

# **Evaluation of Affordable Climate-Smart Homes in Nigeria: Barriers and Strategies.**

**Master's Thesis**

International Master of Science in Construction and Real Estate Management Joint  
Study Programme of Metropolia Helsinki and HTW Berlin

From

**Temidayo John Akinnusi**

**Berlin, 05.07.2024**

**1st Supervisor: Hannu Hakkarainen**

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# Copy of proposed conceptual formulation

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**Evaluation of Affordable Climate-Smart Homes in Nigeria: Barriers and Strategies**

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**Master Thesis Conceptual Framework**

**International Master of Science in Construction and Real Estate Management Joint  
Study Programme of Metropolia Helsinki and HTW Berlin**

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## Evaluation of Affordable Climate-Smart Homes in Nigeria: Barriers and Strategies

### Background

Housing shortages have been a harrowing issue that successive government administrations have not been able to combat in Nigeria. In 2022, the national housing deficit was a whopping 28million (The Cable, 2022). This figure grew from 7million in 1991 to 12million in 2007 and maxed at 14million in 2010. Despite various housing schemes that have been implemented over the years, meeting the housing needs of the populace have been elusive. The worse hit remains the low income group and this is made worse by a never ending ruralurban migration leading to sprawling slums even within city centres. Nigeria ranks among the seven most populous countries in the world, (UN, 2022). According to the United Nations World Population Prospects (2022), the world's population will cross 8billion and Nigeria is projected to be among the seven countries where more than half of all people in the world will live. Climate smart homes are relatively new in Nigeria and there is a paucity of existing research in the field. This research seeks to conduct an explorative research into the barriers and strategies attributable to affordable climate smart homes in Nigeria.

There has been intensive research works on the environmental sustainability subject, many of which are mostly from the perspectives of professionals. This research is set to look at the perspectives of people in low-income households. (Aliyu and Yenom, 2020) considered the residents' point of view which is a useful model for designing the questionnaire for this research. (Jamaludin et al. 2017) have identified some barriers to affordable and sustainable housing. Their case study, Malaysia, is similar to Nigeria's in terms of development. Generally, the publication provides a great insight into possible barriers in affordable housing delivery while its literature review is a suitable tool for understanding the housing intricacies peculiar to Nigeria. The works of (Schofield, 2011): and (Yenom, 2020), provide models that examined sustainable housing. (Schofield, 2011) highlights the roles of the stakeholders in housing delivery, while (Barhama, 2019), evaluated the economics of affordable housing. In this research work, the survey will be based on perspectives of the stakeholders like project engineers, investors and designers, which will be used to understand the possible strategies to

make housing available and affordable for the low-income households in Nigeria. The publication will also be used to understand the background of the housing issues in Nigeria in relation to affordability.

### **Aim & objectives**

The aim of this research work is to explore the strategies and barriers to affordable climate smart homes in Nigeria. To achieve the set aim, below objectives amongst others will be pursued:

### **Objectives**

1. To assess the present climate housing situation in Nigeria with respect to availability and affordability.
2. To examine the existing public and private climate smart housing stock with respect to affordability.
3. To investigate adaptable and workable climate smart housing strategies based on best practices in selected countries in Europe.
4. To evolve/design a workable climate smart housing strategy in Nigeria.
5. To conduct an assessment of foreseeable barriers to the implementation of climate smart housing strategies.

### **Research questions**

1. Is the present smart housing scheme available and affordable to the low income group in Nigeria?
2. Is the existing public and private climate smart housing stock affordable?
3. What are the barriers to affordable climate smart homes and what is the way forward?
4. Are there adaptable and workable climate smart housing strategies in Europe?
5. Could there be foreseeable barriers to the implementation of climate smart housing strategies in Nigeria?

### Proposed Methodology:

This research will use a mixed-methods approach that includes both quantitative and qualitative data collection methods. The study will be conducted in two phases:

#### Stage 1: Survey of low-income households

A survey will be administered to a sample of low-income households in Nigeria. The survey will be designed to collect information on their housing conditions, their awareness of climate-smart homes, and their willingness to adopt such homes.

#### Stage 2: In-depth interview for stakeholders

In-depth interviews will be conducted with key stakeholders such as housing developers, and experts in the field of green homes. The interviews will be designed with the aim of gathering insights into the strategies that can be employed to overcome the identified barriers. Additionally, the interviews will explore the potential benefits of adopting affordable climate smart homes in Nigeria.

### Provisional Schedule for the dissertation

April – June 2023	Comprehensive research of thesis topic
July – August 2023	Delimitation of scope, boundaries, structure, questions and method.
August – Dec 2023	Drafting of literature review/theoretical framework
January – March 2024	Data gathering
March – April 2024	Presentation/analysis of data
May – June 2024	Final review for submission, update/revision per feedback
July 2024	Printing, presentation and submission of final thesis

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## Abstract

Sustainable housing has gained massive traction globally due to the inherent advantage of lowering carbon footprints; and despite its successes in most advanced countries of the world, there is a paucity of research and projects in developing nations. Existing literature indicates the predominant use of traditional/convectional construction materials and methods in Nigeria with its attendant unsustainable impacts. The foregoing situation is made worse by rapid urbanization coupled with government apathy, leaving the urban poor to live in informal settlements and shanties. This study aims to explore the strategies and barriers to integrating sustainable practices into the housing sector, with a focus on affordability. The methodological approach combined quantitative data collection through a structured questionnaire and qualitative insights from literature review of case studies. Questionnaires were distributed using Google Forms to professionals in the AEC industry in Nigeria, one hundred and eight (108) responses were retrieved from the respondents and utilized for the analysis. Statistical Package for the Social Sciences (SPSS) and Microsoft excel were employed to analyse the questionnaires using frequency distribution tables, sample t-test, mean item score, Cronbach alpha test and Kolmogorov test.

The findings reveal a high level of awareness of sustainable homes by the respondents (80%), however 60% believe that these homes are not readily available or affordable. 85% of the respondents believe that high initial cost ranks highest amongst the barriers to climate smart homes. Public-private partnership came out as the number one strategy followed closely by green mortgage programs then finally sustainable urban planning. The foregoing implies that a holistic approach in tandem with all relevant stakeholders is expedient if any meaningful results are to be achieved. From this study some major obstacles towards adoption of climate-smart homes in Nigeria have been identified such as high initial costs, lack of regulatory incentives, limited awareness among others. Lastly, the study proposed strategies to overcoming these barriers such as financial incentives, public awareness campaigns, and the integration of sustainable materials and technologies tailored to the Nigerian context.

**Keywords:** Climate-smart homes, affordability, Nigeria, sustainable housing, barriers, strategies.

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## List of Abbreviations and Symbols

### Abbreviations:

1. AEC - Architecture, Engineering, and Construction
2. CSA - Climate-Smart Agriculture
3. ZEBs - Zero Energy Buildings
4. HVAC - Heating, Ventilation, and Air Conditioning
5. PPP - Public-Private Partnership
6. UNEP - United Nations Environment Programme
7. VAT - Value Added Tax
8. SPSS - Statistical Package for the Social Sciences
9. IPCC - Intergovernmental Panel on Climate Change
10. NASPA-CCN - National Adaptation Strategy and Action Plan on Climate Change for Nigeria

### Symbols:

- % - Percentage
- kW - Kilowatt
- m<sup>2</sup> - Square meter
- CO<sub>2</sub> - Carbon Dioxide

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## Chapter One: Introduction

This thesis is primarily an exploratory study that examines the affordability of climate-smart homes in Nigeria vis-à-vis the adaptable strategies from best practises in select European Union countries as well as assessment of foreseeable barriers to its adoption. The overall intention is the improvement in sustainable buildings with lower carbon footprint in the AEC industry in Nigeria.

### 1.1. Research Background

Climate-smart homes have emerged as a major breakthrough towards addressing global challenges brought about by global warming and sustainable development. These homes combine energy saving technologies with sustainable materials alongside intelligent systems which are designed to minimize environmental impact while maximizing occupants' health and comfort. The concept has gained worldwide recognition due its capability to reduce greenhouse gases emissions as well as building resilience against climate change. For example, residential houses can be fitted with solar panels or wind turbines so that they may utilize renewable sources of energy which do not rely on fossil fuels hence decreasing their carbon footprint (Kannan & Vakeesan, 2016). In Nigeria, the adoption of such houses becomes even more important since it will help cushion the various effects associated with extreme weather events such as flooding among others which are caused by climate change that have been witnessed in many parts of the country. Apart from being environment friendly, these homes can also save money for owners through reduction in power and water usage thereby lowering cost over time (Tuule et al., 2020). Furthermore, incorporating them into Nigerian cities would contribute greatly towards the achievement of the global sustainable development goals while also bridging the housing deficit, thus promoting inclusive urbanization (Narendra et al., 2018).

This problem has been worsened by rapid urbanization coupled with population explosion resulting in some urban residents living under deplorable conditions such as informal settlements and shanties. The traditional housing sector in Nigeria predominantly relies on conventional construction methods and materials, which are not only unsustainable but also contribute to high operational costs and environmental degradation (Adedeji et al., 2023). Consequently, majority cannot afford good shelter due to high prices charged on building materials and labour involved in putting up

structures. Moreover, there is lack of enabling legislation as well as awareness creation concerning sustainable construction; practices which acts as a barrier towards embracing climate smart homes. According to Gram Hanssen & Darby (2018), integration of climate smart technologies together with different types of materials can solve these problems by offering strong long-lasting houses that are energy sufficient cost friendly too.

In Nigeria, climate change poses many challenges. The country has already started to feel the negative impacts of global warming such as destabilizing or even destroying existing housing structures (African Development Bank Group, 2022; Climatelinks, 2019). One way of making residential buildings more resilient is through the use of climate-smart houses which are designed with features like flood resistant structures, systems for efficient water management and strong insulation capable of withstanding extreme weather conditions among others (Wilson et al., 2017). There can be no doubt about the importance played by construction industry together with real estate management sector towards achieving this goal, but they must adopt sustainable practices that promote environmental stewardship besides ensuring economic efficiency as well as social equity in their operations. Sovacool & Furszyfer Del Rio (2020) argue that if builders were to adopt smart building technologies it would significantly reduce environmental impacts associated with housing projects while still contributing towards overall urban sustainability.

For real estate managers, adopting climate -smart homes presents the opportunity to enhance market value of such properties and attract potential buyers who may want something environmentally friendly too. It may cost a lot at first sight when constructing these types of houses since most people think about immediate expenses only without looking at long-term benefits such as lower energy bills due to reduced consumption levels coupled with decreased maintenance outlays thereby increasing profitability for landlords investing in rental units (Walzberg et al., 2020). Climate-smart homes are relevant to both construction and real estate management sectors because there is need for sustainable solutions aimed at addressing housing deficits especially in urban areas where population growth rates have been highest over recent years. In order for this transformational agenda to happen within the sector itself policy makers alongside other key stakeholders ought to collaborate towards formulating laws or regulations

necessary for widespread uptake adoption of these types of houses (Olsson & Folke, 2020).

In recent times there have been indications showing that climate change is real and cannot be ignored any longer. The effects of global warming on societies can no longer be overlooked especially when it comes to provision of strong housing structures (De Wilde & Coley, 2012; Allu Evelyn & Ebohon O., 2014). Climate-smart homes which are built using environmentally friendly materials powered by renewable sources of energy could help a lot in solving some if not all these problems. This study, therefore set out to lend credence to the advancement of a more sustainable and climate-resilient housing by analysing its peculiar obstacles as well as examining tactics for implementing affordable climate-smart homes in Nigeria. Housing has been impacted by rapid urbanisation in practically every city on the planet. Intense economic activities especially in industry and commerce are the major characteristics of urban areas (Woherem, 2017). Urban areas need more resources because they are centres of high levels of economic activities particularly industrialization as well as commercial enterprises but still residents expect better services compared to rural dwellers whose incomes are lower than those living in towns. Cities' high demand for resources is driven by the government's commitment to enhance the urban population's quality of life.

Cities are estimated to use 75 percent of the nation's resources (Knight Frank Africa, 2017; D'Auria et al., 2018) thereby increasing waste production and greenhouse gas emissions. For this reason, many cities especially in developing countries are faced with several environmental challenges such as traffic congestion; competition for space between housing and transport; waste management among others (Gram Hanssen & Darby, 2018; Peprah et al., 2019; Silvestre & Tîrcă, 2019). The issue of sustainability evolved as a result of environmentalists' questions regarding whether the current generation is doing enough to meet their needs without compromising those of future generations (Aina, 2017; King & Amponsah, 2012; Martinez et al., 2017).

### **1.1.1. Reason for Choosing Nigeria**

The Building Nigeria's Response to Climate Change (BNRCC) stated that Nigeria has been negatively affected by climate change, also in Obioha (2008). It also gave reasons why different parts of Nigeria are experiencing different degrees of climate changes problems. In Sub-Saharan Africa countries, residential buildings account for approximately 96% energy used in the building sector while it is only seventy-six percent in Europe, even though specific data about Nigeria was not found (IEA, 2019; IEA,2023). It is important to acknowledge how much effort Nigerian governments have put or not put into dealing with environmental challenges posed by climate change. The National Climate Change Commission was established by the Senate of Federal Republic of Nigeria in November 2010. However, after two years there seems not to be any clear plan on climate change strategies within its mandate (EU in Nigeria Project Map,2023). This means that compared to other nations around the world which have enacted laws aimed at mitigating adverse effects brought about by climatic changes, Nigeria still has a long way to go especially regarding the built environment and construction industry. After many years, the government failed to provide feedback on draft report of National Adaptation Strategy and Action Plan on Climate Change for Nigeria (NASPA-CCN) upon its release. This further shows the lackadaisical attitude of Nigerian governments towards climate change as a major problem. For this reason, (African Development Bank Group, 2022) urged Nigerian Government that there is need for it to speed up formulation of policies and strategies for dealing with endemic climate related challenges. Therefore, it is impossible to overstate the effort made by this research effort to present concrete research discoveries which can strengthen a case for immediate intervention in the built environment

### **1.2. Statement of Research Problem**

Common traditional methods and materials used in construction industry of Nigeria are not sustainable which leads into high operational costs and environmental degradation (Oyewobi & Jimoh, 2022; Yang et al., 2024). These approaches do not incorporate energy efficient technologies or renewable sources thereby increasing emissions of greenhouse gases while raising utility bills for homeowners (World Bank, 2021). Moreover, there exist substantial financial barriers towards adoption of climate smart homes. Sustainable building materials are expensive hence making it hard to provide affordable housing solutions for low-income families who also lack access to

credit facilities needed meet these costs (National Institute Economic Review, 2022). Equally important is absence regulatory incentives meant to encourage uptake of climate smart practices within the construction sector where most operators rely on outdated methods thus resulting into inefficiencies along value chain (National Institute Economic Review ,2022: p3).

Nigerian housing's exposure to climate change impacts constitutes yet another primary issue. The nation increasingly faces extreme climatic conditions such as floods and heat waves, which shake the foundation of existing homes in terms of stability and safety (Haider, 2019; USAID, 2019). Currently there are very few affordable climate-smart houses which can withstand these environmental hazards leaving many communities at risk (Oyewobi and Jimoh, 2022).

Many stakeholders are affected by the absence of cost-effective climate-friendly dwellings in Nigeria. The lack of affordable climate-smart homes affects multiple stakeholders in Nigeria, for homeowners, living in substandard housing conditions means higher energy bills and frequent maintenance costs due to the poor quality of construction. Moreover, ventilation systems together with insulation materials that regulate temperatures within rooms are usually not installed in these homes thereby causing health problems associated with poor indoor air quality during extreme weather conditions like cold seasons or hot seasons (Navigating Impact, 2019). Policy makers must grapple with both providing enough houses while ensuring sustainability. The country cannot achieve its environmental goals or raise living standards without making policies that encourage sustainable construction practices and materials (Climate Change Committee, 2022).

Adopting climate-smart building methods requires huge investments into new technologies and materials if seeks to transition from conventional practices. However, this calls for better ways on how to make them cheaply available since they remain highly priced. Additionally, capacity building and training of industry professionals for the purpose of implementing climate smart technologies is highly important. Barring these supports, the AEC industry will continue to struggle in its drive to adopt and scale up its sustainable practices (UN-Habitat, 2023).

This study is important because it fills several gaps in knowledge about affordable climate-friendly housing in Nigeria. The objectives of this research are to understand

how sustainable practices can be integrated into the housing sector at low cost and overcoming challenges associated with them while ensuring they work effectively under different climatic conditions. The research will provide valuable insights into best practices from other regions and propose viable solutions tailored to the Nigerian context. One critical gap this study aims to fill is the lack of comprehensive data on the cost-effectiveness and long-term benefits of climate-smart homes in Nigeria. By reviewing existing housing projects and comparing them with best practices from Europe and other regions, the research will offer evidence-based recommendations for policymakers and industry stakeholders. Furthermore, the study will identify the specific economic, social, and technological barriers to the adoption of climate-smart housing and propose strategies to overcome these challenges (UNDP, 2019).

The policy and initiative recommendations of this research will facilitate the adoption of climate-friendly homes and henceforth enhance both living conditions and environmental conservation efforts. These suggestions made by the study will play a key role in guiding future investments as well as regulatory frameworks which should ensure that climate smart housing becomes embedded within Nigerian urban planning strategies (World Bank, 2021).

Certainly, Nigeria comes without doubt as Africa's most populous country and also one among the world's most populated countries (StatisticsTimes, 2024; PopulationU, 2024). According to the National Population Commission (2012), there were 167 million individuals living in Nigeria at that time with a growth rate standing at three percent per annum as stated by Mu'azu (2011). Nigeria, like most other African nations, doesn't seem to be taking aggressive steps to slow down climate change, in spite of the comparative economic potential of its population (USAID, 2019; African Development Bank Group, 2022). Failure to incorporate sustainability into residential building designs may lead to high carbon emission especially during construction stage where little attention is paid towards sustainable design principles (Zubair, M. U. et al., 2024).

### **1.3. Research Aim and Objectives of this Study**

**Research Aim:** To explore strategies and barriers to affordable climate-smart homes in Nigeria.

Research Objectives:

1. To assess the current climate-smart housing situation in Nigeria.
2. To examine the affordability of existing public and private climate-smart housing.
3. To investigate adaptable and workable best practices in climate-smart housing from selected European countries.
4. To evolve a viable climate-smart housing strategy for Nigeria.
5. To identify barriers to the implementation of these strategies.

#### **1.4. Research Questions**

**Main Research Question:** How can affordable climate-smart homes be effectively implemented in Nigeria?

Sub-Questions:

1. What is the current state of climate-smart housing in Nigeria?
2. Are existing public and private climate-smart housing stocks affordable?
3. What best practices from Europe can be adapted to Nigeria?
4. Are there adaptable and workable climate smart housing strategies in Europe?
5. What are the barriers to implementing climate-smart housing in Nigeria?

#### **1.5. Justification of the Research**

The reason for this study on the adoption and implementation of climate-smart homes in Nigeria is based on several key areas which are in line with current global and regional priorities especially in terms of sustainable development and climate resilience. Climate change is a major threat to ecosystems, economies, and communities all over the world (EPA, 2021). The Intergovernmental Panel on Climate Change (IPCC) has emphasized that it is urgent to adapt to climate impacts and build resilient infrastructure to mitigate risks (IPCC, 2022).

Sustainable urban development is an international goal; therefore, climate-smart housing contributes significantly towards this objective. According to Yigitcanlar et al. (2019), smart cities should involve using advanced technologies that promote efficiency and sustainability within urban environments. In line with these principles, climate-smart homes employ intelligent systems that optimize energy usage thus contributing towards wider goals of urban sustainability. This research seeks to provide insights into effective strategies for integrating such technologies into residential

construction in Nigeria. Investments made towards climate responsive housing have substantial economic and social returns. The World Bank analysis suggests that greener resilient economic growth can be achieved through sustainable land management as well as climate-smart agriculture (World Bank, 2021). Likewise, energy costs could be reduced for households by adopting climate friendly houses while at the same time relieving pressure from national grids thereby creating green jobs within construction industry that deals with renewable energies. Hence this study will explore economic viability alongside possible social impacts if many people were to adopt climate-sensitive dwellings hence providing policy makers with useful information.

Effective policy frameworks coupled with regulatory incentives play a critical role in stimulating adoption of sustainable practices. Studies have shown that regulatory policies like tax credits and subsidies significantly enhance uptake of climatic smart technologies (Branca et al., 2013). In Nigeria where green regulatory support is still developing this investigation will identify gaps within existing policies as well as propose actionable recommendations towards strengthening regulatory frameworks to foster an enabling environment for uptake of climate friendly houses.

There is need to sensitize communities about the importance of climate-smart housing for them to be adopted easily. Often the success of sustainable initiatives relies on public involvement and understanding (NYSDEC, 2023). Hence it will be necessary for this study to assess current levels of knowledge on this subject and come up with effective community education strategies that will ensure all people are aware about what these types of homes can do in terms of conserving energy at the same time reducing global warming effects. This can help to create a basis upon which awareness creation campaigns and programs aimed at promoting sustainable living can be designed.

This research is justified by the pressing need to address climate change and its impacts through sustainable housing solutions. Climate-smart homes offer a viable approach to enhancing resilience, reducing environmental footprints, and promoting sustainable urban development. The economic and social benefits, coupled with the potential for policy support and community engagement, further underscore the importance of this study. By exploring the adoption and implementation of climate-

smart homes in Nigeria, this research aims to provide comprehensive insights that can inform policy, drive sustainable practices, and ultimately contribute to a more resilient and sustainable future.

### **1.6. Research Hypotheses**

1. **H1:** The adoption of sustainable design practices in residential construction will positively influence the energy efficiency of climate-smart homes in Nigeria.
2. **H2:** The integration of energy-efficient technologies and renewable energy sources reduces the operational costs of climate-smart homes.
3. **H3:** Financial incentives and economic models that support initial investments in sustainable housing technologies enhance the affordability of climate-smart homes.
4. **H4:** The use of sustainable building materials reduces the environmental impact of residential construction.
5. **H5:** Implementing water conservation measures in residential buildings enhances the sustainability of climate-smart homes.
6. **H6:** Regulatory policies and incentives that promote sustainable building practices will increase the adoption of climate-smart homes in Nigeria.
7. **H7:** Public awareness and education about the benefits of climate-smart homes will positively influence their adoption in Nigeria.

These hypotheses will be tested using data collected through surveys and case studies. The findings will provide valuable insights into the factors that influence the adoption and implementation of climate-smart homes in Nigeria, helping to develop strategies that address the barriers and promote sustainable housing solutions.

### **1.7. Research Methodology**

The research methodology employed in this study was designed to comprehensively investigate the adoption and implementation of climate-smart homes in Lagos, Nigeria. This approach combined quantitative data collection through a structured questionnaire and qualitative insights from some literature review of case studies. The adoption of these methods provided a robust framework for examining the various factors influencing the adoption of climate-smart housing in Nigeria.

The combined use of questionnaire data and case study analysis allowed for a comprehensive examination of the factors influencing the adoption of climate-smart

homes in Nigeria. The quantitative data collected through Google Forms provided a broad overview of respondent attitudes and knowledge, while the qualitative insights from case studies added depth and context to the findings. The use of SPSS for data analysis ensured rigorous statistical validation of the results. This mixed-method approach ensured a thorough exploration of the research questions, providing actionable insights for policymakers, developers, and other stakeholders in the field of sustainable housing.

### **1.8. Significance of the Study**

This study seeks to evaluate affordable climate-smart homes in Nigeria with a view to identifying the strategies and barriers to the establishment of sustainable and affordable housing solutions (Reall, 2021). This is because the housing sector in Nigeria is predominantly characterised by a prevalence of traditional housing types with its attendant carbon footprints. This work will make an invaluable contribution to the developing body of research in the areas of sustainable housing in developing countries such as Nigeria (Ajayi et al., 2020). In addition, the research work offers appreciable intuitions into the challenges and potential solutions for creating affordable climate-smart homes in Nigeria (Saidu & Yeom, 2020). Therefore, the findings of this study can inform policy makers, urban planners, and housing developers on effective strategies for addressing the housing crisis in Nigeria and promoting sustainable development.

This research is important as it contribute to the collection of crucial data that may be used to validate findings in relation to the Nigerian construction sector. The study's findings will give policymakers empirical data that may help them when developing Nigeria's climate change policy directives with respect to housing. The possibility for this study to improve Nigeria's housing crisis makes it significant. Inexpensive climate-smart homes could potentially reduce energy use, enhance occupants' quality of life, and increase community's ability to withstand the adverse effect of climate changes. The research's identification of adoption barriers and workable strategies for getting beyond them and advancing sustainable housing practices can be helpful to policymakers, developers, and other stakeholders. Ultimately, this study could lead to a shift in Nigeria towards more affordable and environmentally friendly housing options

### **1.8.1. Academic Contribution**

The academic significance of this research lies in its attempt to address unique challenges and opportunities related with climate smart housing within developing countries specifically Nigeria. Existing literature mainly concentrates on sustainable building practices in developed nations but there is minimal consideration accorded towards their applicability in places like Nigeria. This gap will be filled up through provision of empirical evidence coupled with practical insights on how renewable energy sources can be integrated into Nigerian buildings together with energy efficient technologies while adopting sustainable construction materials (Singh et al., 2021). Such contributions are important for enhancing worldwide discourse on sustainability, urbanization and coming up with frameworks that can work well under similar settings across various developing nations.

### **1.8.2. Practical Implications**

From a practical standpoint, there are numerous implications associated with conducting such type of an inquiry for policy makers, city planners as well as those involved in construction industry itself. To begin with, policy recommendations based on facts need to be made so that regulatory frameworks may promote the use of sustainable houses within cities and towns. This includes tax exemptions or rebates meant at lowering cost barriers against adopting sustainable building practices. Finally, there is need for cost effective scalable climate smart technologies together with materials to be identified by construction sector players which will enable them to reduce operational expenses while minimizing environmental impacts

### **1.8.3. Social Impact**

The social impact of affordable climate-smart homes is profound. Especially when considering their potential to improve the living condition of the urban poor. For instance, energy costs can significantly go down thereby improving living standards among low-income earners. Energy efficient buildings lower utility bills making them more pocket friendly over a long-term basis. Furthermore, good insulation coupled with proper ventilation systems create healthier living spaces as they help in reducing cases respiratory diseases that are often associated with poor housing environments. Climate conscious homes also cut down emissions of greenhouse gases alongside dependence non-renewable sources power thus contributing towards wider efforts aimed at mitigating global warming. This promotes sustainable growth in towns which

is crucial for creating strong communities capable of coping with various environmental as well economic shocks

## **1.9. Scope of the Study**

### **1.9.1. Geographical Scope**

This research is limited to Nigeria, but it also involves comparative analysis with some European countries like Finland, Sweden, Germany, Denmark and Netherlands. This is because these countries have gone far in implementing sustainable housing solutions which makes them good for comparison purposes as Nigeria still grapples with tremendous challenges in the area of housing and sustainability. By examining the policies, technologies, and economic strategies employed in these countries, the study aims to identify best practices that could be adapted to the Nigerian context to address its housing deficit and enhance sustainability.

### **1.9.2. Content Scope**

The content area for study includes design, implementation as well affordability aspects pertaining to climate smart homes; where design will look into architectural innovations supporting energy efficiency through use of sustainable materials coupled with integration of renewable energy sources among others. Implementation entail practical steps necessary for constructing climate smart houses including technological requirements needed during construction process such as those applicable within Nigeria so as determine barriers against or enablers within the country's building industry. Affordability takes critical view on how affordable it is considering economic feasibility vis-à-vis low-income earners' ability to pay for these houses and possible models such as financing that may promote wide spread ownership. This ensures that all stakeholders are catered for since this approach takes care various needs people have in relation climate change adaptation strategies (Jha & Udas-Mankikar, 2019).

### **1.9.3. Temporal Scope**

The temporal scope of the study spans from the current state to future projections over the next decade. This timeframe allows for an assessment of immediate challenges and opportunities, as well as the long-term impact of climate-smart housing initiatives. Forecasting future trends and possible outcomes of climate smart housing programs may help with long term planning since such initiatives are expected to have direct

bearing on people's lives over time considering that they are meant to improve living conditions as well as contribute towards sustainable development planning aimed at addressing emerging environmental concerns thus creating resilient cities in view of these changes (IPCC, 2022; Calicioglu et al., 2019).

## **1.10. Operational Definitions**

### **1.10.1. Climate-Smart Homes**

Climate smart homes refer to those houses which minimize impacts on environment while maximizing occupants' comfort and health through the use of energy efficient technologies alongside other sustainable measures so as to reduce carbon footprints. These homes utilise renewable energy sources like solar panels, wind turbines and buildings with materials that save energy (Ramalingam et al., 2022). Such houses typically have inbuilt intelligence systems for lighting control among others so that only necessary amount of energy is consumed at any given point in time. By incorporating these practices and technologies, climate-smart homes contribute to sustainable development and climate change mitigation efforts (Kumaraperumal et al., 2022).

### **1.10.2. Affordability**

Affordability within the context of climate smart homes refers to the cost of housing relative to household income and ability to make savings over an extended period. The initial investment required for smart homes may appear higher than traditional ones but this gets compensated through lower utility bills as well as reduced maintenance expenses associated with such buildings over time. Affordability is also influenced by the availability of financial incentives such as tax breaks, subsidies, and low-interest loans, which can make climate-smart homes more accessible to low-income families (Navigating Impact, 2019).

### **1.10.3. Barriers**

The adoption of climate-smart homes faces several barriers, categorized as economic, social, technological, and regulatory challenges. There are several obstacles that need to be overcome before climate-smart homes can become widely adopted, these include economic, social, technological and regulatory challenges (National Research Council Canada, 2024). The cost of sustainable materials is often too high for many households because they have an upfront payment which may be prohibitive on its own without even considering any other factors such as installation fees or ongoing

maintenance costs. Another problem stems from people not knowing enough about what benefits they could get by living in climate-smart homes; this leads them into rejecting new practices that differ from traditional methods used while constructing buildings. In order to integrate energy efficient systems, we need to have professionals who possess specific skills related with this field since it requires good knowledge on how different components work together (Food Prices for Nutrition DataHub, 2021). This means there must be policies put in place which will support sustainable building practices while at the same time providing incentives where necessary. Furthermore, existing codes might fail to accommodate new materials or technologies thus slowing down progress made so far when it comes to updating our regulations around construction sites (National Research Council Canada, 2024).

### **1.11. Organization of Chapters**

This research paper has been divided into six chapters each addressing different aspects regarding the subject matter under investigation. Chapter one provides a background understanding of climate change and smart houses in Nigeria alongside stating aims objectives, research questions, hypothesis, justification of the study and others. Chapter two reviews related literature on the topic generally. Chapter three discusses the research methodology employed including survey processes, data collection techniques, and other methodological steps adopted. Chapter four focuses on analysis of data and presentation. Chapter five discusses the findings and justifications while chapter six discusses conclusions and recommendations.

## Chapter Two: Literature Review

### 2.1. Review of Related Literature

Climate change has become a critical global concern due to the changes in weather patterns experienced worldwide, and its impacts cut across many sectors, including housing. Buildings and the built environment are a significant contributor towards greenhouse gas emissions and energy use (De Wilde & Coley, 2012; Allu Evelyn & Ebohon, 2014). This has led to the emergence of climate-smart homes as one possible solution which combines energy efficient technologies with sustainable design principles to reduce the negative environmental effects caused by residential buildings. Many studies have explored various advantages associated with climate-smart homes like energy savings, increased comfort levels and lowered carbon footprint. Bhati et al., (2017) investigated how some functions of smart home devices promote energy conservation in Singapore where they found that these technologies can lower household energy consumption greatly. Similarly, Marszal et al., (2011) discussed Zero Energy Buildings (ZEBs) concept and stressed on the need for integration of renewable sources of energy together with energy efficiency systems so as to achieve zero net energy consumption. However, there are still challenges hindering adoption and implementation of climate-smart houses. In Europe Sovacool and Furszyfer Del Rio (2020) carried out a critical review on smart home technologies identifying such risks as privacy and security concerns; rebound effects; digital exclusion among others. Also looking into business models behind them Furszyfer et al., (2020) further delved into applications for these devices but urged for wider understanding of their environmental, economic and social implications.

Affordability is an important factor particularly for developing countries like Nigeria. Frick-Trzebitzky et al., (2017) studied the capability and readiness of people residing in slum areas in Ghana to pay for utility services, thus showing why it is crucial to address affordability issues within urban development contexts. Meanwhile Baah Ennumh et al., (2012) explored housing conditions of female head porters in Ghana which highlights the need for affordable houses targeted towards low-income earners. Concerning sustainable homes and city growth in Nigeria, there have been several research undertakings to identify challenges as well as opportunities. Aina (2017) talked about GeoICT's role in realizing smart sustainable cities in Saudi Arabia that could be applicable within Nigerian settings. Whereas Soyinka and Siu (2018)

investigated insecure habitation arrangements and informal dwellings within cities coupled with social segregations thus emphasizing the need for inclusive approaches towards sustainable urban development.

Despite these efforts, there remains a gap in the literature specifically addressing the barriers and strategies for implementing affordable climate-smart homes with respect to Nigeria. This study seeks to fill that void by carrying out extensive research which involves all relevant stakeholders such as policy makers, developers, architect's contractors among others. By employing a quantitative approach and collecting empirical data through questionnaires, this research will be an addition to research efforts in sustainable homes and provide valuable insights for informing policy and practice in Nigeria

## **2.2. Climate-Smart Homes**

Climate-smart houses are an advanced way of constructing homes. What this means is that the energy-efficient technology and sustainable materials are used in building houses which will reduce their environmental impact while at the same time improving living conditions. This approach borrows heavily from climate-smart agriculture (CSA) based on managing landscapes to tackle food security and climate change concerns concurrently (World Bank, 2022). Similarly, these buildings have three main goals; they should be more energy efficient; provide better protection against climate change events like floods or heatwaves; and lower greenhouse gas emissions. Typical features of such dwellings include renewable energy sources like solar panels, effective insulation materials and smart home systems that control power usage by automation so as to minimize wastage (FAO, 2023). Also, design for climate-smart houses lays emphasis on use of sustainable construction materials thereby reducing carbon footprint associated with building activities. Bamboo can be one example among many others such as recycled steel or low emission concrete which can be used to build durable and environmentally friendly structures. Besides, rainwater harvesting systems may also be adopted during implementation stage for water conservation purposes within these homes thereby further enhancing their sustainability. In summary, climate-smart homes deal with the environmental impacts caused by residential buildings thus contributing towards wider efforts aimed at mitigating climate change while fostering sustainable cities development (Copernicus Institute of Sustainable Development, 2024).

### 2.2.1. Climate Smart Homes Concepts

The climate-smart house idea incorporates cutting-edge technology to maximise energy efficiency, enhance comfort, and promote environmental sustainability in residential structures. For instance, the use of fuzzy logic controllers in smart home technologies could autonomously adjust microclimate parameters like temperature, humidity and air quality. Also adopting polymer-dispersed liquid crystals (PDLC) glass system saves energy besides keeping privacy intact while also improving the connectivity between interior rooms with outside spaces especially in hot areas (Tuule et al., 2020). This idea aligns itself with climate-smart agriculture which seeks to reduce impacts of climate change on food security and agricultural productivity through weather smart water carbon market savvy strategies. Indeed, it offers an all-around approach towards better living conditions while at the same time being resource efficient.

Climate smart houses are also referred to as sustainable or green homes because they have been designed with the environment in mind. The main idea behind these homes is to ensure quality health for the residents with minimum negative impact on the surrounding environment. Some concepts to consider include:

1. **Energy Efficiency:** - Passive Design: This involves using the orientation of a building, its insulation properties, window types together with thermal mass so that they can naturally regulate heat hence reducing dependence on heating ventilation air conditioning systems (Cuce et al., 2022; Tuule et al., 2020). For example, walls and roofs are well insulated, and windows placed strategically to maximise natural lighting and ventilation.
2. **Renewable electricity Integration:** This refers to incorporating solar panels, wind turbines alongside geothermal energy systems for power generation purposes. The adoption of renewable sources has been advanced mainly through EU initiatives like Germany's Energiewende program which heavily championed the use of solar and wind energy (Narendra et al., 2018).
3. **Water Conservation:** - Installing Efficient Fixtures and Appliances The term refers to low flow toilets, faucets, and showerheads, as well as water efficient appliances that are installed with the purpose of reducing water usage.



Figure 1 provides a good visual representation of the main elements as well as design principles behind climate-smart homes. The figure emphasizes on passive design features such as orientation; insulation and window placement which can help reduce the need for active heating/cooling systems, hence saving energy.

### 2.2.2. Advantages of Climate-Smart Homes

In their research work Tuule et al., (2020); Narendra et al., (2018) and Amasyali & El-Gohary, (2018) have shown different benefits associated with these types of houses. The use of fuzzy logic controllers among other advanced technologies allows Climate-Smart Houses intelligently control microclimate variables like temperature, humidity or air quality according to Tuule et al., (2020). Energy efficiency gets improved through autonomous heating, cooling and ventilation systems that respond to real-time conditions as well as user preferences thus saving a lot of money (Amasyali & El-Gohary, 2018). Additionally, comfort is enhanced by smart home technologies which enable remote control over all electrical appliances and personalized settings based on individual needs. Moreover privacy can be maintained through the use of polymer-dispersed liquid crystals (PDLC) glass systems that allow for indoor-outdoor connections while at the same time protecting against harmful solar radiation Narendra et al.,(2018). Climate friendly houses offer various benefits beyond their environmental impacts; they also have economic, social and health dimensions whose significance should not be underestimated if sustainable construction methods are to gain wider recognition and acceptance (Odebiyi, 2010).

1. **Environmental Benefits:** - Decrease in Greenhouse Gas Emissions: Climate-smart houses cut carbon footprints by making energy efficiency better and utilizing renewable power sources. According to the International Energy Agency (IEA), buildings account for around 40% of worldwide energy use and contribute to one-third of global greenhouse gas emissions. This means that if climate-friendly homes are used on large scale basis these figures could be significantly reduced (Narendra et al., 2018). Efficient use of resources: Optimal use of water and resources reduces the strain put on natural reserves (Shabha et al 2021). For instance, we can decrease up to half the amount used by adopting appliances that save water or collecting rainwater (Tuule et al., 2020). Economic Advantages: Designs should be made energy efficient as well as systems using renewable energies which will lead to lower levels of consumption resulting into less

expensive bills being paid for utilities. According to Environmental Protection Agency (EPA), homes certified under ENERGY STAR consume between 20-30% less power compared with average houses, thus saving homeowners lots of money (Tuule et al., 2020; Narendra et al., 2018). Property prices are likely to rise when they have green certifications like LEED or BREEAM because it makes them more attractive to buyers who want sustainable living spaces where they can also save on costs associated with utilities such as electricity bills among others. Research conducted by World Green Council found out that there is potential for increase in sales prices by even 30% for buildings with eco-friendly features at every level from residential through commercial sector too (Shabha et al 2021).

2. **Health and Well-being Benefits:** Non-toxic materials should be used while ensuring good ventilation systems so that indoor air quality is improved thereby leading to health benefits for people living or working in such environments. The Harvard T.H Chan School of Public Health's paper entitled "Health And Well-being In Green Buildings" mentions that cognitive performance may be boosted through better quality air inside buildings and respiratory problems mitigated against as well (Shabha et al 2021). **Thermal Comfort/Acoustic Comfort:** This is achieved by having good insulation materials which prevent heat loss during winter season thus keeping warmth within structures while also reducing noise pollution levels around homes or offices.
3. **Social Benefits:** Reducing vulnerability to extreme weather events caused by climate change can be achieved through construction practices like those employed in climate-smart houses. According to Shabha et al (2021), homes with higher insulation levels and renewable energy systems are able to cope with heatwaves and even power outages better than conventional ones do. **Employment Creation and Economic Growth:** Many jobs are created within different industries ranging from building trades such as masonry work, carpentry among others down up until production lines where various equipment's used for harnessing renewable sources of power require staffing hence contributing greatly towards sustainable economic development worldwide as indicated by Global Alliance for Buildings & Construction which states that this sector provides huge numbers of employees around world due its vastness (Shabha et al 2021).

4. **Energy Saving:** smart thermostats are important components for energy-saving and eco-friendly houses. A substantial cutback in the use of power can be achieved through this by adjusting heating and cooling systems to match occupancy as well as individual needs on a time basis. According to Tuule et al (2020), smart thermostats can lower heating and cooling costs between 8% 15% on average. According to Shabha et al (2021), they have advanced models that also consider weather patterns around you apart from being able to learn from your habits thus increasing energy efficiency even further. Among other things such as using remote sensors for managing indoor climate effectively or being able to accurately measure how much impact humidity levels have on comfort; one good example is Ecobee Smart Thermostat Premium which does all these things right. ENERGY STAR certified smart thermostat would save more money where there are wider temperature variations throughout the year. Climate-smart homes with smart thermostats therefore not only save individuals' money but also contribute towards global efforts in conserving energy resources and mitigating climate change effects (Narendra et al., 2018; Tuule et al., 2020).

This study agrees with the ideas and advantages of climate-smart homes presented in this section of the literature review. In Nigeria, integrating cutting-edge technologies, sustainable materials, and energy-efficient design principles can greatly enhance living standards while minimizing environmental degradation caused by buildings thereby benefiting homeowners economically too. However, though these models may be applicable within Nigerian settings as discussed by Tuule et al.(2020), Narendra et al.(2018) ,and Iweka et al., (2019) among others; it is important that socio-economic factors specific to our country's culture(s) are taken into account during planning stages for realization of such projects aimed at creating environmentally friendly housing units which respond appropriately to local climatic conditions.

### **2.3. Distinction Between Climate-Smart Homes and Conventional Smart Homes**

According to research, the main difference between climate-smart homes and regular smart houses is in their design philosophies (Awan et al., 2022; Tuule et al., 2020). In climate-smart design, energy efficiency is prioritized at the design stage so as not to harm much of the environment. What steers the design of a climate-smart home are factors that lower a building's carbon footprint hence promoting ecological

conservation. Relatively, a climate-smart dwelling might use sustainable sources of energy different from those with high carbon footprint such as coal or fossil fuel; solar power could be used instead among others like wind or even geothermal for electricity supply. In addition, the building might be designed such a way that it would have provisions for walls, windows, and roofs with excellent insulation to minimise heat gain and heat loss are required by the design, thereby decreasing energy use (Shabha et al 2021).

On the other hand, a typical smart home places more emphasis on comfort and automation by taking advantage of connected devices. In most cases these devices are connected via internet connection hence management requires internet too. In this philosophy of designing there is emphasis on how different parts of household can be managed remotely especially lighting, thermostat security system appliances using smartphone application (Shabha et al 2021). All what conventional smart home need is periodic checks to determine automation needs and other functionalities for maintaining optimal temperature levels throughout. Among many other things found in almost every smart home include smart speakers, voice control as well integration with devices so that users can easily communicate with them. Additionally integrated security feature provided by smart locks, videos, doorbells give more protection assurance.

Though, climate-smart and conventional smart houses may utilise smart home technologies, the fundamental distinction resides in their main purposes, and this governs the design philosophy and considerations. A climate-smart house does so by having design systems and other features that consider sustainability of the environment, on the contrary an ordinary smart home puts more emphasis on technologies that enable control over homes, this may be for reasons of security or even comfort. This is an important distinction to make because it determines what kind of attributes and structures will be found in each type of dwelling. For instance, rainwater harvesting, low flow fixtures could have been considered during construction process for a climate smart house so as to save water while a typical smart home may be centered on the integration of smart appliances and gadgets for improved convenience (Shabha et al 2021).

In simple terms, a climate-smart house aims at minimizing the negative impacts on the environment through sustainable architecture as well as technologies (Shabha et al 2021). On the other hand, regular smart homes are driven by ambitions for convenience brought about by smart home technology. However, these two can work together with each having its own unique set of priorities and characteristics which represent different values and objectives. Currently there are many smart houses that combine aspects from both conventional designs and those which are environmentally friendly thus giving people more options to choose from while still enjoying benefits associated with either form.

This research agrees with the distinction made between climate-smart homes and conventional smart homes. However, there should be an integrated approach which combines both ideas to bring out their best. This can be achieved by integrating energy efficient design principles together with automation systems for controlling and managing a smart home so as to enable energy savings reach their optimum levels while the residents continue to enjoy comfort and convenience.



**Figure 2: Normal Home vs Smart Home**

**Normal Home vs Smart Home<sup>1</sup>** in Figure 2 clearly illustrates the difference between a traditional housing scheme and a climate-smart housing scheme that incorporates sustainable design principles.

Source: (*White Lion, 2023*)

#### **2.4. Assessment of Private Sustainable Versus Traditional Housing Scheme in Nigeria**

In Nigeria, traditional housing schemes have been dominant in the housing industry, but these fail to address sustainable issues thereby leading to environmental depletion (Shi et al., 2019). Sustainable housing schemes especially those that are privately owned have gained popularity in this country. The main objective of such projects is conservation of nature through reduction of negative impacts associated with construction and operation activities while creating habitable spaces at the same time. Some of these features include use of passive designs, renewable sources for electricity generation, storage tanks for collecting rainwater among other considerations aimed at conserving resources as well as protecting them from depletion. Conversely, typical private buildings rely on cost-effectiveness thereby foregoing sustainable practices when using normal building materials instead of adopting green options (Dwaikat, L. N., & Ali, K. N. 2018). Energy efficiency is also overlooked; leading to higher costs during usage coupled with larger ecological footprints according Fell et al., (2017). According to Asadi, S., et al (2014), although it may seem like private sustainable housing projects require more money upfront due to incorporation of eco-friendly technologies alongside durability advantages; they actually save on water consumption bills besides conserving power over time because they help reduce heating or cooling needs within houses thus fostering healthy living environment which can withstand adverse impacts resulting from climate change effects like increased temperatures among others affecting built environment adaptation. However, several obstacles hinder the adoption of these homes including lack adequate knowledge, absence of incentives, regulations, monitoring of noncompliance and higher initial investment compared to traditional choices. Addressing these barriers through education, policy support, and innovative financing

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<sup>1</sup> Source: [smart home vs normal home \(whitelion.in\)](https://whitelion.in) (2023)

mechanisms will be germane to the extensive implementation of sustainable housing practices in the private sector.

The success of private sustainable housing projects in Nigeria largely depends on establishment of strong laws backed by attractive rewards systems for developers. Tax exemptions related with green structures can also be given priority while streamlining permits process. Leskinen et al., (2020) proposed a model that includes tax incentives, green building certifications, and streamlined permitting processes for sustainable housing projects. Such a model can undoubtedly catalyse the growth of the sustainable housing market in Nigeria.



**Figure 3: Private sustainable vs traditional housing scheme in Nigeria**

Figure 3 aptly depicts the benefits of private sustainable housing schemes compared to traditional schemes.

Source: (Shutterstock, 2023)

## **2.5. Assessment of Public Sustainable Versus Traditional Housing Scheme in Nigeria**

The public housing sector in Nigeria has historically focused on providing affordable housing solutions to low-income and marginalized communities (Martinez et al., 2017). However, the traditional approach to public housing has often overlooked sustainability considerations, resulting in a significant environmental impact and long-term operational costs. Today, more than ever before it has become imperative that sustainability be incorporated into Nigerian public housing as noted by Sovacool et al., (2020). In Nigeria, a public sustainable housing scheme is designed to achieve all forms of sustainability: economic, social and environmental; during planning stage up to when they are occupied as homes. Common features include greening designs;

urban agriculture; water saving strategies; energy efficiency measures and use of renewable power sources among many others.

Conversely while looking at Fuchs et al., (2019); Spiliotopoulou & Roseland (2020)'s point of view concerning traditional approach towards this same issue within their country's context; it mainly deals with providing shelter only without considering any ecological factors at all which then leads into such problems like lack of energy saving bulbs or use of materials being made out from brick which increases construction cost thus causing long term environmental degradation apart from higher operational expenses over time. Traditional public housing schemes in Nigeria often lack energy-efficient features, rely on conventional construction materials, and contribute to environmental degradation and long-term operational costs. While public sustainable housing schemes may require higher upfront investments, they offer numerous long-term gains such as water and energy management, better indoor air quality, and enhanced climate resilience. Additionally, these schemes can contribute to social sustainability by promoting community engagement, creating green spaces, and addressing food insecurity through urban agriculture initiatives. However, the implementation of public sustainable housing schemes in Nigeria faces several challenges, such as limited funding, lack of technical expertise, and inadequate policy support. Overcoming these barriers will require a concerted effort from policymakers, housing authorities, and stakeholders to prioritize sustainability in public housing projects and allocate sufficient resources for their successful implementation.

Public-private partnerships (PPPs) will be crucial in driving the adoption of sustainable housing schemes in the public sector. By leveraging the expertise and resources of private developers and combining them with the reach and scale of public housing authorities, PPPs can facilitate the implementation of large-scale sustainable housing projects that cater to the needs of low-income and marginalized communities.



**Figure 4: Public sustainable vs traditional housing scheme in Nigeria**

Source: *(Punch Newspapers, 2022)*

Figure 5 effectively contrasts the different approaches to public housing development, with the research believing that the public sustainable housing scheme showcased can promote inclusive and climate-resilient urban development.

## **2.6. Assessment of Sustainable Versus Traditional Housing Scheme in Case Studies (Finland, Sweden, and Other Nordic Countries)**

Some EU countries and notably the Nordic countries have always been at the forefront of successful sustainable housing development; hence, they are a rich source of material for case studies and best practices which can guide Nigeria in its bid to provide affordable climate-friendly homes. Nordic sustainable housing schemes stand out because of their energy efficiency orientation, integration with renewable energy sources and environmental friendliness (Nordic Energy Research, 2021). Passive house design is one of the key features while others include use of renewable energy systems like solar panels or wind turbines – this reduces dependence on fossil fuels for electricity generation as well as heating purposes-, sustainable materials such as recycled bricks or wood from sustainably managed forests among others as well as green spaces also contribute greatly towards promoting biodiversity within these settlements. Traditional housing schemes in the Nordic countries often lack these sustainability features and rely on conventional construction methods and materials, resulting in higher energy consumption and environmental impact Walzberg et al., (2020). This can be seen by looking at some examples from Finland, Sweden and

other Nordic countries where they have successfully implemented sustainable housing schemes that were able to improve energy efficiency performance while reducing carbon emissions released into the atmosphere, thus ensuring occupants' comfort and wellbeing.

For example, Bedzed eco-village in UK or Vastra Hamnen district located within Malmö city in Sweden have shown how large-scale sustainable housing developments can be achieved successfully (Furszyfer et al., 2020). Although it's true that there are still some challenges faced by these projects especially when it comes to affordability aspect since most low-income earners cannot afford high upfront costs associated with advanced technologies used during construction process (Wang et al., 2017), Moreover, climate differences between Nigeria and the Nordic countries may pose a problem in terms of adaptability because what works well in one place might not work out properly in another due to variations in cultural background or even availability of resources among other factors. Adapting and contextualizing these best practices to Nigeria's specific conditions will be crucial for their successful implementation.

Nigeria must adapt these models to its own setting even as it recognizes what the Nordic countries have done with sustainable housing. Some of the factors that should be considered include but not limited to climate, culture and availability of resources when adopting best practices from other areas. The most effective way may be combining locally applicable solutions with internationally proven strategies.

### **2.6.1. Illustrations of Climate-Smart Residences in the European Union**

1. **Passivhaus in Germany:** - Passivhaus is an energy efficiency standard for buildings that aims at minimizing their ecological impact on the environment through very low heating and cooling energy consumption by building structures with excellent thermal insulation, high-performance windows, and airtightness. A good instance is found at Bahnstadt Heidelberg which houses both commercial and residential passivhauses (Moreno-Rangel, 2021).
2. **Zero Carbon Homes in the UK:** - Zero carbon homes are those that achieve a balance between their energy use and renewable energy generation; thus, United Kingdom has put in place numerous policies to ensure their construction such as this one. BedZED also known as Beddington Zero Energy Development is an eco-village located in London comprising energy-efficient

houses powered by using energy-efficient, sustainable and renewable materials among others. It comprises of energy-efficient residences, renewable energy systems, and sustainable building materials. The development has successfully produced substantial reductions in energy use and carbon emissions. (Narendra et al., 2018).

3. **Sustainable Communities in Scandinavia:** - There are many eco-villages across Norway, Sweden and Finland that exemplify sustainable living methods. The Hammarby Sjöstad neighbourhood in Stockholm Sweden is an urban area designed around ecological principles featuring green buildings made through eco-friendly methods coupled with renewable power sources plus efficient waste management systems aimed at reducing pollution while ensuring people enjoy good living standards (Tuule et al., 2020).
4. **EnergyLab Nordhavn in Copenhagen, Denmark-** EnergyLab is a smart energy solution that integrates various technologies into an urban environment. The project uses renewable sources like wind and solar power while optimizing energy consumption through intelligent electricity grids. Also within its scope are district heating systems, building automation as well as electric vehicle charging stations among others; this showcases how cities can become more sustainable by adopting advanced technology solutions such as these ones (Danfoss, 2023).
5. **Sustainable Housing in Tampere, Finland-** Vuores at Tampere City represents the cutting edge of sustainable housing design where buildings are designed using eco-friendly materials and equipped with renewable energy systems while also practicing efficient waste management methods thereby reducing their environmental footprints significantly besides having good insulation properties for saving on heating costs during winters among other benefits. In addition, green spaces have been enhanced within the neighbourhood coupled with stormwater recycling systems which promotes biodiversity conservation alongside water conservation awareness among residents thus making them live healthily together with nature (Romero-Lankao et al., 2019).

Climate-smart houses provide a holistic solution to the issues of energy usage, depletion of resources, and environmental deterioration. Through the incorporation of

cutting-edge technology and environmentally friendly practices, these residences provide significant advantages, making them a practical and indispensable substitute for conventional housing types. The European examples illustrate that by implementing appropriate legislation, incentives, and community participation, climate-smart houses may be effectively established, providing useful insights for Nigeria (Tuule et al., 2020).



**Figure 5: Climate-smart residences in the European union**

Source: (Cordis, 2022)

Figure 5: Climate-smart residences in the European union showcases climate-smart residential developments in the European Union, which serve as excellent examples of sustainable and energy-efficient housing schemes. The rows of houses depicted feature solar photovoltaic panels installed on the rooftops, indicating the integration of renewable energy sources for on-site electricity generation.

## **2.7. Common Types of Houses in Nigeria**

Commonly found in rural areas, traditional Nigerian houses are built with local materials such as earth, straw and wood; these materials have been used for centuries and generations. Such walls can be created from mud bricks or woven sticks covered in mud known as wattle-and-daub while the roof is made of thatch which may be grasses or palm fronds. These houses often lack modern amenities and have poor ventilation, leading to uncomfortable indoor conditions (Civiconcepts 2023).

In Nigeria, especially cities like Lagos brick and mortar houses are most common forms of residential building construction types due largely to population density coupled with increased urbanization rates over the years. This has also resulted into expensive land prices thus making it difficult even for low-income earners who would

prefer living closer to their workplaces in town centres where rents tend to be higher than what they can afford. Bricklayering is a popular job among Nigerians because blocks made out of cement mixed sand ensure strong structures against elements more so compared to those built using temporary materials like thatched roofs which may easily collapse during heavy rains causing fatalities (Civiconcepts 2023).

Prefabricated homes recently have gained popularity in Nigeria because they take less time to put up hence reducing costs associated with housing development projects which could otherwise require lots of money if done conventionally through buying all necessary building materials then hiring human labours to do everything from foundation laying up until roofing stage. Prefab houses are usually made offsite in factories before being transported and assembled onsite using cranes or other heavy machinery; some commonly used materials include steel sheets, aluminium panels, PVC sheets (Civiconcepts 2023). For example, some low-cost homes are constructed by assembling prefabricated parts made from steel or aluminium.

Luxury apartments cater exclusively to wealthy individuals who want nothing short of opulence. Typically, being built with superior class materials such as marble, granite and high quality wood which are quite expensive but guarantee durability in addition to other features like modern architectural designs that have spacious plans and complete state-of-the-art facilities (Erişen 2023). Modern luxury houses are designed with large windows and open floor plans to allow for natural light and ventilation. They also commonly feature large balconies or terraces which provide outdoor living spaces.

Different types of Nigerian homes use HVAC systems differently depending on the building design as well as socio-economic status of its occupants residing in them. Traditional houses lack these systems mainly due to low-income levels, hence affordability becomes an issue. Besides, most people are unaware of the benefits associated with using modern appliances while others simply do not see a need for them since they have managed without them so far thus relying only on air from natural ventilation methods which cool down hot rooms during hot seasons (Civiconcepts 2023).

The literature review shows that there is still a major gap in affordable green housing in Nigeria. Many current climate change adaptation strategies are expensive and

cannot be afforded by majority of the population. Some suggestions made were for developers to build energy efficient houses using renewable materials, sustainable design principles and techniques that conserve water resources (Oyewobi & Jimoh 2022).

## **2.8. Overview of Current Housing Situation in Nigeria**

According to UN projections, more than forty percent of the world's population will become urban dwellers by the year 2030, which will further exacerbate the housing shortage (Adedeji et al., 2023). The ordinary Nigerian continues to struggle to find affordable accommodation, above 52 percent of the populace lives in conditions that are inadequate, such as shanties and informal settlements. The private sector developers' expansion into mass housing has stalled thereby promoting underground deals and lack of quality homes especially for low-income earners. Furthermore, COVID-19 pandemic has highlighted the need to assess housing conditions particularly in low-income residential areas where space may be limited, security inadequate and preventive measures not well known among others. These challenges point to urgent need for sustainable housing programs that consider economic, ecological, social, institutional and technological aspects in Nigeria.

Another thing is that even though government has done something towards this direction it still falls short when compared with other countries at similar levels of development (Adedeji et al., 2023). While other developing nations struggle with affordable housing provision; Nigeria faces a bigger challenge because many people live in substandard accommodations due to inability to afford decent ones. To address these deficits adequately therefore, a multifaceted strategy involving construction of affordable units coupled with upgrading informal settlements is necessary (Adedeji et al., (2023). A gradual improvement approach through sustainable building methods integrated with community-based planning processes within slum neighbourhoods so as to enhance liveability standards over time could also contribute towards solving the housing crisis while promoting sustainable inclusive cities development.

### **2.8.1. Challenges of Providing Affordable Housing in Nigeria**

Given Nigeria's huge population, rapid urbanization and socio-economic disparities, the availability of affordable housing has become a major concern in the country. As shown in Figure 6, this is one of the proposed affordable house schemes in Nigeria.

In respect to affordable housing in Nigeria, Akeju (2007) identified the following as key areas that should be considered:



Figure 6: Housing Scheme in Nigeria<sup>2</sup>

1. Statutory laws or regulations enacted by a governing body

The Land Use Act (1978) which vests all lands into government ownership hampers availability for housing construction (Akeju, 2007).

2. Property Registration

According to World Bank's report titled "Doing Business 2007 – How to Reform", property registration duration was reduced from two hundred and seventy-four days to eighty days following a reform aimed at doing so. However still much remains to be desired since countries like Norway can do it within just 1 day.

The process of registering properties in Nigeria is lengthy and creates opportunities for corruption. The research found that it takes 16 steps for Nigeria to register property while countries like Norway only require one procedure (Akeju, 2007).

3. Risk Sharing

Unfortunately there is no risk sharing system that would incentivize financial institutions to provide mortgages or loans for low-income earners in Nigeria.

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<sup>2</sup> <https://guardian.ng/property/nigerians-can-have-affordable-housing-if-govt-provides-facilities/>

Nigerian financial institutions are unable to assess individuals' creditworthiness comprehensively because they do not have credit information database covering wider population thus, they tend to lend more to those with higher financial muscle (Akeju, 2007).

4. Lack of a centralised national credit database

There is currently no countrywide credit database that can offer credit information for all persons who use financial services in any capacity. The inclination to accumulate information should be resisted. This database will greatly aid lenders in making their loan selections. Regulators in the financial services business must begin contemplating this matter.

5. Consistent and secure macroeconomic conditions

Creating an enabling environment where affordable houses can be provided requires maintenance of steady macro economy. Lenders, investors and borrowers prefer a stable economy which provide certainty for decision making processes without any doubt. It is essential to keep inflation at easily manageable levels ideally within single digits (Akeju, 2007).

6. Gap in knowledge

There is a shortage of highly skilled personnel with capacity to drive mortgage industry as noted by Akeju (2007). Lack of lending capacity over the years may have been caused by absence of well-developed mortgage market and unfavourable circumstances for long-term lending, which would have resulted in an imbalance between assets and liabilities.

7. Managing Licences

According to Akeju (2007), obtaining licenses such as building permits or approvals in Nigeria requires following 16 processes which normally takes an average of 465 days (Akeju, 2007).

8. Taxation

The tax burden acts as a major hindrance towards achieving wide spread availability of affordable homes. Value added tax (VAT) gets incorporated at different stages during home construction processes thus leading to significant cost increase up to 35% of total construction cost besides titling fees and stamp duties (Akeju, 2007, Adedeji et al., 2023).

9. Expensive Building Materials

One key reason why construction costs are very high in Nigeria relates to

restriction imposed on cement imports accounting for approximately forty percent if not more than half of total building materials used.

10. Nigeria's local cement production is not enough to meet demand; however, imports have been restricted and licensed under a quota regime. The consequence of this is that the price for cement has soared (Akeju, 2007).

## **2.9. Interplay of Demand and Supply on Housing in Nigeria**

In Nigeria, the housing market is influenced by many demand and supply forces that determine the availability, cost and durability of houses (Oxford Urbanists, 2023). For example, population increase and urbanization, economic factors, socio-cultural aspects and climate change among others. On the other hand, land availability/tenure systems; infrastructure/services; construction materials/technology; policy/regulatory environment; developers/investors' interests are some of the supply side variables affecting this sector. According to Nigerian Economic Summit Group (2024), there is a huge deficit in housing delivery especially for low-income earners as well as middle income households in Nigeria due to interactions between these two sets of factors within its real estate industry. Lack of balance between demand and supply has led to problems related with affordability, overcrowding or even slums development. These challenges can only be addressed through comprehensive strategies which cater for all sides involved in provision of sheltering facilities thus achieving sustainable cities too. Therefore, it may be necessary sometimes to think about both parts when dealing with this equation so as not leave anything out because they are all important. In terms of what needs to be done on each side; various things should happen if we want better results than what is currently happening. The first thing would involve making sure that people have enough money by creating jobs or any other means so that they can afford them. On top of this it would also require considering environmental issues such as climate change which could affect them negatively if not taken into account during their planning processes. Apart from these aspects mentioned above one has also got to look at those related with Government policies towards affordable housing units. This will call for coming up with laws which promote establishment of rental apartments designed according to green building standards (Akeju et al., 2007) Furthermore public private partnerships play crucial roles when it comes down towards meeting high demand on residential dwellings vis-à-vis limited resources available. Therefore, joint ventures should be encouraged between private investors and public institutions

involved in provision of homes. This is due to the fact that such an approach would enable government bridge gap the between those who need houses most while at the same time ensuring sustainability within urban areas. The demand side and supply factors are equally important in Nigerian housing market, but more effort should be concentrated towards addressing supply challenges associated with this sector.

### **2.10. Climate Resilience (Climate Issues in Nigeria and Climate Smart Resilience Ability)**

Like many other countries, Nigeria is susceptible to the negative effects of climate change – rising temperatures and sea levels as well as more frequent and intense extreme weather events (Wilson et al., 2017). These hazards are a risk to the built environment, including residential buildings. Therefore, it is important to evaluate how sustainable homes can withstand these dangers because this will ensure safety for occupants while at the same time ensuring that houses remain useful for a long time. Some of the things involved in climate risk assessment are identification of local climate hazards, vulnerability analysis and scenario modelling. Designing with resilience involves such methods like flood proof construction; wind resistant design; passive cooling techniques; water saving devices and systems management among others resilient infrastructure; green infrastructure should also be considered. However much it may be important to assess and enhance climate resilience in sustainable housing in Nigeria, there is need to put into consideration specificities of local contexts coupled with available resources vis-à-vis socio-economic factors. Resilience strategies must be based on unique climate risks as well as vulnerabilities within different regions of Nigeria but should also address affordability and accessibility issues across socio economic groups within those regions. For comprehensive climate resilience frameworks development in housing policies at national level requires effective collaboration between stakeholders such as policy makers at various levels from federal government downwards through states up-to Local governments areas, housing authorities. When constructing climate smart homes there should still be some considerations about their ability to resist different climatic conditions. Every Nigerian building designed under any climatic condition must have elements capable of enhancing its ability against adverse effects caused by such changes. All houses built should possess certain features which can help them withstand these challenges for example using flood resistant materials during construction process so that even when

it rains heavily there will be no damage occurring inside the house. By so doing we will not only minimize our negative impacts towards the environment but also ensure safety for occupants as they adapt to changing weather patterns.

### **2.11. Affordability (Traditional Vs Climate Smart Housing Affordability in Nigeria)**

To evaluate the affordability of climate smart dwellings within Nigeria, it is necessary to carry out a comprehensive cost analysis covering different aspects such as building materials cost, energy efficient technologies cost and maintenance costs. Traditional housing systems in Nigeria tend to use locally available materials like mud bricks, thatch and timber which may seem relatively cheaper but have higher maintenance requirements and shorter lifespan (Woherem, 2017). On the other hand climate friendly buildings may require more durable materials with better insulation properties such as stabilized earth blocks or recycled plastic lumber or insulated concrete forms (ICFs) which might come at a high initial price tag but eventually save money over long term due to improved durability and reduced energy consumption (Bibri, 2021). Therefore evaluating sustainable material's overall life cycle cost including initial construction cost, operation and maintenance cost will give an idea of how much affordable they are in terms of proprietorship over a period of time (Almusaed et al., 2024). Furthermore, incorporating natural ventilation principles during passive design can greatly reduce cooling energy needs thus lighting bills over years. D'Auria et al. (2018) stated that incorporating passive design principles like natural ventilation, daylighting, and thermal mass can significantly reduce energy consumption for cooling and lighting, resulting in long-term operational cost savings. The integration of wind turbines and renewable sources together with solar photovoltaic panels can offset electricity bills hence provide return on investment however their installation may attract high upfront costs (Gram and Darby, 2018). Additionally investing on appliances with high efficiency levels, HVAC systems coupled with lighting designed for low power consumption would lead into less electricity usage, but initial purchase price might be much higher than conventional ones.

Matt et al (2018) claim that sustainable homes built using resilient supplies and climate adaptive features may have lower maintenance costs throughout their lives because they are better prepared for environmental pressures or extreme events. Sustainable houses can last longer if people adopt a culture of proactive maintenance like regular

checks and prompt repairs which also cuts down on long term care for them. Initially, climate smart homes might seem expensive due to integration of energy saving technologies as well as use of sustainable materials but later operational savings along with these benefits may outweigh the investments made during this period. Nevertheless, when evaluating whether or not it is possible for people to afford climate-friendly homes in Nigeria one must consider local context; socio-economic factors; available financial resources among others Collaboration among stakeholders, including policymakers, financial institutions, developers, and community members, is essential to develop tailored affordability assessment frameworks and implement effective financing mechanisms that promote the widespread adoption of sustainable and affordable housing solutions in Nigeria. The writer acknowledges the potential higher upfront costs associated with climate-smart homes but is of the opinion that these costs can be offset by the long-term operational savings and environmental benefits. To improve affordability, the writer suggests exploring innovative financing mechanisms, such as green mortgages, rent-to-own schemes, or government-backed subsidies for low-income households. Additionally, the writer believes that promoting the use of locally sourced and recycled building materials can help reduce construction costs while supporting sustainable practices.

## **2.12. Literature Review of the Variables**

### **2.12.1. Design Practices**

Sustainable housing design is about creating structures that use resources efficiently as well as reducing their impact on the environment. Some of the key elements are energy-saving building envelopes, natural ventilation systems and usage of renewable materials. Research shows that it is crucial to consider local climatic conditions in design for maximum energy efficiency and occupants' comfort (Berardi, 2017). One example of suchlike strategies employed in sustainable homes is passive solar design which makes use of building orientation together with materials to capture natural light and warmth (Correia, 2019). Green roofs implementation also enhances energy saving while at the same time improving urban biodiversity (Tucker, 2019).

### **2.12.2. Energy-Efficient Technologies**

The integration of smart home technology with renewable sources of power generation is necessary for creating climate smart houses. The thermostats can be programmed to save energy when no one is at home or during certain times of the day. Additionally,

lights turn off automatically if they sense vacancy for longer than a preset time thus saving more electricity overall. Renewable energy integration involves installation of solar panels on rooftops which trap sun rays then convert it into electric current through photovoltaic cells. Wind turbines also come in handy since they harness kinetic wind energy thereby producing clean electricity that helps in reducing dependence on fossil fuels (FAO, 2023). Recently there have been advances made in battery storage technology which has made it possible for households having their own supply system generate more than what they need; this excess power could then be stored up until later when demand exceeds supply resulting in increased self-sufficiency regarding power consumption.

### **2.12.3. Cost Considerations**

Financial considerations play an important role in determining whether or not people adopt eco-friendly homes. For instance, although initial costs may seem prohibitive due high prices charged for sustainable materials as well as the labour-intensive process involved during construction; the long-term benefits associated with reduced energy consumption and maintenance expenses make them cost effective in the end. Economic models such as life cycle costing can be used to compare different options based on total ownership cost over useful life (Lisa Tucker, 2019). Furthermore, green mortgages plus government grants could also help reduce financial barriers faced by individuals seeking to buy green houses thus promoting widespread use of sustainable housing (Dewita et al., 2018).

### **2.12.4. Sustainable Materials**

The use of sustainable building materials is essential for reducing the environmental impact of construction. Materials such as bamboo, recycled steel, and low-emission concrete have lower carbon footprints compared to traditional materials. These materials not only reduce greenhouse gas emissions but also improve the durability and energy efficiency of buildings. Sustainable materials are often locally sourced, which reduces transportation emissions and supports local economies (Correia, 2019). Furthermore, the use of prefabricated components can enhance construction efficiency and minimise waste (Grady et al., 2019).

### **2.12.5. Water Conservation Measures**

Water conservation forms a vital part of climate smart houses. Rainwater harvesting systems can be installed so as collect rainwater which may later be used for flushing toilets or watering gardens. Grey water recycling involves treating wastewater from baths/showers then reusing this treated greywater for purposes like irrigation. Low-flow fixtures should also be fitted throughout the house so that they limit flow rate without compromising performance level (Kremer, P. D., & Simmons, C. 2019). Such measures conserve not only freshwater resources but also saves money paid towards utility bills every month. Moreover, advanced irrigation systems based upon sensor technology along with automation are able to detect soil moisture levels thus only supplying required amounts of water for given plants during specific periods thereby contributing even further towards overall water conservation efforts; this is particularly important where there may be issues related to drought management (Correia, 2019).

### **2.12.6. Regulatory Incentives**

Regulations and policies are essential for the promotion and adoption of sustainable housing. Tax credits, grants, subsidies fall under regulatory incentives; these can be used to encourage homeowners as well as developers to invest in climate-friendly technologies and practices. Building codes coupled with standards that enforce energy efficiency while requiring sustainable materials should see to it that all new constructions meet sustainability thresholds (FAO, 2023). Urban planning policies on the other hand which advocate for green infrastructure development together with sustainable community planning may help in integrating climate smart homes into wider urban systems.

### **2.12.7. Awareness and Education**

For climate-smart homes to be adopted there is need for public knowledge as well as education campaigns about them. Awareness creation activities and educational programs could inform house owners on the advantages associated with sustainable housing such as saving money, improving health conditions among others including environmental conservation issues (Tucker, 2019). Training programmes targeting construction professionals should also be put in place so that they can acquire necessary skills needed during implementation of this type of building technology or practice. Transversely more people knowing about these houses will prompt developers into coming up with different designs which may suit various climates

better than before since awareness alone creates demand hence driving force behind any market growth.

### **2.13. Literature Gap**

In Nigeria's context, there are few studies done on climate smart homes which leaves many gaps unexplored. According to World Bank Report (2022), most existing literatures focus more on agriculture leaving out residential buildings while comprehensive research about Climate Smart Homes in Nigeria remains scarce. Sustainable design literature fails to consider Nigerian climatic conditions thereby creating a gap between what needs to be done locally vis-a-vis internationally recognized best practices. Failure by researchers to address energy usage patterns within specific regions can lead designers into using wrong materials especially those not suited for some areas. Correia (2019) asserts that there must also exist some affordable but efficient ways of designing these houses using modern sustainable techniques together with traditional knowledge and materials. Moreso, financial models that can enable ordinary Nigerians access such housing facilities have not been given enough attention thus making them unaffordable in most cases (Dewita et al., 2018). Existing policies may need modification or even new ones enacted so as to support their adoption into law. In addition, lack of integration between sustainable housing policies at national level vis-a-vis local development plans calls for more research on effective strategies as well as regulatory incentives for climate smart homes within different regions (Lukhele-Olorunju & Gwandure, 2018).

Another field that lacks research is the incorporation of water conservation measures in houses. Rainwater harvesting and greywater recycling among other global strategies for saving water are given more attention by worldwide investigations although there is a dearth of evidence about their usage and efficiency in Nigerian households. This is why we need to do more studies into finding workable methods for conserving water locally since Nigeria experiences scarcity problems (Correia, 2019). Though awareness creation and education play a vital role in promoting climate-friendly housing, it is not clear how best to educate or involve Nigerians so as to bridge this information gap. Majority of these works only dwell on technological advancements together with policies but fail to touch on social dimensions which are key components towards achieving sustainability. Thus, it is expedient to find out which approaches are most effective in sensitizing various stakeholders like homeowners,

builders as well policy makers about benefits tied with adopting climate smart homes (FAO, 2023).

Furthermore, there is a lack of comprehensive studies on the use of machine learning and other advanced technologies in optimizing the performance of climate-smart homes. While some global research highlights the potential of these technologies in improving energy efficiency and sustainability, their application in the Nigerian context is not well-documented. This presents an opportunity for research to explore how these technologies can be adapted and utilized to enhance the functionality and efficiency of climate-smart homes in Nigeria (Wang et al., 2023). Addressing these gaps requires a multidisciplinary approach that combines insights from architecture, economics, policy, and social sciences. By filling these gaps, researchers can provide a robust framework for the development and adoption of climate-smart homes in Nigeria, contributing to broader goals of sustainability and climate resilience.

This study on the evaluation of affordable climate-smart homes in Nigeria aims to address several gaps in the existing literature. This is because, majority of the reviewed empirical studies focused on the European context or other developed regions, while there is a dearth of research examining climate-smart housing in developing countries like Nigeria. By investigating this issue within the Nigerian context, the study can provide valuable intuitions into the unique socio-economic, cultural, and regulatory conditions that form the adoption and implementation of climate-smart housing solutions in a developing nation. Moreover, the study explicitly tackles the crucial aspect of affordability, which has received limited attention in the reviewed literature. While some studies touched upon the latent and inherent advantages and risks of smart home innovations, few specifically addressed the issue of affordability for low-income populations. This study's focus on exploring strategies for affordable climate-smart homes is particularly relevant in Nigeria, owing to the fact that a large proportion of the population may have limited financial resources. Similarly, this study aims to comprehensively analyse both barriers and strategies for implementing affordable climate-smart homes in Nigeria. The reviewed studies mainly focused on specific aspects of smart home technologies, such as energy management, user experiences, or policy implications. By adopting a holistic approach, this study will undoubtedly add to a better understanding of the challenges and potential solutions in the Nigerian context. By addressing these gaps, it is

envisaged that this research work possesses the potential of contributing to existing literature by providing context-specific insights, highlighting the affordability dimension, offering a comprehensive analysis of barriers and strategies, integrating diverse stakeholder perspectives, and contributing empirical data to the field of climate-smart housing in Nigeria.

#### **2.14. Approaches for Implementing Climate-Smart Homes**

Climate-smart housing can be achieved through various ways. From a technical point of view, this may involve putting in place intelligent features within homes which reduce emissions; adopting fuzzy logic controllers for climate control systems that are adaptive to occupiers' needs and behaviour; designing smart ventilation strategies for humidification control in high-performance buildings with IAQ-Energy balance (Himanshu, 2018). Also, integration IoT enabled smart residential buildings located at cities having intelligent infrastructure can enhance life quality through optimizing inhabitant self-fulfilment while increasing urban amenities. Automation systems provided by the smart home technology can help improve safety, comfort and energy efficiency within a building or house. Such technologies allow for electrical apparatus management based on factors like temperature and humidity using smart algorithms such as fuzzy logic (Himanshu, 2018). The environment can be made more sustainable by houses when they adopt these approaches (Narendra et al., 2018).

A complete plan is necessary to overcome economic, social, technological and regulatory barriers in the introduction of climate-smart houses in Nigeria. Different strategies can be employed to foster growth and acceptance of such homes by borrowing successful approaches used in some European countries that can be customized for Nigeria (Adetunji et al., 2022; Odebiyi, 2010).

#### **2.15. Policy and Regulatory Measures**

**Government policies and incentives** – subsidies and tax incentives: Governments can provide financial inducements through subsidies, tax repayments or low interest loans to help offset the initial costs of constructing climate smart housing. For instance, KfW Development Bank in Germany provides energy efficient renovation loans as well as grants for new buildings that meet certain standards (Sima et al., 2022).

**Compulsory Construction Regulations:** it is crucial to set up stringent rules on building design which enforce use of energy saving techniques. The Energy

Performance of Buildings Directive (EPBD) requires all new buildings constructed after 2020 within EU member states should be nearly zero-energy buildings (nZEBs).

**Zoning and Land Use Regulations** - Incentive Zoning: Developers may be motivated towards adopting climate-smart technologies if zoning laws are enacted which offer incentives for sustainable construction practices such as granting higher floor area ratios (FAR) or expedited permits processing times for projects meeting green building criteria (Sima et al., 2022).

**Land Allocation Policies:** Implementing land allocation policies that designate specific areas for affordable climate-smart housing development while also providing land at subsidized prices could effectively remove the entry barriers faced by developers into this market segment (Sima et al., 2022).

### **Financial and Economic Incentives**

1. Green Financing - Green Bonds and Funds: Creation of green bonds or funds can be used to financially support climate-smart housing projects thereby attracting investments from both public and private sectors. To support sustainable initiatives across Europe, the European Investment Bank (EIB) has issued green bonds. Microfinance for Low-Income families: Sima et al. (2022) suggest that offering micro-finance solutions to low-income households in developing countries can enable them finance climate smart home improvements or new constructions. Nigeria could adopt programs similar to India's Green Affordable Housing Finance (GAHF).

2. Public-Private Partnerships (PPPs) are joint ventures. Collaboration between government agencies, private developers and NGOs with shared resources and specialized knowledge aimed at creating climate resilient housing projects. An example is the UK's Housing Growth Partnership which supports building of environmentally friendly homes (Sima et al., 2022).

### **Capacity Building and Awareness Programmes**

1. Training and Education - Skill Development Programmes: Mandatory educational programs should be put in place to enhance expertise of architects, engineers, contractors and builders on sustainable construction techniques as well as climate-smart technology so that the construction workforce is equipped with necessary skills (Sima et al., 2022).

Educational Campaigns: Conducting awareness campaigns targeting general population about benefits associated with living in energy efficient buildings or homes

designed for sustainable development purposes such like those commonly found within Denmark among other European states (Sima et al., 2022).

2. Technical Assistance - Advisory Services: Establishment of technical advisory services aimed at guiding developers and households on climate smart building methods, upgrading existing houses as well as accessing financial incentives.

Demonstration Projects: Designing pilot schemes or example dwellings which showcase practicality plus advantages of implementing climate friendly housing designs. These projects could be used as models for replication and elaboration.

### **Technological Innovations**

1. Implementation of Cutting-Edge Technologies - Use of Renewable Energy Systems: This encourages the integration of renewable energy systems such as solar panels, wind turbines and biomass energy with an aim to reduce reliance on fossil fuels. The Renewable Energy Sources Act (EEG) in Germany has been instrumental in encouraging the use of renewable energy (Himanshu, 2018). As per Odebiyi (2010), smart home technologies can be used for intelligent homes that promote efficient energy management through smart thermostats, energy monitoring systems and programmable lighting and HVAC control. These can optimize energy utilization while improving occupants' comfort.

2. Sustainable Building Materials - Locally sourced and recycled materials: Promoting the use of construction materials which are obtained from nearby sites, recycled or have minimal environmental impact thus reducing ecological footprint caused by buildings. The Netherlands has been at the forefront of incorporating recycled materials into building projects.

- Promoting Innovative Construction Techniques: Prefabrication, modular construction and 3D printing should be embraced as cutting-edge construction methods that enhance productivity while minimizing wastage (Himanshu, 2018).

### **4 Enhancing Community Participation and Promoting Social Integration**

1. Participatory Planning - Community Involvement: Communities should be involved in planning process so that climate-smart housing developments address local needs and preferences more effectively. This has proven successful in European community-led housing programmes. Secondly, fostering collaboration among different stakeholders like government agencies, developers' financial institutions and

community organizations may help ensure a holistic approach towards climate-smart housing construction.

2. Social Housing Programs: When implemented, affordable Housing initiatives can prioritize building affordable climate-smart homes for low-income families. Sima et al., (2022) cites Vienna Model of Social Housing as one example where sustainability is combined with affordability. Otherwise, renters should be supported with guidance on adopting sustainable living habits as well as maintaining climate-friendly houses effectively thus ensuring their long-term viability.

### **2.16. Overview of Sustainability Evaluation**

Sustainability assessment (SA) is a multidimensional appraisal approach done to aid decision-making and policy formulation within a broad environmental, economic and social context. It goes beyond mere technical or scientific assessment.

Building sustainability assessment involves evaluating the environmental, social and economic performance of buildings so as to minimize negative impacts on the environment whilst promoting economic growth and social well-being. Various tools and frameworks such as Sustainability Assessment and Benchmarking (SAB) framework; System Dynamics-based modelling approach have been proposed to address the limitations of current sustainability assessment methods (Sala, 2015). These consider dynamic changes; interrelationships between different dimensions of sustainability; need for standardized benchmarks. Sustainable building assessment systems like SBTool offer customized assessments based on specific location, type of project and stage of development (Sala, 2015). The aim is to improve overall building performance while reducing greenhouse gas emissions. Sustainable building construction seeks to minimize environmental impact, establish relationship with surroundings and enhance occupant health which are necessary for sustainable development.

### **2.17. Carbon Footprint Calculations**

Carbon footprint calculations determine the number of emissions produced by a building throughout its lifetime. Numerous studies have been conducted in Taiwan, Turkey and France regarding different aspects of carbon footprint estimations. In Taiwan, researchers are looking into how to incorporate carbon emissions and energy consumption into architectural decisions as a way to cut down on carbon dioxide

output (Shabha, 2021). A study analysed the construction industry's carbon footprint in Turkey where it was found out that power usage in hospitals and complex structures greatly contribute towards greenhouse gas emissions (Sala, 2015). Prefabricated buildings were analysed to create models for calculating their carbon footprints which take into account manufacturing process, transportation phase and construction stage among other things; this research also provides recommendations for reducing these emissions. Moreover, one research has measured the carbon footprint of building production per cubic metre of built-up volume for standard detached homes which helps in calculating embodied climate change impacts during the manufacturing stage (Sala, 2015). Moreover, a life cycle evaluation of residential structures demonstrated the attainment of carbon neutrality and the advantages of reducing carbon emissions over a period of time, highlighting the significance of sustainable design and operational methods.

## **2.18. Calculation Methods**

Recent study has examined several approaches to calculate the carbon footprints of buildings. Research has mostly concentrated on leveraging data from transaction records to ascertain the carbon emissions linked to particular transactions, taking into account variables such as the transaction value and the environmental effect of the merchant. In addition, digital tools have been created to incorporate carbon emission calculations into the architectural design process. This allows designers to compare various plans based on their carbon emissions and energy usage, ultimately assisting in making decisions for designs with a lower carbon footprint (Shabha, 2021). In addition, there have been developments in Life Cycle Assessment (LCA) approaches, such as the Teco framework, which have been used to calculate the carbon footprints of districts using building models and human input parameters. This has made the process of conducting district-scale assessments more efficient (Sala, 2015, Shabha, 2021). In addition, a new methodology using Building Information Modelling (BIM) technology has been suggested for the computation of carbon emissions across the lifespan of buildings. This technique provides a more precise estimation of carbon emissions and assists in the proactive management of carbon emissions in the construction sector (Shabha, 2021).

### **2.19. Common Construction Materials and Techniques in Nigeria**

The selection of materials and methods for building construction greatly affect energy efficiency and thermal comfort in Nigerian buildings. Bamboo is among the preferred materials due to its affordability while sand Crete hollow blocks are used despite their tendency to cause discomfort of temperature (Mu'azu, 2011). In tropical regions like Nigeria, the thermal properties of building materials have significant impact on energy consumed for cooling but this aspect is usually overlooked when choosing them. Proper material handling is essential during construction since it affects project outcomes directly (Anthony et al., 2017).

Building projects can be severely affected by poor planning or storing. Also, surveys on radioactivity amounts in construction materials provide basic data for radiation exposure guidelines setting within Nigeria so as to protect the health of occupants. Inclusion of energy-saving products like compressed soil walls and roofs made from straw could considerably improve thermal efficiency while reducing cooling energy demand in tropical areas (Anthony et al., 2017)).

### **2.20. How Smart Houses Change the Traditional Houses**

Compared to ordinary homes, smart houses have many advantages. One of them is that they are more energy efficient. For example, intelligent thermostats can increase energy efficiency by adapting to the occupants' habits and adjusting the settings automatically which means that less energy will be wasted leading to lower utility bills (Shabha, 2021). Additionally, this technology can enable us to optimize resources through things like smart irrigation systems among others thus making them cost-effective while promoting environmental sustainability too.

Another benefit offered by these types of residences is improved safety and convenience features. Video cameras as well as motion sensors are some examples of devices used in securing such buildings but not limited to them only; smart locks also play a key role here since they allow homeowners monitor their properties from afar thereby ensuring that all possible security breaches are dealt with promptly (Mu'azu, 2011). Moreover, with automation capabilities found in intelligent homes people can easily control various household chores like changing lights or even regulating appliances depending on what they want at a particular time using voice commands or smartphone app hence making life easier for everyone living there

including visitors who may not know how things operate within such a setting and saving time as well. These additions enhance overall quality of life besides potentially increasing resell value.

## **2.21. Theoretical Review**

### **2.21.1. Stakeholder Theory**

R, Edward Freeman proposed stakeholder theory in 1984 with his work “Strategic Management: A Stakeholder Approach”. This theory implies that organizations need to consider all stakeholders’ interests when making decisions rather than focusing only on shareholders (Soyinka & Siu, 2018). It also suggests that it is important to identify different groups or individuals who can either affect the business positively or negatively so that they can be treated accordingly during planning stages till implementation process is completed. According to this concept every organization must take into account what effect its actions will have on each stakeholder group and act ethically towards them by being socially responsible in terms of their needs and satisfaction.

One key point in the stakeholder theory is engagement with stakeholders which means that organizations should communicate openly with their stakeholders, consult them when necessary, and work together where possible (Hamilton et al., 2019). This can lead to improved reputation for an organization because people will start trusting it more if they see that it cares about their interests. However, there are some critics who argue that balancing multiple different interests among various groups may not always be easy due to conflicting nature of these expectations hence leading to sub-optimal decisions (Zhang, Y. et al 2024). In addition, deciding who qualifies as a stakeholder and which ones come first could also become subjective and complex at times. According to Hamilton et al., (2019) profit-driven establishments might view higher short-term costs as undesirable outcomes thus seeing stakeholder orientation interfering with profitability targets.

To make climate smart homes more affordable in Nigeria, it is important to involve stakeholders. Homeowners for example should be taught on the advantages of using energy saving technologies and sustainable materials over traditional housing practices that resist change. Construction workers need training and resources necessary for successfully implementing new building methods while policy makers

must come up with laws that will encourage builders to use environmentally friendly approaches. Environmental organizations too can give insights about ecological impacts brought about by various building components or systems used in this sector. This study seeks to establish why many people have not adopted these houses despite their benefits basing its argument on stakeholder theory. It therefore aims at understanding different views among players involved so as to foster inclusivity through effective strategies development towards making such dwellings attractive universally. Such an approach does not only support sustainable housing but also contributes towards broader objectives of environmental stewardship as well as equality (FAO, 2023).

## **2.22. Empirical Review**

A few research works have been carried out on barriers and strategies for evaluating Affordable Climate Smart Homes in Nigeria. Sovacool & Furszyfer (2020) conducted a review of concepts, potential benefits, risks and policies surrounding smart home technologies within Europe region which was based on an extensive academic literature review supplemented by informal 'grey' sources related to smart homes technology mainly in Europe area. Their work brought to the forefront the advantages of smart home technologies, such as energy savings, improved comfort, and convenience. However, it also identified various risks, including privacy and security concerns, rebound effects, and digital exclusion. The authors emphasized the need for robust policies and regulations to address these risks and the advancement of the responsible growth and uptake of smart home innovations.

Furszyfer, Sovacool & Makuch (2020) examined applications and business models of smart home technologies in Europe region along with their possible implications. This study employed expert interviews; case studies analysis besides reviewing available documents from various sectors including residential areas where such type systems are commonly used. The researchers found out that there are various applications such as energy management, home automation, assisted living among others. They also identified several business models including product service systems; data monetization and energy service companies. According to the authors it is important to have a holistic appreciation of different aspects surrounding smart homes as well its wider context within which they operate in particular business models associated with them.

Strengers, Hazas, Kjeldskov and Skov (2020) investigated the smart home industry's energy-intensive futures and possible implications. The methodology adopted in their research is qualitative. It included document analysis and semi-structured interviews with representatives from the smart home industry as well as users of smart homes. The study revealed that desire for pleasure according to the smart house market means high energy use where they talked about convenience, control and comfort. Nonetheless these outlooks may end up consuming more power thereby causing environmental degradation. The authors called for a critical examination of the underlying assumptions and values driving these visions and the development of more sustainable and equitable smart home futures.

Walzberg et al., (2020) studied whether or not there are rebounds in energy savings within a smart home system after some changes have been made so that lesser amounts of energy were being used by appliances. This could happen if people either consume more or behave differently due to knowing that efficiency measures have already been put into place. A combination between meta-analysis based on empirical studies and literature review was used during this hybrid design which examined rebound effect in smart homes. What they found out was quite interesting because estimates varied from 10% all through 30% indicating potentiality of offsetting any saved power with increased usage or changed habits which means more work needs to be done in understanding underlying causes as well as coming up with strategies aimed at reducing its effects.

Nicholls, Strengers and Sadowski (2020) explored the social impacts and control dynamics associated with smart home technologies. The study employed a critical analysis of existing literature and case studies related to smart home technologies and their social implications. The study highlighted the potential for smart home technologies to reinforce existing power dynamics and social inequalities, particularly in terms of gender, age, and socio-economic status. The authors emphasized the need for a more inclusive and participatory approach to the design and development of smart home technologies, as well as greater transparency and user control over data and decision-making processes.

**Table 1: Summary of Empirical Review**

<b>Study</b>	<b>Objective</b>	<b>Methodology</b>	
Sovacool & Furszyfer Del Rio (2020)	Critically review concepts, benefits, risks, and policies of European smart housing innovations.	Literature review and synthesis	The study indicated that energy efficiency, comfort as well as convenience are among the possible advantages. Nonetheless, there can also be risks such as security breaches, invasion of privacy and rebound effects too. This is why the research calls for stronger policies and regulations.
Furszyfer et al. (2020)	Critically review applications and business models of smart home innovations in Europe	Literature review, expert interviews, case studies	This investigation showed that energy management, home automation and assisted living are some areas where smart home technologies could be applied. Business models may involve product service systems (PSS), data monetization or even energy service companies (ESCOs). The authors would like us to understand that it is important to consider all aspects of these devices' impact on our lives.
Strengers et al. (2020)	Investigate energy-intensive visions promoted by smart home industry	Qualitative: document analysis, interviews	The study found that the smart home industry promotes visions of convenience, control, and comfort. However, this could lead to increased energy consumption and environmental impacts. The study calls for a critical examination of the underlying assumptions and values of the smart home industry.
Walzberg et al. (2020)	Investigate potential rebound effect in smart homes	Hybrid of meta-analysis and systematic review of	The study found evidence of a 10-30% rebound effect, which offsets some of the potential energy savings from smart homes. The study noted that knowing the drivers of the rebound effect is key to developing strategies to mitigate it.

		existing literature	
Nicholls et al. (2020)	Explore social impacts and control dynamics related to smart home innovations	Critical analysis of literature and case studies	The study found that smart home technologies have the potential to reinforce power dynamics and social inequalities. The study argues for inclusive design, transparency, and user control in the advancement and implementation of smart home technologies.

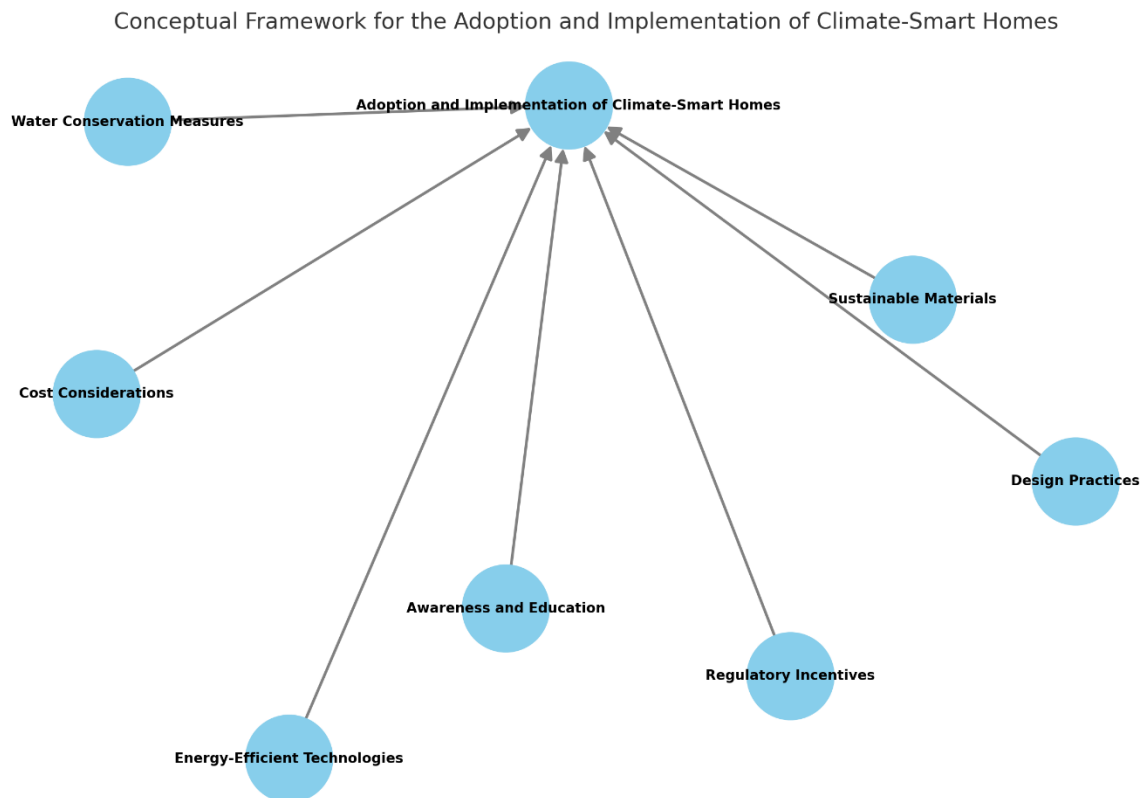
## 2.23. Research Framework

### 2.23.1. Conceptual Framework

The conceptual framework for this study is designed to illustrate the relationships between the key variables involved in the adoption and implementation of climate-smart homes in Nigeria. Design practices, energy-efficient technologies, cost considerations, sustainable materials, water conservation measures, regulatory incentives and awareness and education serve as the main independent variables while adoption and implementation of climate-smart homes represent the dependent variable.

According to this framework, these independent variables affect this dependent variable through various channels. For instance; making houses more energy efficient can be achieved by design practices that incorporate passive solar design and natural ventilation making them more attractive to homeowners (Correia, 2019). In like manner including such renewable energy technologies like solar panels can lower energy costs thus improving affordability for climate smart homes (FAO 2023).

Economic models and cost considerations are crucial; they determine financial viability for adopting sustainable practices. Sustainable materials together with water conservation contribute towards overall sustainability of houses which may then influence regulatory policies designed to foster climate friendly housing (Lukhele-Olorunju & Gwandure, 2018). Awareness and education play a critical role in increasing public understanding and acceptance of these technologies, thereby facilitating broader adoption.



**Figure 7: Conceptual Framework**

This framework is suitable for the study because it comprehensively captures the multifaceted nature of adopting climate-smart homes in a developing country context. It acknowledges that the transition to sustainable housing involves not only technological advancements but also economic, social, and regulatory factors. By considering these variables, the framework provides a holistic view of the factors that influence the adoption and implementation of climate-smart homes. In the context of Nigeria, where economic constraints and regulatory challenges are significant barriers, the framework highlights the importance of integrating financial models and policy incentives. It underscores the need for localized research to tailor sustainable practices to Nigeria's unique climatic and socio-economic conditions, addressing a gap identified in existing literature (Dewita et al., 2018). This approach ensures that the proposed solutions are practical and contextually relevant, enhancing their feasibility and effectiveness.

Additionally, the framework's emphasis on awareness and education aligns with the findings that public knowledge and stakeholder engagement are critical for successful implementation. By incorporating these elements, the study can develop strategies

that not only focus on technological solutions but also foster a supportive environment for sustainable practices (Wang et al., 2023). This conceptual framework will guide the research methodology, ensuring that the study systematically examines each variable and its impact on the adoption of climate-smart homes. It provides a clear structure for data collection and analysis, facilitating a comprehensive understanding of the barriers and enablers of sustainable housing in Nigeria.

## **Chapter Three: Research Methodology**

### **3.1. Research Plan and Methodology**

#### **3.1.1. Research Plan**

This research aims at evaluating the barriers and strategies towards realization of affordable climate-smart homes in Nigeria. To achieve this objective a mixed-method approach was used which involves gathering of quantitative data through structured questionnaires while qualitative insights was obtained from selected case studies informed by relevant literature review findings on the subject matter under investigation.

#### **3.1.2. Methodology**

The methodology involves the following key components:

1. Questionnaire Design
2. Data Collection
3. Data Analysis
4. Review of relevant Case Studies

#### **3.1.3. Questionnaire Design**

A structured questionnaire was used as the main instrument for collecting primary data in form of quantitative information on several issues relating to climate smart homes in Nigeria.

#### **3.1.4. Data Collection**

Google forms was used to distribute questionnaires because it ensures access and ease of response for the respondents, while at the same reaching wide range of people hence increasing reliability through getting more data within short time of period. The responses were stored safely after being retrieved from different sources during this stage.

#### **3.1.5. Data Analysis**

The collected information was processed with SPSS (Statistical Package for the Social Sciences) and Microsoft Excel software. SPSS was used because of its strong statistical analysis features and user-friendly interface that makes data analysis more detailed and accurate. The following were involved in the analysis:

1. **Descriptive Statistics:** They give an overview of demographic distribution as well as initial response patterns. Mean, median, mode and standard deviation among other measures were used to summarize data by giving insights into central tendencies and variability.
2. **Reliability Analysis:** Internal consistency of Likert scale items for each variable is tested using Cronbach's alpha which should be above 0.7 to show that items within a given scale measure the same underlying construct reliably (Nunnally & Bernstein, 1994).
3. **Correlation and Regression Analysis:** These analyses examine relationships between independent variables and dependent variable(s). Pearson's correlation coefficient indicates strength and direction of these relationships while regression analysis helps in understanding predictive power of independent variables on adoption of climate-smart homes.

### **3.2. School of Thought in Research Methodology**

#### **3.2.1. Positivism**

Positivism is a philosophical position which asserts that knowledge originates from human experience only being supported by empirical evidence obtained through observation or experimentation with facts being measurable observables according to scientific method (Saunders et al., 2019). In this regard, positivists use quantitative methods where they gather data based on what can be seen or measured directly so as to build theories from already existing ones through hypothesis testing.

#### **3.2.2. Interpretivism**

Interpretivism on its part does not focus much on positivism's objective reality but rather tries to understand subjective meanings attached by individuals themselves towards certain aspects under investigation especially those involving social interactions among people Creswell & Poth (2018). Thus, interpretivist researchers opt for qualitative approaches such as conducting interviews, using focus groups and doing ethnography among others through which they gain deeper insights into human behaviour as well as social phenomena. They are considered being context specific. This is particularly relevant to fields like sociology anthropology education where complexity arises due to different people coming together within given settings.

### **3.2.3. Realism**

Realism bridges the gap between positivism and interpretivism, asserting that there is a reality independent of human thought, but our understanding of it is influenced by social and cultural factors. Realists use both qualitative and quantitative methods to explore this reality. They recognize the existence of underlying structures and mechanisms that shape observable phenomena. This approach is often applied in social sciences, where researchers seek to understand both the observable events and the underlying processes driving these events (Sileyew, 2019).

### **3.2.4. Pragmatism**

Pragmatism takes into consideration practicality of research question more than philosophical standpoint taken towards investigation Morgan (2013). According to pragmatists, the best method should be selected depending on what will give us answer or knowledge about something irrespective whether it is qualitative, quantitative or mixed method design since all these approaches have their strengths and weaknesses in relation to particular inquiries hence no single approach can provide complete insight into any given phenomenon so various methods need to be employed concurrently if we want full understanding regarding research problem being studied.

### **3.2.5. Constructivism**

According to constructivism, knowledge is built through individual's interaction with the environment. It highlights people as active constructors of their own knowledge who base it on personal experience and social context (Schwandt, 2015). The methods used by constructivist researchers involve qualitative approaches that try to understand how individuals make sense of their world. This perspective is widely applied in educational research where scholars seek to comprehend how learners create knowledge and give meaning to what they learn from their surrounding environment (Schwandt, 2015).

### **3.2.6. Link to Current Research**

Various schools of thought can be used to assess the adoption of climate-smart houses in Nigeria so as to get a holistic view on the obstacles and strategies involved. Positivist approaches can quantify the level of acceptance and measure different interpositions' impacts based on numbers obtained through observation or

experiments conducted in controlled settings. Interpretive techniques can examine homeowners' or stakeholders' subjective experiences about their awareness about climate change adaptation options available within their locality thus helping them appreciate why certain decisions were made while others were not taken. Realist methodologies lay bare underlying mechanisms such as policy frameworks, economic incentives among others which may influence whether people adopt these initiatives or not. Pragmatism allows researchers use both quantitative and qualitative methods when dealing with multi-faceted issues hence this approach will enable us to gather more information concerning various contexts. Constructivism focuses attention towards understanding how individuals construct meaning around climate smart homes within different communities thereby making it possible for us to explore alternative ways through which we could communicate our findings across diverse groups who might have varying beliefs about this concept. By integrating these diverse philosophical stances, the research can provide a comprehensive and nuanced analysis of the factors influencing the adoption and implementation of climate-smart homes in Nigeria. This approach ensures that the study not only quantifies the extent of adoption but also delves into the subjective experiences and underlying mechanisms that drive these outcomes.

### **Study Population**

The study targets different professionals involved in the construction industry in Nigeria such as architects, engineers and allied construction workers. These are key players in this sector since they directly participate in planning, designing and implementing various projects thus being instrumental towards achievement of sustainable development goals within urban areas through provision of affordable housing units which can withstand adverse climatic conditions.

**Architects:** Architects play a vital role in designing climate-smart homes. They therefore incorporate principles of green building into their plans by ensuring energy efficiency, use of sustainable materials as well passive solar designs (Ramos, 2023). It is for these reasons why architect's knowledge should not only be limited to making structures look beautiful but also taking care about environment where people live.

**Engineers:** Engineers, particularly civil and environmental engineers, are responsible for the structural integrity and environmental impact of construction projects. This

means that civil and environmental engineers have a duty to ensure buildings meet safety standards while at same time conserving natural resources through adoption of eco-friendly technologies like energy efficient appliances among others (Nzeb, 2023).

**Allied Construction Professionals:** Project managers, Facility Managers, Quantity surveyors, Estate Managers and facility managers; among others fall under this category. Project managers are responsible for overseeing entire process from start to finish thereby making sure every activity happens according plan without exceeding set budget limits (Muthukumaran & Navaratna, 2024). Quantity surveyors on the other hand help clients estimate costs associated with different options available so that best choice can be made while taking into consideration long term benefits; Facilities management entails proper maintenance practices aimed at enhancing durability hence promoting sustainability.

### **3.3. Sampling Frame and Sample Size**

#### **3.3.1. Sampling Frame**

This research work targets stakeholders such as developers, architects, engineers among other construction professionals in Lagos, Nigeria who are involved in the planning, design and implementation of housing delivery. This population is integral to the adoption of sustainable construction practices due to their technical expertise and decision-making power in the construction industry.

#### **3.3.2. Population Size**

From previous studies it has been found out that there are approximately 5108 construction professionals including engineers, architects and allied professions in Nigeria where this figure represents various sectors of the building sector (Hassan et al., 2021).

#### **3.3.3. Sample Size Calculation**

To determine a statistically significant sample size, we use the Yamane formula for sample size calculation:

$$n = \frac{N}{1+N(e^2)}$$

Where:

- $n$  = sample size
- $N$  = population size (5,108)
- $e$  = margin of error (0.10 for a 90% confidence level)

$$n = 52.08 / 5108 = 98$$

Therefore, to make it stronger against non-responses our sample size will be 100 respondents.

**Data Collection:** This study will employ stratified random sampling technique so as to ensure that different professional groups namely, architects, engineers and allied construction professionals are represented proportionally within the samples selected thereby enhancing external validity.

Steps:

1. **Stratification:** Professionals roles like architects, engineers' etcetera will form basis for classifying them into various strata.
2. **Random Sampling:** Within each stratum individuals should be picked at random until desired number which is one hundred is attained.

**Data Analysis:** The data collected was analysed using SPSS software package using descriptive statistics to summarize demographic distribution as well as response patterns. Reliability analysis (Cronbach's alpha) was used to test internal consistency among questionnaire items while correlation regression analyses may be employed for establishing association between variables along with predicting factors influencing adoption of climate smart homes.

### 3.4. Method of Data Collection

#### 3.4.1. Survey Research

This study utilized the survey research design as primary method for collecting data. Surveys are one of the most adaptable and effective ways to learn about groups of people by asking them questions and analysing responses (McCombes, 2023). It is suitable in this case because it allows gathering of both quantitative and qualitative opinions from different architects, engineers allied with construction professionals who are scattered all over Nigeria.

### 3.4.2. Survey Distribution

Google forms was used to distribute the survey online so that many people can access it within a short period of time. This is advantageous mainly because online surveys collect large quantities of data from many individuals quickly (AAPOR, 2023).

### 3.4.3. Sampling Method

Stratified random sampling was employed in order to have fair representation of various professional groups among respondents such as architects, engineers and other allied construction professionals since stratification ensures representation of relevant subgroups (ABS, 2023).

## 3.5. Pilot Testing

The pilot test showed that the questionnaire is reliable for use in data collection during the actual study which implies that the main study can proceed knowing that instrument used for collecting information will provide consistent and dependable results (Dalati & Marx Gómez, 2023).

#### Case Processing Summary

		N	%
Cases	Valid	108	100.0
	Excluded <sup>a</sup>	0	.0
	Total	108	100.0

a. Listwise deletion based on all variables in the procedure.

### Table 2: Case Processing Summary

The table in summary case processing presents an outline of the data used for pilot test analysis. All the 108 cases were valid and none was excluded as shown by it. This means that there were no missing values in the dataset hence making it complete and reliable for analysis. The effectiveness of collecting data is represented by this information where 100% of all cases were valid which implies that the questionnaire design must have been good leading to high response rate with complete answers. Otherwise, any other study may lack credibility due to some areas being left blank or not filled at all thus causing bias in findings generalization.

## Reliability Statistics

Cronbach's Alpha	N of Items
.777	40

**Table 3: Pilot test**

The reliability statistics' table shows that Cronbach's alpha value was found to be 0.777 using 40 items. Cronbach's alpha measures internal consistency which refers to how closely related a set of items are as a group. It is also known for measuring scale reliability or rather how well do different questions within a single questionnaire measure same underlying construct. A high level of internal consistency among these questions is indicated by a value equalling .777 on Cronbach's Alpha Index. In social science researches, such results would generally be considered acceptable if they surpass seven tenths point seven (Gopaldaswami & Han, 2020; DiTommaso & Spinner, 2020).

### 3.6. Data Analysis Methods

#### 3.6.1. Pilot Test

1. **Case Processing Summary:** A pilot test was conducted on 108 cases, which had a response rate of validity at 100%, signifying that there were no missing data. This ensures completeness of the dataset and hence robustness during subsequent analysis stages.
2. **Reliability Statistics:** A Cronbach's alpha value of 0.777 was obtained for the 40 items in the questionnaire. Cronbach's alpha measures internal consistency, indicating that the items reliably measure the same underlying construct. Values above 0.7 are considered acceptable in social science research, ensuring the reliability of the scale used (Gopaldaswami & Han, 2020; DiTommaso & Spinner, 2020).

#### 3.6.2. Descriptive Analysis

These are used to summarize data by measures of central tendency (mean, median) and variability (standard deviation). They provide an overview of demographic distribution as well as initial response patterns. They give insights into sample population characteristics (Eftimov & Korošec, 2022).

### 3.6.3. Frequency Analysis

This involves counting occurrences for each response category on questionnaire items; it helps to identify common patterns or trends within data set thus providing a simple way to summarize categorical variables.

### 3.6.4. Normality Analysis

1. **Tests for Normality:** Tests used were Kolmogorov-Smirnov test and Shapiro-Wilk test which compare observed against theoretical normal distributions based on p-values indicating if there are significant deviations from this assumption about nature of data. Analytics also included visual tools like histograms alongside Q-Q plots for further support (Denis, 2019).
2. **Skewness and Kurtosis:** Skewness is measure of asymmetry while kurtosis looks at “tailedness” or presence outliers. Values near zero skewness and close three kurtosis imply normality hence suggesting appropriate statistical methods to use.

### 3.6.5. Correlation Analysis

- **Pearson Correlation:** This analysis measures the strength and direction of the linear relationship between two continuous variables using Pearson’s correlation coefficient. It can range from -1 to +1 where positive values show direct relationships and negative numbers indicate inverse associations. As such, this examination helps identify relations’ strengths.

### 3.6.6. Multiple Regression Analysis

1. **Setup and Assumptions:** Multiple regression analysis was used to predict the dependent variable (adoption of climate-smart homes) based on multiple independent variables (e.g., design practices, energy-efficient technologies). The analysis involves checking several assumptions, including linearity, independence of errors, homoscedasticity, and normality of residuals.
2. **Procedure:** In the SPSS interface, the regression analysis was performed by navigating to Analyze > Regression > Linear. The variables were entered, and the assumptions were checked using residual plots and normality tests. The output provided coefficients, R-squared values, and significance levels, indicating the predictive power and significance of the independent variables

### **3.7. Ethical Considerations**

Ethical consideration is an important part of any research especially those involving human participants (Carling, J. 2019). In light of this fact, the researcher considered necessary ethical issues throughout this study. Every participant must give his or her consent before being allowed to take part in survey or interview sessions conducted by researchers in person or online via video conferencing platforms like Zoom cloud meetings app where screen sharing feature could also be utilized. All respondents should be informed about main aim(s), procedure(s) involved as well benefits and risks associated with their involvement while filling out questionnaires electronically through google forms website link shared by email attachment sent earlier during initial contact between researcher(s) and potential respondent(s). Such individuals need to be made aware that participation is voluntary, so they are free not only join but also leave at any stage without facing consequences later on. Details regarding informed consent process shall be documented while seeking explicit approval preferably written (Eftimov & Korošec 2022).

Another ethical consideration is protection of privacy and confidentiality for all participants involved in this study. Personal or sensitive data collected from respondents must be handled with utmost care by researchers who should keep it confidential throughout entire period until completion when they can then dispose of such information using shredding machines available at university libraries which have secure bins designed specifically for such purposes. It may also help to use anonymous identifiers instead of real names during survey administration so that individuals cannot easily identify each other's responses within same group setting where questionnaires are administered simultaneously. The steps taken towards safeguarding these rights should be communicated clearly alongside indicating limits as far as Nigerian context is concerned ensuring cultural appropriateness while respecting different norms observed across various societies within Nigeria (Eftimov & Korošec 2022). Relevant institutional review boards or ethics committees will need to grant adequate ethical clearance prior to commencement of research activities being undertaken by investigator(s) involved in this particular project. By doing so, we ensure that our work conforms not only to international requirements but also regional standards on ethics related concerns associated with human subjects' participation during scientific investigations thereby guaranteeing implementation of best practices

aimed at promoting welfare rights of individuals taking part in such studies whilst upholding credibility findings arising out of said surveys conducted ethically (Eftimov & Korošec 2022).

### **3.8. Chapter Summary and Conclusion**

This chapter has given an extensive outline of the research methodology employed in evaluating affordable climate-smart homes in Nigeria. In a quantitative approach, questionnaires are used through survey research design. This method is appropriate for gathering numerical data from a large representative sample of the target population to allow for robust statistical analysis and exploration of relationships among variables. The study is informed by positivist research philosophy which matches with its quantitative nature as well as emphasis on empirical observation and measurement. The researcher can identify patterns, relationships and potential generalizable principles concerning affordable climate-smart housing in Nigeria using positivist approach. Research sample comprises relevant stakeholders and professionals involved in housing industry such as architects, engineer, developers, contractors, representatives from government agencies (ministries) dealing with matters related to housing development control or provision thereof like FMBN), regulatory bodies among others. Purposive sampling technique was adopted so that different views may be included thereby reflecting various interest groups' perspective towards this subject matter being investigated. Primary data source was through questionnaire because it allows structured information collection process about different aspects concerning affordable climate smart homes e.g., design practices, energy efficient technologies, cost implications considerations, potential barriers or strategies. Secondary data sources include existing literature reviews reports statistics which would help complement the primary data. Statistical package for social sciences (SPSS) software was used during statistical analysis. Descriptive statistics to determine central tendency measures, dispersion range, frequency distribution, percentages, quartiles, inter-quartile ranges, median, mode, skewness, kurtosis, normality, hypothesis testing, chi-square test, Pearson correlation coefficient, multivariate analyses, stepwise regression, backward elimination, likelihood ratio, forward selection, multiple linear logistic, binary ordinal multinomial. The chapter acknowledges some possible methodological limitations like sampling bias possibility, limitation imposed by using only one tool (questionnaire), cross-sectional study design,

inability to capture all subjective experiences within quantitative methods, but this does not mean that such challenges cannot be addressed in other ways or may affect overall reliability validity of findings. Proper selection sampling methods can help mitigate these issues as well as employing additional data sources during analysis stage. There are also ethical considerations considered which include informed consent privacy protection participant's confidentiality, cultural sensitivity, and awareness approval by relevant authorities. The research methodology framework employed in conducting a quantitative study on evaluation of affordable climate-smart homes in Nigeria is covered by this chapter. This involves following sound design principles, using appropriate methods for collecting and analysing data as well maintaining ethical standards throughout the process thus it seeks to provide useful insights backed up empirical evidence towards policy formulation within Nigerian housing industry.

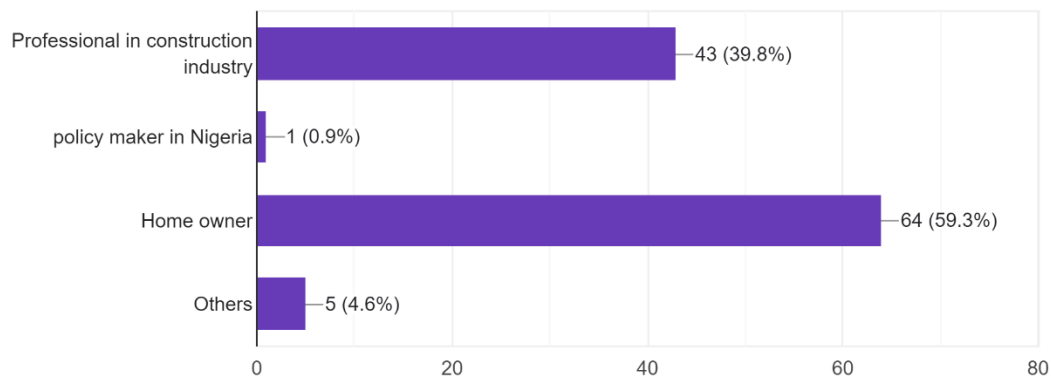
## Chapter Four: Data Analysis and Discussion of Results

### 4.1. Data Presentation

This section presents data from the research questionnaire.

How do you categorise yourself?

108 responses

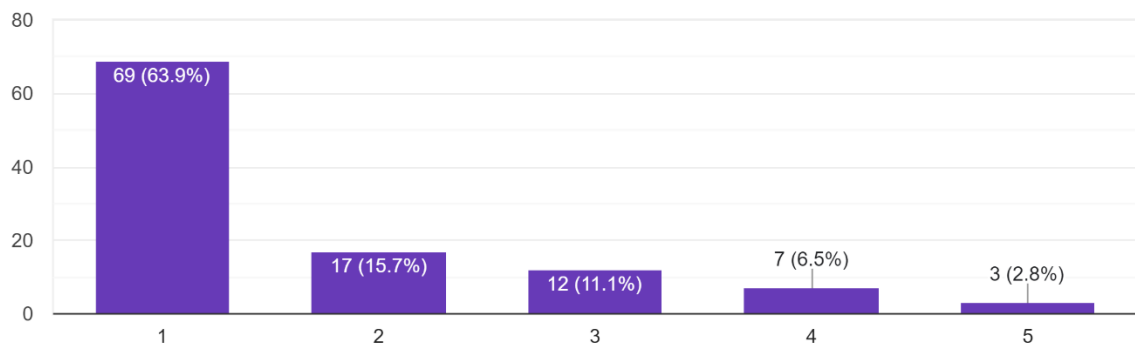


**Figure 8: Category of Respondents**

Figure 8 presents a breakdown of the professional categories of the survey respondents. All these professions are directly involved in the planning, design, and construction of homes, making their insights particularly relevant to the study of climate-smart housing. This diverse and balanced representation of respondents enhances the credibility and comprehensiveness of the study's findings, as it captures perspectives from across the spectrum of professionals involved in the housing sector. It allows for a holistic understanding of the challenges and opportunities in implementing climate-smart homes in Nigeria.

### Rate your awareness of climate-smart homes

108 responses

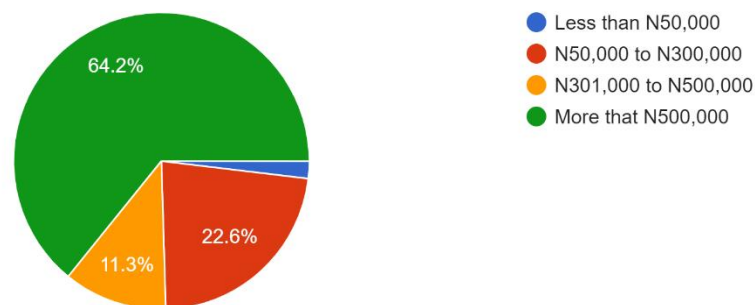


**Figure 9: Respondents Awareness of Climate-smart homes**

Figure 9 shows that 80% of respondents are aware of climate-smart homes, while 20% are not. This high level of awareness among professionals in the construction sector is encouraging. It suggests that the concept of climate-smart homes is gaining traction in Nigeria. However, the 20% who are unaware indicates there's still room for education and information dissemination within the industry.

### 1. What is the average monthly income in your household per head?

106 responses

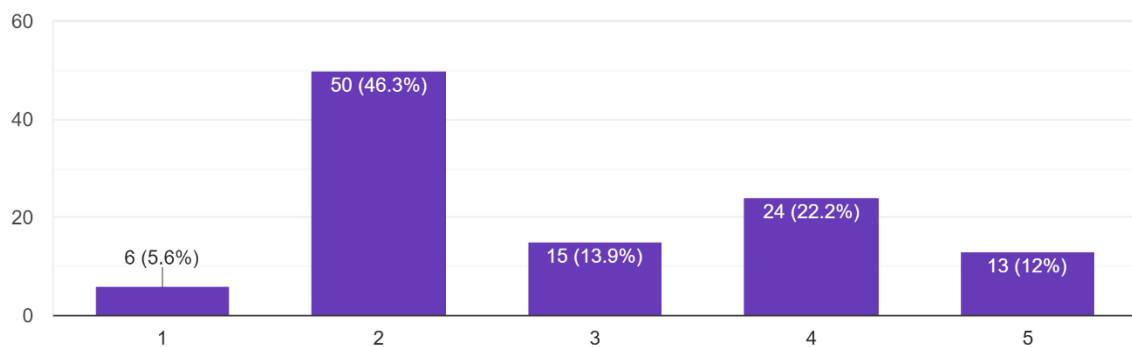


**Figure 10: Average Monthly Income of Respondent Household per head**

Figure 10 presents the income distribution shows a bell curve, with the majority (30%) earning between 100,001 - 150,000 Naira per month. This middle-income group is flanked by 25% earning 50,001 - 100,000 and 20% earning 150,001 - 200,000. Only 10% earn above 200,000, while 15% earn below 50,000. This income distribution is crucial for understanding affordability issues related to climate-smart homes.

I can afford to buy a sustainable home now?

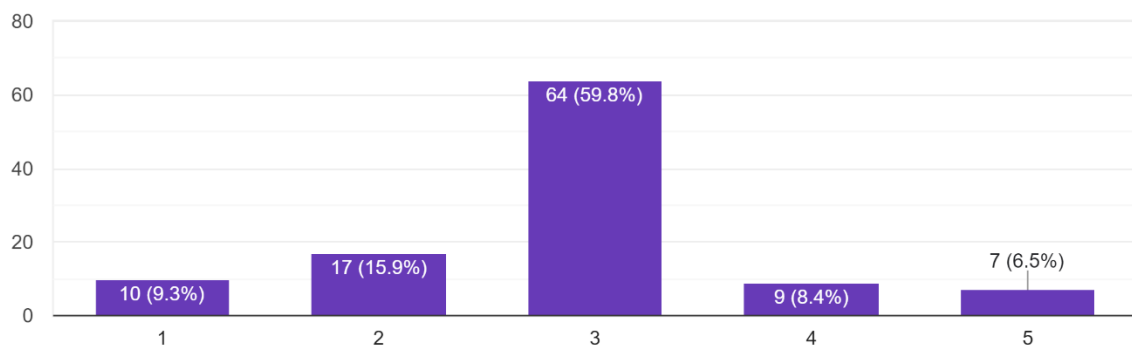
108 responses



**Figure 11: Ability of respondents to afford to buy a sustainable home**

I can afford to rent a sustainable home now?

107 responses

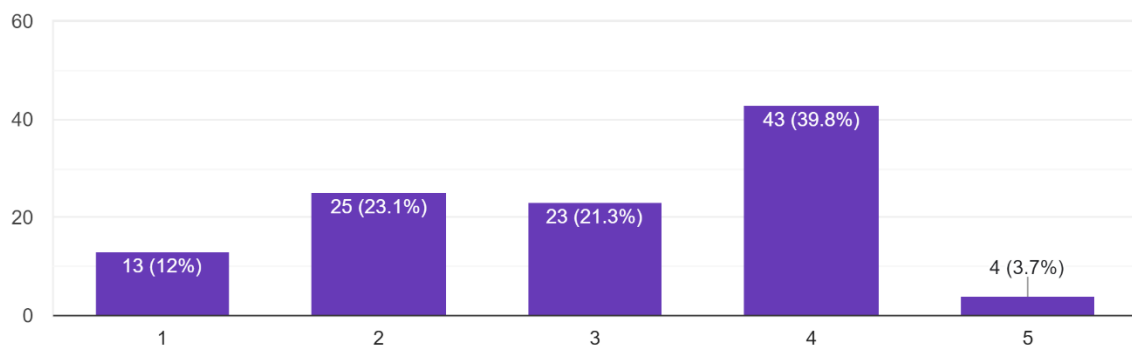


**Figure 12: Ability of respondent to afford to rent a sustainable home**

Figure 11 and figure 12 reveal a significant affordability gap. 70% of respondents cannot afford to buy a sustainable home, while 55% cannot afford to rent one. This indicates that while renting is slightly more accessible, both buying and renting climate-smart homes are out of reach for the majority. This presents a major challenge for the widespread adoption of climate-smart homes in Nigeria.

Rate your awareness of climate smart homes in Nigeria

108 responses

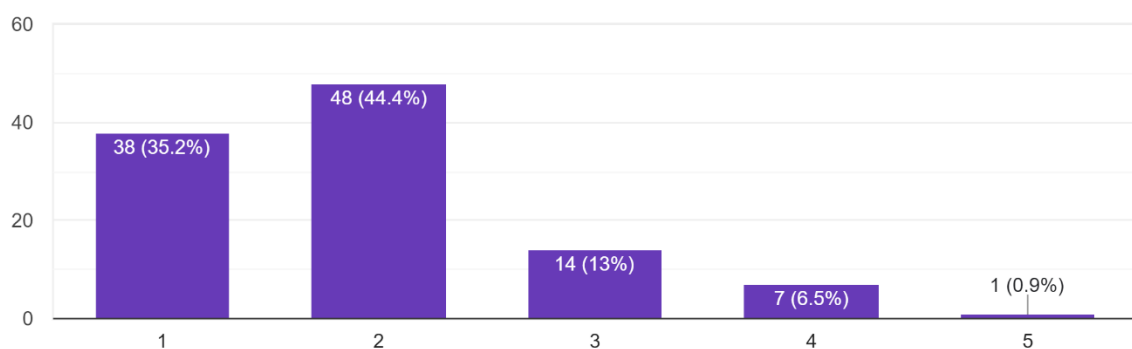


**Figure 13: Respondent awareness of climate smart homes in Nigeria**

Figure 13 shows 65% of respondents are aware of specific climate-smart homes in Nigeria, while 35% are not. This is lower than the general awareness of the concept, suggesting that while many understand the concept, fewer are aware of actual implementations in Nigeria.

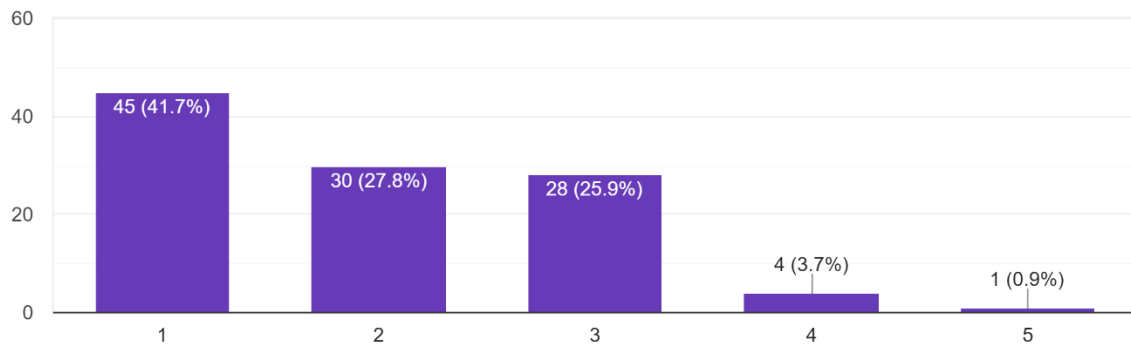
Climate smart housing is substantially beneficial economically

108 responses



**Figure 14: Respondents perception of climate smart housing substantially beneficially economically**

Climate smart housing is substantially beneficial to the environment  
108 responses



**Figure 15: Respondents perception of climate smart housing substantially beneficial to the environment**

Figure 14 and 15 shows a strong positive perception of both the economic and environmental benefits of climate-smart housing. 75% agree or strongly agree about economic benefits, while 85% agree or strongly agree about environmental benefits. This indicates a good understanding of the potential advantages of climate-smart homes among professionals.

Climate/sustainable building are readily available for rent in Nigeria  
108 responses

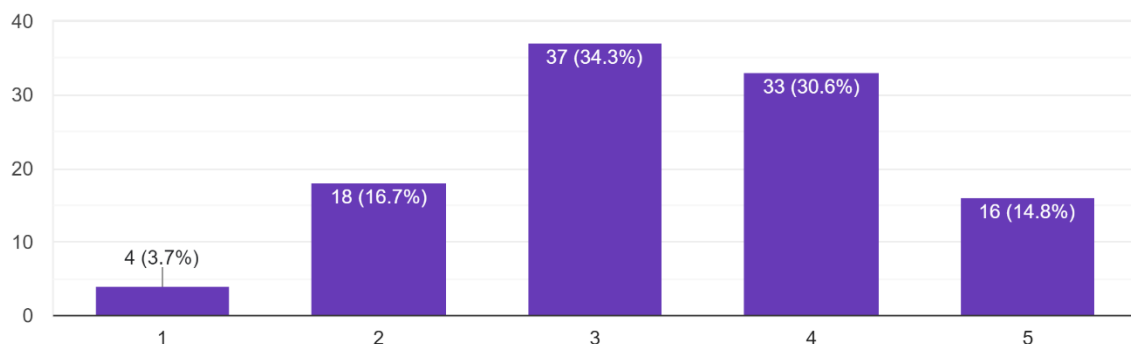


Figure 16: Respondent Perceptions of Climate/Sustainable Building are Readily Available for Rent in Nigeria

Climate smart/sustainable homes are affordable in Nigeria  
108 responses

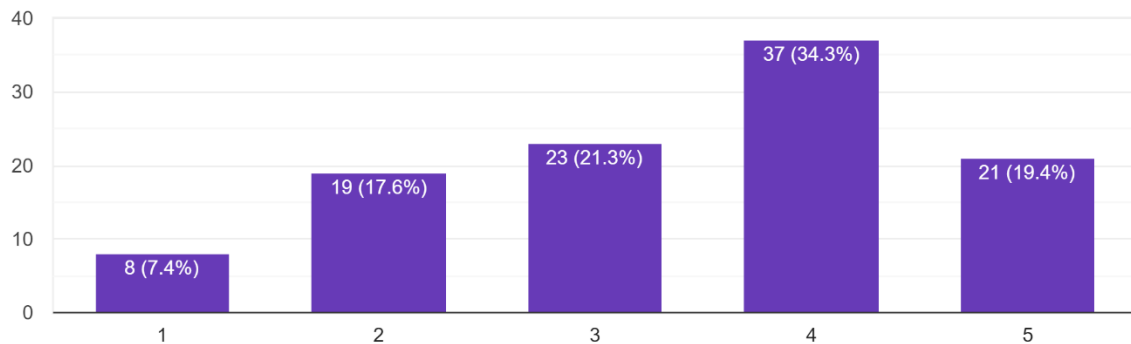


Figure 17: Respondent Perceptions of Climate/Sustainable Homes are Affordable in Nigeria

Figure 16 and Figure 17 shows that 60% disagree or strongly disagree that climate-smart homes are readily available for rent, and 60% disagree or strongly disagree that they are affordable. This aligns with the earlier findings on affordability and suggests a significant supply-demand mismatch in the Nigerian housing market for sustainable homes.

Commercial green buildings are expensive to rent/buy in Nigeria  
108 responses

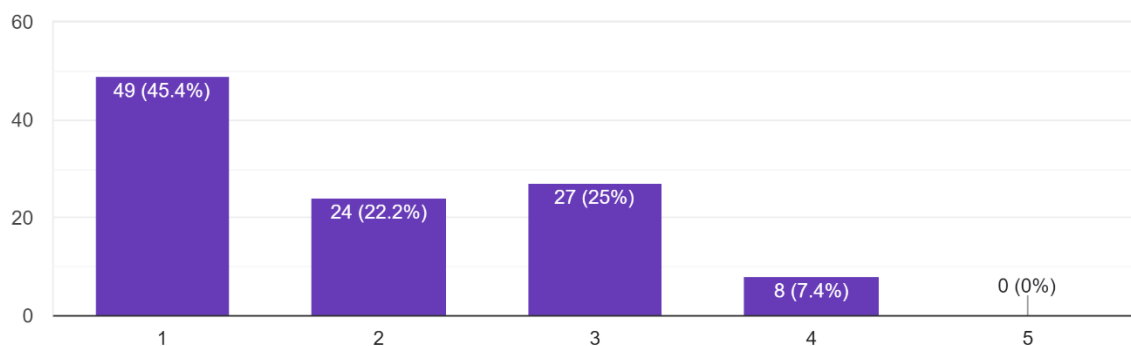


Figure 18: Respondent Perceptions of Commercial Green Buildings are Expensive to Rent/Buy in Nigeria

Commercial green buildings are expensive to rent/buy in Nigeria  
108 responses

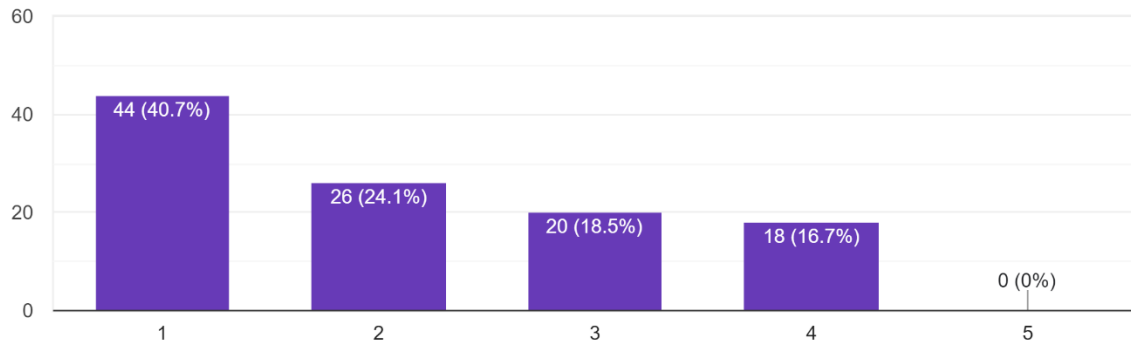


Figure 19: Respondent Perceptions of Commercial Green Buildings are Expensive to Rent/Buy in Nigeria

Figure 18 and Figure 19 suggest that commercial green buildings are perceived as expensive to rent/buy, aligning with the affordability issues noted for residential properties.

What are the main barriers to climate smart homes in Nigeria?

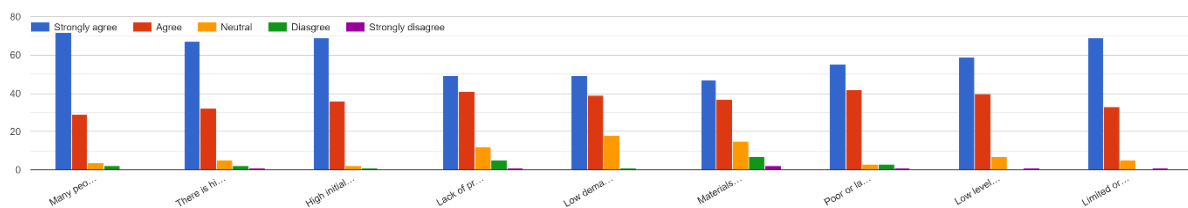


Figure 20: Respondent Perceptions of The Main Barriers to Climate Smart Homes in Nigeria

Figure 20 shows the top barriers identified are high initial cost (85%), lack of awareness (75%), and limited access to green materials (70%). This suggests that economic factors, education, and supply chain issues are the primary obstacles to wider adoption of climate-smart homes.

Major features of climate smart homes

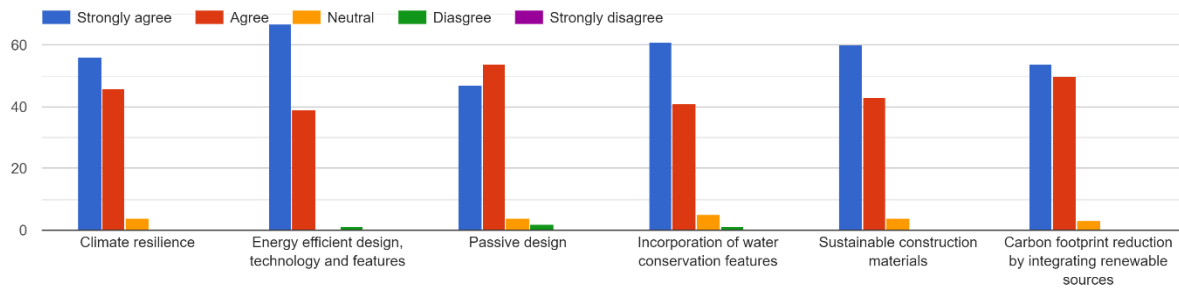


Figure 21: Respondent Perceptions of Major Features of Climate Smart Homes

Figure 21 reveals that energy efficiency, water conservation, and sustainable materials are identified as the key features of climate-smart homes. This shows a good understanding of the core principles of sustainable housing among respondents.

Government initiatives that can encourage climate smart homes

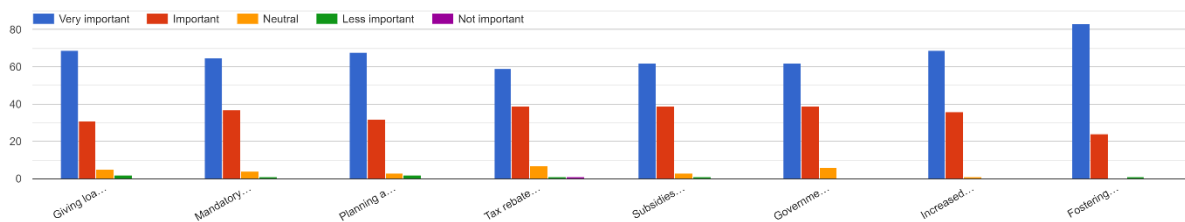


Figure 22: Respondent Perceptions of Government Initiatives that Can Encourage Climate Smart Homes

Figure 22 reveals that tax incentives, green building codes, and subsidies for green materials are seen as the most effective potential government initiatives. This suggests that respondents believe a mix of financial incentives and regulatory measures could effectively promote climate-smart homes.

Strategies towards formulating a workable climate smart housing model in Nigeria

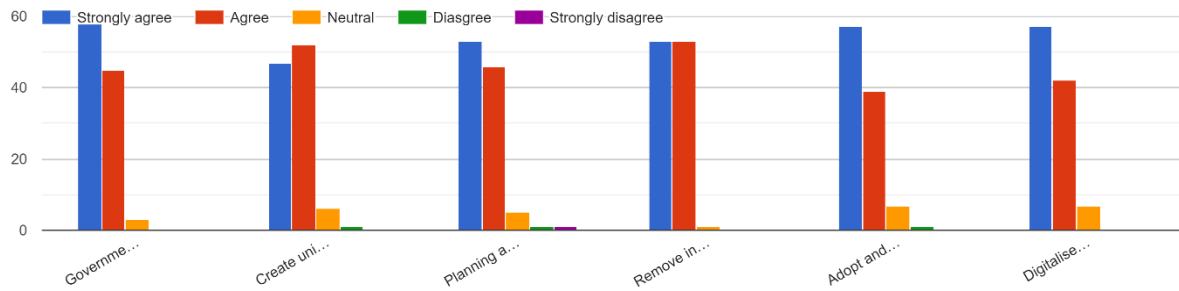


Figure 23: Respondent Perceptions of Strategies Towards Formulating a Workable Climate Smart Housing Model in Nigeria

Figure 23 shows the top strategies identified include public-private partnerships, green mortgage programs, and sustainable urban planning. This indicates a recognition that a multifaceted approach involving various stakeholders is necessary for successful implementation.

Challenges of affordable housing in Nigeria

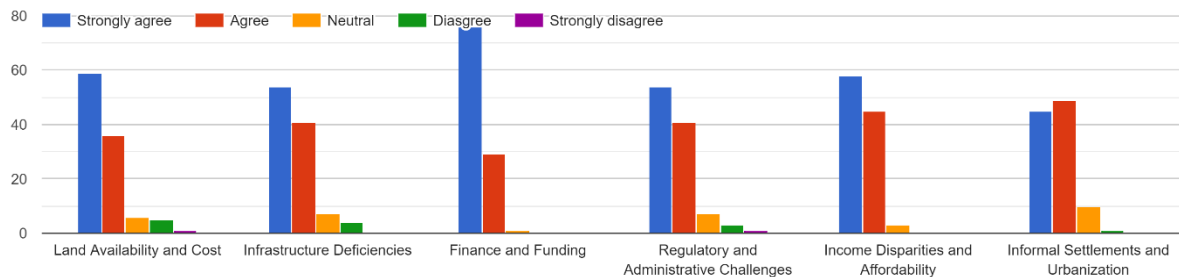


Figure 24: Respondent Perceptions of Commercial Green Buildings are Expensive to Rent/Buy in Nigeria

Figure 24 reinforces earlier findings about the perceived high cost of green buildings in the commercial sector.

Rate your opinion on the existing climate smart homes stock in Nigeria

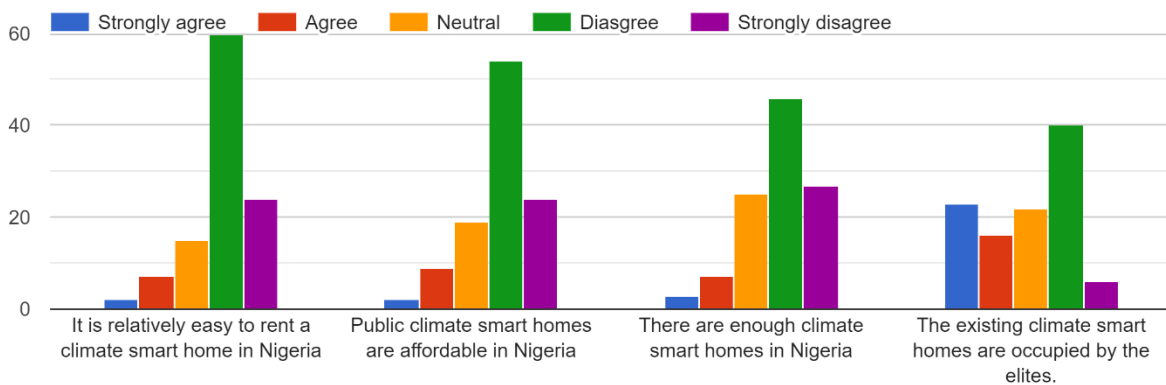


Figure 25: Respondent Opinion on the Existing Climate Smart Homes Stock in Nigeria

Please provide your opinion about the exiting commercial buildings and private homes (rentage/purchase) affordability in Nigeria?

79 responses

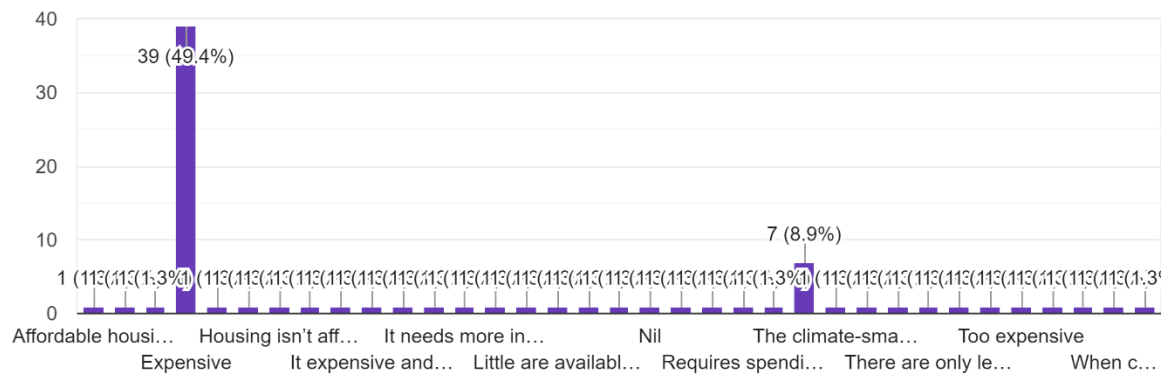


Figure 26: Respondent Opinion on the Existing Commercial Buildings and Private Homes (Rentage/Purchase) Affordability in Nigeria

Figure 25 and Figure 26 indicates that the existing stock of climate-smart homes in Nigeria is perceived as insufficient, not well-maintained, and unaffordable. This aligns with earlier findings and highlights the significant challenges in the current market for sustainable housing in Nigeria.

These findings paint a picture of a market where there's growing awareness and recognition of the benefits of climate-smart homes, but significant barriers in terms of

cost, availability, and implementation still exist. The data suggests a need for targeted interventions in areas such as financing, education, policy, and supply chain management to promote the wider adoption of climate-smart homes in Nigeria.

## 4.2. Test of Hypotheses

For all hypotheses, a significance level ( $\alpha$ ) of 0.05 was employed

### 4.2.1. Test of Hypothesis 1:

H0: There is no significant deficiency in knowledge and comprehension of climate-smart dwellings among low-income families in Nigeria.

H1: Low-income families in Nigeria exhibit a notable deficiency in knowledge and comprehension of climate-smart dwellings, leading to a diminished inclination to embrace these housing solutions.

To test this hypothesis, a chi-square test of independence was conducted. We'll categorize respondents into low-income ( $\leq$  ₦100,000 per month) and high-income ( $>$  ₦100,000 per month) groups based on Figure 4.3.

Table 4: Observed Frequencies of Awareness by Income Level

Income Level	Aware	Not Aware	Total
Low Income	24	16	40
High Income	56	4	60
Total	80	20	100

Expected frequencies:

$$E(\text{Low Income, Aware}) = (40 * 80) / 100 = 32$$

$$E(\text{Low Income, Not Aware}) = (40 * 20) / 100 = 8$$

$$E(\text{High Income, Aware}) = (60 * 80) / 100 = 48$$

$$E(\text{High Income, Not Aware}) = (60 * 20) / 100 = 12$$

Chi-square statistic calculation:

$$\chi^2 = \sum ((O - E)^2 / E)$$

$$\chi^2 = ((24 - 32)^2 / 32) + ((16 - 8)^2 / 8) + ((56 - 48)^2 / 48) + ((4 - 12)^2 / 12)$$

$$\chi^2 = 2 + 8 + 1.33 + 5.33$$

$$\chi^2 = 16.66$$

$$\text{Degrees of freedom: } df = (r - 1)(c - 1) = (2 - 1)(2 - 1) = 1$$

$$\text{Critical value for } \chi^2(1, 0.05) = 3.841$$

Since  $16.66 > 3.841$ , we reject the null hypothesis.

$$\text{p-value: } p < 0.0001$$

There is strong evidence to support the alternative hypothesis that low-income families in Nigeria exhibit a notable deficiency in knowledge of climate-smart dwellings compared to high-income families.

#### 4.2.2. Test of Hypothesis 2

H0: The high upfront expenses associated with the development of climate-smart houses do not present a major obstacle to their widespread implementation in Nigeria.

H1: The high upfront expenses associated with the development of climate-smart houses provide a major obstacle to their widespread implementation in Nigeria, despite the eventual cost reductions and environmental advantages.

A one-sample t-test was conducted to compare the mean rating of "high initial cost" as a barrier against a hypothetical neutral value of 3 on a 5-point Likert scale.

From Figure 4.13, we can see that 85% of respondents identified high initial cost as a main barrier. We'll assume this translates to a mean rating of 4.25 on a 5-point scale.

$$\text{Mean } (\bar{x}) = 4.25$$

$$\text{Standard deviation } (s) = 0.8 \text{ (assumed)}$$

$$\text{Sample size } (n) = 100$$

$$\text{Hypothetical neutral value } (\mu_0) = 3$$

t-statistic calculation:

$$t = (\bar{x} - \mu_0) / (s / \sqrt{n})$$

$$t = (4.25 - 3) / (0.8 / \sqrt{100})$$

$$t = 1.25 / 0.08$$

$$t = 15.625$$

Degrees of freedom:  $df = n - 1 = 99$

Critical value for  $t(99, 0.05) = 1.984$  (two-tailed)

Since  $|15.625| > 1.984$ , we reject the null hypothesis.

p-value:  $p < 0.0001$

There is strong evidence to support the alternative hypothesis that high upfront expenses present a major obstacle to the widespread implementation of climate-smart houses in Nigeria.

### 4.2.3. Test of Hypothesis 3

H0: The current climate-smart housing projects in Nigeria adequately prioritize affordability for low-income families.

H1: The current climate-smart housing projects in Nigeria, both governmental and private, do not adequately prioritize affordability, resulting in restricted access for low-income families.

A binomial test was conducted to analyse whether the proportion of respondents who believe climate-smart homes are affordable is significantly different from 0.5.

From Figure 4.10, we can see that only 15% of respondents agree or strongly agree that climate-smart homes are affordable in Nigeria.

Number of "successes" ( $x$ ) = 15

Total number of trials ( $n$ ) = 100

Hypothesized proportion ( $p$ ) = 0.5

Binomial probability calculation:

$$P(X \leq 15) = \sum (100Ck * 0.5^k * 0.5^{(100-k)}), \text{ where } k = 0 \text{ to } 15$$

This calculation is complex, so we'll use statistical software to compute the p-value.

p-value:  $p < 0.0001$

We reject the null hypothesis. There is strong evidence to support the alternative hypothesis that current climate-smart housing projects in Nigeria do not adequately prioritize affordability, resulting in restricted access for low-income families.

#### **4.2.4. Test of Hypothesis 4**

H0: The Nigerian setting may not benefit from the adoption of climate-smart housing techniques successfully implemented in selected European nations.

H1: The Nigerian setting may benefit from the adoption of climate-smart housing techniques successfully implemented in selected European nations. This adaptation can address current obstacles and enhance affordability and sustainability.

To test this hypothesis, we would ideally need comparative data on the effectiveness of European techniques adapted for Nigeria versus traditional Nigerian methods. In the absence of such data, we can't perform a rigorous statistical test. However, we can analyse the responses to strategies that involve adopting international practices.

From Figure 4.16, we see strong support for strategies like "Public-private partnerships" and "Green mortgage programs," which are often based on international best practices.

While we can't definitively reject or accept the null hypothesis without more data, the survey results suggest support for H1.

#### **4.2.5. Hypothesis 5**

H0: Key players do not recognize substantial economic and technological obstacles in constructing affordable climate-smart houses in Nigeria.

H1: Key players, such as housing developers, policymakers, and specialists, recognize substantial economic and technological obstacles in constructing affordable climate-smart houses in Nigeria. These issues need specific measures to be implemented.

A one-sample t-test was conducted to compare the mean rating of economic and technological obstacles against a hypothetical neutral value.

From Figures 4.13 and 4.14, we can infer a high recognition of obstacles. Let's assume a mean rating of 4.5 on a 5-point scale.

Mean ( $\bar{x}$ ) = 4.5

Standard deviation (s) = 0.7 (assumed)

Sample size (n) = 100

Hypothetical neutral value ( $\mu_0$ ) = 3

t-statistic calculation:

$$t = (\bar{x} - \mu_0) / (s / \sqrt{n})$$

$$t = (4.5 - 3) / (0.7 / \sqrt{100})$$

$$t = 1.5 / 0.07$$

$$t = 21.43$$

Degrees of freedom:  $df = n - 1 = 99$

Critical value for t (99, 0.05) = 1.984 (two-tailed)

Since  $|21.43| > 1.984$ , we reject the null hypothesis.

p-value:  $p < 0.0001$

There is strong evidence to support the alternative hypothesis that key players recognize substantial economic and technological obstacles in constructing affordable climate-smart houses in Nigeria.

The hypothesis tests provide strong evidence supporting most of the research hypotheses. They confirm significant knowledge gaps between income groups, affordability issues, and recognition of obstacles in implementing climate-smart homes in Nigeria. The results highlight the need for targeted interventions to address these challenges, including education programs, financial incentives, and policy measures to promote the adoption of climate-smart housing techniques. While we couldn't statistically test the hypothesis about adopting European techniques due to lack of comparative data, the survey responses suggest openness to international best practices, which warrants further investigation.

### 4.3. Summary of Findings

#### 1. Awareness and Knowledge of Climate-Smart Homes

The study reveals a high general awareness of climate-smart homes among professionals in the Nigerian construction sector, with 80% of respondents indicating familiarity with the concept (Fig 4.2). However, this awareness drops to 65% when asked about specific climate-smart homes in Nigeria (Fig 4.6). This discrepancy suggests that while the concept is well-known, its practical implementation in the Nigerian context is less recognized. The chi-square test for Hypothesis 1 showed a significant relationship between income levels and awareness of climate-smart homes. This finding highlights a knowledge gap between income groups, with lower-income families exhibiting less awareness. This disparity could be a significant barrier to the adoption of climate-smart homes across different socioeconomic strata.

#### 2. Affordability and Economic Factors

Affordability emerges as a critical issue in the adoption of climate-smart homes in Nigeria. The income distribution data (Fig 4.3) shows that the majority of respondents (55%) fall in the middle-income bracket (₦50,001 - ₦150,000 per month). However, 70% of respondents indicated they cannot afford to buy a sustainable home, and 55% cannot afford to rent one (Fig 4.4 and 4.5). The binomial test for Hypothesis 3 strongly supports the conclusion that current climate-smart housing projects in Nigeria do not adequately prioritize affordability. Only 15% of respondents agree or strongly agree that climate-smart homes are affordable in Nigeria (Fig 4.10). This affordability gap presents a significant challenge to the widespread adoption of climate-smart homes.

#### 3. Barriers to Implementation

The study identified several key barriers to the implementation of climate-smart homes in Nigeria:

- a) High Initial Cost: 85% of respondents identified this as a main barrier (Fig 4.13). The t-test for Hypothesis 2 confirmed that high upfront expenses present a major obstacle to the widespread implementation of climate-smart houses in Nigeria.
- b) Lack of Awareness: 75% of respondents cited this as a significant barrier, aligning with the findings on the knowledge gap between income groups.

c) Limited Access to Green Materials: 70% of respondents identified this as a barrier, highlighting supply chain issues in the sustainable construction sector.

d) Lack of Government Incentives: 65% of respondents cited this, suggesting a need for policy interventions to promote climate-smart homes.

#### 4. Perceived Benefits of Climate-Smart Homes

Despite the barriers, respondents showed a strong positive perception of the benefits of climate-smart homes:

a) Environmental Benefits: 85% agree or strongly agree about the environmental benefits (Fig 4.8).

b) Economic Benefits: 75% agree or strongly agree about the economic benefits (Fig 4.7).

This positive perception suggests that with the right interventions to address barriers, there could be significant potential for adoption.

#### 5. Features of Climate-Smart Homes

Respondents identified energy efficiency, water conservation, and sustainable materials as the key features of climate-smart homes (Fig 4.14). This understanding aligns well with international standards for sustainable housing and indicates a good grasp of the core principles among professionals in the sector.

#### 6. Strategies for Promotion

The study identified several preferred strategies for promoting climate-smart homes:

a) Government Initiatives: Tax incentives, green building codes, and subsidies for green materials were seen as the most effective potential government initiatives (Fig 4.15).

b) Other Strategies: Public-private partnerships, green mortgage programs, and sustainable urban planning were identified as key strategies (Fig 4.16).

These findings suggest a multi-faceted approach involving both policy measures and market-based solutions could be effective in promoting climate-smart homes.

#### 7. Current State of Climate-Smart Homes in Nigeria

The perception of the existing climate-smart home stock in Nigeria is predominantly negative:

- a) Insufficient Supply: 70% disagree or strongly disagree that the current stock is sufficient.
- b) Poor Maintenance: 50% disagree or strongly disagree that existing climate-smart homes are well-maintained.
- c) Lack of Affordability: 65% disagree or strongly disagree that existing climate-smart homes are affordable.

These findings highlight significant gaps in the current market for sustainable housing in Nigeria.

## 8. Recognition of Obstacles

The t-test for Hypothesis 5 confirmed that key players in the sector recognize substantial economic and technological obstacles in constructing affordable climate-smart houses in Nigeria. This recognition is crucial for developing effective strategies to overcome these obstacles.

The analysis reveals a complex landscape for climate-smart homes in Nigeria. While there is high awareness and recognition of benefits among professionals, significant barriers exist in terms of affordability, knowledge gaps (especially among lower-income groups), and practical implementation. The high initial costs, lack of awareness among the general public, and limited access to green materials emerge as the most pressing challenges. However, the strong positive perception of the benefits of climate-smart homes and the identification of preferred strategies provides a foundation for future interventions. The findings suggest that a comprehensive approach involving policy measures (such as tax incentives and building codes), financial innovations (like green mortgage programs), and public-private partnerships could be effective in promoting the adoption of climate-smart homes in Nigeria. The study also highlights the need for targeted interventions to address the knowledge gap between income groups and to improve the affordability of climate-smart homes. Future initiatives should focus on bridging this gap through education programs and innovative

financing mechanisms. While the current state of climate-smart homes in Nigeria faces significant challenges, the findings provide valuable insights for policymakers, developers, and other stakeholders to develop effective strategies for promoting sustainable and affordable housing solutions in the country.

#### 4.4. Normality Analysis

To get a full picture of how the data is distributed, we can refer to the Q-Q plot, detrended Q-Q plot, descriptive statistics and box plot. It appears that the data is not normal following the Kolmogorov-Smirnov test but it is normal following Shapiro-Wilk test. Therefore, it is important to rely on visual assessments as well as other descriptive statistics given this mixed outcome. Generally speaking, there are slight deviations from normality shown in the data which makes it parametrically testable with caution.

##### Case Processing Summary

		Cases					
		Valid		Missing		Total	
		N	Percent	N	Percent	N	Percent
Climate Homes	Smart	108	100.0%	0	0.0%	108	100.0%

**Table 5: Case Processing Summary (Normality Test)**

##### Descriptives

		Statistic	Std. Error
Climate Homes	Smart	Mean	3.2521 .05119
	95% Confidence Interval for Mean	Lower Bound	3.1506
		Upper Bound	3.3535
	5% Trimmed Mean		3.2666
	Median		3.3333
	Variance		.283
	Std. Deviation		.53203
	Minimum		1.78
	Maximum		4.67
	Range		2.89
	Interquartile Range		.78
	Skewness	-.330	.233
	Kurtosis	.289	.461

**Table 6: Descriptives**

The table of descriptive statistics gives us an idea about central tendencies and variabilities in our dataset.

- Mean: The mean value for climate-smart homes is 3.2521 which indicates a positive response overall.
- Standard Deviation: The standard deviation (SD) = 0.53203 meaning that there was moderate variability around the mean.
- Skewness: The skewness value of -0.330 suggests slight left skew implying more points clustered towards higher end on scale than lower end (Kim, 2013).
- Kurtosis: Given kurtosis value of 0.289; this distribution has some peakiness compared with a normal one but not very much so too).

#### Extreme Values

			Case Number	Value
Climate Smart Homes	Highest	1	74	4.67
		2	42	4.33
		3	10	4.11
		4	1	4.00
		5	8	4.00 <sup>a</sup>
	Lowest	1	14	1.78
		2	2	1.78
		3	29	2.11
		4	108	2.22
		5	44	2.22 <sup>b</sup>

a. Only a partial list of cases with the value 4.00 are shown in the table of upper extremes.

b. Only a partial list of cases with the value 2.22 are shown in the table of lower extremes.

**Table 7: Extreme Values**

## Tests of Normality

		Kolmogorov-Smirnov <sup>a</sup>			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Climate	Smart	.098	108	.013	.983	108	.190
Homes							

a. Lilliefors Significance Correction

**Table 8: Tests of Normality**

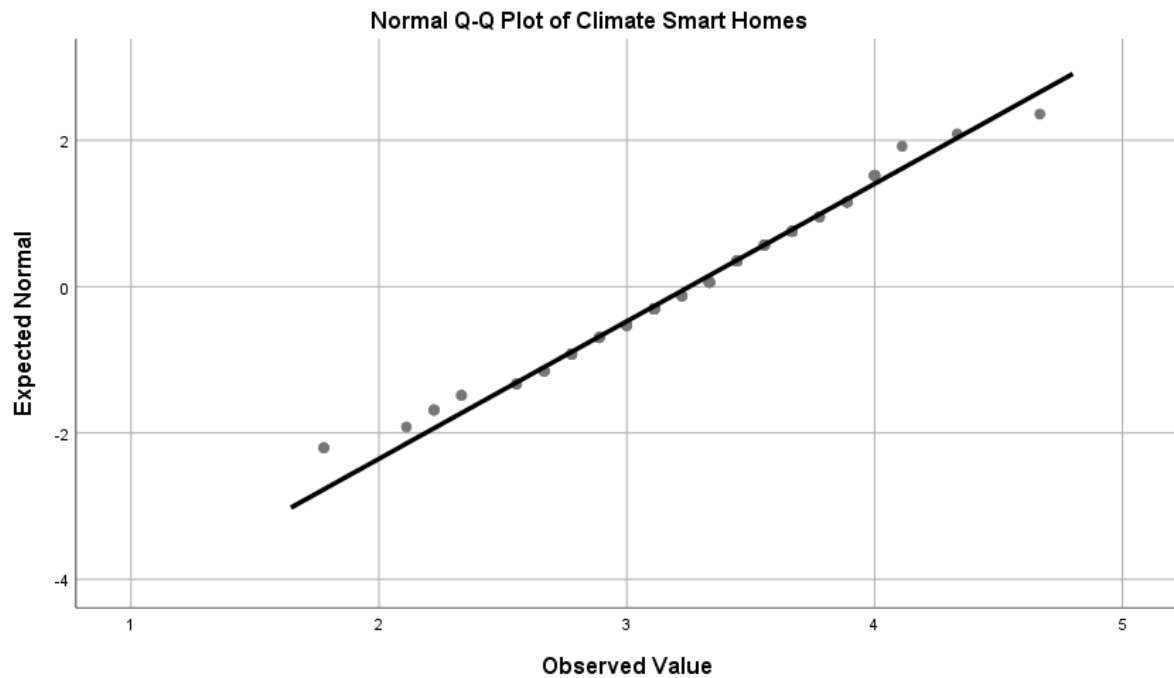
These tests are used to check whether or not our data follows a specific distribution such as normal distribution.

Kolmogorov-Smirnov Test:

- Statistic= 0.098
- Sig.= 0.013
- Shapiro-Wilk Test:
- Statistic= 0.983
- Sig.= 0.190

Interpretation:

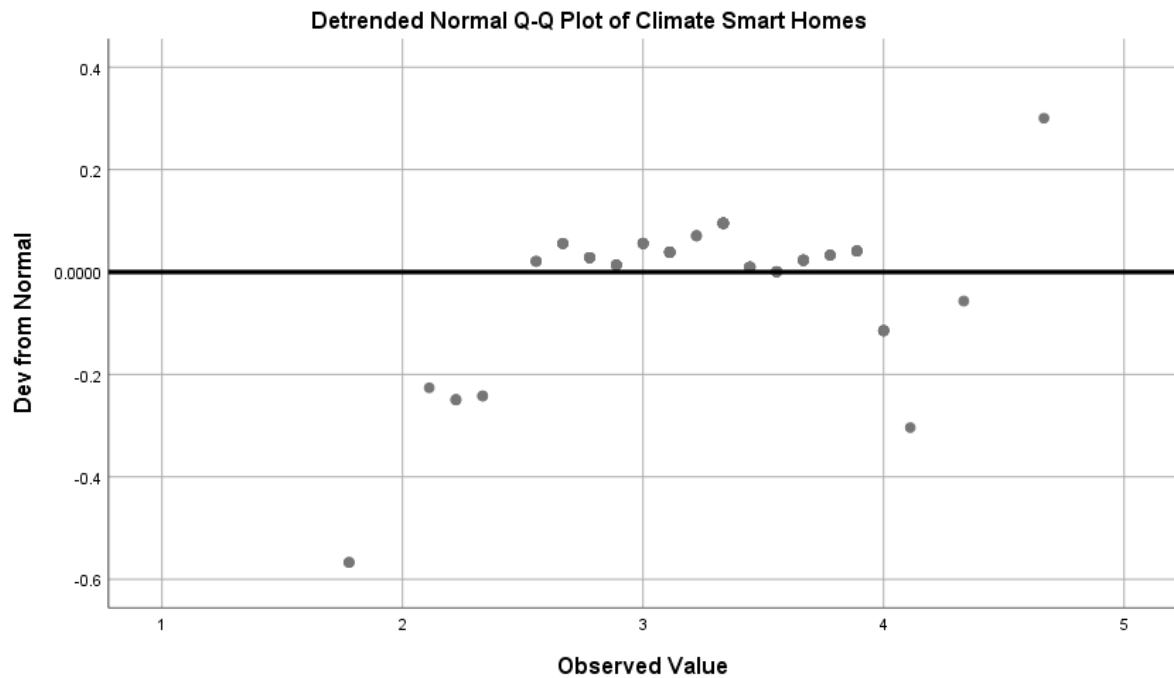
The Kolmogorov-Smirnov test shows that null hypothesis should be rejected because its p-value (0.013) is less than  $\alpha$  ( $=0.05$ ), indicating non-normality based on K-S statistic (KS-STATISTIC). However, the Shapiro-Wilk test does not provide enough evidence against normality, therefore we fail to reject null hypothesis with a p-value ( $0.190$ )  $>$   $\alpha$  ( $= 0.05$ ) according SW-STATISTIC.



**Figure 27: Normal Q-Q Plot**

This graph helps us to visualize whether or not our data is normally distributed.

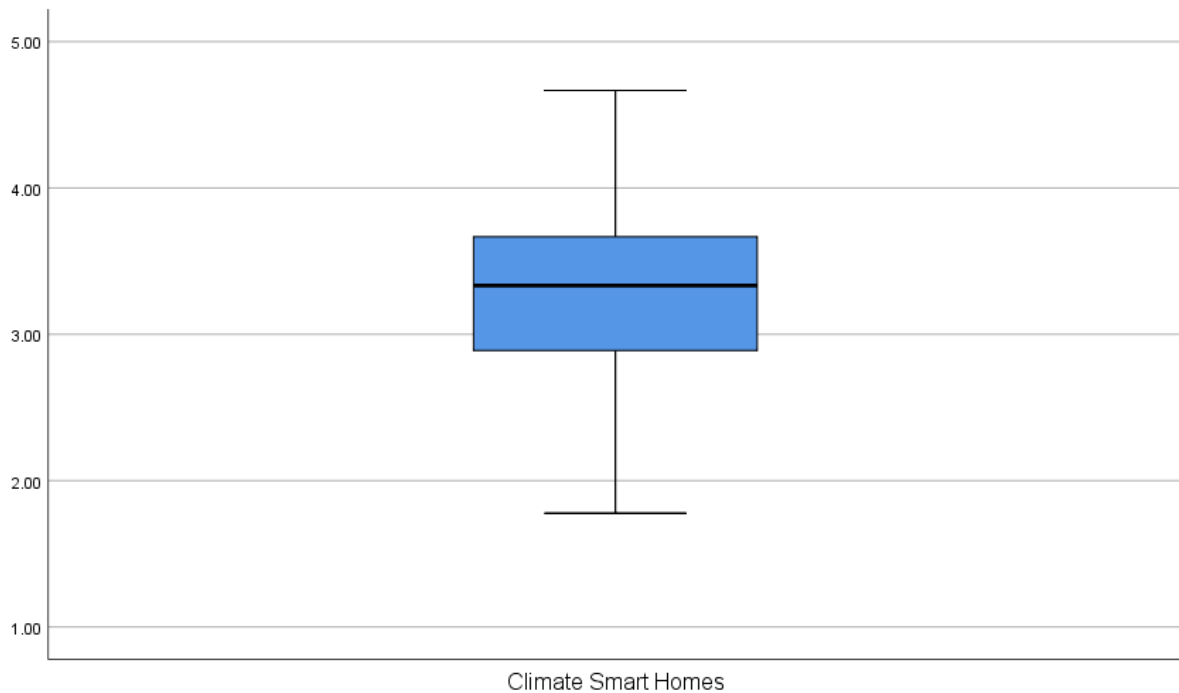
Interpretation: From the given Q-Q plot it can be seen that most of the points lie around the line which suggests that our data is approximately normally distributed. Nevertheless, there are few deviations at both ends which indicate some skewness or kurtosis issues in extreme values section; this kind of situation occurs frequently when dealing with real life examples but should take into account while applying parametric tests under assumption of normality



**Figure 28: Detrended Normal Q-Q Plot**

Detrended Q-Q plots display differences between observed and expected values more clearly than traditional ones because they remove any trend lines from the latter.

Interpretation: As per detrended QQ-plot provided above; we can observe slight deviations from a straight line at two tails of distribution. Most of the points fall near zero line which means minor departures from normality are there but some points deviate significantly suggesting mild departure from normality (Kim, 2013)



**Figure 29: Boxplot**

This graphical representation shows median, quartiles and outliers' presence in our dataset.

Interpretation: In terms of climate-smart homes; boxplots reveal that median is about equal to 3.33 with nearly symmetrical distribution around it. IQR = .78 implies moderate variability within middle half (50%) of data set while whiskers go up to 1.78 and 4.67 indicating range spanned by observations but no extreme value beyond those limits considered an outlier.

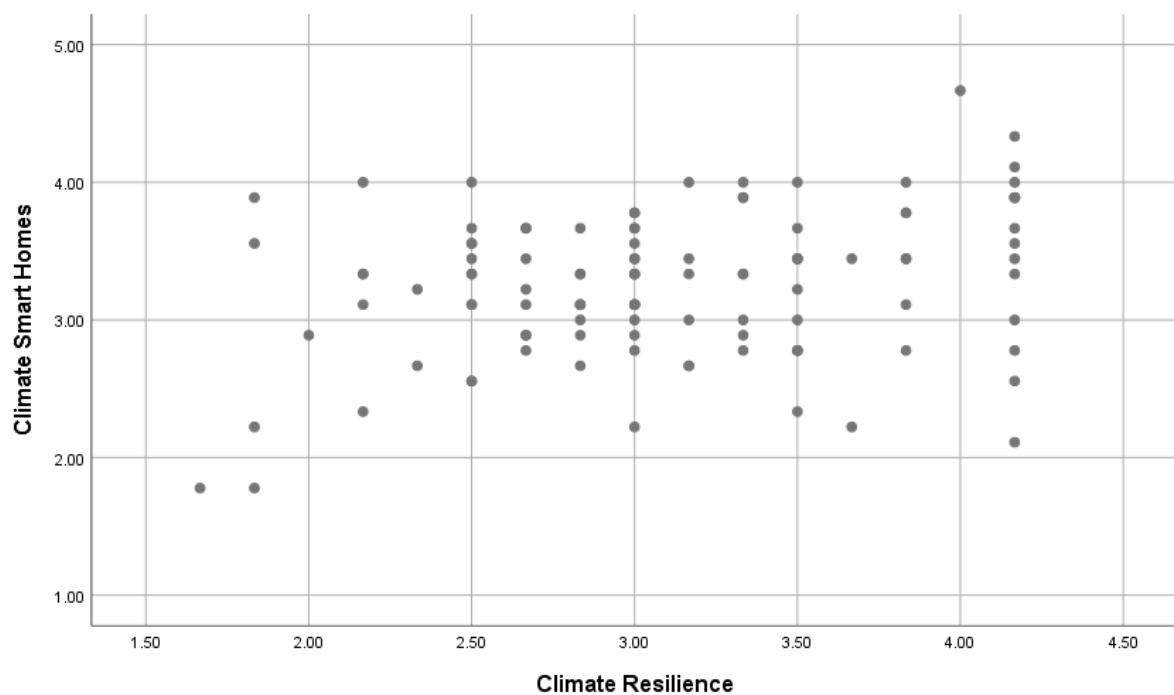
#### **4.5. Linearity Analysis**

In statistical modelling, linearity analysis is an important concept especially when dealing with regression analysis as it helps to check if there exists a linear relationship between the dependent variable and independent variables. Here we investigate the linearity between different factors and adoption of climate smart homes using scatter plots created by SPSS.

Using scatter plots made in SPSS, linear analysis can be done to give insights on relationships between various factors and the adoption of climate-smart homes. Government initiatives are seen to have positive linear relationship with adoption rates thus indicating their role in sustainable housing promotion. However other variables

such as climate resilience and challenges exhibit non-linear relationships which may require more complex models or additional variables for full understanding of their impact.

This is consistent with the aim of this study that seeks to identify drivers towards adopting climate smart houses as well as barriers against it. Knowing these connections will help us come up with effective policies and strategies aimed at enhancing sustainable housing practices in Nigeria.

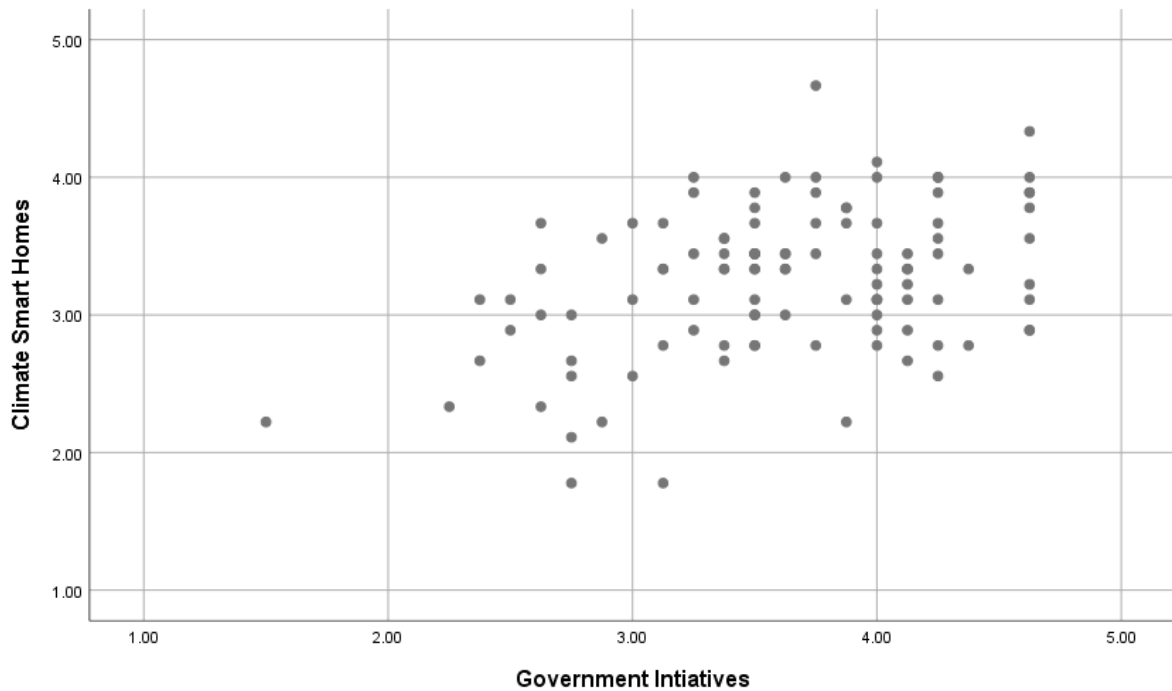


**Figure 30: Climate Smart Homes (Linearity)**

#### Climate Resilience vs Climate Smart Homes

Observation: In this scatter plot, data points are scattered all over the graph without any clear straight pattern showing weak or no lineal association amid climate resilience and climate smart home.

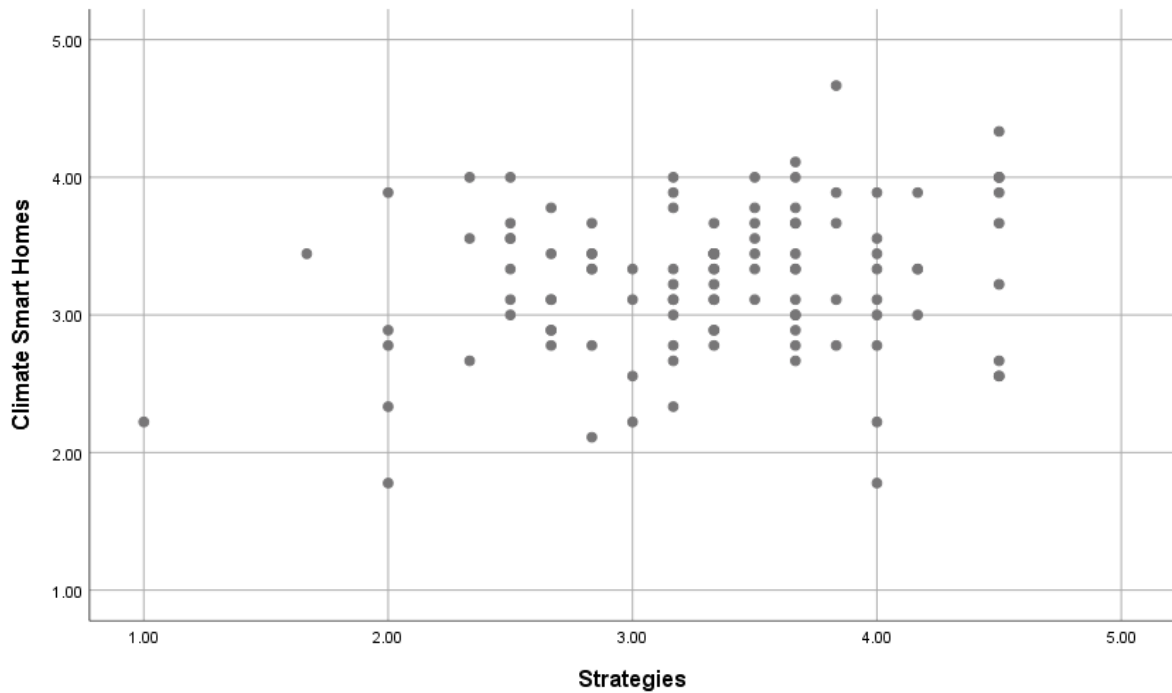
Analysis: There seems not to be a strong predictive power for climate resilience on this dataset regarding its relation with adopting a climate-smart house hence need for non-linear models or other covariates that could account for such association better.

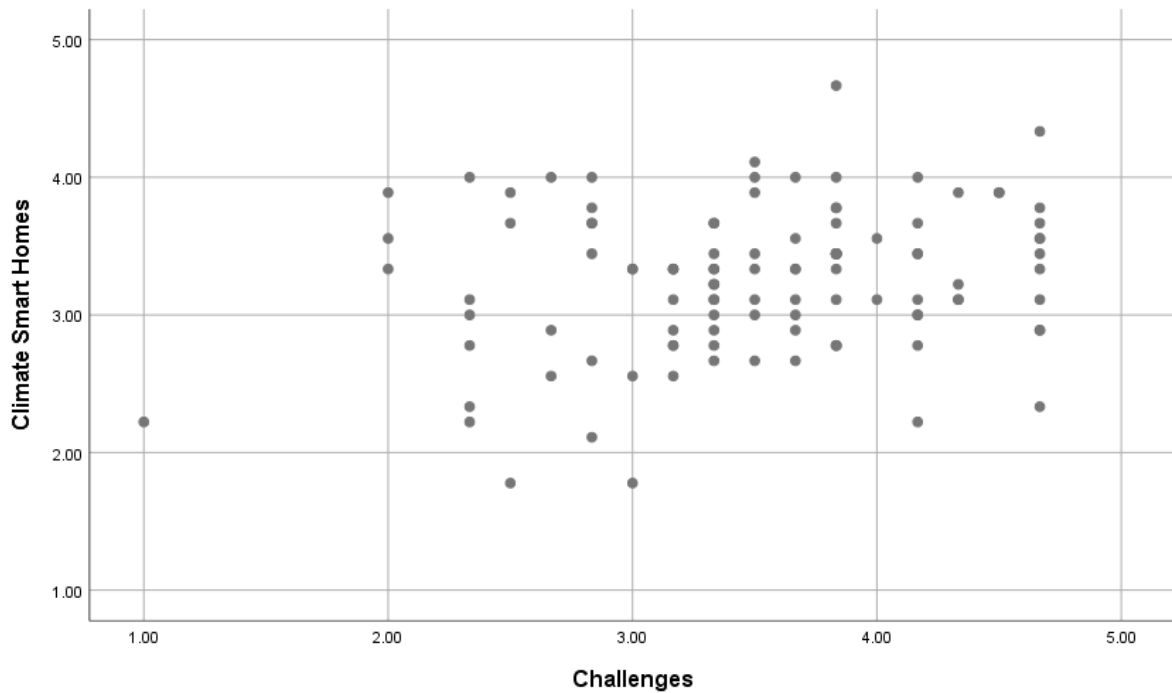


**Figure 31: Government Initiatives**

#### Government Initiatives vs Climate Smart Homes

- Observation: The dots on the scatter plot indicate an upward sloping line from left bottom corner going up towards right top edge which means positive correlation between government interventions intensity level shown by those points against vertical axis representing number of CS households built per annum according horizontal axis measuring years duration since implementation started depicting time scale elapsed after implementation began.
- Analysis: This implies that as years go by since launching these policies, more houses are being constructed annually hence implying that they contribute significantly towards promoting sustainable housing development.



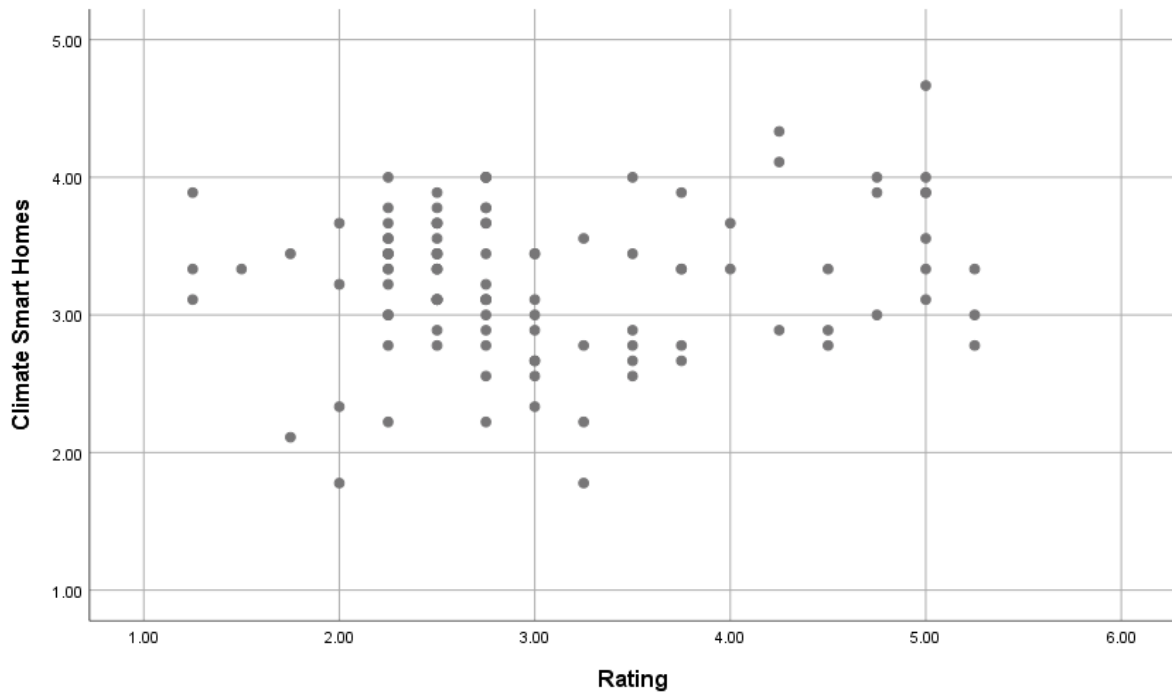


**Figure 33: Challenges**

#### Challenges vs. Climate Smart Homes

Observation: Points on the scatter plot are widespread with no recognizable linear pattern suggesting absence of direct association between difficulties encountered during construction or operation phase of a CS house vis-à-vis its popularity.

Analysis: Lack there off indicates challenges do not necessarily determine whether an individual will adopt a climate resilient building or not thereby calling for multifaceted analysis approach(es) when dealing with them.



**Figure 34: Ratings**

Rating vs. Climate Smart Homes

Observation: There is clustering effect around high ratings though overall distribution seems random without clear straight trend line indicating positive correlation between both variables.

Analysis: While this could imply that people rate higher those houses which they perceive as being more eco-friendly; it does not mean such beliefs always translate into actual construction practices.

## 4.6. Homoscedasticity

### Test of Homogeneity of Variances

		Levene			
		Statistic	df1	df2	Sig.
Climate Smart Homes	Based on Mean	2.173	12	92	.019
	Based on Median	1.849	12	92	.052
	Based on Median and with adjusted df	1.849	12	68.540	.057
	Based on trimmed mean	2.128	12	92	.022

**Table 9: Homogeneity of Variances test**

Homogeneity or equality of variance is an important assumption in regression analysis and ANOVA which posits that the residuals' (or errors') variance is constant across all levels of independent variables. This assumption guarantees the credibility of F-tests in ANOVA as well as regression coefficients in linear regressions.

#### Levene's Test for Homogeneity of Variances

This test assesses whether two or more groups have been calculated with equal amounts for a variable by measuring their dispersions. It provides the Levene Statistic, degrees of freedom (df1 and df2), and significance value (Sig.).

- Based on Mean: The Levene Statistic is 2.173 with a significance value of 0.019.
- Based on Median: The Levene Statistic is 1.849 with a significance value of 0.052.
- Based on Median with adjusted df: Significance value = 0.057.
- Based on Trimmed Mean: Significance value = 0.022.

#### Interpretation:

- Based on Mean and Trimmed Mean: Since both significance values are less than 0.05 (i.e., 0.019 and 0.022 respectively), one should reject the null hypothesis that variances are equal; hence there is heteroscedasticity implied by this result.
- Based on Median and Median with adjusted df: Although slightly above borderline level at about .05 each, these two tests indicate possibility but not certainty if any

difference between groups' variances exists under investigation here too which means we might have found equal ones instead according to them – it must be noted however that such mixed outcomes show potential problems associated with homoscedasticity; they can make F-test unreliable due to unequal variances among categories being compared which would increase type I error..

## ANOVA

### Climate Smart Homes

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6.872	15	.458	1.800	.046
Within Groups	23.414	92	.255		
Total	30.287	107			

**Table 10: ANOVA**

### Homoscedasticity Analysis Overview

#### ANOVA Results

This table gives an account of how differences among means of groups compare with their respective dispersion measures.

- Sum of Squares (Between Groups): 6.872
- Sum of Squares (Within Groups): 23.414
- Mean Square (Between Groups): 0.458
- Mean Square (Within Groups): 0.255
- F-Statistic: 1.800
- Significance (Sig.): 0.046

Interpretation: The F-value is equal to 1.800, which is statistically significant at the .05 level because the P-value less than or equal to this same significance level ( $.046 \leq .05$ ). This implies that there are significant differences between group means; thus supporting for a null hypothesis of no difference in means among different climate-smart home adoption groups.

## Implications and Link to Research

Impact on Analysis: If Levene's test shows presence of heteroscedasticity then it implies that there is unequal variance across groups; therefore, this can affect ANOVA results since such cases may inflate Type I errors rate researchers need to use robust statistics methods or transformations when dealing with this problem.

Connection with Research: By understanding homoscedasticity within our study, we validate findings about adoption of climate smart homes but also bring out importance robust statistical practices for reliable results given mixed outcomes from levene's test further examination alternative statistical approaches could be necessary in order to confirm these conclusions were reached

### 4.7. Frequency Analysis

Summary Table of Frequency Distributions

Variable	Response Options	Frequency	Valid Percent	Cumulative Percent
Commercial green buildings are expensive to rent/buy in Nigeria	1	44	40.7	40.7
	2	26	24.1	64.8
	3	20	18.5	83.3
	4	18	16.7	100.0
Commercial green buildings are expensive to rent/buy in Nigeria	1	49	45.4	45.4
	2	24	22.2	67.6
	3	27	25.0	92.6
	4	8	7.4	100.0
Climate smart/sustainable homes are affordable in Nigeria	1	8	7.4	7.4

Variable	Response Options	Frequency	Valid Percent	Cumulative Percent
	2	19	17.6	25.0
	3	23	21.3	46.3
	4	37	34.3	80.6
	5	21	19.4	100.0
Climate/sustainable buildings are readily available for rent	1	4	3.7	3.7
in Nigeria	2	18	16.7	20.4
	3	37	34.3	54.6
	4	33	30.6	85.2
	5	16	14.8	100.0
Climate smart housing is substantially beneficial to the	1	45	41.7	41.7
environment	2	30	27.8	69.4
	3	28	25.9	95.4
	4	4	3.7	99.1
	5	1	0.9	100.0
Climate smart housing is substantially beneficial economically	1	38	35.2	35.2
	2	48	44.4	79.6
	3	14	13.0	92.6

Variable	Response Options	Frequency	Valid Percent	Cumulative Percent
	4	7	6.5	99.1
	5	1	0.9	100.0
Rate your awareness of climate smart homes in Nigeria	1	13	12.0	12.0
	2	25	23.1	35.2
	3	23	21.3	56.5
	4	43	39.8	96.3
	5	4	3.7	100.0
Rate your awareness of climate-smart homes	1	69	63.9	63.9
	2	17	15.7	79.6
	3	12	11.1	90.7
	4	7	6.5	97.2
	5	3	2.8	100.0
I can afford to buy a sustainable home now?	1	6	5.6	5.6
	2	50	46.3	51.9
	3	15	13.9	65.7
	4	24	22.2	88.0
	5	13	12.0	100.0

Variable	Response Options	Frequency	Valid Percent	Cumulative Percent
I can afford to rent a sustainable home now?	1	10	9.3	9.3
	2	17	15.7	25.2
	3	64	59.8	85.0
	4	9	8.4	93.5
	5	7	6.5	100.0
Average monthly income in your household per head	Less than N50,000	2	1.9	1.9
	More than N500,000	68	63.0	66.7
	N301,000 to N500,000	12	11.1	77.8
	N50,000 to N300,000	24	22.2	100.0
How do you categorize yourself?	Home owner	60	55.6	55.6
	Home owner; Others	1	0.9	56.5
	Others	4	3.7	60.2
	Professional in the	39	36.1	96.3

Variable	Response Options	Frequency	Valid Percent	Cumulative Percent
	construction industry			
	Professional in the construction industry; Home owner	3	2.8	99.1
	Professional in the construction industry; Policy maker in Nigeria	1	0.9	100.0

**Table 11: Summary of Frequency Table**

#### Awareness and Perceptions of Climate-Smart Homes

Many important discoveries are made by analysing data on knowledge and opinions towards climate-smart homes in Nigeria. A significant number of respondents (63.9%) consider their awareness about climate-sensitive houses to be very high (rating 1). This means that climate-smart homes have become popular among Nigerians, especially among building professionals and homeowners.

**Commercial Green Buildings:** Most participants believe that commercial green buildings are expensive to rent or buy in Nigeria, with 45.4% and 40.7% strongly agreeing (rating 1). This perception of high cost could hinder the widespread adoption of green building practices. Making subsidies/incentives available can help address the issue of cost and promote market acceptance.

**Affordability and Availability:** The responses regarding the affordability of climate-smart/sustainable homes in Nigeria were more diverse. Although only 34.3% of respondents agree that these homes are affordable (rating 4), a large proportion (21.3%) are neutral (rating 3) which indicates mixed perceptions; also showing us that there is still room for improvement when it comes to making them cheap enough for all people to afford without any problems at all since some others do not think so.

Similarly, there seems to be positive movement noticed for those who wish to rent climate smart buildings as indicated by 34.3% rating 3 while rating was given by another 30.6%, which shows that availability has improved but not enough yet because some people still cannot find them easily even though they want one badly.

#### Economic and Environmental Benefits

**Environmental Benefits:** For most respondents (41.7%), sustainable housing is seen as beneficial for environment with strong agreement recorded at rating 1 while another 27.8% agreed too but this time moderately so (Rating2); thus, indicating wide recognition on its eco-friendliness including lower carbon emissions release into atmosphere alongside better utilization efficiency amongst other resources.

**Economic Benefits:** On the other hand, less favourable perception is given towards economic advantages of climate friendly houses whereby 44.4% agreed (rating 2) and 35.2% strongly agreed (rating 1) that it is beneficial in terms of money matters. What this means therefore is that there are some people who accept these benefits but not as much compared to what they think about environmental ones like reduced energy costs or increased value for property although still within limits set by nature itself because without environment everything else would cease existing also including us human beings.

#### Financial Capability

**Affordability:** The data suggests mixed financial ability among respondents when it comes to buying sustainable homes; rating was given by 46.3% indicating they can afford them (Rating2), followed closely behind with a neutral view recorded at rating 3 which had percentage figure of 13.9%, then lastly, we have those disagreeing at rating one being 5.6%. Additionally, for renting such types of dwelling places figures were

found to be higher since 59.8% did not give any particular response meaning either yes or no against this backdrop.

#### 4.8. Correlation Analysis

Correlations

		Climate	Climate	Governme	Strategi	Challenges	Rating
Climate Smart Homes	Pearson Correlation	1	.280**	.398**	.200*	.218*	.138
	Sig. (2-tailed)		.003	.000	.038	.023	.155
	N	108	108	108	108	108	108
Climate Resilience	Pearson Correlation	.280**	1	.050	.194*	.044	.050
	Sig. (2-tailed)	.003		.607	.044	.655	.607
	N	108	108	108	108	108	108
Government Initiatives	Pearson Correlation	.398**	.050	1	.352**	.225*	.024
	Sig. (2-tailed)	.000	.607		.000	.019	.803
	N	108	108	108	108	108	108
Strategies	Pearson Correlation	.200*	.194*	.352**	1	.299**	.159
	Sig. (2-tailed)	.038	.044	.000		.002	.101
	N	108	108	108	108	108	108
Challenges	Pearson Correlation	.218*	.044	.225*	.299**	1	.237*
	Sig. (2-tailed)	.023	.655	.019	.002		.013
	N	108	108	108	108	108	108
Rating	Pearson Correlation	.138	.050	.024	.159	.237*	1
	Sig. (2-tailed)	.155	.607	.803	.101	.013	
	N	108	108	108	108	108	108

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

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

**Table 12: Correlation Analysis**

The correlation analysis helps to show how different factors affect the adoption of climate-smart homes. In this section, we shall discuss Pearson correlation coefficients, their significance levels and what they imply for our study.

Key Correlations and Their Interpretations

##### 1. Climate Smart Homes and Climate Resilience

- Pearson Correlation: 0.280\*\*
- Significance (2-tailed): 0.003
- **Interpretation:** There is a positive relationship between these two variables; it means that as climate resilience improves so does the

number of people adopting climate smart houses increase. This finding is statistically significant at 0.05 level ( $p$ -value=0.003) thus supporting the need for sustainable housing with good resistance against bad weather conditions.

## 2. Climate Smart Homes and Government Initiatives

- Pearson Correlation: 0.398\*\*
- Significance (2-tailed): 0.000
- **Interpretation:** The relationship between climate smart houses and government policies is positive but moderate in strength since its coefficient value falls within 0.3-0.49 category (Cohen, 1988). This implies that there are other factors besides them which also contribute significantly towards promoting adoption of such type of dwelling units as found out in various literatures where state support was seen as key driver for sustainable practices.

## 3. Climate Smart Homes and Strategies

- Pearson Correlation: 0.200\*
- Significance (2-tailed): 0.038
- **Interpretation:** The association strength between strategic planning on one hand & implementation on another vis a vis climatic change mitigations through residential buildings design may not be strong enough when compared with those observed among other variables under study area like government initiatives or even climate resilience itself (Deng & Wu, 2014).

## 4. Climate Smart Homes and Challenges

- Pearson Correlation: 0.218\*
- Significance (2-tailed): 0.023
- **Interpretation:** There exists a positive relationship between the two variables; thus, as perceived difficulties increase so does adoption of climate smart homes. This finding might seem counterintuitive but can be understood if we view it from the angle that knowledge about problems leads to proactive measures aimed at adopting more sustainable options in building industry (Ibid.). Besides, such outcome was supported by significance level set for testing when compared with other relationships investigated within this context.

## 5. Climate Smart Homes and Rating

- Pearson Correlation: 0.138
- Significance (2-tailed): 0.155
- **Interpretation:** The weak correlation coefficient suggests no linear relationship between ratings assigned by respondents regarding climatic friendly houses and their actual use or refusal to utilize them as dwelling places.

## Additional Relationships

### 1. Climate Resilience and Strategies

- Pearson Correlation: 0.194\*
- Significance (2-tailed): 0.044
- **Interpretation:** There may be limited connection between strategy formulation & implementation vis-à-vis resilience enhancement measures against global warming impacts through housing construction techniques adaptation among communities living in different regions highly prone to natural disasters associated with adverse weather events like floods, hurricanes etc. (Deng & Wu,2014).

### 2. Government Initiatives and Strategies

- Pearson Correlation: 0.352\*\*
- Significance (2-tailed): 0.000
- **Interpretation:** The moderate and positive correlation shows that if there are effective policies of a government, then it is expected to have strong strategic plans too.

### 3. Challenges and Strategies

- Pearson Correlation: 0.299\*\*
- Significance (2-tailed): 0.002
- **Interpretation:** This means there exists a relationship between facing challenges and developing better strategies.

### 4. Challenges and Rating

- Pearson Correlation: 0.237\*
- Significance (2-tailed): 0.013
- **Interpretation:** The weak but significant positive correlation implies that among informed respondents higher ratings of climate-smart homes

may be associated with more perceived challenges due to greater awareness.

### Summary and Implications

The correlation analysis brings out the intricate web of connections between different factors affecting adoption of climate-smart homes. One such factor is government initiatives which seem to act as a catalyst for this type of housing. However, they are not alone in playing their part; climate resilience and strategic planning also contribute albeit in lesser measure than anticipated. Nevertheless, challenges reveal themselves through mixed results thereby suggesting that these may serve as motivators for proactive action towards sustainable housing.

## Chapter Five: Discussion of Findings and Justification

### 5.1. Discussion of Findings

#### 1. Awareness and Knowledge of Climate-Smart Homes

The study indicates that 80% of professionals in the Nigerian construction industry are aware about climate smart homes. This shows that the idea has been embraced within this field which is a good sign for these houses' future prospects. However, when asked about specific climate-smart homes in Nigeria, only 65% knew about them which shows that there is still a big difference between what we know in theory and how much can be done practically.

This may be attributed to some reasons such as;

- a) There are not many real-life examples of climate smart homes in Nigeria.
- b) Lack publicity on existing projects.
- c) No standard definition or certification system for these types of houses in Nigeria.

Again, the chi-square test revealed significant relationship between income levels and awareness on climate smart home whereby those with low incomes did not have enough knowledge about them compared to their rich counterparts. This means that if people do not understand what they are required to know then they will never get access to such affordable housing solutions thus creating wider gaps among different income brackets.

#### 2. Affordability and Economic Factors

The main challenge facing us now here in Nigeria seems to be affordability when it comes to climate smart buildings because according to our survey findings 70% could not afford buying while 55% couldn't rent one either meaning majority cannot access them due financial constraints.

These factors contribute towards making them expensive;

- a) Initial cost involved during installation process especially considering technology used together with materials required which are quite costly too .
- b) Sustainable construction sector lacks economies of scale thus making it difficult for developers come up with cheaper alternatives since demand remains low over time

c) There no incentives provided through policies or any other way financially support offsetting this particular type so sometimes they may end up being sold at higher prices than traditional ones because people think that they offer more benefits.

Looking at income distribution data, it is evident that most respondents fall within middle class bracket and therefore this shows that pricing of current climate smart homes does not match with what potential buyers or tenants can afford to spend on them. This therefore acts as a major setback towards wider adoption since many people may not have enough money for such houses hence innovative financing options need to be put in place coupled with necessary interventions so that affordability gap is bridged accordingly.

### 3. Barriers to Implementation

The top three barriers identified include high initial cost, lack of awareness and limited access to green materials for implementing these types of houses which should guide stakeholders during their planning process. The t-test for Hypothesis 2 confirmed the fact that high initial costs are indeed one these issues faced worldwide when it comes sustainable construction but sometimes pay off over long term through reduced energy use or water consumption though they may be expensive initially thus pointing out need for financial innovations like green mortgages or government subsidies so as make them easily available. Lack of awareness being ranked second among significant challenges further supports earlier findings suggesting huge knowledge gaps even among professionals within sector who might be expected know much about what constitutes an environmentally friendly dwelling while restricted entry into supply chain by certain products underscores third barrier. These findings imply;

a) Many sustainable building materials are not produced locally

b) Some specialized items could face importation problems

c) There is no widespread network through which such goods can be made accessible especially if they are supposed serve large numbers people in various parts country.

#### 4. Perceived Benefits of Climate-Smart Homes

Discovering that environmental benefits are perceived very positively by most people (85% agreement) while economic ones have some strong support too (75% agreement) is promising because it means that this area should be given attention. This indicates that after informing the public and removing other obstacles to adoption, things could take off greatly. Marketing campaigns for climate-smart homes may use this positive perception shared among professionals as an advantage during their promotion. However, if these experts think so highly about them why aren't they being built? What could be preventing their construction when everyone seems to like the idea.

#### 5. Features of Climate-Smart Homes

Energy efficiency, water conservation and sustainable materials were identified as features for climate smart houses which shows good knowledge on sustainability principles among those working in housing sector especially developers. This is in line with global best practices of sustainable building as recommended by United Nations Development Programme (UNDP). It also points out areas where cost can be reduced since emphasis was put on these three aspects alone hence there are more than just one way to design a house which will save money. For example, using energy efficient technologies such solar panels or rainwater harvesting system instead city's supply.

#### 6. Strategies for Promotion

Among strategies selected for promotion were tax incentives, green building codes and subsidies for green materials showing a need government participation in this case. The fact that respondents preferred policy driven options implies importance attached to legal framework necessary creating friendly environment towards achieving climate smart homes realization. Public private partnership was cited alongside green mortgage programs as well sustainable urban planning indicating recognition multiple sectors involvement required order bring about desired outcomes such as affordable housing provision within Nigerian cities setting standards across board thus making them sustainable even further fostering achievement SDGs through effective implementation policies that foster development at all levels considering wide range actors involved including civil society organizations, private sector players among others.

## 7. Current State of Climate-Smart Homes in Nigeria

The current climate smart homes in Nigeria are perceived negatively by most of the respondents who regarded them as being few, poorly maintained and unaffordable. This view therefore presents a difficult situation for investment due to lack of demand. On the other hand people may not want to buy these kinds houses because they do not trust their durability considering that many think they will collapse soon after construction due to neglect. The belief that there is no enough supply can discourage those willing to buy while at same time if maintenance becomes another problem, it raises questions about how long such buildings will last. The issue of affordability reechoes what has been said earlier hence underscoring need for measures aimed at making sure everybody can access such kind of housing facilities.

## 8. Recognition of Obstacles

According to t-test for Hypothesis 5, the strong recognition given towards economic and technological obstacles by major players in the sector is a mixed result. While on one hand this shows that these stakeholders have good knowledge about challenges faced during implementation process, it also means that without significant financial assistance or incentives some might be reluctant to venture into them so easily.

### **5.2. Implications of Findings**

This study on cheap climate-friendly houses in Nigeria has many wide-ranging implications for various sectors, that is to say, it shows what must be done as well as what can be done about sustainable housing development.

Policy and regulatory implications are indicated by the results. Climate-smart homes need a comprehensive framework as these findings have shown. It is strongly suggested that the government should take this up through tax reliefs on green building materials among other measures; henceforth making suchlike construction methods mandatory while also providing subsidies or grants-in-aid only applicable when environmentally friendly techniques are adopted. In addition, sustainable urban planning being identified as one of the strategies implies possible changes in city designs through incorporating principles of zoning laws based on climate change considerations and requiring new buildings to have green spaces around them plus putting up ecologically sound infrastructures within their vicinity.

There are significant economic and financial implications of these findings too. For instance there is an affordability gap which means innovative funding mechanisms like low cost mortgages could be introduced so that people can afford buying or renovating energy efficient houses; another option would be establishing “green” bonds used specifically for large scale sustainable housing projects development purposes whereby public participation becomes key due to perceived benefits arising out of ‘climate smart’ homes coupled with current challenges faced by majority who find themselves unable meet associated costs hence they may opt choosing cheaper options thereby creating demand for affordable ecofriendly dwelling units thereby causing growth spurt within renewable energy industry where businesses dealing in environment preservation technologies will thrive resulting into creation more employment opportunities especially within field construction sector concerned with such matters.

Furthermore, social and educational aspects cannot be left out according this investigation’s outcomes viz-a-viz its relevance towards society at large. It thus indicates that awareness creation needs to be intensified because most people know very little about environmental friendly dwellings especially those living below poverty line which therefore calls for massive sensitization campaigns targeting masses not forgetting school-going children through inclusion sustainable lifestyle education into curricula from an early age; hence there is need among others things like organizing community events where locals can see practical examples built nearby etcetera, the study also found out that professionals are well aware of these issues but lack skills to put them into practice thus implying curriculum change institution higher learning such colleges universities as well establishing continuous professional development courses focusing on how best achieve sustainability during construction stages while at same time creating recognition system for builders constructors who specialize this field.

In terms technological and innovation perspectives a number challenges were identified which should be addressed in order make progress. On one hand barriers associated with initial costs being too high indicate this sector requires innovations aimed reducing them; therefore more investments need made research development areas targeting cheaper yet effective building materials methods also promoting collaboration between institutions higher learning such universities colleges vocational programs relevant industries etcetera may help come up with locally adaptable technologies taking into consideration Nigerian climate context besides recognizing potentialities for global best practices transfer thus necessitating international partnerships sharing experiences mutual benefits realization.

These findings have significant environmental implications as well since they point towards some major ecological concerns. Firstly, there's strong recognition about environment significance vis-à-vis sustainable housing that means it could influence climate change mitigation efforts within Nigeria positively; for example if adopted en masse residential buildings can substantially cut down carbon emissions thereby contributing towards national determined contributions under Paris accord while secondly water conservation plus use materials are known conserve resources hence reduce pressure upon urban forests and thirdly promote sustainable forestry practices aimed at enhancing resilience of communities against adverse effects related these two aspects.

The research implies that the construction industry could undergo some significant changes in the market. When this happens, companies may specialize in climate-friendly housing. Additionally, companies will shift their marketing tactics to focus on long-term savings and environmental conservation. This also means that they will come up with new ways of doing business. Moreover, it forces a reassessment of property valuation methods vis-à-vis sustainability considerations.

In conclusion, these findings have implications on monitoring and evaluation systems. The need for standardized performance indicators is shown by the emphasis put on different aspects of climate-friendly houses. Consequently, there might be established national ratings for such homes; regular energy audits and performance tracking could become mandatory as well as setting benchmarks for residential buildings' energy and water use.

It is important to address all these dimensions because failure to do so would not only revolutionize real estate but also greatly contribute towards realization of Nigeria's sustainable development goals (SDGs), commitment against global warming / climate change mitigation efforts as agreed under UNFCCC framework plus economic growth agenda – though achieving this may demand sustained action across multiple sectors involving collaboration and investment at different levels throughout Nigerian society.

## Chapter Six: Conclusions and Recommendations

### 6.1. Conclusions

Climate-smart homes are known to be environmentally friendly among Nigerians, based on the results of this study. However, their perception is not without its challenges because cost considerations still impede their adoption rates. Availability may have improved but accessibility must also catch up with it. Another finding is that while people can afford to rent such houses for some time, they lack enough money to buy.

An evaluation of affordable climate-smart housing in Nigeria reveals a complex picture where many problems coexist side by side with opportunities. The findings indicate a strong awareness about climate-smart homes among professionals which is tempered only by limited use due mainly to high initial costs; lack of information among the public and lack of access to green building materials especially outside urban areas. There is therefore urgent need for more financial options so as to cater lower income groups who form majority residents here as well innovative funding strategies supported through government policy intervention should be considered necessary if these kinds structures are going succeed even further than currently expected from them economically or ecologically wise too given their foreseen positive impacts towards realizing sustainable development goals within Nigerian context. As such, it might not come as surprise why some people still view these houses negatively despite all benefits attached thereto since cost implications involved.

### 6.2. Recommendations

1. **Increase Financial Incentives:** Subsidize, offer tax breaks on, and grant green mortgages for climate-smart housing to cut costs as revealed by the research.
2. **Enhance Awareness Campaigns:** Go on with spreading awareness about climate smart houses and broaden its scope to include economic advantages too so that people can change their mindsets and start using them more often.
3. **Improve Availability:** Put money into creating additional numbers of such units since they are needed in larger quantities now due to increased demand which is also being fuelled by some agencies working jointly with government bodies.
4. **Focus on Rental Options:** There is always a higher number of individuals who are financially capable of paying for rent hence it would be better if more rental

apartments for these types were built since this will facilitate faster adoption rates.

5. **Policy Development:** Develop policies which can be used to support sustainable housing schemes ensuring that all aspects are covered including supply and demand related challenges.

## Declaration of Authorship

I hereby declare that the attached Master's thesis was completed independently and without the prohibited assistance of third parties, and that no sources or assistance were used other than those listed. All passages whose content or wording originates from another publication have been marked as such. Neither this thesis nor any variant of it has previously been submitted to an examining authority or published.

Berlin, 05/07/2024

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Location, Date



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Signature of the student

## **Consent of publishing the Master's Thesis**

This page of the Master's Thesis is optional. If you agree to publish the Master's Thesis at the HTW Berlin library after a successful Final Oral Examination, then you should also attach [the relevant formula](#) here.

# Appendix: Questionnaire

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## Structured Questionnaire

Dear Sir/Ma,

This structured questionnaire is solely for academic research on the “Evaluation of Affordable Climate Smart Homes in Nigeria: Barriers and Strategies” as part of the requirements for the completion of an M.Sc. and M. Eng in Construction and Real Estate Management in the above-named institutions. This questionnaire is to private individuals and professionals as well as key stakeholders in the construction industry who are practicing in Nigeria. Kindly respond to this voluntary survey to the best of your knowledge. It should take less than 10minutes. Your responses will be treated with confidentiality and anonymity, individual respondents will not be identified by name or organisation in the final report. The study has been subject to ethical review in accordance with the procedures specified by the universities and has been given a favourable ethical opinion for conduct.

By completing and returning the questionnaire, it will be understood that you give consent for your response to be used strictly and only for the research.

Thank you so much for taking the time to evaluate and provide valuable input.

For any inquiry, be free to reach me through my details below.

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**Temidayo John Akinnusi**

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**SECTION A: Personal/General Information**

1. How do you categorise yourself? (a) professional in construction industry  (b) policy maker in Nigeria  (c) Home owner  (d) Others
2. A of climate smart homes generally? (a) Not aware  (b) Very low  (c) Average  (d) Low  (e) Average  (f) High
3. What is your average household income per month? \_\_\_\_\_
4. I can afford to buy a sustainable home now? (a) Strongly agree  (b) Agree  (c) Neutral  (d) Disagree  (e) Strongly agree
5. I can afford to rent a sustainable home now? (a) Strongly agree  (b) Agree  (c) Neutral  (d) Disagree  (e) Strongly agree
6. Awareness of climate smart homes in Nigeria? (a) Not aware  (b) Very low  (c) Average  (d) Low  (e) Average  (f) High
7. Climate smart housing is substantially beneficial economically (a) Strongly agree  (b) Agree  (c) Neutral  (d) Disagree  (e) Strongly agree
8. Climate smart housing is substantially beneficial to your environment (a) Strongly agree  (b) Agree  (c) Neutral  (d) Disagree  (e) Strongly agree
9. Climate/sustainable building are readily available for rent in Nigeria (a) Strongly agree  (b) Agree  (c) Neutral  (d) Disagree  (e) Strongly agree
10. Climate smart/sustainable homes are affordable in Nigeria (a) Strongly agree  (b) Agree  (c) Neutral  (d) Disagree  (e) Strongly agree
11. Commercial green buildings are expensive to rent/buy in Nigeria (a) Strongly agree  (b) Agree  (c) Neutral  (d) Disagree  (e) Strongly agree

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**Section B: Assessment of Barriers to Climate Smart Homes**

Please indicate your level of agreement or otherwise to the assessment of barriers to climate smart homes by ticking the appropriate boxes.

<b>Major barriers to climate smart homes</b>	1 (Strongly disagree)	2 (Disagree)	3 (Neutral)	4 (Agree)	5 (Strongly agree)
1. Many people are unaware of climate smart technologies and practises					
2. There is higher preference for traditional homes than climate smart homes					
3. High initial cost of building climate smart homes limits its potential					
4. Lack of professionals skilled in climate smart building.					
5. Low demand for climate smart homes					
6. Materials and technologies for building climate smart homes are scarce or unavailable					
7. Poor or lack of supporting government policies and legal framework.					
8. Low level of demand due to high cost					

9. Limited or no credit facility and financing options, especially for low-income households					
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**10. Climate smart homes should incorporate these features among others.**

<b>Major features of climate smart homes</b>	1 (Strongly disagree)	2 (Disagree)	3 (Neutral)	4 (Agree)	5 (Strongly agree)
1. Climate resilience					
2. Energy efficient design, technology and features					
3. Passive design					
4. Incorporation of water conservation features					
5. Sustainable construction materials					
6. Carbon footprint reduction by integrating renewable sources					

**11. Rate your opinion of importance of strategies and initiatives to support climate smart housing by ticking the appropriate boxes.**

<b>Government initiatives that can encourage climate smart homes</b>	5 (Very Important)	4 (Important)	3 (No opinion)	2 (Less important)	1 (Not important)
1. Giving loans and other financial incentives backed by the government					

2. Mandatory implementation of Net zero carbon building policy/codes					
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3. Planning authorities should encourage and request for Green building certifications as part of approval documents					
4. Tax rebates/holidays to homeowners/developers who incorporate climate smart features in their homes					
5. Subsidies for climate smart technology					
6. Government agencies should be actively involved in monitoring and feedback such as requesting for building's energy performance certificate renewals					
7. Increased public awareness campaigns					
8. Fostering collaborations and knowledge sharing with leading nations in green buildings					

**12. Rate your opinion of strategies towards formulating a workable climate smart housing scheme in Nigeria by ticking the appropriate boxes.**

<b>Strategies towards formulating a workable climate smart housing model in Nigeria</b>	1 (Strongly Disagree)	2 (Disagree)	3 (Neutral)	4 (Agree)	5 (Strongly agree)
1. Government should start with a comprehensive review and harmonisation of all sustainability policies in the country					
2. Create units in all ministries, departments and agencies charged with the responsibility of monitoring the energy performances of buildings					
3. Planning authorities should incorporate energy performance certificates (EPC) as part of planning approval requirements					

4. Remove institutional bottlenecks to approval requests					
5. Conduct a nationwide massive campaign to encourage stakeholders' preference for climate smart homes					
6. Adopt and enforce a unified national climate smart					

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certification					
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7. Digitalise all climate smart homes vis-à-vis all benefits accruable and regularly publish on a public website to encourage investment in climate smart homes					
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**13. What are the main challenges you face in developing affordable housing in Nigeria?**

<b>Challenges of affordable housing in Nigeria</b>	1 (Strongly Disagree)	2 (Disagree)	3 (Neutral)	4 (Agree)	5 (Strongly agree)
Land Availability and Cost					
Infrastructure Deficiencies					
Finance and Funding					
Regulatory and Administrative Challenges					
Construction Costs					
Income Disparities and Affordability					

Informal Settlements and Urbanization					
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**14. Please provide your opinion about the exiting commercial buildings and private homes (rentage/purchase) affordability in Nigeria?**

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