship with surrounding environment | ☐ | ☐ | ☐ | ☐ |
| 28. Sunlight control | ☐ | ☐ | ☐ | ☐ |
| 29.Specifications | ☐ | ☐ | ☐ | ☐ |
| 30.Water efficiency(usage & harvest) | ☐ | ☐ | ☐ | ☐ |
| 31. Waste control | ☐ | ☐ | ☐ | ☐ |

| F: Evaluating the perception of participants on the level of involvement for professional bodies |
|---|

| Please tick appropriate box in the table to rate your agreement to the following statements | (4) Strongly agreed | (3) Agreed | (2) Disagree | (1) Strongly Disagree |
|---|---|---|---|---|
| 32.Professional bodies can be involved in the awareness of its members on climate change problems | ☐ | ☐ | ☐ | ☐ |
| 33.Collaborations amongst the built environment professionals is needed to ensure sustainability of the built environment | ☐ | ☐ | ☐ | ☐ |

| G: Assessing perceptions of participants on Government involvement |
|---|

| Please tick appropriate box in the table to rate your agreement to the following statements | (4) Strongly agreed | (3) Agreed | (2) Disagree | (1) Strongly Disagree |
|---|---|---|---|---|
| 34.Government has been involved adequately in the awareness and sensitization of climate change problems | ☐ | ☐ | ☐ | ☐ |
| 35.Government has put in place policies and actions to stem climate change impacts on residential buildings | ☐ | ☐ | ☐ | ☐ |
| 36.Government has the capabilities to ensure compliance of building standards and implementation | ☐ | ☐ | ☐ | ☐ |
| 37.Government should enforce all housing providers to imbibe sustainable design choices for residential buildings | ☐ | ☐ | ☐ | ☐ |

38. Any other relevant comments..........................................................................
.......................................................................................................................
.......................................................................................................................

Thank you for your time.

**APPENDIX 7: INTERVIEW INSTRUMENT**

**RESEARCH INTERVIEW INSTRUMENT**

**Section A: Structured interview questionnaires for all built environment professionals**

**Basic information**

**Please tick appropriate box □ below**

1. Gender? Female □ Male □

2. Practice? Academic □ Private □ Government (Public) □

3. Profession? Architect □ Builder □Building contractors□ Civil Engineer □Housing Provider/Agency□

4. Years of practice? 5-10 □ 11-15□ 16-20□ 21-25□ 26-30 □ 30+ □

5. Practice area climate type?
i) Tropical rainforest climate or the equatorial monsoon□
(South-East, South-West and South-South)
ii) Tropical savannah climate or tropical or tropical wet and dry climate □
(North-Central, North-East, North- West)
iii) The alpine climate or highland climate or mountain climate□
(Jos-Plateau, Mambila Plateau and Obudu Mountains)

**Section B: Unstructured questions**

1. Research has shown that climate change and buildings are interrelated with each having an impact on the other. In the Sub-Saharan Africa buildings contribute a significant amount of carbon emissions causing climate change. On the other hand climate impacts have affected many buildings across Nigeria. Briefly comment on this information based on your observations and experience.

2. Similarly, research findings in the west and a few developing countries suggested that the integration at the design stage of buildings the synergy of mitigation and adaptation are achievable and enhances the climate resilience of buildings. In your opinion can this be applicable to Nigeria?

3. Do you think the built environment professionals have adequate knowledge and information on climate change and buildings?

4. What is your suggestion on ways to increase awareness and knowledge of climate change to the built environment professionals?

5. What in your opinion are the main impacts of climate change on residential buildings in your climate region?

6. What are the sustainable design criteria and or climatic parameters relevant to your climate type to be considered based on your experience?

7. Would a design guide for residential buildings in Nigeria be an effective tool for the production of sustainable buildings? Please explain with reasons.

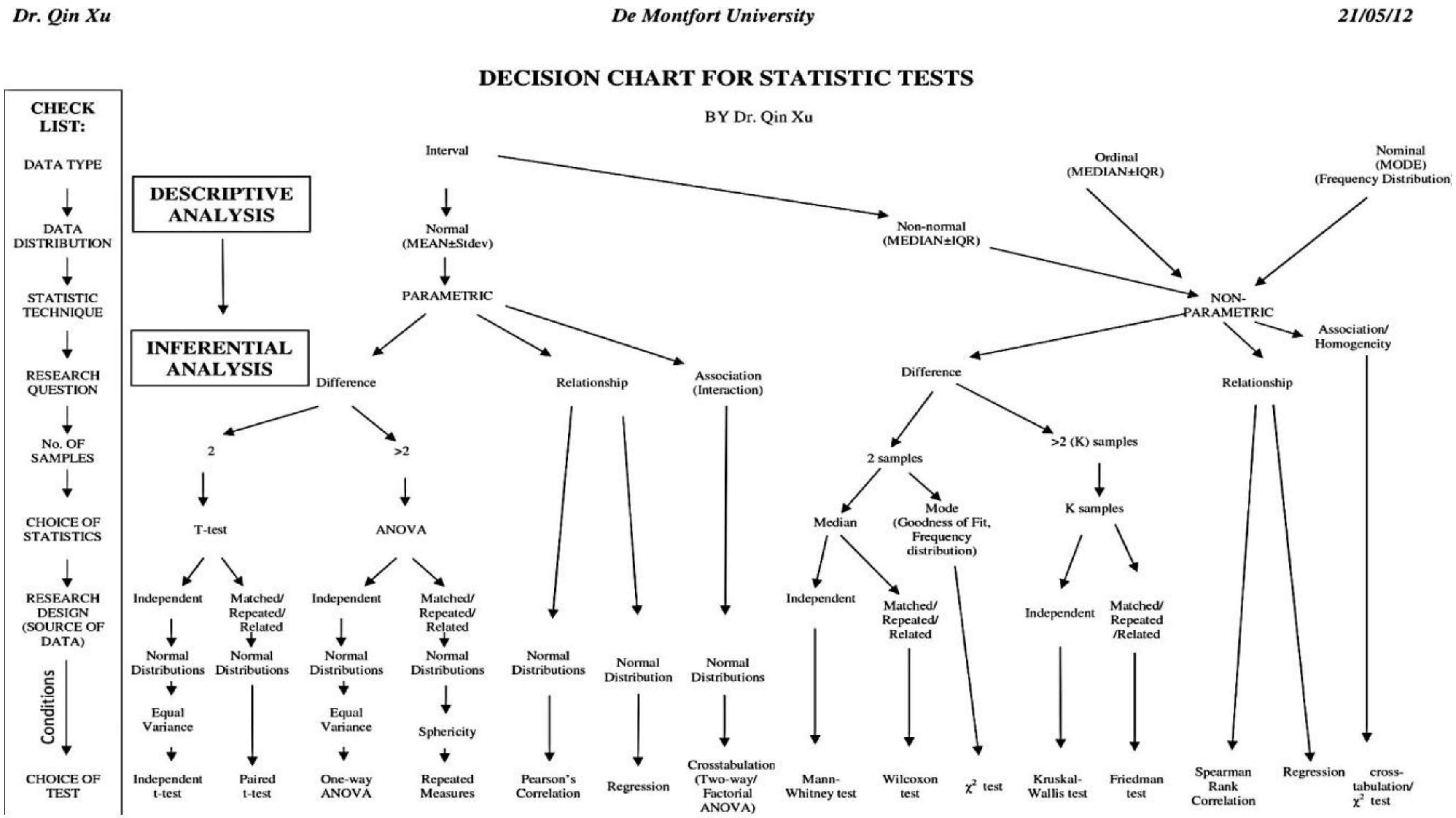
8. Do you think individual designers and professional bodies would adopt or use where available a design guide? What are the prospects and challenges?

9. What are your views about collaborations amongst built environment professionals in Nigeria?

10. Do you have any additional comments regarding this research focus?

Thank you for your time

## APPENDIX 8: DECISION CHART FOR STATISTICS




*One-sample tests are also available: e.g., comparing collected sample's mean or median with a known population or published studies. Single set of frequency distribution data can be analysed using $\chi^2$ homogeneity test.*

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(4) Copies of appropriate other ethical committee permissions (internal or external) or supporting documentation
(5) If appropriate: a list of proprietary drugs or commercial drugs to be used in the proposed investigation including formulation, dosage and route of administration and known adverse side effec
(6) A statement of your competence to carry out this research as a student or a brief one page curriculum vitae for each applicant, including recent publications (staff only)
(7) Other documentation as advised necessary:

There are normally four possible outcomes from reviewing the activity against the procedures in plac

1. no ethical issues
2. minor ethical issues which have been addressed and concerns resolved
3. major ethical issues which have been addressed and concerns resolved
4. ethical issues that have not been resolved/addressed

Provisional approval could be given at the discretion of the Research Ethics Committee.

*Authorisation is dependent on Faculty. Please refer to your faculty guidelines for details on how outcomes are reached:*

- The reviewer advises the PMB/SAB/REC of those activities in the first three outcomes.
- Activities in the fourth outcome are submitted to the Faculty REC for resolution
- The approved form must be kept with project documents, e.g. be included as an appendix in the report.

Signature of researcher / student Date 13/03/2013

Signature of supervisor Date 03/04/2013

Line Manager or Head of School signature (Staff only) Date 22/04/13

Jim Emmer

This form complies with the DMU policy statement on Human Research Ethics, a full copy of whicl can be found in the General Regulations and Procedures Affecting Students.

A separate form is required for each project.

## ADVANCE APPROVAL OF RESEARCH ACTIVITY INVOLVING HUMAN RESEARCH ETHICS

1 Respondents' co-operation in a research project is entirely voluntary at all stages. They must not be misled when being asked for co-operation.

2 Respondents' anonymity must be strictly preserved. If the Respondent on request from the Researcher has given permission for data to be passed on in a form which allows that Respondent to be identified personally:

(a) the Respondent must first have been told to whom the information would be supplied and th purpose for which it will be used, and also

**APPENDIX 10: LIST OF PEER REVIEWED PUBLICATION**

**1. LIST OF PEER REVIEWED CONFERENCE PAPERS**

Allu, E. L. A. Ebohon, O. J. and Taki, A. H. (2013) Architectural Design: Its Roles on Buildings for Sustainable Development. International Postgraduate Research Conference IPGRC, 8TH – 10TH April, Salford-UK, pp. 92-104

Ebohon, O. J. Taki, A. H. and Allu, E. L. A. (2013) Sustainable Agenda: Challenges of Mitigation and Adaptation in the Nigerian Built Environment. Proceeding of the Architects Registration Council of Nigeria ARCON 6TH Architects Colloquium, 22nd – 25th April, Abuja-Nigeria, pp. 150-173

Allu, E. L. A. and Ebohon, O. J. (2014) Climate Change and Buildings in Nigeria: Lessons from a Field Survey. Euro-American Conference, for Academic Disciplines Paris, 31ST March – 03RD April, Paris www.euroamericanconference2014.sched.org/

**2. PAPER SUBMITTED TO PEER REVIEWED JOURNAL**

Allu, E. L. A. and Ebohon, O. J. (2014) Climate Change and Buildings in Nigeria: Lessons from a Field Survey. International Journal of Arts and Sciences IJAS

University of
**Salford**
MANCHESTER

**SCHOOL OF THE
BUILT ENVIRONMENT**

# IPGRC 2013
# International Post Graduate Research Conference

8 - 10 April 2013

IPGRC conference pack final version.indd 1 13/03/2013 15:25

**APPENDIX 11: PEER REVIEWED CONFRENCE PAPER 1**

# Architectural Design: Its Roles on Buildings for Sustainable Development

E. L. A. Allu, O. J. Ebohon and A. H. Taki

*Leicester School of Architecture, De Montfort University Leicester, UK.*

evelynallu28@yahoo.com, p10559866@dmu.ac.uk

**Abstract**

Research has shown that climate change has affected and will continue to affect humans and natural systems globally as a result of anthropogenic activities on the natural environment. These activities within the built environment cause the emission of green house gases from buildings that in turn contribute to climate change. Furthermore, over 40% of these green house emissions are from buildings and therefore, there is an urgent need to reduce these green house emissions of which can be achieved through the use of sustainable architectural building designs. This paper presents the causal relationship between buildings and climate change and draws its analysis from various literatures which highlight the role of architectural design in a changing climate for a sustainable future. This paper concludes that architectural design is an early process strategy and a key factor in achieving resilience to buildings, friendly built environment and a means to sustainable development.

**Keywords**

Architectural Design, Buildings, Climate Change and Sustainable Development.

## Introduction

In view of the global challenges on the environment by climate change, the international agenda on sustainable development and the need for sustainable buildings spur the interest for this study. This paper examines the challenge of climate change within the built environment and highlights the international agenda on sustainability in relation to buildings. To do this, it argues for the use of sustainable design options that are environmentally friendly. Different literature is reviewed to have an in depth knowledge about the discussion and arguments that link climate change, buildings and the role of architectural design. The role of the built environment professionals and architecture is therefore critical, for the realisation of sustainable buildings. An earlier study has identified the Architect as a key player amongst other allied built environment professionals (Janda, 2010).

Furthermore, this paper presents an argument for the use of sustainable design strategies by architects as a tool that would enhance the attainment of sustainable development through the provision sustainable buildings. This position is in agreement with Halls & Rovers (2003) who argues that buildings are major players for sustainability in local and global communities. Finally, by highlighting the role of design in sustainable building development, the paper notes that designs strategies are available to the architect and suggest that research is the first step to sustainability in the built environment regarding buildings and climate change (Pyke et al, 2012).This sums up the motivation for this research review.

## Method and Methodology

This paper forms parts of an early stage of a PhD research and therefore a brief concise and well outlined survey of existing related literature, reports and other documentations are reviewed to argue for this conference paper. Subsequent publications would include information from field survey. The findings from this paper are drawn from reviews which validate design as a means for the architect to produce sustainable buildings. It is also an attempt to make a wakeup call on architects to deviate from traditional design practices to sustainable design considerations.

## Literature Review

### *Buildings and Climate Change*

Buildings are man-made structures built for human habitation and other uses. Buildings form a large part of the built environment and this paper does not refer to a particular building type, they however, constitute a major aspect of human activities in the built environment. Research has also identified buildings as key players with climate change (Steemers, 2003; Lofness, 2004; IPCC, 2007). Buildings, additionally play a major role in the development of every country and forms a central part of every human daily activity (Cam, 2012), they are also significant to both the climate and the environment as acknowledged by Lam et al (2005) 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'.*

Lam et al (2005), pp. 277.

Buildings account for about 30-50 percent of the world's carbon emissions and energy consumption depending on the country (Altomonte, 2008; Omer, 2008; UNEP, 2009; Robert and Kummert, 2011). This leaves no doubts as to the relationship of buildings to the environment, and their causality to climatic changes.

Buildings may not be directly related to climate change but are seen as a major human activity that contributes hugely to greenhouse gas emission to the atmosphere resulting to global warming and of which subsequently builds up into climate change (Levine, 2008; Larsen et al, 2011; Robert and Kummert, 2011; de Wilde and Coley, 2012).

Ebohon (1996) in his position reveals that the natural environment and the built environment are closely linked and further observed that about 75% of all known factors that contribute to environmental degradation are from the built environment. Ebohon's position further highlights the inevitability of taking sustainable actions. This position is echoed in the UN Habitat (2009) report that once again re-establish the relationship between buildings and the environment and the fact that buildings are vulnerable to the negative impacts of climate change.

Most studies show that a high potential for the reduction of carbon emission and cost-effective energy savings will rely on the design of new buildings (Roberts, 2008; Apay, 2011; Robert and Kummert, 2011). Other research has also shown that sustainable strategies are necessary and achievable through the design of new buildings (UNEP, 2009; Akadiri et al, 2012). Furthermore, the long lifespan of buildings and the long hours of human occupation in buildings make any design decisions made today go a long way in affecting the future (UNEP, 2009; Architects 2030, 2010; Wong, et al. 2010; Gething, 2011).

Climate Change has become a global environmental problem, which has continuously affects all human livelihoods that has also become a major challenge to sustainable development. In the field of architecture the challenge is mainly on how to employ strategies in the design of buildings that address the role of buildings in relation to climate change and the environment.

The anthropogenic activities of man are mainly the causality of climate change (IPCC, 2007; Wilby, 2007; Commission for Architecture and the Built Environment CABE, 2009; Berrang-Ford et al, 2011). The link between climate and buildings is therefore significant for growth and development. The interrelationship between buildings and climate change has also been emphasised (Parry et al, 2007; Simone, 2011; Pyke et al, 2012; William et al, 2012).

It is however, the ability of these buildings not to have a negative influence on the environment that makes sustainable options desirous and important (Sanders and Phillipson, 2003; Milne, 2004, Colker, 2006). The definition of climate change by IPCC relates the changes in climate change to both natural and anthropogenic influences as the quote below suggest,

> *'A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use'.*
>
> IIPC (2007b), pp. 557.

These forcings include variations in solar radiation, deviations in the Earth's orbit, changes in greenhouse gas concentrations as well as orogenesis (mountain-formation) and continental drifts. However, research in the built environment are particularly interested in climate change that is as a result of global warming arising from greenhouse (ghg) gas emissions increase due to antropegenic activites within the built environment (O'Brien et al, 2004; Adger et al, 2005).

However, the huge carbon emissions, especially from buildings have continually attracted concern by researchers on the continuality of the changing climate, which affects life and the built environment and the need for a critical assessment are emphasised (Keller, 2003; Trenberth, 2005; Fagre, 2007; VijiyaVenkataRaman et al, 2012). Evidently, earth's climate is changing, and the scientific consensus is that the change is increasing more rapidly than was earlier anticipated (Karl et al, 2009; NASA, 2011). This is the time to act even more seriously than before.

On the other hand, climate change has been observed to also have some direct effects on buildings and their performance, the magnitude of which are also dependants on the locations of such buildings (Camilleri et al, 2001; Adger; 2005; Crawley, 2007; Georgiadou et al, 2012).

Given the scenario on the role of buildings in the built environment and their interrelationship with climate change, professionals within the industry needed to be proactive. Furthermore, this propels the architect amongst other allied professionals in the built environment as the key player and the leadership to find architectural solutions (Janda, 2011).

This paper is particularly concern with the role of buildings which have be identified to be important to the environment and the consequently environmental sustainability. The curiousity would be to know if these buildings can be geared towards solving the increasing global environmental and developmental problems. Thus, the emergence of sustainable development.

***Sustainable development***

Sustainable development as a term came to limelight and made popular by the Brundtland Report (WCED, 1987), the report shaped the world approach toward development based on the three concepts of environmental growth, economic models and social well-being that are guided by choices that do not deprive the future generations. These guided principles are therefore, processes that serve as channels towards growth and sustainable development. The quotation below further clarifies how the concept three concepts are being pursued.

> *'Humanity has the ability to make development sustainable – to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs. The concept of sustainable development does imply limits – not absolute limits but limitations imposed by the present state of technology and social organisation on environmental resources and by the ability of the biosphere to absorb the effects of human activities'.*
>
> WCED (1987), pp.43)

This quotation directly relates to the practice of architecture, which design and produces building for now and the future due to the longevity associated with buildings. The three pillars of sustainable development are: environmental sustainability, economic sustainability and social sustainability, they also are interdependent and all encompassing as shown in Figure 1. Thus the products of any architectural design must be duly linked with all three pillars in order that sustainable development would be ensured in the built environment.

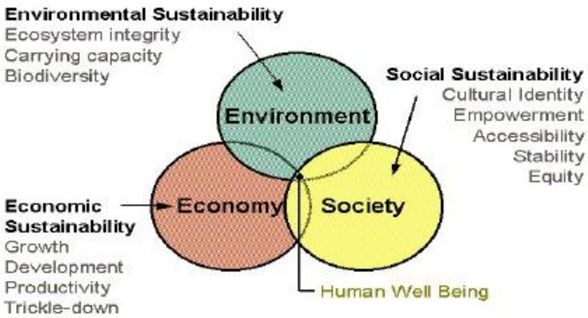


Figure1. Sustainable Development Source: http://www.arch.hku.hk/research (accessed 02/1/12).

In 1989 the United Nations initiated the 1992 Rio Janeiro conference to discuss the theme 'Environment and Development' leading to the 'Rio Declaration' that gave birth to the Agenda 21. Agenda 21 is the blue-print for sustainable development which had the endorsement of 179 Governments and Heads of States. By implication it aims at addressing globally; the promotion of environmental, economical and socially conscious sustainable developmental processed. In addition it requires all environmental stakeholders (architects etc) to play their roles in ensuring sustainable development to further promote the aims of the Agenda 21 (UN, 2009).
However, in the drive for sustainability there is the caution for cost implication. This caution was sounded shortly after the sustainable development came to limelight by Ozkan (1998) cited in Antoniou (1998) who expressed the notion that sustainability should not in any way add to cost but to serve as a way in which opportunities are improved upon. Thus improving the architectural practice at the design stage of buildings is by no means a venture that would necessarily add to the cost of buildings in the long run.

Sustainable development in the building sector requires considerations of climatic factors and future impacts of buildings to the environment (Colker, 2006; Hales et al, 2007; Lehman, 2010). Additionally, sustainable buildings are expected to have low or minimal negative impacts on the natural and built environments, the ecosystems, and to add quality values to human, aestetics,economic social caitals and diversities (Hadjri and Onyango, 2007; Burton, 2009; Wang et al, 2010).

***Sustainable architecture and design***

The interrelationship between buildings, the environment and climate has been highlighted, so also the need for a sustainable building through sustainable design in the earlier paragraphs of this paper. The continues demand for new buildings and infrastructures (Joseph and Abraham, 2010) present an overwhelming challenge to the architect's design approach, processes and choices; to reflect sustainable options, user comfort, cost and aesthetical value (Hui, 2004; Bunz et al, 2006; UNEP, 2009; Lehman, 2010).

Achieving sustainable living at an early stage in buildings is an attainable goal through architectural design processes that are holistic. An earlier study by Straube (2006) suggested that making buildings sustainable is practicable and achievable and a vital key for sustainable development. He also added that the key factors for a sustainable environment includes; awareness of the problems involved, design skills and specifications, construction and building operations. It is arguable to single out design because it is an initial intervention, getting it wrong means other factors would sway.

Architectural design deals with the science and art of bringing together elements to create a functional building or structure in line with a chosen approach in order to achieve the proposed brief within available limits. It is the choices to be made and the approaches to be explored by the architect as a building designer that forms the primary focus of this paper. These choices and strategies have significant implications; for the buildings in themselves and the built environment.

The architectural practice (especially design) reflects on the interrelationship between buildings and climate which in turn affects the environment in which the building is located (Lam et al, 2005). Basically, a sustainable design is a futuristic design that is conscious of environmental considerations for today and the future. Sustainable design is often use interchangeable with sustainable architecture. Sustainable architecture also referred to as 'green architecture' which is defined as;

> *'Green architecture, or green design, is an approach to building that minimizes harmful effects on human health and the environment. The "green" architect or designer attempts to safeguard air, water, and earth by choosing eco-friendly building materials and construction practices'.*
>
> Craven (2013), pp. 1.

Given the above definition, it is also easier to refer to sustainable or green design as deliberate conscious design that is environmental friendly. According to Craven (2013) the goal of a green design is to be sustainable in its decisions, choices and applications and went further to items the characteristics of a green architecture to include the following:

- Ventilation systems designed for efficient heating and cooling
- Energy-efficient lighting and appliances
- Water-saving plumbing fixtures
- Landscapes planned to maximize passive solar energy
- Minimal harm to the natural habitat
- Alternate power sources such as solar power or wind power
- Non-synthetic, non-toxic materials
- Locally-obtained woods and stone
- Responsibly-harvested woods
- Adaptive reuse of older buildings
- Use of recycled architectural salvage
- Efficient use of space

These characteristics suggest that due the challenges of a changing climate the role of design is no longer business as usual. The International Panel on Climate Change IPCC (2007) expressed concerned and suggests that buildings must be made to reduce drastically their energy consumption and be made to adapt to the impacts of climate change. This poses a challenge to the architecture professional (Marsh et al, 2010), who is faced with a critical challenge of producing designs that addresses energy performance of buildings in order to reduce carbon emissions from the increasing energy demand in buildings without a compromise to comfort, cost, flexibility of the building to adapt to changing climate, durability, aesthetics and increase the life span of the building (Petersen and Svendsen, 2010; Grierson, 2011). Making the architect to become more conscious during the design processes in creating buildings that would satisfy the overall goal of sustainability in providing a sustainable building that would lead to sustainable development in the long-run.

However, Gul and Mendes (2012) conducted a study titled, 'Designing Domestic Buildings for Future Summers: Attitudes and Opinions of Building Professionals'. Even though this study is targeted at domestic buildings it has bearings on the built environment and design, some of their result covers to a large extend all buildings. Their study employed the use of questionnaires, focus groups and semi-structured interviews on the built industry professionals and alarmingly their findings showed that traditional design practices; which adhere strictly to client's requirements, meeting minimum standards and regulations and cutting capital cost were still being maintained. Implying that the traditional design practices are being maintained, which excludes climatic and futuristic sustainable consideration even in the UK.

In their conclusion Gul and Mendes (2012) observed amongst many the quote below:

> *'Delivering buildings that provide the optimal balance between a high quality indoor environment and reduced carbon dioxide emissions is a challenge that is becoming increasingly important. The decisions we make today will determine how well buildings can deliver on those objectives over their design lifetimes'.*
>
> Gul and Mendes (2012), pp. 759.

This quote sums up the important role design plays in the life of a building. Other concluding remarks that have direct relevance to this paper are; to encourage design professionals in the building industry to use related available tools (like the UK climate projections UK09 and the Low Carbon Futures LCF) as a soft landing framework, choices by designers to include future energy and performance, designers to adopts favourable active and passive design strategies and to incorporate sustainable building practices in line with government initiatives for sustainable development.

### *Design criteria for environmental sustainability*

A recent study carried out by Conejos et al (2013) supports the use adaptive reuse tools in the design of new buildings in order to reduce carbon emissions and promote the built environment sustainability. Their study was carried out using a mixed method methodology through the use of literature review, case study analysis, expert interview and practitioner survey to collect data, triangulate and validate their findings.

Furthermore, Conejos et al (2013) assert the importance of knowing how new buildings are designed for future buildings adaptability and sustainability. They also generated some design criterions that were based on their current and previous study (see Conejos, 2011; Conejos, Langston and Smith 2011). The sustainable design concept/ guidelines formulated in terms of their category and criterion that includes the Tables 1a-1d (the table is split into three to conform to the conference regulation to have a table within the same page).

Table 1a: List of design criteria based on experts' (for Physical, Economic and Functional). Source: Conejos et al (2013), pp. 99. (adopted version).

| Category | Criterion |
|---|---|
| Long Life (Physical) | -Structural Integrity-structural design of the building to cater future uses and loads<br>- Material Durability-durability of the building asset<br>-Workmanship-quality of craftsmanship of structure and finishes<br>-Maintainability-building's capability to conserve operational resources<br>- Design Complexity-various geometries associated with the building's design and |

| | |
|---|---|
| | innovation<br>-Foundation-differential settlement and substrata movement |
| Location (Economic) | -Population Density-location within major city, CBD, etc<br>- Market Proximity-distance to major city, CBD, etc<br>- Transport Infrastructure-availability and access Site Access-proximity or link to access roads, parking and communal facilities<br>- Exposure-views, privacy Planning Constraints-site selection, planning, neighbourhood and building design, etc.<br>- Plot Size-built area, spatial proportions, enclosure, etc. |
| Loose Fit (Functional) | -Flexibility-space capability to change according to newly required needs, plug and play elements, etc.<br>-Disassembly-options for reuse, recycle, demountable systems, modularity, etc.<br>-Spatial flow-mobility, open plan, fluid and continuous<br>-Convertibility-divisibility, elasticity, multi functionality<br>Atria-open areas, interior gardens, etc<br>Structural Grid-ideal and economical limit of span and fully interchangeable<br>-Service Ducts and Corridors-vertical circulation, service elements, raised floors, etc. |

Table 1b gives a self explanatory of three categories; physical, economic and functional considerations and the sustainable design criteria for each and same application follows for Tables 1b and Table 1c respectively.

Table 1b: List of design criteria based on experts' (Technological, Social and Legal)
Source: Conejos et al (2013), pp. 100. (adopted version).

| **Category** | **Criterion** |
|---|---|
| Low Energy (Technological) | -Orientation-micro climate sitting, prevailing winds, sunlight,<br>Glazing-sunlight glare control and regulate internal temperatures,<br>-Insulation and Shading-thermal mass, sunshades, automated blinds, etc.<br>-Natural Lighting-inclusion for natural daylight, efficient lighting systems, etc.<br>-Natural Ventilation-optimise airflow, quality fresh air, increased ambient air intake, etc.<br>-Building Management Systems-monitor and control building operations and performance systems<br>-Solar Access-measures for summer and winter sun |
| Sense of Place (Social) | -Image/Identity-social and cultural attributes, values, etc.<br>-Aesthetics-architectural beauty, good appearance, proportion, etc<br>-Landscape/Townscape-visual coherence and organization of the built environment<br>-History/Authenticity-original fabric, timelessness, socio-cultural traditions, practices, historic character or fabric, etc. |

| | |
|---|---|
| | - Amenity-provides comfort and convenience facilities<br>-Human Scale-anthropometrics and fit to average human scale<br>Neighbourhood-local and social communities |
| Quality Standard (Legal) | • Standard of Finish-provision for high standard workmanship<br>• Fire Protection-provisions for fire safety<br>• Indoor Environmental Quality-provisions for non-hazardous materials, natural fabrics, etc.<br>• Occupational Health and Safety-special needs of occupants, health and safety risks, building hazard and risk management plan<br>• Security-provision of direct and passive surveillance designs Comfort-hygiene and clean environment, etc<br>• Disability Access-provision for disability easement, facilities, etc.<br>• Energy Rating-environmental performance measures<br>• Acoustics-noise control, sound insulation, etc. |

**Table 1c** List of design criteria based on experts' (Political) Source: Conejos et al (2013), pp. 100 (adopted version).

| Category | Criterion |
|---|---|
| Context (Political) | • Acoustics-noise control, sound insulation, etc. Context (Political) Adjacent Buildings-adjacent enclosures, vertical and visual obstacles<br>• Ecological Footprint-appropriate measure of human carrying capacity<br>• Conservation-principles, guidelines, charters governing tangible and intangible heritage protection<br>• Community Interest/participation-Stakeholder relationship and support<br>• Urban Master plan-integrated skyline, urban landscape, built environment design and management/practice<br>• Zoning-land uses and land patterns<br>• Ownership-collaborative commitment, sense of community or ownership, etc. |

**Conclusions and further research**

Literature were reviewed to investigate the relationship between climate change, buildings and sustainable development in the built environment and what roles architectural design play in the life of a building. As indicated by the study, there exist interrelationship between buildings, the built environment and climate change.

Buildings serve as interface between the indoor and the outdoor environments as well as a major contributor to carbon emission that causes climate change and of which in turn affects and have negative impact on buildings. Thus, both have complimenting roles but the potentials for the positive roles are to be pursued.

Studies have also shown that a high potential of reducing carbon emissions and enhancing climate sensitive buildings lies in the design of sustainable buildings, through incorporating sustainable conscious choices: passive design that allows for natural capacity and recognises sustainable concept of economics, environmental and social practices within communities. The role of architectural design is therefore, crucial and relevant in the improvement of the buildings themselves and their roles on the environment in ensuring a friendly environment that promotes and pursue sustainable developmental goals.

Sustainable design is the architectural design approach that architects explore to create sustainable buildings in meeting with the continuous need and demand for buildings and at the same time pursuing the global agenda of sustainable development. Architects must therefore, make sustainable design decisions for sustainable buildings that would not only reduce emission, provide comfort and friendly environment but to also promote sustainable development. Sustainable buildings are therefore necessary, vital, and important for local and global communities. This paper also serves as a wakeup call to architects to integrate these options in their building designs

The scope of this paper is limited to the early stages of a PhD research and basically a general approaches to findings are employed. Further study will engage empirical study to give specific data for specific communities in the quest for sustainable development that have become synonymous with local and global communal growth that do not compromise the future.

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6TH ARCHITECTS COLLOQUIUIM 2013

**Theme**: Sustainable Agenda (Agenda 21).

**Sustainable Agenda: Challenges of Mitigation and Adaptation in the Nigerian Built Environment.**

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**Abstract**

This paper acknowledges the connection between climate change, sustainable development and the main aim of Agenda 21 in the built environment. Climate change is evidently the most challenging phenomenon on the global environment. The built environment, particularly buildings emit about 40 percent of all known greenhouse gas carbons globally leading to climate change. Mitigation and adaptation have been the two separate traditional strategies for tackling climate change, but currently researches especially in the developed countries are now focusing on the linkages of mitigation and adaptation strategies which offer a high potential towards meeting the sustainable agenda in the built environment. Thus, a sustainable built environment is achievable through sustainable buildings. Nigeria's challenge is how its buildings can be made to mitigate their emissions and at the same time to adapt to the already changing climate. This paper reviews relevant literatures and presents; the synergies and the link between mitigation and adaptation, its applications and the potentials these strategies offer to the built environment as key to achieving the main aim of Agenda 21 in Nigeria. It also discusses the need for architects to shift from traditional design processes to sustainable passive design options and for their choices to reflect considerations for the future generations. The paper concludes that architects are key players for achieving the Sustainability Agenda in the built environment and the importance of collaborations with other stakeholders is also emphasised. Finally, the paper proposes the adoption of mitigation and adaptation synergies into the Nigerian efforts in advancing the Sustainable Agenda.

**Keywords: Adaptation, Buildings, Built environment, Mitigation, Nigeria, Sustainability Agenda.**

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## Introduction

The human activities of the building sector and property related services are the main causes of the environmental and climatic challenges being experienced. These human activities and the resultant challenges have generated a global concern and the need for sustainable solutions at local, national and global levels informed the emergence of Agenda 21. Agenda is the 21st century blueprint for actions to be taken on the impacts of human activities on the environment at the different levels, which has continuously become a subject of debate for practitioners and researcher (Fitzgerald, 2010; Ebohon 2011). Furthermore, the adverse impact on the physical environment by human activities has been termed climate change and the connection between climate change and sustainable development has also been acknowledged in literature (IIPC, 2001; Swart et al, 2003; Sathaye et al, 2006). Butt et al (2010) have again emphasised and further argued that the impacts of climate change are a continuous threat to the sustainable agenda and if no action is taken this would increase. Therefore, increasing risks, climate change vulnerabilities as well as serving as an impediment to achieving sustainable development.

Climate change is as a result of greenhouse gas emissions from buildings which constitute a large percentage of the built environment. Climate change poses a great challenge to the natural and built environment (Pyke et al, 2012). Also the built environment is notably the world's largest sector with huge economic vibrancy. Chan (2009) posit that in every country the construction industry underpins businesses, industries and their daily life. This lays the background to the important role the building sector plays and how crucial it has become to transform it into a sustainable compliant industry to ensure a sustainable built environment.

Traditionally, mitigation and adaptation have been identified as strategies and used separately to curb the menace of climate change (IIPC, 2007; Klein et al, 2007; Ayers and Huq, 2008), and still happening (Locatelli et al, 2011). This is now changing both in research and in practice, particularly in the area of building design. The synergies between mitigation and adaptation strategies have become the current focus for research and applications, particularly in the built environment sector (Klein, 2007).

There is the urgent need for developing countries such as Nigeria to take advantage of the synergies between mitigation and adaptation, as this constitute a holistic approach to climate change issues, and avoid the mistakes made earlier by many developed countries that pursued mitigation and adaptation measures independently of one another (Ayers and Huq, 2008). This has the potential of shortening the learning curve.

The global environmental challenges being experienced has also imposed higher standards, requirements, expectations and demands on built environment professionals to deliver services that have minimal impact on the environment. For the architecture profession, these services should begin at the design stage of the building where it is easier and more cost effective to design out most of the climate change challenges that have been identified.

Theoretically, the advantage of this is that once sustainability is designed into buildings at the design stage, it becomes difficult to ignore by other built environment professionals and end users throughout the lifecycle processes of such buildings. This is why the role of the architects is fundamental to any mitigation and adaptation measures to reverse and contain climate change impacts. Thus, architects do need to embrace the concept of sustainable development and begin to mainstream it into the design philosophy for implementation in practice. As Architects are usually at the helm of procurement, they have a pivotal role to play in leading and engaging with other allied built environment professions to fully embrace the concept of sustainable development (Krippenorff, 2006). Indeed, the multidisciplinary collaborations and perspective on designs is one of the linchpins of the concept of sustainable development, and it has been emphasised that this is the only way that the different challenges posed by climate change to the built environment can successfully be addressed (Coley and Lemon, 2006; Hebel, 2007; Ebohon, 2011; Ogbonna and Allu, 2011).

The structure of the rest of the paper starts with a critical review of the sustainability agenda, built environment and climate change, Nigeria's peculiarities, highlights and relates the paper's subject area to sustainable development, definitions and strategies of mitigation and adaptation in the built environment are presented. Studies on the applications of both synergies are also reviewed to draw out the potentials to achieve sustainable development in the built environment in Nigeria.

**Sustainability Agenda**

In 1989 the United Nations initiated the 1992 Rio Janeiro conference to discuss the theme 'Environment and Development' leading to the 'Rio Declaration' that gave birth to the Agenda 21. Agenda 21 is the blue-print for sustainable development which had the endorsement of 179 Governments and Heads of States. An adoption from Ebohon (2011) suggested four main operational themes that guide the Agenda enumerated below as:

- **Social and economic dimensions**; in developing countries, poverty, consumption patterns, population, health, human settlements and the integration of environment and development.
- **Conservation and management of resources;** atmosphere, land, forests, desserts, chemical, hazardous radioactive solid wastes and sewages.
- **Strengthening the role of major groups;** women, children and youth, indigenous people, non-governmental organizations, local authorities, workers, business, industries, farmers and technologists.
- **Means of implication;** finance, technology transfer, science, education, capacity building, international institutions, legal measures and information.

The first themes relate to the relationship between man, and the integration of the environment and developmental growth which is the primarily the concern for architecture. The other themes are focused to address globally the processes that promote and preserve the environment, sustainable economic development, and social security and justice. This makes the building sector of particular relevance to meeting the focus of the Sustainable Agenda; being a vital contributor to the social and economic development by providing housing and infrastructure, as well being a huge consumer of non-renewable resources, a substantial source of waste, a polluter of air and water, and an important contributor to land degradation (Wallbaum and Buerkin, 2003). Furthermore, it is expected that all environmental stakeholders (architects etc) to play their roles in ensuring sustainable development to further promote the aims of the Agenda 21 (UN, 2009). The built environment stakeholders should be actively engaged in the integration of the environment and development, in processes to conserve and manage its use of resources, strengthens the roles of its professionals (especially the architects) for sustainable actions and implement sustainable applications as a means to promoting the Sustainable Agenda and undoubtedly the synergies of mitigation and adaption offers a huge potentials in this regard.

**The Built Environment, Climate Change and Sustainable Agenda**

> *"The built environment is made up of existing and newly constructed buildings including the man-made surroundings such as green and blue spaces. Climate Change will have an impact on the design, construction, management and use of these buildings and surroundings".*
>
> Scotland's Climate Change Adaptation Framework (2011) p. 1

From the introduction of this paper, we are able to highlight the relationship between buildings and climate change and noted that buildings constitute a significant part of the built environment. Additionally the above quote is assertive to the fact that buildings play a vital role in the sustainability of the built environment.

According to Akadiri et al (2012) a sustainable building approach enhances the way forward for the building industry to achieve sustainable development which does not compromise environmental protection (less wastage and increasing reuse and recycle of building materials). Although a sustainable built environment is desirous to achieve the aim of the Sustainable Agenda as well as one of the goals of the Millennium Development Goals (MDGs), a sustainable built environment must therefore emerge from buildings that are designed to mitigate and adapt to the already changing climate. However, Yohe et al (2007) has noted that climate change is an impediment to achieving sustainable development. This assertion expresses the growing concern on the relationship between climate change and sustainability of the built environment with attention being focused on the construction industry.

On the other hand, within the construction industry emphasis are on the strategy for new buildings to have long-term drive solutions (Schiller, 2007). This is particularly so because buildings contribute a substantial percentage of greenhouse gas (ghg) emissions compared to other sectors. Globally, the building sector contributes more than 40 percent global emissions and 50 percent of energy consumption (UNEP, 2009; Hepbasli, 2012).

**The Nigerian Peculiarities**

An overview

Nigeria lays about 3.0 meters above sea level, with land mass area occupies about 14 per cent of West Africa total land mass, has a total coastline length of 850km, with the Atlantic Ocean forming the southern boundary and the country lies between 4°N and 14°N and between 3°E and 15°E. It is bordered on the north, east, and west by Niger, the Cameroon, and Benin Republic respectively as clearly shown in figure 1. Nigeria's spans widely in its latitude and longitudinal location which is likely the explanation for the different climatic zones and the impact degree of climatic changes and vulnerabilities. Plates 1-3 show the impacts of climate change in the Nigerian built environment from different climatic/geo-political zones in Nigeria.


Figure 1 Map of Nigeria showing location latitudes and longitude
Source: http://www.infoplease.com/atlas/country/nigeria.html
(Accessed 2/3/2012).

Nigeria is a sub-Saharan African country whose population keeps growing from 68.7 million in 2004 to about 154 million people in 2011 with current figures at 167 million and covers a vast land area of 923, 768 km2 (Federal Department of Agriculture (FDA) 2008; UNDP, 2010; National Population Commission, 2012; Pat-Mbano and Alaka, 2012). The sub-Saharan region is said to have become poorer in the last generation, making it difficult to cope with the challenges of climate variability already being experienced due to its poverty level (Washington et al. 2003). In addition to these problems Nigeria's housing deficit is about 10 million (Ademiluyi, 2010). Although there is no certified data for Nigeria, the sub-Saharan

Africa residential buildings consumes 96 per cent of the total in the building sector (Earth Trends, 2005). Therefore, much more emissions are on the way if sustainable actions are ignored. An earlier study by Holmes (2003) asserts that poverty and environmental challenges go hand-in-hand and further argued that a twin strategy of mitigation and adaptation are required for any developing countries like Nigeria to succeed.

Plate 1 Coastal submerged communities in Western Nigeria.
Source: www.vanguardngr.com (Accessed 06/02/2013).


Plate 2 Gully erosion affecting houses and roads in Eastern Nigeria.
Source: www.google.co.uk.images (Accessed 05/12/12).

Plate 3 - Desertification leaving house bare of vegetation North Eastern Nigeria.
Source: www.google.co.uk.images (Accessed 05/12/12).

Figure 2 shows the raising trend of C02 emission from the developing countries and these emissions are mainly from buildings, making Nigeria a probable major emitter in the near future if the design of the expected new housing are left unchecked at the early design stage, more so that the building sector offers a high potential to avert the likely situation of greater emissions as well as promoting the actualisation of sustainable development.

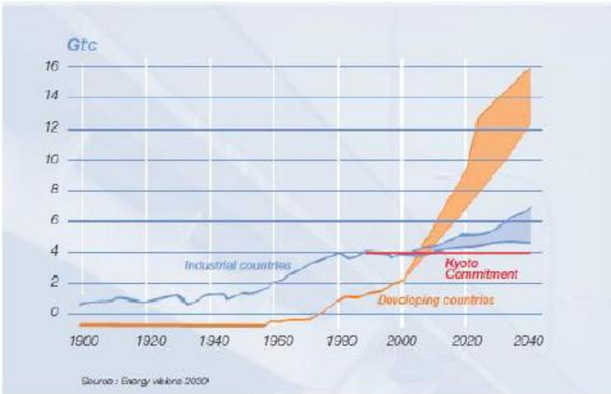


Figure 2 Emissions Trends in the Developed and Developing Countries (1900- 2040)
Source: adopted from UNEP, (2007) pp.2

**Mitigation and Adaptation**

Mitigation is defined by IPCC (2001) as an anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse, and some of its important measures includes carbon sequestration, clean development mechanism, joint implementation and use of reusable and non-polluting sources of energy such as solar, wind and geothermal sources (VijiyaVenkataRaman et al. 2012). Adaptation on the other hand refers to the necessary adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects (IPCC, 2001). Historically, mitigation and adaptation strategies were considered without exploring the potentials links between them (Jones et al, 2007; Ayers and Huq 2009). However, adaptation has only recently been topical and relevant owing to continuous increase in climate change incidences and impacts (Swart and Raes, 2007; Ericksen et al. 2011), requiring the pursuit of mitigation and adaptation measures as a common strategy (Laukkonen et al. 2009).

**Mitigation in the building sector**

The importance and relevance of mitigation in the built environment sector is succinctly captured by Cam (2012) when he argued that *"in the building sector, approaches to climate change mitigation must be in harmony with the wider sustainable development context"*. In other words, harmonising mitigation and sustainability is not optional but why this may be the case, Cam (2012) noted some limitations to mitigation, as a standalone strategy, when it comes to the building sector in particular and more so to the built environment sector in developing countries, as identified below:

- Lack of awareness and access to technical knowledge
- Segmentation and fragmentation of the building sector
- Perceived financial disincentive
- Consumerism aspiration and rebound effect.

These problems are more pronounced in developing countries such as Nigeria where limited and accurate data availability is a major problem (Ademiluyi, 2010), and also the increasing compartmentalisation of the built environment into different professions can make collaboration, especially at the design stage of building relatively difficult (Klein, 2007; Laukkonen et al, 2009). However, in some architectural practices in the developed countries there is implementing information technology software that allows different built environment professions to work on a project from remote locations. This is further compounded by the seemingly lack of trust between and amongst the professions. Also, the difficulty of adapting acquired foreign tastes and preferences to local conditions in general (Ekeng and Ewah, 2010), which also apply to building design, as most clients fight against adaptation to local climatic conditions in Nigeria, despite the obvious benefits constitute a major barrier to mitigation as a standalone measure. Similarly, lack of access to finance and technology also renders mitigation measures difficult to implement particularly in the developing countries as a standalone policy.

This can be overcome with conferences such as this to raise awareness, research and documentation of data from findings and using statistical data to argue for policies that promote sustainability which in itself is a worthy long-term investment. Local technologies and case studies must be show cased and celebrated to raise awareness.

### Adaptation in the building sector

The importance of adaptation has been summed up in the quote below;

> "Adaptation to climate change needs to be seen as an integral part of a country's development planning, rather than a separate issue".
>
> Chambwera and Stage, 2010, pp.4

In other words, adaptation and development policies must be seen as one for climate change impacts to be effectively managed and for growth and development to continue. When this concept is applied to buildings, it requires that adaptation measures should be woven into the design process for the simply reasons that once the building is built, limited opportunities exist to adapt the building to local climatic environment (Pyke et al, 2012).

It is therefore necessary to know areas where mitigation and adaptation strategies are relevant for implementation in the design of buildings. These have been summarised and presented in Table 1.

Table 1 Attributes Relevance and Suitability of Mitigation and Adaptation Synergies

| **Attributes, relevance and suitability** | **Mitigation** | **Adaptation** |
|---|---|---|
| Aim | Aimed at reducing and controlling ghg in the atmosphere | Aimed at reducing vulnerability |
| Benefit level | Local action with global long-run effect | Local planning action with local effect on micro climate |
| Cost effectiveness | short-term (Immediate) | Long-term |
| Focus and Design considerations | Reduce emissions from buildings, reduce energy consumption and increases efficiency | Both proactive and anticipatory climatic considerations and actions are incorporated in to improve resilient to uncertainties |
| Operational Stages | Mainly at design stage | Both at design and post design stages |
| Collaboration/outlook | Allows for global collaborations between designers, researchers and climate experts globally | Allows for locally focused collaborations research and applications of synergies |
| Effective portfolio | Mitigation policy instruments and design tools and standards for effective mitigation actions | Adaptation policy instruments and design tools and standards are required to further reduce risk |
| Research and Development | Encourages continuous research along the paths of sustainable development actions | Encourages continuous research towards enhancing sustainable planning for growth and development |

Sources: Adopted from similar studies from Klein, 2007 and Wreford, 2012.

The summation of Table shows that both mitigation and adaptation have the same targets; to reduce the impacts of climate change on humans and the environment. However, it has been noted that the inter-linked between mitigation and adaptation are not yet fully explored for better quality short-term and long-run strategies (Smith and Olesen 2011). Therefore, further research is on-going.

**Synergies of Mitigation and adaptation**

The synergies of mitigation and adaption are necessary to promote sustainable development in the built environment. In an earlier study Bicikova et al (2007) argued that developments should focus on the integration of mitigation and adaptation especially in coping with climate change and developing local capacity for realistic implementation pathways. Again their argument was re-echoed at a later study as quoted below;

> *"...the separation treatment of mitigation and adaptation in both science and policy has hindered progress against the fundamental sustainable development challenges of climate change."*
>
> (Ayers and Huq, 2009, p.754)

Ayers and Huq (2009) also asserts that developing countries are more prone to the challenges of climate change and are yet at the stage of mitigating climate change problems. The strategies that link mitigation and adaptation are currently in the domain of developed countries (Manoj, 2009; Biesbroek et al, 2010). However, Article4.1 (a) of the United Nations Framework Convention on Climate Change (UNFCCC) supports the integration of mitigation and adaptation by all counties (UNFCCC, 2009). While synergies are being developed in western countries adaptation and mitigation, either as standalone or synergised measures are still to permeate building design and construction processes in the developing countries (Biesbroek et al, 2010). This an apparent mistake that the built environment in Nigeria cannot afford to continue to make.

**Application of Mitigation and Adaptation Synergies in the Built Environment**

- Green roof and garden design: reduces; flooding, run-offs, reduces strain on drainages, increased biodiversities in urban areas and also serve as part of landscape See plate 4 (A and B).
- Tree planting in cities: reduces urban heat island and mitigates by sinking carbon and provides natural cooling for internal of buildings, improves environmental pollution and beautify surrounding. See Plate 5.
- Coastal realignment and Open storm-water system: likely flood prune areas to be designed as open-plan spaces which helps to adapts warmer climate and reduce flooding. (Tax breaks for practitioners could encourage more participation). Plate 6
- Use of local and low water plant for landscaping and shading (mitigates to rising temperature and adapts the impacts)

- Use of locally sourced materials: 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 on the emissions from transportation. (Specifications).
- Passive sustainable design and construction: solar gain orientation, solar energy panels which allows for shading. See Plate 7.
- Urban density: brings all services within easy reach of the urban population thereby obviating the needs for long distance travels and neighbourhood schemes encourage community participation in sustainable activities; gardening, walking to shops and garden and thereby reducing urban carbon sources. See Plate 8
- Reuse and recycle materials: as much as possible materials from demolished should be use in future development; garden furniture (kerbs, slabs, seats). See Plate 9.

Source: adopted from Landscape Institute, 2008; Laukkonen et al, 2009; Bell et al, 2012.

These exemplified applications of synergies are all achievable application within the built environment in the developing countries, however challenges were noted by Klein (2007) to include; political leanings, both professional and public perceptions and behaviours, beliefs and values at all levels of implementations. These challenges can be easily identified with Nigeria where experiences have shown that; politics, ethnic and religious beliefs, perceptions and individual and group values slow down processes that lead to developmental strides and growth.


Plate 4A Roof Garden Source: www.shutterstock.com (Accessed 03/02/2013)

Plate 4B Roof Garden in Sheffied, UK.
Source: www.shutterstock.com (Accessed 03/02/2013)

Plate 5 Tree planting in cities (Munich)
Source: www.landscapeinstitute.org (Accessed 03/02/2013).

PLATE 6 Coastal realignment Sutcliff Park, UK.
Source: www.landscapeinstitute.org (Accessed 03/02/2013).



Plate 7 Roof garden and solar panel shading in Poland.
Source: www.shutterstock.com (Accessed 03/02/2013)

Plate 8 Urban Density: sustainable compact design approach (Munich).
Source: www.landscapeinstitute.org (Accessed 03/02/2013).

Plate 9 Use of reuse and re-cycle materials in neighbourhoods (Manchester).
Source: www.landscapeinstitute.org (Accessed 03/02/2013).

These examples, apart from exhibiting the environmental impact but also demonstrates the need for collaborations between; designers, landscape architects, climate scientists, builders, structural engineers and researchers.

The application of mitigation and adaptation synergies is still at an early stage there are However, a number of limitations have been identified to include the following:

- Lack of coordination in supporting the synergies due to fragmentation of the building process and sector.
- Institutional complexes arising from both different operational level and actors
- The dense-built environment (which reduces the use of cooling aid and flooding)
- The uncertainty of climatic changes

Adopted from (Klein, 2007; Ayers and Huq 2009; Laukkonen et al, 2009).

Although addressing these limitations are beyond the scope of this presentation, it would encourage further studies amongst built environment professionals, particularly architects in Nigerian to be proactive and engage in collaborative efforts to ensure the delivery of sustainable buildings in particular, and the built environment in general. Indeed Shaw et al (2007) have argued that incorporating both synergies of mitigation and adaptation are necessary owing to the enormous advantages conferred on other wider goals of development.

On the other hand the advantages of mitigation and adaptation synergies include:

- Alleviation of poverty especially in developing countries and achieving the Millennium Development Goals (MDGs) that promotes sustainability.
- Allows for complimentary strategies and overlaps
- Makes sustainable development easier to be achieved
- It is "crucial" for the built environment due to long life span associated with infrastructures
- Promotes group work, participation and collaborations

Adopted from (Klein, 2007; Ayers and Huq 2009; Laukkonen et al, 2009; Bell et al, 2012).

Effective exploitation of the synergy between adaptation and mitigation offers huge opportunity for the Nigerian built environment to become sustainable, as the synergy between mitigation and adaptation, if successfully exploited facilitates:

- **Smart planning:** this is particularly synonymous with proactive adaptation which promotes sustainable climate resilient buildings.
- **Enhances conscious effort**: Usually at the design stage and are shown on the aesthetics buildings produced and landscape designed due to considerations for the natural environment.
- **Added value**: high valued and quality built environment
- **Cost effective**: high potential cost benefit over time (against the seemly initial high cost)
- **Governance**: Allows for intuitive appeal of conducting Climate Change policies

- **Multiple operational levels**: Allows for simultaneous actions at all levels (individual, local, national and international). The ability to think local and act global.

- **Near win-win targets**: combining adaptation and mitigation policies facilitate a better co-ordinated approach to the climate change impacts on the built environment sector because of the overlap functions associated with the pillars of sustainability (economical, environmental and social considerations).

- **Collaborations**: coming together by mitigation and adaptation experts allows inter-disciplinary perspectives on climate change impacts on the built environment, leading to enriched solutions and policies.

These would not only advance and promote sustainable development but also boost poverty alleviation through the provision of new jobs. Ayers and Huq (2009) study conducted in Bangladesh suggests that integration and adaptation can be implemented simultaneously, conferring huge benefits, and the knowledge of this bodes well for other hot climates like Nigeria who are striving to promote sustainable built environment.

Finally, this paper advocates the need for integrating mitigation and adaptation policies or measures in dealing with climate change owing to the huge benefits in avoiding conflicting policies and duplication of efforts, resulting in huge savings with regards to money, time and efforts.

**Summary, conclusions and recommendations**

The challenges of a changing climate, population growth, and the demand for sustainable built environment will necessitate significant changes to the approach designers need to take to construct and deliver the urban form of the 21$^{st}$ century. This is best achieved by harnessing the synergies between adaptation and mitigation measures for combating climate change. Evidence abound how such a strategy will benefit a country such as Nigeria, particularly given the extreme manifestations of climate change that it is being witnessed recently.

More research into localised mitigation and adaptation synergies are on-going globally. Nigeria has the potential and human resource to develop its capacity further to identify these synergies for itself and address the challenges posed by climate change.
More research into localised mitigation and adaptation synergies are on-going globally. Nigeria has the potential and human resource to develop its capacity further to identify these synergies for itself and address the challenges posed by climate change.
Also the architect has a key role not only as a designer but in its co-ordinating role, as he sits at the helm of the procurement process to rally allied built environment professions to embrace the concept of sustainable development. The paper recommends the following:

1. To synergise mitigation and adaptation measures and introduce them into design and construction and delivery processes.

2. Government, professionals, practitioners and communities to work together in a collaborative manner and produce effective policies to drive sustainable development in the built environment More innovative research, training and brainstorming workshops/ conference on sustainability to be encouraged at all levels (document and disseminate findings).

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## APPENDIX 13: PAPER 3

# CLIMATE CHANGE AND BUILDINGS IN NIGERIA: LESSONS FROM A FIELD SURVEY

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## Abstract

A number of studies have acknowledged that climate change and buildings interrelate and suggested that sustainable design and construction are key factors to reducing the greenhouse gas (ghg) emissions from buildings. These studies also argued that climate change effects can be country specific, hence the need for localised interventions. Other researchers have also carried out studies on sector based strategies involving the built environment professionals and their roles. Yet the roles of the built environment professionals in developing economies and especially in the Sub-Saharan Africa received little attention. A review of these studies is undertaken to derive themes for the qualitative survey conducted on some built environment professionals (architects, builders, engineers and planners) in Nigeria. This research study investigates; the knowledge and awareness level of these professionals, their current practices and how to improve these practices. Findings from the interview survey showed that there is generally, a low level of sustainable information, knowledge and awareness amongst these interviewees. The study further proffers recommendations for the development and the overall sustainability of the built environment in Nigeria.

**Key words:** built environment, climate change, sustainability, Nigeria

**Appendix 14: CONFERENCE CERTIFICATE**

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# Certificate of Achievement

**Evelyn L. A. Allu**

Is awarded this certificate in recognition of

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