AN ASSESSMENT OF THE ADOPTION OF SMART BUILDING CONCEPT IN THE NIGERIAN CONSTRUCTION INDUSTRY

BY

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ABSTRACT

Technological penetration across developing countries has impacted the construction industry, with more construction stakeholders deploying various technologies into the building lifecycle's design, construction, management, and maintenance. The building sector has evolved by adopting and implementing smart tools for its operations over the past few years. Building information modelling (BIM), the internet of things (IoT), and smart devices (sensors) are game-changers that have helped to reduce the complexity of construction activity and increase productivity. Meanwhile, introducing the sustainable development concept in the construction industry has enabled the proper management of the earth's natural resources and provided a pathway for ecosystem balance alongside socio-economic development. Amid the skyrocketing population growth, urban sprawl, and globalization, the building industry is confronted with the challenge of providing adequate and holistic built infrastructures such as efficient energy management, good water supply, occupants' indoor comfort, and the management of construction waste. The smart building concept (SBCs), which employs sustainable construction whereby the built product is constructed according to best practices, including efficient energy use, the recycling of raw material, and the realization of a sustainable and carbon-free environment, has demonstrated the digitalization of sustainable development in the construction industry. Therefore, this dissertation seeks to asseeement of the adoption of smart building concepts in the Nigerian construction industry. The research poses the following questions: 1) What is the awareness level of construction professionals in the adoption of the smart building concept (SBCs) in the Nigerian construction industry? 2) What factors can enhance the awareness of the smart building concept among construction professionals in the Nigerian construction industry? 3) What factors enhance the adoption of SBCs among professionals in the Nigerian construction industry? 4) What are barriers to adopting SBCs in construction projects in the Nigerian construction industry? A random sampling technique in selecting the construction professionals. The total population of construction professionals within the study area is 5,108, comprising construction professionals of Architects, Builders (Mechanical, Electrical, and Structural), Engineers, and Quantity Surveyors practicing in Lagos state. The sample size selection was made using the Yamane formula (1967) for calculating sample size. Therefore, the sample for this study is 363. A well-structured questionnaire of 363 was administered to construction professionals to gather relevant data on the topic. The data collected were analyzed using the Kruskal Wallis H test and weighted mean, factor analysis, and binary regression analysis, and mean item score and agreement analysis technique. The key finding of the research indicated that construction professionals are generally aware of the smart building concept. Administration, education, organizational, and environmental factors were discovered to enhance the adoption of smart building concepts among construction professionals. Furthermore, the research indicates that energy and cost-saving, job creation, safety and security, and health care are the critical factors enhancing in adoption of smart building concepts among construction professionals in the Nigerian construction industry. Lastly, the research result discovered that the high cost of smart building materials, inadequate power supply, resistance to change from the use of traditional technology, poor maintenance culture, poor knowledge of smart building technology, inadequate well-trained labour in the practice of smart building construction, and inadequate finance schemes are the significant barriers to the adoption of smart building concept. Based on this research finding, the research recommends that construction professionals engage more in smart building concepts, propagating the country's awareness and development of smart building construction. Furthermore, the government should establish a common platform for the collaboration of all stakeholders, such as professionals in the construction industry and academia, by way of policymaking and funding of research and development towards implementing these smart technologies. It will go a long way for employment creation and improve the country's economy. This study contributes to the body of knowledge by discovering the critical factors that will aid the successful adoption of the smart building concept in the Nigerian construction industry.

Keywords: sustainable construction, smart building concept, digitalization, sustainable development goals.

DECLARATION

I, CYRIL CHINONSO EJIDIKE, at this moment, declare that this dissertation is the candidate's original work. Every Source cited, or text has been appropriately referenced. The research work is the original write-up, which has not been previously submitted or published in part or totality for another degree at any other University.

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DEDICATION

This dissertation is dedicated to the Lord God Almighty, who created and gifted me with this opportunity and given me strength and patience throughout the master's journey. This dissertation is also dedicated to my parents, brothers, sister, and adorable niece for their unwavering support and prayers.

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Ejidike Cyril Chinonso and Mewomo Modupe Cecilia (2021). *A Review of Barriers to The Adoption of Smart Building Concepts (Sbcs) In Developing Countries***.** 15th Built Environment Conference Durban 2021 (Asocsa). 26th-28 September 2021**.**

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LIST OF ABBREVIATIONS

BIM	Building information modelling
IOT	Internet of things
NIA	Nigerian Institute of Architecture
NIOB	Nigerian Institute of Building
NIOQS	Nigerian Institute of Quantity Surveying
NSOE	Nigerian Society of Engineers
SBCs	Smart building concept
WCED	World Commission on Environment and Development

CHAPTER ONE

1.1 INTRODUCTION

This dissertation appraises the critical factors that can support the successful adoption of the smart building concept in the Nigerian construction industry. This chapter specifically presents the background information, problem statement, aim of the study, research questions, objectives, motivation, and justification for this study.

1.2 BACKGROUND STUDY

Technological penetration across developing countries has impacted the construction industry, with more construction stakeholders deploying various technologies into the building lifecycle's design, construction, management, and maintenance (Kochovski and Stankovski 2018). The building sector has evolved by adopting and implementing smart tools for its operation over the past years. Building information modelling (BIM), internet of things (IoT), and smart devices (sensors) are game-changers that have helped reduce the complexity of construction activity and increase productivity (Olawumi and Chan 2020).

Due to the skyrocketing population growth, urban sprawl and globalization, the building industry is confronted with the challenge of providing adequate and holistic built infrastructures such as efficient energy management, good water supply, occupants' indoor comfort, and construction waste management (Li, Endter-Wada, and Li 2015; Indrawati, Yuliastri, and Amani 2017). Meanwhile, the introduction of the sustainable development concept in the construction industry has enabled the proper management of the earth's natural resources and provided a pathway for ecosystem balance alongside socio-economic development (Berardi, GhaffarianHoseini, and GhaffarianHoseini 2014). The smart building concept (SBCs), which combines sustainable construction practices, including using energy efficiently, recycling the raw material, and the realization of a sustainable and carbon-free environment to construct products, has demonstrated the digitalization of sustainable development in the construction industry (Hwang and Tan 2012; Okoye and Okolie 2014; Glavič 2021).

The construction industry's response to sustainable development goals (SDGs) introduces efficient energy use, encourages locally available raw materials, and advances conventional building techniques (Riley, Thatcher, and Workman 2006; Omer 2017). Achieving the SDGs requires promoting efficient technologies and the practice of smart concepts in the built environment (Darko and Chan 2018). It is not easy to think of a smart building without associating it with aspects of sustainability in the construction industry (Akadiri, Chinyio, and Olomolaiye 2012). According to the World Commission on Environment and Development (WCED 1987), sustainability refers to the "development that meets current needs without jeopardizing future generations' ability to meet their own" say cited(Diri and Elisha 2021p:15). Over time, building practitioners have become vital in energy management, protecting and restoring ecological balance, increasing economic efficiency, and improving human comfort and satisfaction through technology (digitalization) (Tan and Taeihagh 2020).

The Intelligent Building Institute of the United States defined a smart building as a structure that optimizes its four essential elements: structures, systems, services, and management, as well as the interrelationships between them, to deliver a productive and cost-effective environment (Omar 2018). The SBCs change traditional building construction and maintenance methods and improve building production and maintenance through the increased use of sophisticated technologies (digital), standardized methods, components, and fabrication offsite (Gbadamosi et al. 2019).

The construction industry in developed and developing countries has greatly adopted the smart building concept principles. Honeywell and IHS (2015) and Arcadis (2020) report that developed counties have adopted and implemented smart building concepts in their construction industry to produce buildings and prevent greenhouse gas emissions in the construction industry. According to Honeywell and IHS (2015), the smart building concept in developed countries like the UK and the United States is already in use for the planning and construction of buildings in cities such as San Francisco, which use the concept for the generation of 227 000 kilowatt-hours per year, through the incorporation of an integrated hybrid solar array and wind turbine installation.

In developing countries like Indonesia, smart buildings and smart cities have positively impacted the economy and people's lives, satisfying their wants and needs. Also, smart buildings have saved energy and reduced energy power from 765,228.16 kWh to 499,067.01 kWh equal to a 34.78% reduction (Berawi et al. 2017; Indrawati, Yuliastri, and Amani 2017). According to Frost and Sullivan (2009), smart buildings can detect the buildings' performance and configuration according to environmental constraints around the building. They highlighted that the building should familiarize itself with diverse environmental situations by using the occupants' behavior data. Indrawati, Yuliastri, and Amani (2017)explained smart building as the collaboration of building automation, system integration, and telecommunication for efficiency, functionality, optimization, comfort, and economic stability. Harris (2012) stated that smart buildings could reduce building costs and energy consumption by combining operation and automation optimizations of building control compared to conventional buildings. Furthermore, the author explained that SBCs collaborates with telecommunications, building automation, and system integration to optimize economic, energy efficiency, conformability, functionality, and building stability.

1.3 PROBLEM STATEMENT

This study deals with a critical problem in the Nigerian construction industry and other developing countries. Due to a low level of awareness and lack of adoption of smart building concepts in the Nigerian construction industry, construction professionals have not taken full advantage of the smart building concept (Makarfi, 2015; Oyewole, Araloyin, and Oyewole, 2019). Ogunde et al. (2018) noted that the Nigerian construction industry still faced considerable challenges in terms of inadequate power supply, lack of technical knowledge, high cost of purchasing devices and high maintenance costs, poor maintenance cultures, and occupant's comfortability (Iwuagwu and Iwuagwu 2014). This challenge has caused difficulties in the building industry (Chan et al. 2017). According to Isa, Jimoh, and Achuenu (2013), the building industry is essential for most developing and emerging economies. It is seen as a driver of economic growth, especially in Nigeria. Most developing countries still engage in the conventional building construction technique, which delays the progress and development of the industry (Chukwu et al. 2019; Gbadamosi et al. 2019). The use of smart buildings is rapidly increasing around the world cities. While the SBCs are not new in the building sector of the construction industry, the commercial industry is making use of the concept in their banking building through the use of automated opening and security doors (Ogunde et al. 2018). Based on their evaluation of the residents' awareness and aspiration for Smart building features in Lagos, Oyewole, Araloyin, and Oyewole (2019) concluded sensitizing government authorities, developers (construction professionals), and property users, in particular, is critical. Furthermore, the study by Eseosa and Temitope (2019), which involved the design optimization and implementation of a smart building management system in Nigeria, concluded that the advantage of using smart buildings would go a long way toward addressing power shortages in the country by utilizing energy-efficient measures to control buildings electro-mechanical equipment.

Evidence and previous research indicate that construction professionals in the building sector of the Nigerian construction industry have not taken full advantage of the Smart Building Concepts. Despite its various advantages, its concepts are yet to be fully grasped by Nigerian construction professionals.

Therefore, the need arose for the successful adoption of the SBCs in the building sector of the Nigerian construction industry, whereby the building industry will meet the increasing demand for housing due to the nation's increasing population growth (Eseosa and Temitope 2019). This study, therefore, investigates the critical factors for the successful adoption of the smart building concept in the Nigerian construction industry.

As a result of the factors mentioned above, this research aimed to address the following questions:

1. What is the awareness level of construction professionals in adopting the smart building concept (SBCs) in the Nigerian construction industry?

2. What factors can enhance the awareness of the smart building concept among construction professionals in the Nigerian construction industry?

3. What factors enhance the adoption of SBCs among professionals in the Nigerian construction industry?

4. What are barriers to adopting SBCs in construction projects in the Nigerian construction industry?

1.4 RESEARCH AIM AND OBJECTIVE

The research aimed to investigate the critical factors influencing the successful adoption of smart building concepts in the building sector of the Nigerian construction industry

This research work aims at realizing the following objectives:

1. To investigate construction professionals' awareness level of the adoption of SBCs in the Nigerian construction industry.

2. Investigate the factors that can enhance the level of awareness of smart building concepts among construction professionals in the Nigerian construction industry

3. To assess the factors that can enhance the adoption of SBCs among professionals in the Nigerian construction industry

4. To identify the barriers to the adoption of SBCs in construction projects in the Nigerian construction industry

1.6 MOTIVATION FOR STUDY

The motivation for this master's topic is to deepen my understanding of smart building construction management, considering sustainability and construction digitalization in the building construction industry. The study will expose professionals to the knowledge needed in modern construction practice worldwide.

1.7 JUSTIFICATION OF THE STUDY

The use of digitalization, such as smart tools, digital twins, and BIM, has steadily changed how information about our built environment is shaped, stored, and distributed among professionals. Digitalization is the future and the solution to the difficulties of the building construction industry (Wang et al. 2012, Boje et al. 2020). According to Yuliastri and Amani (2017), a smart building is one of the most promising modern developments in the construction industry and a measurement tool for the growth of the construction industry. Ye et al. (2020) added that there is a need to integrate the smart building system into the design method, construction operation, and management of building to reduce cost and energy usage in the building sector of the construction industry. Also supported by Hamma-adama and Kouider (2018), smart building integration into building control minimizes processes to lower the cost of operation and energy, which will increase the productivity and comfortability of the occupant than the conventional buildings in the construction industry.

According to Liu, Issa, and Olbina (2019), adopting a smart building is subject to many critical factors, and these factors should be identified and understood. Eadie et al. (2013) opined that information on the factors influencing the adoption of a smart building could promote the construction industry. The construction industry in developed countries has adopted smart building and is moving forward (Honeywell and IHS 2015). It is a wake-up call, a significant challenge for developing countries like Nigeria to adapt smart buildings in their building construction industry to use new and innovative processes for delivering projects. Iwuagwu and Iwuagwu (2014) highlighted that those smart buildings in the Nigerian construction industry had not experienced a significant increase due to the cost and insufficient power supply. This challenge is a limiting factor in the drive to adopt smart buildings by professionals and owners in the country.

Recently, modern technology improvements have occurred in other industries like manufacturing, distributing, and supplying equipment (Xu, Xu, and Li 2018). Therefore, incorporating the smart building concepts is central to integrating intelligent technologies (Baleta et al.2019).

Ogunde et al. (2018) found a lack of awareness of BAS by professionals in their paper Assessment of Integration Of Building Automation Systems in Residential Buildings in Developing Countries: Professionals' Perspectives in Nigeria. Likewise, the study of Ghansah et al. (2020) Underlying indicators for measuring the smartness of buildings in the Ghana construction industry identifies a low level of knowledge about smart building technologies. Ghansah et al. (2021b) Assessing the Level of Awareness of Smart Building Technologies (SBTs) in the Developing Countries study indicates a low level of SBTs among professionals in the construction industry of Ghana. Finally, Owusu-Manu et al. (2021) examined Factors influencing the decision to adopt Smart Building Technology (SBT) in developing countries, and the study identified that it is moderately high in the Ghanaian construction industry, which further revealed that Privacy and Security, “IT Professional Support, Top Management Support. This research identifies a problem in the adoption of smart building concepts in the building sector of the Nigerian construction industry. Since this is a new area of modern technology in Nigeria, there is an apparent lack of knowledge in the Nigerian construction industry. This study will serve as a means of advocacy to federal and state governments, developers, and owners of buildings to engage in the use of smart building construction practices for the sustainability of the construction industry.

1.8 SCOPE OF THE STUDY

This research intends to cover the vital essence of the critical factors for the successful adoption of smart building concepts in the Nigerian construction industry. However, the scope of the study covers the practicing construction professionals in Lagos State in South Western Nigeria. Lagos State is the economic hub and the most technologically advanced state in Nigeria.

1.9 BRIEF LITERATURE REVIEW

According to Froufe et al. (2020), smart buildings are rapidly increasing in cities worldwide. The smart building concept is not new in the construction industry but has evolved due to new technologies like the internet and deep machine learning. Therefore, smart building concept is a sustainable philosophy of building design, construction, and maintenance of the building life cycle, which complies with the ecosystem, economy, and social life (Koko and Bello 2020). According to Kashada, Li, and Kashadah (2016), adopting the smart building concept includes five stages: the awareness stage, conviction stage, decision-making stage, implementation stage, and confirmation stage. Renaud and van Biljon (2008) revealed that smart building concept adoption is a process that begins with the professional and owners' awareness and implementation of smart building practices in our present construction industry. Obat (2016), revealed that critical factors (CFs) play a pivotal role in successfully adopting and implementing many new technologies. Therefore, the need arises to explore the critical success factors for implementing and adopting smart building concepts in the Nigerian construction industry. Owusu-Manu et al. (2021) identified the instrumentation and control factor, computer self-efficacy factor, participation, and collaboration factor, viable funding strategy, top management support, connection with professionals, and interoperability as CFs influencing the adoption of a smart building.

1.10 RESEARCH METHODOLOGY

The comprehensive approach to the design process of conducting research entails theoretical phases that support data collecting and analysis (Chun Tie, Birks, and Francis 2019). This study employs a quantitative research approach design was adopted using the instrument of questionnaires. It is objective and scientific in nature, and it comprises the gathering of quantitative data that can be subjected to rigorous quantitative analysis using standard statistical techniques in a formal and disciplined manner (Nunayon, Olanipekun, and Famakin 2020). The study employed a random sampling technique in selecting the construction professionals. These include architects, builders (Mechanical, Electrical, and Structural), engineers, and quantity surveyors practising in Nigeria.

1.11 OVERVIEW OF THE CHAPTERS

Chapter 1: Introduction

This chapter presents the research and delivers the background and problem of the study, justification of the research, the research questions, the research objectives, the research methodology, limitations, assumptions, and ethical considerations.

Chapter 2: literature review

This chapter contains an extensive review of the literature on the level of awareness of the components of SBCs among construction professionals in the Nigerian construction industry. It investigates the factors that can enhance the level of awareness of smart building concepts among construction professionals in the Nigerian construction industry; assesses the factors that influence the adoption of SBCs among professionals in the Nigerian construction industry, and identifies the barriers to the adoption of SBCs in construction projects in the Nigerian construction industry

Chapter 3: Research methodology

Chapter 3 concentrates on the methodology used to reach the project aims. It provides definitions and brief descriptions of the research methodology. The chapter then describes the population and the sample drawn from it. Furthermore, it states how the information is to be analyzed and presented to assess the data collected.

Chapter 4: Data Collection and Analysis

This chapter presents the analysis of the data collected. The data were analyzed using SPSS. The presentation of data was based on a series of tables compiled in several sections derived from the research and discussed in the literature review and preceding chapters.

Chapter 5: Conclusions and Recommendations

The last chapter presents the conclusions drawn based on the research findings, recommendations, and further research opportunities.

1.12 CONCLUSION

This chapter has presented the various components and the eventual framework for the whole study on the appraisal of the critical factors for the successful adoption of smart building concepts in the Nigerian construction industry. The aim and motivation of the study were discussed, and research questions, objectives, and scope were set for the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter reviews the general literature on critical factors for the successful adoption of Smart Building Concepts (SBCs) in the Nigerian Construction industry, investigating the level of awareness of SBCs among construction professionals in the Nigerian construction industry. It investigates the factors that enhance awareness of smart building concepts among construction professionals in the Nigerian construction industry; assesses the factors that influence the adoption of SBCs among professionals in the Nigerian construction industry. Lastly, it identifies the barriers to adopting SBCs in the Nigerian construction industry construction projects.

With the emergence of sophisticated technologies such as the internet of things (IoT), smart devices (sensors), and building information modelling, the introduction of the smart building concept in the building sector of the construction industry has impacted the behaviour of the building in various ways such as high performance in the building, comfortability of occupants, and efficiency of energy management in the building (Ghansah et al., 2020). According to Gbadamosi et al. (2019), a smart building differs from a conventional traditional building in design, construction management, and maintenance of the building life cycle, which involves using technologies.

2.2.1 Definition of Smart Building Concept

Indrawati, Yuliastri, and Amani (2017) defined the smart building concept as the collaboration of building automation systems, integration systems, and telecommunication systems for the smart building's efficiency, functionality, optimization, comfort, and economic stability. Buckman, Mayfield and Beck (2014) identify the smart building concept in four significant accounts, which are intelligent, enterprise, control, and construction materials, which should be adaptable to the building system to meet building progress in terms of energy efficiency, comfort, satisfaction and longevity (life cycle).

2.1.2 Overview of Smart Building Concept in the Construction Industry

Various studies on the smart building concept in the construction industry have used various expressions to practice the smart building concept. The smart building concept has gradually increased since its introduction in 1989 by the intelligent building institute of the United States. Since its introduction, the smart building concept has progressively increased in development and practice (Olanipekun 2017). Dodge (2016) revealed that the smart building concept had been accepted globally, encouraging its development. Bao et al. (2020) opined that the clamour for smart building practices had increased worldwide. The use of smart buildings is rapidly increasing in cities around the world. The smart building concept is not new in the construction industry but has evolved due to new technologies like the internet and deep machine learning (Froufe et al., 2020). The smart building concept is a sustainable philosophy of building design, construction, and maintenance of the building life cycle, which complies with the ecosystem, economic and social life (Koko and Bello, 2020). According to Vattano (2014), the smart building concept is the brightest contemporary trend integrating the ideas of smart mobility, smart technology, smart economy, smart people, smart government, and smart environment that reduce the building practice impact on the environment in the construction industry. Attoue, Shahrour, and Younes (2018) opined that the smart building concept uses smart technology to improve comfort and satisfaction and reduce energy consumption in a building.

A study conducted by Berawi et al. (2017) revealed that the smart building concept uses automation. Newman et al. (2020) opined that the smart building concept uses smart technology like Industry 4.0 and Construction 4.0. Moreover, Taktak, Abdennadher, and Rodriguez (2017) revealed that the smart building concept encompasses the development of the design, construction, materials stage, and the maintenance of the building life cycle. The aim is to reduce the cost of energy consumption, increase the occupant's comfort, and reduce harmful gases to human health and the environment.

2.1.3 Smart Environment in Sustainable Construction

According to Guedes et al. (2018), construction is an essential aspect of a country's economic development; it allows for creating smartly built infrastructure amenities such as smart buildings, smart grids, and smart transportation. Goh et al. (2020) emphasized that sustainable construction is part of sustainable development goals. Various components achieve sustainable development in a smart environment, such as Smart Cities, Smart Grids, and Smart Meters. A smart environment forms part of sustainable construction by using automation operation, recycling raw materials, and reducing harmful greenhouse gases during the construction practice and the functionality of the building life cycle (Olanipekun, 2017). However, building construction and demolition of built products use a lot of energy and raw material, negatively impacting the environment, affecting the ecosystem balance in harmful greenhouse gas emissions and construction waste (Wang et al., 2012).

According to Gadakari, Mushatat, and Newman (2014), research revealed that sustainable construction is a process of overpowering the negative impacts of construction operations on the environment and achieving sustainable development goals by delivering economic, social, and environmental sustainability through digitalization. According to Zainul (2010), economic sustainability in construction refers to the financial benefit of the project's stakeholders and professionals, putting the built environment first. Goh (2017) revealed that social Sustainability involves the development of the community, occupant comfort, occupant health and safety, public engagement, occupant access to services, and equality and diversification. Grierson (2009) opined that environmental Sustainability is the efficient use of the earth’s natural resources to reduce the impact of the built environment on the earth and restore the harmony between the environment and the earth’s natural resources.

2.1.3.1 Smart City

According to Harrison et al. (2010), smart cities are metropolitan areas that use operational data (live data) to optimize city operations, such as transportation statistics, power consumption statistics, traffic congestion data, and public safety data. Data from street lights are one example of live data. The live data on the street light contains an alarm indicating a street light failure, using the geographic information system (GIS) to locate and replace the broken street light.

According to Dameri (2013), a smart city is also described as a physical area in which information communication technology (ICT), energy production, logistics (transportation), and e-government work together to improve the well-being of citizens and intellectual development, and environmental quality.

Al Dakheel et al. (2020) asserted that in the context of smart city development, intelligent, innovative infrastructure and digital technologies should be utilized while optimizing technologies to meet the needs of people and communities. The creation of intellectual capital and developed cities require the ability to use digital technology to improve the performance and competencies of the built infrastructure to produce knowledge and translate it into distinct unique ICT data acquisition and open communication systems. (Dameri, 2013; Al Dakheel et *a*l. 2020). Analysis, visualization, modelling, and data simulation help make better operational decisions in achieving smart cities (Gil-Garcia, Pardo, and Nam, 2015).

FIGURE 2. 1 Smart city Source (Al Dakheel et al. *2020)*

2.1.3.2 Smart Grid and Smart Meter

According to Höjer and Josefin (2014), smart grids are electric infrastructure power grids, through automated control, metering technology, and sensing to improve power efficiency, enhance reliability and safety, and the smooth integration of renewable energy sources and storage resources for distribution of generated electricity. According to Gil-Garcia, Pardo, and Nam (2015), Smart grids use transmission and circulation technology to supply power from centralized and distributed generation plants to clients. Data and communications improvements are used to work, control, and check the lattice (ICT) (Govinda. 2015). These advancements enable energy companies to flawlessly control power requests while ensuring efficient and reliable power delivery at a lower cost.

According to Govinda (2015), smart meters are advanced energy metering systems that allow bidirectional data connection and the collection of information about electricity provided to the power grid from client's premises and the execution of control commands remotely and locally. According to Depuru et al. (2011), a smart meter is an advanced energy meter that measures electrical energy use and provides more information than a traditional energy meter. Smart meters can read and securely transfer real-time energy usage data, including voltage, phase angle, and frequency values. The capacity of smart meters to communicate data in both directions allows for the collection of information on electricity sent back to the power grid from client premises. A smart meter system contains the meter itself, communication infrastructure, and control devices (Vojdani 2008).

FIGURE 2. 2 Smart metering Figure - Source (Harris 2012)

2.1.4 Smart Building in the Context of Occupancy

The emphasis on occupancy and higher-level contact with the inhabitants of a building is a commonly discussed area as to how much power the occupant of a building should be provided to meet both comfort and energy efficiency standards. However, the current specifications are advanced building research principles that stress establishing a convergence between occupants. Attention has been given to the construction industry of developing countries to increase the productivity and management of building products through smart building technology construction (Kleissl and Agarwal 2010). Meanwhile, according to Honeywell and HIS (2015), the construction industry in developed countries has adopted the principles of the smart building concept to a considerable extent. Moreover, Arcadis (2020) reported that in developed countries like the United Kingdom, United States of America, and Germany, the construction industry has adopted and implemented smart building concepts to produce buildings and prevent greenhouse gas emissions.

For example, Honeywell and IHS (2015) indicated that the smart building concept is already used to plan and construct buildings in cities around the United States. Cities such as San Francisco use the concept of generating 227 000 kilowatt-hours per year by incorporating an integrated hybrid solar array and wind turbine installation. In Indonesia, using a smart building and the smart city has positively impacted the economy and people's lives, satisfying their wants and needs, and the use of the smart building has been able to save energy and reduce energy power from 765,228.16 kWh to 499,067.01 kWh equal to a 34.78% reduction (Berawi et al. 2017; Yuliastri and Amani 2017). In developing countries, some of the building construction industry is behind in the adoption and implementation of smart building concepts, which hinders their progress, development, and growth (Gottfried 2019). In Ghana and other developing countries, the construction industry has focused on environmentally sustainable construction practices, which is part of the smart building concept by developing a structure that is energy efficient, consumes less water, and reduces greenhouse gas emissions which allows the professionals to create adaptable capabilities for environmentally sustainable construction practices (Mensah 2016).

2.1.5 Evolution of smart building concept in Nigeria construction industry

The population of cities in Nigeria is overgrowing due to the development of the urban cities and the movement of people from rural settlements to urban settlements in search of basic amenities for a living (Oke and Omole, 2019). The large population sizes typify many Nigerian cities in Kano in the country's Northern region and Anambra and Lagos in the South Eastern and South Western region, respectively. This dense population causes difficulty in managing construction waste, scarcity of primary resources, and air pollution from the construction activities (Shafii, Arman Ali, and Othman 2006). The harmful consequences of building practices on the environment have led to the demands for improvement in building projects, waste management, and energy efficiency in the construction industry (Nduka and Ogunsanmi 2015). Efforts to save and improve the construction industry from harmful practices and greenhouse gas emissions have led to the clamour to adopt the practice of smart building concepts among the professionals in the construction industry that will eliminate the release of harmful gases and reduce waste from the construction industry (Nduka and Ogunsanmi 2015)

2.2 AWARENESS OF SMART BUILDING CONCEPT (SBCs) AMONG CONSTRUCTION PROFESSIONALS

The smart building concept has gained traction among construction professionals and academics working to preserve the environment and advance the construction industry's building sector (Ogunde et al., 2018). According to Kashada, Li, and Kashadah (2016), adopting the smart building concept is considered in the following five stages: the awareness stage, conviction stage, decision-making stage, implementation stage, and confirmation stage.

The awareness stage involves the end-users and professionals acquiring information and knowledge about the technology. In contrast, the conviction stage involves the end-users and professionals choosing to adopt the new technology, while the decision-making phase involves the end-users and professionals deciding to adopt the new technology. Both parties finally implement the new technology in the implementation stage. Conclusively, in the confirmation stage, both the end-users and professionals assess the result of new technology and expect better outcomes. Ahiabor (2019) posited that many organizations and professionals lack a complete understanding of the smart building concept, which has hindered the adoption and implementation of smart buildings in the construction industry. The smart building concept potential has not been fully exploited due to the lack of awareness by the organization and construction professionals.

In another vein, Renaud and van Biljon (2008) revealed that smart building concept adoption is a process that begins with the professionals' and owners' awareness of the smart building practice and implementation in our present construction industry. Ogunde et al. (2018) opined that awareness of the smart building concept is vital for the adoption and implementation in the building sector of the construction industry. Usman and Khamidi (2012) revealed that awareness of the smart building concept refers to strategies and exercises that help professionals understand the concept.

Research into the construction industry in developing countries indicates that the adoption of smart building concepts, attributed to a low level of awareness and cognizance of SBCs amongst construction professionals, is still low (Ghansah, Owusu-Manu, and Ayarkwa, 2019). Ahiabor (2019), in his study, posits that the smart building concept needs better understanding by the professionals in the adoption of smart building technologies and creates clear opportunities for development by the real estate agent and developer. Mensah (2016) opined that awareness of environmental construction sustainability as part of smart building among professionals is still low due to a lack of knowledge on how to execute the practice.

In Nigeria, as a developing country, few researchers have worked on smart buildings; most researchers have worked on the awareness of intelligent buildings, building automation, and smart building features in the Nigerian construction industry. Makarfi (2015), in his study, "An assessment of the level of awareness of intelligent building amongst Nigerian architects, a case study of Kaduna metropolitan area," concluded that despite the intelligent building being part of the smart building concept, his study discovered that the awareness of intelligent building is deficient among the architect professionals in the construction industry of the Kaduna metropolitan area.

Ogunde et al. (2018) assessed the integration of building automation systems in Nigeria's residential areas and discovered a low level of awareness among construction professionals, an essential part of a smart building. Oyewole et al. (2019) evaluated the awareness of smart building features and discovered that it is fair; they also noticed that the construction professionals were not fully aware of them. Ghansah's (2020) study revealed that the level of awareness of smart building concepts among construction professionals in the Ghanaian construction industry is moderately average and that there is a need for enlightenment on the adoption of smart building concepts to improve the energy efficiency, occupant comfort, and sustainability

2.2.1 Component to measure smart building

The component for measuring the smart building concept is critical for its adoption in the construction industry as a result of its positive impact on several aspects of human life; including how people live in comfort, how they fulfil their wants, security, long-term flexibility, and demands, and how people support their lifelong comfort needs (Yuliastri and Amani, 2017). Furthermore, Indrawati, Yuliastri, and Amani (2017) identified seven components to measure the smart building: building automation system, building control system, energy management system, safety and security management system, enterprise management system, green building construction, and IT network connectivity.

2.2.2 Building Automation System

According to Ogunde et al. (2018), building automation systems employ computers and information technology (IT) to manage building appliances for improved building performance. On the other hand, the control system is a sophisticated network of electronic devices that monitor and control a building's mechanical, electronic, and lighting systems. Temperature control, energy management, fire, and security systems are all separated in a traditional building.

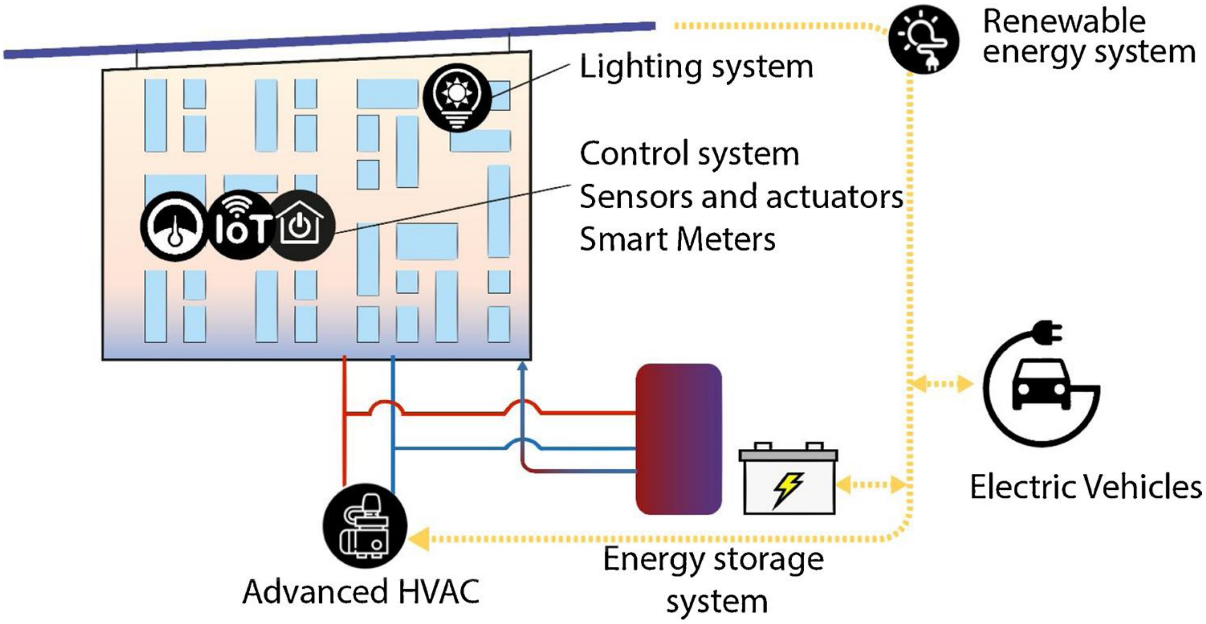

FIGURE 2. 3 Building automation system - Source (Al Dakheel et al. *2020)*

2.2.3 Energy management system

An energy management system (EMS) improves energy efficiency and maximizes energy savings over time(Batov 2015). According to Sgrò (2018), an energy management system ensures that energy consumed in the building is controlled and monitored. Amaral, Reis, and Brandao (2013) further explained that EMS is a system that monitors the cost of energy at home and controls how much energy is used, such as lowering the costs of operations and maintenance or even lowering the costs of fixed appliances.

2.2.4 Building control system

According to Wu and Noy (2010), a building control system is essential in managing occupant comfort and monitoring the heating, ventilation, and air conditioning (HVAC) and lighting systems used, reducing energy waste. An example of a building control system is an occupant sensor. Occupancy sensors (g) aid in energy conservation. The HVAC and lighting systems can stop when occupancy sensors detect no movement for a predetermined amount of time; When the HVAC and lighting systems detect occupancy once more, they restart operating according to the user's preferences.

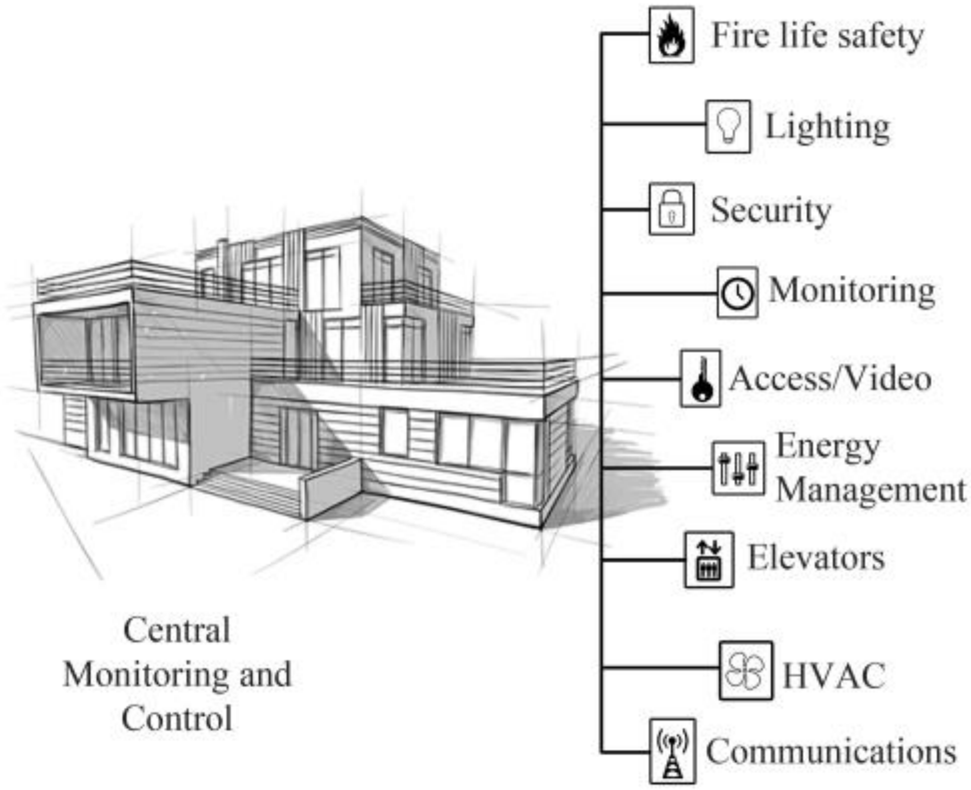

FIGURE 2. 4 Building monitoring and control - Source (Vattano 2014)

2.2.5 Safety and Security Management System

According to Honeywell and IHS (2015), the way a building responds to threats, manages access to the facility, secures lives and assets, and makes it comfortable and productive are all examples of safety and security systems (illumination, thermal comfort, air quality, connectivity, energy availability).

2.2.6 Enterprise Management System

According to Buckman, Mayfield, and Beck (2014), an enterprise is a new emerging integrated system within the smart building concept; consisting of a combination of software and hardware used to overcome fragmented, non-proprietary, and non-compatible legacy systems, allowing building operations to be optimized toward the building functions. Developing a method that uses the data gathered is called enterprise, for instance, reserving a hotel for a conference or meeting or planning a movie schedule in a theatre.

2.3 FACTORS THAT ENHANCE THE LEVEL OF AWARENESS OF SBCs

The smart building concept embraces many technologies, which requires enlightening construction professionals and end-users about its operation and maintenance. Renaud and van Biljon (2008) opined that adopting any new technology commences with awareness from both the professionals and the clients. The promotion of new technology to be accepted and applied to a new concept in any organization or country needs to discover the factors that will enhance the promotion (Otegbulu 2011). Technology adoption is associated with awareness among potential adopters (Kashada, Li, and Kashadah, 2016). However, Ghansah et al. (2021) classified the factors that enhance the level of awareness of SBCs into organizational structures, environment and laws, and Conversance in information technology.

2.3.1 Organizational Structures

The awareness of smart buildings should be incorporated into various organizations to ensure that workers understand smart buildings. However, it may challenge the status quo, lead to complexity, and require a high level of learning and training, as Lin and Ho (2011) affirmed. According to Azeem et al. (2017), the awareness of smart building will be enhanced by creating public awareness of smart initiatives and promoting successful smart building projects as examples. Various construction firms should plan effective training programs to impart knowledge of smart building practices to their employees and suppliers to reach this goal (Sarkis 2012). Ehrenhard, Kijl, and Nieuwenhuis (2014) suggested providing funds and regulatory incentives for smart building construction development and organizational commitment toward smart building to enhance awareness of SBCs.

2.3.2 Environment and Laws

According to Diabat and Govindan (2011), government regulations are significant influencers on the awareness level of smart building concepts in the construction industry of their sustainability potential. The government has encouraged the adoption of information technology legislation that provides a framework for a low-carbon economy (Rahim and Musa, 2019). Zainul (2009) identifies improvement of occupants' productivity/satisfaction, building waste management, and the ecology of the smart building that improves land protection through the technologies during clearing activity to reduce the environmental problem. Sovacool and Furszyfer Del Rio (2020) revealed that security, low-cost loans, and subsidy from the government would enhance the smart building concept adoption.

2.3.3 Conversance in information technology

Knowledge of technologies surrounding smart building concepts has been a key factor in adopting and implementing. According to Renwick, Redman, and Maguire (2013), it requires the knowledge and skills of professionals in information technology to make a significant contribution to the adoption and implementation of smart building concepts. Lin and Ho (2011) and Rahim and Musa (2018) revealed that enhancement of the awareness of the smart building concept is from educational training (conferences/seminars) for professionals, developers, and policymakers. According to Ghazilla et al. (2015), a professional desire to promote the smart building as an environmental product, peer firm influence, new market opportunities, and industrial sectors initiatives for the smart building can enhance the awareness of the smart building concept in the construction industry. According to Chew et al. (2020), the availability of institutional facilities for research and development helps increase awareness of smart building construction.

2.4 CRITICAL FACTORS FOR SUCCESSFUL ADOPTION OF SBCs

2.4.1 Factors that influence the adoption of SBCs among professionals in the Nigerian construction industry

According to Wiesel et al. (2012), smart buildings have a positive impact on the environment, such as better energy management, air quality, and water efficiency, as well as reduced pollutants, when compared to typical traditional buildings, which result in a healthier and more environmentally friendly atmosphere. Many developed and developing countries have adopted a series of smart building-related policies, including mandatory regulations, financial incentives, and tax concessions, to promote the development of smart building projects over the years, owing to the environmental, social, and economic benefits of smart buildings (Mohd Asmoni et al. 2015). There are a variety of approaches to control and improve the current nature of smart building construction activity to make it more environmentally friendly while maintaining the valuable output of these activities; proper adoption and implementation are critical to smart building success (Ofori-Boadu et al. 2012). Critical success factors (CSFs) are used to understand management activities better. As a result, a specific list of CSFs for smart building concepts must be identified and examined to improve the smart building concept's chances of success (Li et al., 2011).

The research on critical success factors was first carried out and published by Ronald Daniel in 1961. His study focused on the management information system related to industry success factors (Mukhtar et al., 2017). In 1982, Rockart developed the concept of critical success factors for the Sloan School of Management and used it in project management and information systems (Mukhtar et al., 2017). Toor and Ogunlana (2009) implied that CFs are an element with significant contribution and are vital for implementation success. According to Westerveld (2003), critical success factors are levers that the project manager (professionals) can pull to increase the likelihood of successfully implementing new technology. According to Obat (2016), (CFs) plays a pivotal role in successfully adopting many new technologies. Gichoya (2005) considered critical factors as elements present in the construction industry that serve as a roadmap to overcoming potential barriers in implementing smart building concepts. Therefore, the need arises to explore the critical success factors for the adoption of smart building concepts in the building sector of the Nigerian construction industry as a developing country. According to Oyebanji, Liyanage, and Akintoye (2017), critical success factors (CSFs) for achieving sustainable social housing (SSH) determined critical success factors in the perspective of environmental factors and economic factors and social factors.

Furthermore, Sfakianaki (2019) classified CSF into five categories for the adoption and implementation of sustainable construction which smart building concepts form the larger part of the sustainable development goal. These categories are environmental factors, economic factors, social factors, design and technique factors, and policy and regulation factors. Meanwhile, Owusu-Manu et al. (2021) identified the instrumentation and control factor, computer self-efficacy factor, participation, and collaboration factor, viable funding strategy, top management support, connection with professionals, and interoperability as factors influencing the adoption of a smart building. Li et al. (2019) study focused on the critical factors for stakeholders in the success of a project.

2.4.2 Environment critical factors

An environmental factor is one of the tools which construction professionals and policymakers can use to voluntarily implement an environmental policy in the building sector of the construction industry (Sfakianaki 2019). Oyebanji, Liyanage, and Akintoye (2017) assessed the Critical Success Factors (CSFs) for achieving sustainable social housing (SSH); the study opined that environmental factors are beneficiary factors; identifying physical environment policy, land use policy, safety, and security, quality program, environmental protection while playing more attention in taking smart building development decisions.

Furthermore, Sfakianaki (2019) revealed that protecting the natural environment is essential in the production and interaction of economic activities to prevent the depilation of the environment. The study identifies construction waste management, energy and cost-saving, pollution generation control, and climate protection policy as a factor in protecting the environment. In another vein, a study carried out by Frödell, Josephson, and Lindahl (2008) indicated that the environmental factors for successful implementation of smart building concept by professionals are construction waste management, indoor air quality, smart building procurement system, commitment to project time, connection with fellow professionals, demolition waste management, conservation of the resource, climate protection.

2.4.3 Economic critical factors

According to Wiesel et al. (2012), economic factors reflect the financial affordability of the construction professionals and developers to implement and execute their projects to achieve sustainable practices through the smart building. Achieving economic CSFs in the construction industry's building sector will increase the demand and supply of smart buildings. Mohd Asmoni et al. (2015) identify the stakeholder engagement of qualified professionals. Ayoola

(2019) and Kara (2011) identify management support as one of the requirements for the successful implementation of smart building concepts in the construction industry, which are: quality policy and procedure, communication, latest technological tools, conservation of resources available, employee satisfaction level, innovation development, speed of service delivery, operational performance, financial -strength and liability, job creation and client awareness and orientation. Oyebanji, Liyanage, and Akintoye (2017) identify viable funding strategies, selection of smart materials based on low risk to the environment, budgeting and control of subcontractors, risk communication and attitude, affordability and availability of cloud-based technology, and employer satisfaction level as the critical factors for successful adoption

2.4.4 Critical social factor

According to Ismail, Halog, and Smith (2017), the smart building concept in the construction industry is essential for creating a sustainable building, contributing to building structures that meet people's social standards. Indrawati, Yuliastri, and Amani (2017) revealed that adopting the smart building concept in the Indonesian construction industry plays an essential role in propelling the overall growth rate of urbanization compared to other non-conforming countries in South-Eastern Asia. According to Shurrab, Hussain, and Khan (2019), social factors are essential in implementing social value that provides building and human shelter. The social factor shoulders the responsibility for a large portion of sustainable development in the construction industry. Willar et al. (2020) opined that the critical factor impalement by the Indonesian construction industry was the implementation of the environmental and occupational health and safety management system, the development of the concept of minimal construction waste produced during construction work and checking and testing the required material in construction work.

In that case, project owners and users acquire adequate training to utilize smart buildings before handover. Hamid (2016) identified the following as critical factors, quality assurance procedure, communication of information and knowledge-sharing within the industry, availability of smart building technological tools, increased research in the industry and academia, employer satisfaction level, and interest in innovation development.

2.4.5 Competencies factor

Professional competencies are the fundamental requirement for the successful adoption of new technology. They set common standards that can be used to manage and develop professionals in the construction industry (Succar, Sher, and Williams, 2013). The study by Dainty, Cheng, and Moore (2005)revealed that identifying professional competencies will facilitate smart building concept adoption and assist in clarifying the professional's role in multidisciplinary collaboration. It is essential to understand the meaning of the term professional competency.

The competencies required for the successful adoption of new technology (smart building concept) into the building sector of the construction industry of developed and developing countries by professionals are a set of skills, attitudes, and knowledge necessary for the adoption and implementation (Dada and Jagboro 2012). According to Esa and Samad (2014), professionals directly impact 34-47% of the adoption and success of the project in the construction industry. There is a need to explore the professionals' competencies required to successfully adopt and implement the smart building concept, which is vital to developing the smart building concept (Hwang and Ng 2013).

The smart building concept has gained attention and recognition in the construction industry in the last 10 to 15 years to achieve sustainable development goals in the building sector of the construction industry by solving the environmental problem (Lokman, Asmoni, and Shaari, 2017). Smart building construction operations deserve attention in the delivery methods in the building construction industry, which demands a unique operational environment that encourages collaboration (teamwork) and cooperation (information sharing) among professionals and stakeholders for the project's success and benefit (Fischer et al., 2013).

Professional competency is critical in implementing SBCs to provide an operational environment that promotes collaboration among professionals (Esa and Samad, 2014). Professionals are responsible for managing the smart building's development and maintenance, as well as its environment; as a result, professional competencies are one of the most critical determinants of their performance, and they must possess specific competencies to excel at their jobs (Moradi, Kähkönen and Aaltonen, 2020).

According to National Postsecondary Education Council (2002), professional competency combines knowledge, leadership, and experience required to achieve a task. Ley and Albert (2003) described professional competencies as technical capabilities to measure and envisage future performance. Trichet and Leclère (2003)opined that professional competency is an effective combination and implementation of smart material resources to achieve the economic, social, and physical task of reaching a set of objectives.

2.4.5.1 Definition of competency

Fedrick W. Taylor introduced the word competency in 1919 in "The Principles of Scientific Management," followed by the studies of McClelland in 1973, Boyatzis in 1982, and in 1993, Spencer and Spencer elaborated on competency in the field of management (Lokman, Asmoni, and Shaari, 2017).

TABLE 2. 1 Definition of competency

Source	Definition of competency
Holmes and Joyce (1993)	Competency is a term used to describe an action that a person in a specific occupation should exhibit, linked with the ability to transfer Skills and Knowledge. furthermore, it is a description of an action, behaviour, or result that someone should be able to perform
Spencer and Spencer (1993)	Competency is an underlying characteristic of an individual(professionals) causally related to criterion-referenced effective and superior performance in a job.
Bratton (1998)	Competency as Knowledge, trait, motive, Skill, attitude, value, or personal characteristic essential to performing a task
Abraham et al. (2001)	competency is characteristic of traits and behavior essential to perform a task or job.
Project management institute PMI, (2002)	professional competence is a skill, attitude, and Knowledge that affect a significant part of professional performance on the task or job, which can be compared against an accepted standard.
Chen, Partington, and Wang (2008)	competency in terms of "Phenomenography" Phenomenography is a method of study that aims to map the qualitatively varied ways people knowledge, think, perceive, and understand various elements of the phenomena in the world around them. The phonomyography approach differs from traditional attribute-based techniques in that it is founded on phenomenology, which argues that the person and the world are inextricably linked through experience.

Source	Definition of competency
Sang et al. (2018)	competency in three perspectives which are performance, personal, and knowledge competencies.
Moradi, Kähkönen and Aaltonen (2020)	competencies as the abilities to apply skills, knowledge, and personal traits to improve a professional's efficiency and effectiveness in their job performance and, as a result, increase the likelihood of project success
Moradi et al. (2021)	When combined with a situation-oriented goal, competencies are fundamental attributes (motivations, traits, self-image, abilities, and Knowledge).

2.4.5.2 Ideas in Defining Competency needed by the Professionals

TABLE 2. 2 Ideas in defining competency

Source	Knowledge	Skill	Traits	Motive	Image	Ability	Behaviour
Holmes and Joyce (1993)	X	X				X	X
Spencer and Spencer, (1993)	X	X	X	X		X	X
Bratton (1998)	X	X		X		X	
Abraham et al. (2001)			X				X
Project management institute PMI, (2002)	X	X					

Source	Knowledge	Skill	Traits	Motive	Image	Ability	Behaviour
Chen, Partington, and Wang (2008)	X	X				X	
Sang et al. (2018)	X				X	X	
Moradi, Kähkönen andAaltonen (2020)	X	X	X		X		
Moradi et al. (2021)	X	X	X	X	X	X	

From the ideas table, more emphasis is on Knowledge, Skill, and ability as competency.

2.4.5.3 Knowledge

According to Marrelli, Tondora, and Hoge (2005), Knowledge can be concrete, specific, easily quantifiable, or more complex, intellectual, and difficult to evaluate. Furthermore, Lokman, Asmoni, and Shaari (2017) explained Knowledge as information, understanding of facts, rules, principles, guidelines, concepts, theories, or processes required to complete a task successfully. Abraham et al. (2001) explained Knowledge as the key to success due to education and experience in environmental Knowledge. Hwang and Ng (2013) identify the nine (implementation, time, cost, procurement, quality, communication, human resources, scope, and risk) processes on which knowledge is based. Each of the nine knowledge areas contains processes that must be completed within its discipline to achieve effective smart building concept implementation. Dogbegah, Owusu-Manu, and Omoteso (2011) identify organizational management, estimating and tendering, reading and understanding drawings, sustainable smart building construction, sustainable smart building procurement, and health and safety information technology management processes, and Shi et al. (2014) identify conflict and dispute management, drafting contracts, site management, knowledge of sustainable smart building design and standards, claims management, risk management, human resources management, top management support, supply chain management, delegation procedure, cost management, schedule, and planning management processes.

2.4.5.4 Skill

According to Marrelli, Tondora, and Hoge (2005), skill carries out mental or physical tasks with a specific result. Also, the activity-based character of sustainable construction requires a wide range of creative skills, know-how, and current technology skills to achieve smart building output (Shi et al. 2014).

In a similar way to knowledge, skills can range from extraordinarily concrete and immediately recognized jobs, like filing documents alphabetically, quality improvement projects, onsite practical skills, and personnel quality, software (IT) skills, good negotiation skills, familiarity with smart building products and their market, (Hwang and Ng, 2013). Lokman, Asmoni, and Shaari (2017) identify skills in analysis, evaluation, communication, interpersonal, leadership, self-development, management, quantification/measurement, documentation, computer literacy, and technical skills.

- Analysis skill: The ability of professionals to detect, assess, recognize problems and find innovative solutions.

- Evaluation skill: The ability of professional to assess the value.

- Communication skill: The ability of professionals to impart knowledge, ideas, and concepts through oral, written, and visual means.
- Interpersonal skill: The ability to effectively work with others and to be part of a team.
- Leadership skills the ability to lead and motivate.
- Self-Development is the ability to set goals, display enthusiasm, be self-motivated and undertake research.
- Management is the ability to organize, monitor, control, and plan the effective use of resources.
- Technical skill: The ability of professionals to handle the project from start to finish by the design specification to deliver an accurate project.
- Documentation skill is the ability to prepare written information in a format that conveys meaningful information.

2.4.5.5 Ability

Abilities demonstrate the cognitive or physical capability to complete a task with many possible outcomes (Dada and Jagboro, 2012). An ability is a collection of underlying capacities that enable us to learn and perform. These are generally time-consuming and difficult to develop, and they usually include a significant amount of intrinsic ability. For example, analytical thinking comes more naturally to certain people than to others, and it can be difficult for many people to master (Nijhuis, Vrijhoef, and Kessels, 2018). Chen, Partington and Wang (2008) and Sang et al. (2018) classified ability into administration, research and development, qualification and license, operation, supportive, and managerial categories.

- **Administration:** This involves the ability of professionals to organize and fulfill set out objectives. Contract management, human resource management tendering documents, and procurement management requirements.

- **Research and Development** is the ability of professionals to engage in knowledge sharing development and technical educational material to assist professionals in understanding the smart building concept and improving on the existing knowledge.

- **Qualifications and licenses:** These are professional qualities associated with the adequacy of academic degrees, trade skill certificates professional accreditations. Qualifications and licenses are measurable and stand as a means of identification.

- **Operation:** The practices and efforts required to deliver a project or part/aspect of a project. Operational competencies include designing, analyzing, simulating, and estimating smart buildings.

- **Supportive:** These competencies are required to maintain information and communication technology (ICT) systems.

- **Managerial:** This involves the ability of professionals to make a good decision that will drive the adoption and implementation of smart building concepts in the construction industry and managerial requirements such as organizational management, leadership, and strategic planning.

2.4.6 Top management support

According to Owusu-Manu et al. (2021), top management support is critical to adoption, particularly when implementing an innovation. The availability of management reflects the availability of support, which will increase the desire to adopt SBCs. Tsiga, Emes, and Smith (2016) confirmed that top management support provides the professional's assistance with critical activities, comprehension of project difficulty, and stakeholder influence. Dewi et al. (2018) added that in government and private institutions, professional leaders create design policies and strategies that influence the adoption of SBCs and the usage of the policies. Almajed and Mayhew (2014) opined that SBCs require professionals with extensive expertise and a solid commitment to the project and personnel with the most substantial commercial and technical understanding.

2.4.7 Interoperability

Interoperability is a feature that allows all systems or devices to be interconnected and their data and information to be exchanged to analyze or make strategic decisions (Dewi et al. 2018). Ishmael, Ogara, and Raburu (2020) confirmed that interoperability is the main connector in the building system. Facility managers can enjoy smart-building benefits by connecting building and automation systems to enterprise systems. An example is the use of sensors to track foot traffic in retail stores, which is how linked technologies produce insights that lead to more connected technologies providing insight into the design and utilization of building space.

2.4.8 Instrumentation and control

According to Dewi et al. (2018), instrumentation and control is a function that monitors and controls the activities of the building. Berst (2013) added that control provides remote management capabilities in controlling all the devices installed. An example includes switch breakers, while the instrumentation provides monitors and sensors for the air quality sensors, closed-circuit TV, and video monitors.

2.4.9 Viable funding strategy

According to Dewi et al. (2018), viable funding is essential for the successful adoption of smart buildings and further explained that the adoption process considers many parties, which involves high risk and cost. In addition, Cisco (2014) states that a sufficient budget becomes a critical component for successfully adopting the smart building concept. It will affect the government's and professionals' readiness to run the smart building project.

2.4.10 Security and privacy

The security and privacy of the essential smart building are paramount. Whether the facility is a residential building or a company office, humans require complete privacy and security regarding who else has access to the room (Berst, 2013; Ishmael, Ogara, and Raburu, 2020). Security systems designed to anticipate, evaluate, and appraise a crime risk and initiate actions to remove or lessen that danger, building location, and security have been the panacea of the smart building (Ishmael, Ogara, and Raburu, 2020). The presence detection of intruders is now built-in as comprehensive control and protection system, thanks to the increased interoperability of many smart devices (Balint 1995).

2.4.11 Data management

Data management is storing, safeguarding, and processing data while ensuring accuracy, dependability, and timeliness. In a smart building, data is critical, and proper administration is required to ensure data integrity and value (Berst 2013). One step toward appropriate data management is data transparency and sharing policy, including access, authentication, and authorization policies.

2.5 PROFESSIONAL PERCEPTIONS ON THE BARRIERS TO SMART BUILDING CONCEPT ADOPTION

Researchers have investigated the barriers to the adoption of smart building concepts in the building sector of the construction industry of both developed countries like the United States of America (USA), Australia, and England, and developing countries like China, Ghana, Malaysia, and Egypt (Williams and Dair 2007; Persson and Grönkvist 2015; Ghansah, Owusu-Manu, and Ayarkwa 2020; El-Motasem, Khodeir, and Fathy Eid 2021). Environmental challenges are widely recognized in the building sector of the construction industry, and the smart building concept is seen as a feasible strategy for sustaining the construction industry's environmental, social, and economic sustainable development (Olawumi and Chan, 2020). However, in developing countries, smart building practices have yet to be fully adopted and implemented in the building sector of the construction industry (Chan et al., 2017). Despite the numerous benefits of the smart building concept in the construction industry, the concept has not taken full advantage due to the professional perception of the barriers, which has an immense effect on the adoption of the smart building concept in the building sector of the construction industry (Shen, Zhang, and Long, 2017). Shi et al. (2013) and Gobbo Junior, De Souza, and Gobbo (2017) identify the economic barrier, government barrier, and technical and social human barrier as the critical barriers to the adoption of the smart building in the building sector of the construction industry, considering sustainable development.

2.5.1 Economic barrier

According to Meryman and Silman (2004), professionals striving to integrate new technology (smart building concept) into the practice of the building sectors of industrial construction while keeping sustainable practices in mind are likely to face the most significant economic hurdle as a result of their implementation costs. The cost was identified as a significant barrier to smart building adoption. The authors further explained that the perception of the additional cost is a significant impediment for professionals in advising clients and other design team members to incorporate environmental considerations into the design and construction processes (Lam et al., 2009). Chan et al. (2017) argued that the direct delays of procurement requirements cost of construction is proportional to time; any disruption in workflow caused by smart building practices would have an economic impact.

Hwang and Ng (2013) revealed that barriers to smart building adoption are also associated with the high cost of initial construction, the high implementation cost of a smart building, lack of interest and communication among professionals, lack of demand and interest from the clients, and lack of research on the benefits of a smart building. Similarly, Ahn et al. (2013) identified the following as barriers to smart building: the high initial cost of smart building construction, lack of financing schemes, lack of government incentives, unavailability of smart building suppliers, and lack of institutes for research development of smart building technologies. Shen, Zhang, and Long (2017) identified long payback periods from adopting smart building concepts, delays in procurement requirements, high cost of smart building equipment, and high cost of technology research as significant barriers to smart building concept adoption. Hamidi (2010) identified the slow recovery rate of long-term cost as a barrier to the adoption of the smart building, which hinders the development of the smart building concept. Byrd and Leardini (2011) also opined that the high cost of smart building practices often discourages the clients and end-users. Chan et al. (2016) discovered barriers such as the high cost of technologies. Azeem et al. (2017) identified that smart building materials and equipment are too expensive. De-Grotto, Volt, and Frances (2017) identified that ignoring the life cycle cost aspects of the smart building will discourage the adoption of the smart building concept. Hwang and Tan (2012) identified that the lack of interest from them can negatively affect smart building adoption, and the lack of market demand for smart buildings can be attributed to the lack of awareness on the part of the public and owner.

2.5.2 Government Policy Barriers

According to Shen, Zhang, and Long (2017), the effectiveness of initiatives promoting smart building adoption in the building sector of the construction industry is heavily dependent on governmental policies. Azeem et al. (2017) opined that smart buildings would be implemented if the government was devoted to adopting them. This assertion hinges on the fact that the government is the main stakeholder in the construction industry; however, the lack of incentives, obsolete building codes and regulations, a lack of framework, and a lack of promotion of smart building practices have significantly handicapped the adoption drive. Zheng et al. (2016) opined that one of the main barriers is the lack of framework and regulations that reflects the design elements, guidelines, and characteristic of the smart building concept. Fratu and Fratu (2012) further identified that lack of research on concepts and their ignorance to incorporate new technologies by professionals and government are significant barriers. Mahbub (2008) reiterated the lack of use of smart building design by construction professionals during the drawing stage. Alexander (2016) revealed that keeping the client and end-user away from the smart building design and procurement processes will not encourage adoption. Hwang and Ng (2013) opined that it requires more time to implement smart building concept practices onsite; another barrier that discourages the usage by professionals. Iwuagwu and Iwuagwu (2014)opined that lack of electricity supply and low quality of maintenance culture among professionals and the end-user is a significant barrier to adopting the smart building concept.

Shen, Zhang, and Long (2017) opined that the major barrier to adopting smart building concepts is the scarcity of smart materials and products in the building construction industry. Environmentally friendly materials and products that have less impact on the environment are readily available for use in the building construction industry. They identified a lack of financial incentives and legal system and administrative issues as a significant barrier to implementing a smart building. Ahn et al. (2013) and Chan, Darko, Ameyaw and Owusu-Manu (2016) identified lack of building code and regulation, lack of smart building promotion by the government, long payback period, lack of financing schemes, and the risks and uncertainties involved in adopting new technologies. Luthra et al. (2015) identified the lack of ability to meet electric power demand, unavailability of solar radiation data, and lack of political commitment as barriers in the construction industry. Lam et al. (2009) opined that the problem of communication among stakeholders and government could cause a conflict of interests leading to uncertainties and inadequate documentation. Ghansah et al. (2021a)opined that a lack of government and client incentives could be a critical barrier to adopting a smart building.

2.5.3 Social Human and Technical Barrier

Social barriers mainly refer to the influence of public knowledge and awareness, culture, lifestyle, and behaviors (Zhang and Wang 2013). According to Chan et al. (2017), information on the smart building concept is essential for acquiring relevant knowledge; it is also a means of raising public awareness and acceptance of the smart building concept. It helps create awareness for the government and construction industry professionals about the importance of technical and social human involvement in successfully adopting smart buildings. Ma, Badi, and Jørgensen (2016) confirmed that sharing information is critical to successfully implementing a smart building concept in the construction industry. Similarly, the authors notice that professionals' low awareness of smart building concepts is a major barrier to smart building adoption. In some cases, professionals lack the information necessary to develop smart buildings (Hamma-adama and Kouider, 2018). Omopariola, Albert, and Windapo (2019) reported that poor maintenance culture, insufficient power supply, lack of efficiency, lack of expertise for smart building concepts, lack of technical professionals' know-how, fear of uncertainty, or unforeseen circumstances in smart building concepts in the country are the primary barriers to the adoption and implementation of a smart building. They were unaware of viable alternatives or lacked the necessary expertise to implement them in other cases. From a broader perspective, El-Motasem, Khodeir, and Fathy Eid (2021) opined that the trend of smart buildings among professionals is new and very rare in Egypt. There is a lack of studies, guidelines, or benchmarks in Egypt that can be used as a reference to establish new smart buildings. Tan and Wang (2010) also found that the design of the smart building is more complicated than that of a conventional building. In their various studies, Azeem et al. (2017) discovered professionals' resistance to change as a significant barrier to adopting the smart building concept. Chan et al. (2018) identify a lack of professional knowledge and expertise in smart building concepts, a lack of databases and information, and a lack of awareness of smart buildings and their benefits. Chan et al. (2018)further explained that having professional knowledge and expertise is crucial in successful smart building concept adoption. Nguyen et al. (2017) identified a lack of importance attached to the smart building by senior management, professionals' resistance to change, and lack of technical and clear understanding of smart building by professionals, clients, and subcontractors as a critical barriers to smart building concept adoption. Häkkinen and Belloni (2011)identified a lack of information, understanding, knowledge, and awareness of the smart building concept as a barrier to adoption. El-Motasem, Khodeir, and Eid (2021)concluded that the general challenges were re-categorized into six: lack of research work, absence of a comprehensive definition, absence of characteristics, vague objectives lack of framework.

2.6 SUMMARY

Chapter two introduced the critical factors for successful adoption of the smart building concept using relevant literature in line with the study. The chapter also extensively discussed the overview literature on smart building concepts in the sustainable construction practice, which deals with the component to measure smart building, the barriers to the adoption of smart building, and factors that enhance awareness were also discussed in line with other countries.

The next chapter discusses the methodology to be employed in achieving the study's objective.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 INTRODUCTION

Research design is referred to as the research's theory and the reason(s) for the study's design (Mackey and Gass, 2015). According to Easterby-Smith, Thorpe, and Jackson (2012), it is a set of techniques for searching for an inevitable reality and analyzing and disseminating observations about that reality. This chapter discusses the methodology used to achieve the study's aim and objectives. Meanwhile, it demonstrates the research approach based on a specific research methodology. These methods cover specific areas, namely: the data requirement, the study area and population, the sample size and sampling technique, the research instrument, the method of data collection, as well as validity and reliability of the research instrument, and the method for data analyses and data presentation.

The methodology to be adopted is based on the problem and research questions to be investigated; the purpose of the study is to examine the critical factors for the successful adoption of smart building concepts and identify the factors influencing the adoption of smart building concepts in the Nigerian construction industry. The overall research flowchart is shown in Figure 3.1

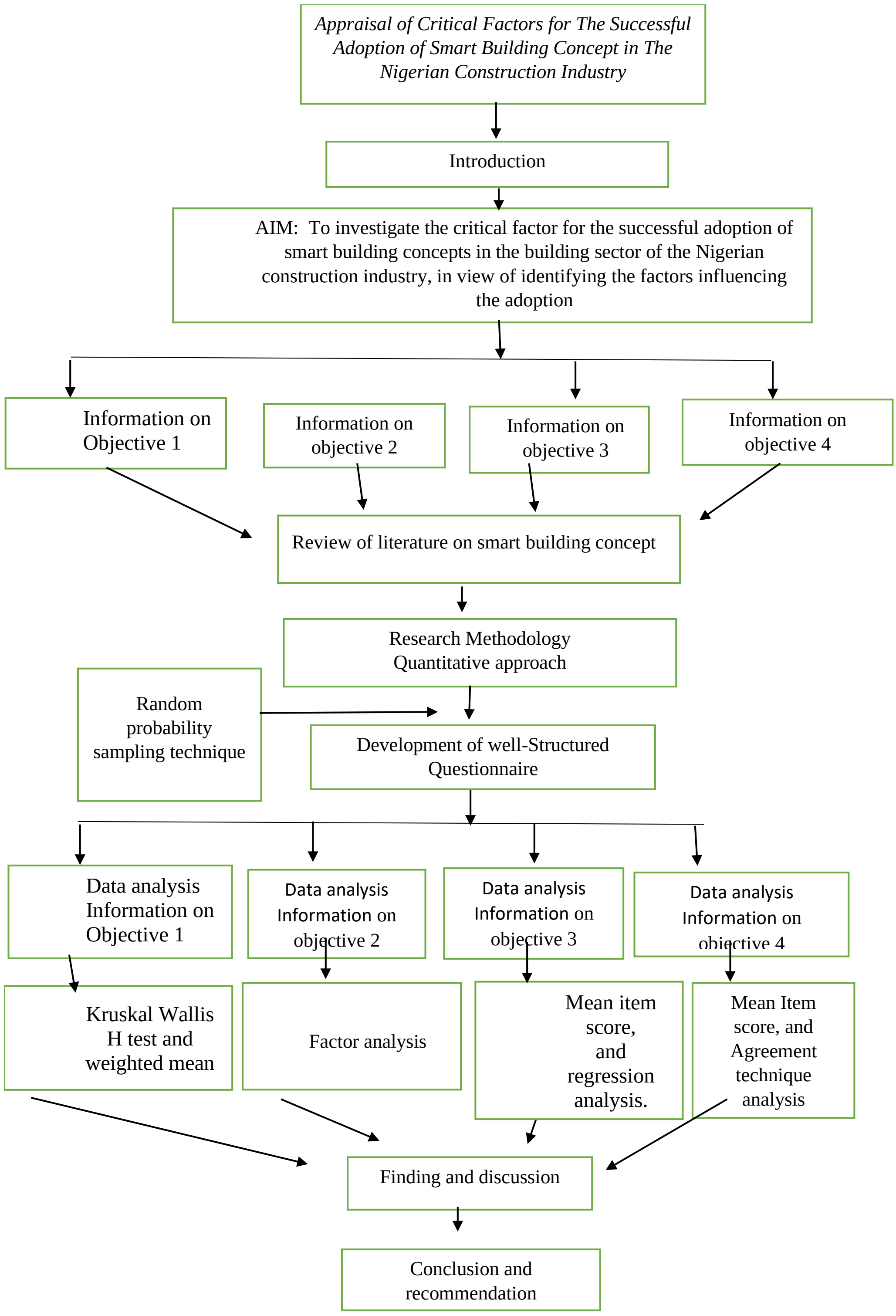

FIGURE 3. 1Research flow chart

3.2 RESEARCH APPROACH DESIGN

Research design is defined by Osanloo and Grant (2016) as the method for structuring an inquiry or investigation to find variables and their relationships. It is a strategy that specifies how, when, and where data will be collected and analyzed (Creswell and Poth, 2016). However, the design to be selected is based on the research approach that is more suitable for the study. Table 3.1 summarises the main categories of research approaches appropriate for every type of design.

TABLE 3. 1Research Approaches and corresponding Designs

Qualitative	**Quantitative**	**Mixed Methods**
Ethnography research	Experimental research	Convergent research
Narrative research	Survey research	Exploratory research
Case study research	Quasi-experimental research	Transformative
Grounded theory	Survey research	

As a result, following critical thought and thorough examination of the research topic, and based on the nature of the research problem under investigation, the best approach that fits this type of design is the survey method (Rahi, 2017). The survey research method is a well-known quantitative approach for gathering data on people's opinions and attitudes about phenomena that objective measures can best explain.

3.3 STUDY AREA

Lagos State is a city in Nigeria's south-western region, between latitudes $6^0$20'00''N and 6^0 40' 0''N, and longitudes $2^0$50'0''E and $4^0$20'0''E, One of Nigeria's 36 states occupies an area of approximately 3,496 km^2 (Kaoje and Ishiaku, 2017). The state is bordered on the north by Ogun State, east by the Republics of Benin, and west by the Atlantic Ocean (Kaoje and Ishiaku 2017). The state has 14 234 million people, with an annual population growth of 5.7%, making it one of the fastest-growing megacities globally (Dano et al. 2020).

Lagos is the industrial and economic hub of Nigeria. On the one hand, its strategic coastal location, economic potentials, and burgeoning population provide livelihood opportunities (Dano et al. 2020), which forms the basis for selecting Lagos State as the study area.

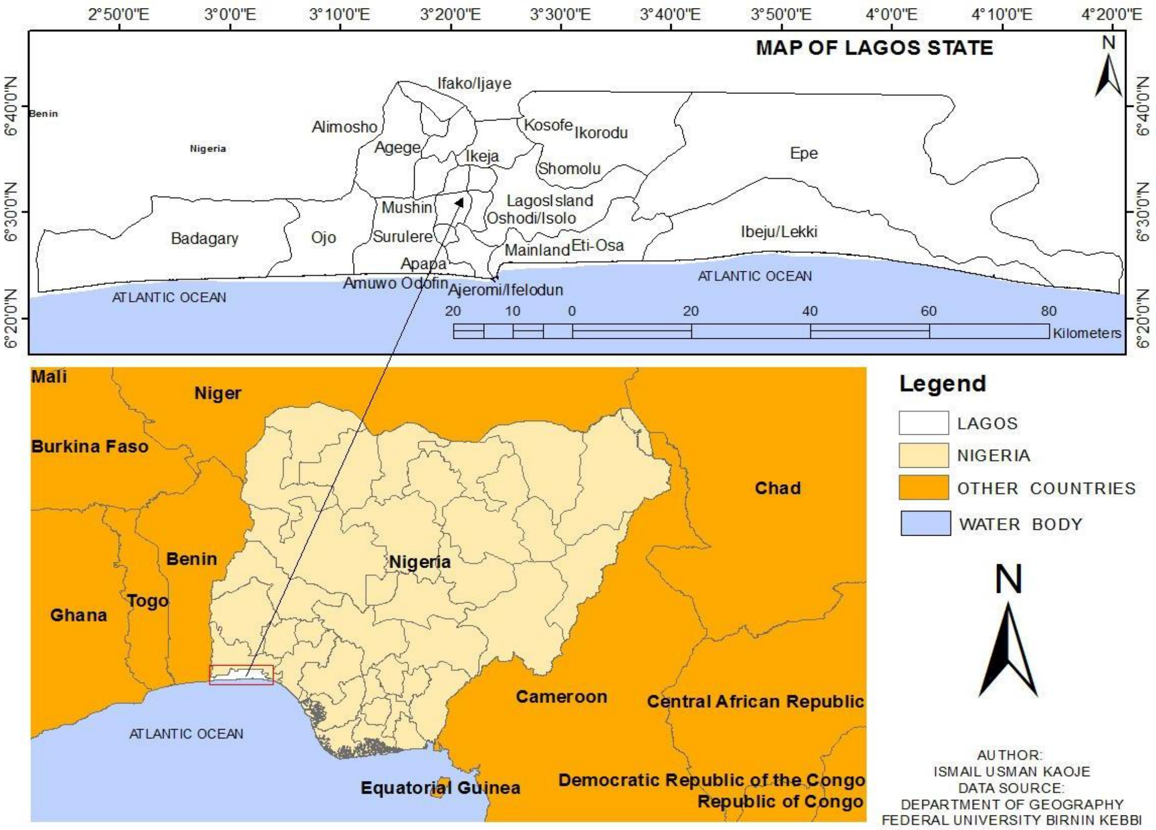

FIGURE 3. 2 Study population map source : (Kaoje and Ishiaku 2017)

3.4 THE STUDY POPULATION

According to Bornstein, Jager, and Putnick (2013), the entirety of all elements under observation, which constitutes all things in any field of investigation, is the study population. Thus, in research, the population can be defined as the entire group of people in a geographical region whose characteristics are estimated. The study population of this research study comprises construction professionals including architects, builders (mechanical, electrical, and structural), engineers, and quantity surveyors practising in Lagos State as they are the primary participants who have substantial involvement and responsibilities in smart building concepts in the Nigerian construction industry

TABLE 3. 2 Sample Population

S/N	Professions	Population	Professionals body (source)
1	Architects	958	Nigerian Institute of Architecture (2020)
2	Builders	610	Nigerian Institute of Building (2020)
3	Quantity surveyors	870	Nigerian Institute of Quantity Surveying (2020)
4	Engineers	2670	Nigerian Society of Engineers (2020)
	Total	5,108	

3.5 SAMPLE TECHNIQUE

According to Nardi (2018), the sampling technique is the most effective way to estimate the amount of data needed and understand how data is gathered within a population to meet the study objectives. The sampling techniques adopted for the study is random probability sampling techniques whereby all the professions has a equal chance and likelihood in the sample of being selected the for the questionnaire.

3.6 SAMPLE SIZE

A sample is a section or subset of the study population selected to research a sampling process. (Taherdoost, 2016). From the study population, the total population of registered construction professionals within the study area is 5,108. According to Islam (2018), the Yamane formula provides a simplified formula to calculate sample sizes.

$$\mathbf{n=} \frac{\boldsymbol{N}}{[\mathbf{1+}\boldsymbol{N}(\boldsymbol{e}^{\mathbf{2}})]}$$

Where: n = the sample size

N = the total population

e = the level of precision was 10%

1= unit (constant)

Architects

$$\mathbf{n=} \frac{\mathbf{958}}{[\mathbf{1+958}(\mathbf{0.1^2})]} = 90.55$$

approximately 91.

Builders

$$\mathbf{n=} \frac{\mathbf{610}}{[\mathbf{1+610}(\mathbf{0.1^2})]} = 86$$

Quantity surveyors

$$n = \frac{870}{[1+870(0.1^2)]} = 89.90$$

approximately 90

Engineers

$$n = \frac{2670}{[1+2670(0.1^2)]} = 96$$

TABLE 3. 3 Sample Size

S/N	Professionals group	Population	Sample size
1	Architects	958	91
2	Builders	610	86
3	Quantity surveyors	870	90
4	Engineers	2670	96
	Total	5,108	363

Therefore, 363 questionnaires were shared randomly with selected respondents in the Lagos State construction industry based on this research.

3.7 METHOD OF DATA COLLECTION

This research employed the use of primary data and secondary data sources. The secondary data was generated from an extant literature review from which the research instrument was developed. The procedure for data collection for this research work was a well-constructed questionnaire. These questionnaires were administered to the registered construction professionals practising in Lagos State, Nigeria, to appraise the critical factors for successfully adopting the Smart Building Concept in the Nigerian Construction Industry.

3.8 RESEARCH INSTRUMENT

The survey research design was used in this study because of its nature. The questionnaire is the most common instrument or technique used to acquire descriptive data from a sample group in survey research (Nardi, 2018) because the respondents have the advantage of supplying data and information from the source. The questionnaire consisted mainly of close-ended questions to ensure that quantitative data were adequately captured. According to Abawi (2013), survey questionnaire is a primary data collection method consisting of a series of questions with multiple options for responses, intending to gather information from participants. A questionnaire was utilized as the research instrument to collect data from prospective professionals in this study. The survey questionnaire was designed to accomplish the objectives mentioned above by gathering data on an appraisal of critical factors for the successful adoption of the smart building concept in the Nigerian construction industry. The questionnaire is divided into five sections. Section one seeks to obtain biographical information of the respondents. Sections two contain awareness of the smart building concept, section 3 contains factors that enhance awareness, section 4 contains critical factors for successful adoption of SBCs, and section 5 contains barriers to adoption of SBCs.

3.9 ADMINISTRATION OF THE QUESTIONNAIRE

The administration of the questionnaire was through physical distribution and collected to professionals. The letter of information and informed consent were part of the information provided to the participants. Since the questionnaire was distributed face to face, the participants read the informed consent form and confirmed their voluntary participation. Three hundred and sixty-three questionnaires were administered to the Lagos State chapter of construction professionals in the Nigerian construction industry. The questionnaire took between 20 and 25 minutes to complete. The overall response rate for this study was (87.05%). From the retrieved questionnaires, two-hundred seventy-six (276) were suitable for analysis with an appropriate response rate of (87.3%) (Owusu-Manu et al. 2021). All COVID protocols were duly observed during the administration of the research instrument

3.10 ASSURANCE OF CONFIDENTIALITY AND ANONYMITY

The data collected was treated anonymously under research ethics rules. The findings of the survey were used for research purposes only. There were no risks, current or anticipated, to any research participant in this study. The researcher took the responsibility to protect the participants as an ethical commitment that considers the participant's rights. Maintaining a high degree of confidentiality and anonymity was a priority for the researcher. No personal details of research participants were required, for example, names, identity numbers, and cell phone numbers. The questionnaire did not include sensitive biographical questions that might identify the participants. The data collection process does not involve access to confidential personal data. Participation in the research was voluntary, and the research participants were allowed to withdraw whenever they liked without any consequences.

3.11 DATA ANALYSIS METHODS

Data analysis was conducted through the primary data collected in the survey questionnaire sent out to the registered construction professionals in the Nigerian construction industry of Lagos State. Data collected was analyzed using Statistical Package for the Social Sciences 26 (SPSS) (Arkkelin 2014). The data analysis was provided using both descriptive and inferential statistics. This method included compiling all the data collected and the findings for the mean score ranking technique, factor analysis technique,

TABLE 3. 4Method of Analysis

S/N	OBJECTIVES	METHOD OF ANALYSIS	Reason
1	To investigate the awareness level of construction professionals to adopt the smart building concept (SBCs) in the Nigerian construction industry.	Kruskal Wallis H test, And weighted mean.	A non-parametric statistical measure of variance between different means is the Kruskal-Wallis H test (Ade-Ojo and Awodele 2020). The Kruskal-Wallis H test was used to see a significant difference in construction professionals' awareness of the smart building concept (SBCs) adoption in the study area
2	Investigate the factors that can enhance the level of awareness of smart building concepts among construction professionals in the Nigerian construction industry	Factor analysis (FA)	According to Chan et al. (2017), Factor analysis reduces and regroups many factors into a smaller set of factors.
3	To Assess the factors that influence the adoption of SBCs among professionals in the Nigerian construction industry	Weighted mean and Binary regression analysis. Logistic model.	The binary regression examines the link between independent and dependent variables (park,2013). The logistic model is used to determine the probability of an event occurring. The event is the critical factor influencing the adoption of SBCs.
4	To identify the barriers to the adoption of SBCs in construction projects in the Nigerian construction industry	Mean Item score and agreement analysis technique (Kendall's coefficient of Concordance)	According to Chan et al. (2017), Kendall's is a non-parametric test used to ascertain the general agreement among rankings.

3.11.1 Descriptive statistics

The descriptive statistics were analyzed using the Statistical Package for Social Science (SPSS) which fully computed the frequencies, percentile, mean item score (MIS), and correlation coefficients of the responses. The results observed from the analysis of the variables are directed toward a skewed distribution.

On a 5-point Likert-type scale, a cut-off point with a mean score > 2.50 has been considered appropriate for determining essential or notable variables (Akhund et al., 2019). Furthermore, Akinrata, Ogunsemi, and Akinradewo (2020) considered elements with an Important Relative Index (RII) of 0.599 (i.e., a mean score < 2.995) to be irrelevant on a 5-point Likert-type scale. Also, Ade-Ojo and Awodele (2020) considered a mean score of 3.00 and above to be statically significant in measuring a 5-point Likert scale. Meanwhile, Opawole and Jagboro (2016) considered a cutoff point of 3.50 appropriate on a 5-point Likert scale. However, compared to other entrants, this was deemed too high. The cut-off point for this study was 3.00, while the Mean Score (MS) was used to rate each item (outcome). Standard Deviation (SD) is also used in cases where two outcomes have comparable MS values.

3.11.2 Inferential statistics

A non-parametric test was used for the inferential statistics to analyze the skewed variable distribution of the respondents' results.

3.11.2.1 Binary Regression

The logistic or logit model is another name for logistic regression. It examines the link between several independent variables and a categorical dependent variable and estimates the probability of an event occurring using data fitted to a logistic curve (Park, 2013). The event in this study is the factors that influence construction professionals' adoption of the smart building concept. Binary logistic regression and multinomial logistic regression are two types of logistic regression models. In this research, binary logistic regression was used.

3.11.2.2 Agreement Analysis Technique

Kendall's coefficient of concordance **(**Kendall's W**)** is a nonparametric test commonly employed to measure agreement among raters by assessing variables (Chan et al., 2018). This method does not require any specific distribution of each variable data tested. Kendall's W test was conducted to check the respondent's agreement on the barriers to adopting the smart building concept in the Nigerian construction industry. Kendall's W ranges in value between 0 to 1, where a value of 0 indicates "no agreement" and 1 indicates "complete agreement (Chan et al. 2018). Meanwhile, Siegel and Castellan (1988) highlighted that the null hypothesis could be rejected. There is some agreement among the respondents if Kendall's W value generated from the test is a low significance (asymptote significance level 0.001).

3.11.2.3 Kruskal-Wallis H test (Hypothesis Testing)

The Kruskal-Wallis H test showed a significant difference in construction professionals' awareness of the smart building concept (SBCs) adoption in the study area. A non-parametric statistical measure of variance between various means is the Kruskal-Wallis H test. It is non-parametric because, unlike the One-Way Analysis of Variance (ANOVA), it does not need a normal distribution (Ade-Ojo and Awodele, 2020). Under a free distribution, the test compares more than two independent variables. According to Pallant (2016), to interpret the significance difference, you can conclude that there is a statistically significant difference if the significance level is below .05.

$$H = \frac{12}{n(n+1)} \sum \frac{Ti^2}{n_i} - 3(n+1)$$

The test's null hypothesis is that all k distribution functions are equal, where n is the total number (all ni) and Ti is the sum of the rankings (from all the samples) for the ith sample.

3.11.2.4 Factor Analysis

The primary goal of factor analysis is to reduce the number of variables to a manageable number of composite variables(Pallant 2016). Factor analysis is a statistical technique that analyzes the association between variables to explain the common underlying dimensions that compose variables referred to as components in this study (Yong and Pearce 2013). Bartlett's test of sphericity was carried out for the principal's suitability, and the Kaiser-Meyer-Olkin (KMO) was carried out for sampling adequacy (Pallant 2016).

3.12 RESEARCH DATA MANAGEMENT PROCEDURE

According to the approved DUT data management information, the information received will be stored on DUT's premises and kept confidential and with a strong password for five years. After that, the data will be destroyed. (Please see the information provided in the letter of information (Appendix A). The researcher analyzed all data acquired from the survey questionnaires and sent them in as part of the dissertation. The participants are entitled to pull out of the study if they wish to do so and continue receiving the appropriate standard of care.

3.13 INCLUSION AND EXCLUSION CRITERIA

Only the Nigerian construction industry construction professionals in Lagos State were included. Construction professionals not practising in Lagos State were excluded.

3.14 VALIDITY AND RELIABILITY TESTS

Content validity was achieved through a pilot test, and construct validity was achieved with principal component (factor) analysis (Asmelash and Kumar, 2019). EFA is a method for examining the interrelationships between variables (Pallant 2016). The questionnaire is subjected to an independent EFA utilizing principal components analysis (PCA) and a rotation dubbed Direct Oblimin. The eigenvalue, or variance derived from a factor more significant than one, is employed (Md Ghazali 2016). The reliability test was achieved with Cronbach's alpha (α) reliability test for this study using the IBM Statistical Package for Social Science (SPSS) Version 26.

3.14.1 Cronbach's Alpha Technique

The reliability of a research instrument is the degree of its consistency that measures the attributes (Mokkink et al., 2010). It enables the researcher to investigate the characteristics of measurement scales and the items that make up the scales. Cronbach's alpha test guaranteed that the questionnaire being administered was reliable. It is the most commonly used method to assess the accuracy of scales (Chan et al., 2018). According to Freud et al. (2017), it is achieved by associating each item of the questionnaire with every other measurement item and then obtaining the average inter-correlation for all the paired relations. This testing method has a coefficient that is utilized as an indicator of internal consistency (value between 0 and 1) of the scale used in the questionnaire, and Pallant (2016) stated that the Cronbach's alpha coefficient should be between 0.7 and above, demonstrate the scale's reliability. Furthermore, alpha values as low as 0.6 are acceptable for freshly constructed scales. Cho and Kim (2015) defined Cronbach's alpha on the mathematical equation:

$$\boldsymbol{\alpha} = \frac{\boldsymbol{K}}{\boldsymbol{K-1}} \left(\frac{\sum_{i=1}^{K} \boldsymbol{\sigma}_{\mathbf{Yi}}^{2}}{\boldsymbol{\sigma}_{x}^{2}}\right)$$

Where: α = Cronbach's alpha value

K = number of items

σx^2 = variance of the total of respondents' scores

σYi^2 = variance of components (i) of the respondents

Using the SPSS 26.0 statistical software, the Cronbach's alpha value computed for the research objectives ranged from 0.720 to 0.954, and this is shown in Table 3.5

TABLE 3. 5 Cronbach's Alpha Value

Objective	**Item**	**Cronbach's Alpha Value**
To investigate the awareness level of registered construction professionals to adopt the smart building concept (SBCs) in the Nigerian construction industry.	7	0.836
Investigate the factors that can enhance the level of awareness of smart building concepts among construction professionals in the Nigerian construction industry	20	0.836
To Assess the factors that influence the adoption of SBCs among professionals in the Nigerian construction industry	18	0.720
To identify the barriers to the adoption of SBCs in construction projects in the Nigerian construction industry	22	0.954

Source: Field Survey (2021)

3.15 METHOD OF DATA PRESENTATION AND ANALYSE

Data for this study were presented using tables, and data analyses were achieved using appropriate descriptive and inferential statistics. Descriptive statistical analysis extensively measures the characteristics of a study population, whereas inferential statistics draw up conclusions or inferences about a population from data sets. The data analyses were facilitated using the Statistical Package for Social Sciences (IBM SPSS Statistics 26). The dependent variables can be predicted in this study, while the independent variables are the predictors. The received data was carried out by mean score ranking, Factor analysis, and agreement analysis techniques using Kendall's coefficient of concordance.

3.16 ETHICAL CONSIDERATION

This research accommodates the protection of the respondents' interests by taking full responsibility during the investigation. The survey respondents were not pressured to respond to this survey. The respondents were briefed about the purpose of the study and how or why they had been chosen. They were free from deception or any form of stress from their participation in this study. The respondents were also guaranteed protection through anonymity.

3.17 SUMMARY

This chapter summarizes the methodology and procedures employed in the whole process of conducting this research. The study makes use of the descriptive design approach.

The study population comprised 363 registered construction professionals, including architects, builders, (mechanical, electrical, and structural) engineers, and quantity surveyors practicing in Lagos state. Due to the study's uniqueness, a purposive sampling technique was adopted. Data for this study was gathered from both primary and secondary sources. The research instrument used was a well-structured questionnaire. (363) copies of the questionnaire were administered in the study area. All data received were analyzed using an appropriate statistical package. In addition, reliability was carried out for all the factors using the Cronbach's alpha (α) reliability test.

CHAPTER FOUR

DATA ANALYSIS AND INTERPRETATION RESULTS

4.1 INTRODUCTION

This chapter presents the analyses and discussion of the findings emanating from the data obtained from the field survey. Data were obtained and analyzed according to the objectives of the study. Respondent demographic characteristics were also examined and presented. Gender, academic qualification, the field of profession, professional qualification, and years of professional experience were among the demographic characteristics analyzed. The chapter presents the discussion and interpretation of the results on the awareness level of registered construction professionals of the adoption of the smart building concept (SBCs) in the Nigerian construction industry. These factors can enhance awareness of the smart building concept among construction professionals in the Nigerian construction industry, the factors that influence the adoption of SBCs among professionals in the Nigerian construction industry, and the barriers to the adoption of SBCs in construction projects in the Nigerian construction industry. Three hundred and sixty-three (363) copies of the questionnaire were administered to construction professionals in the Lagos State chapter of the Nigerian construction industry, and (316) copies of the questionnaire were completed and retrieved.

4.2 BACKGROUND INFORMATION OF RESPONDENTS

The first section of the questionnaire presented the respondent's background information. The respondents' information includes gender, educational qualification, profession, professional qualification (body), and professional experience in the construction industry, which further increased the reliability of the study on the knowledge of smart building concepts. Careful observation from the retrieved data revealed that 276 respondents were aware of SBCs while the remaining 40 were unaware of SBCs (see details in Table 4.2), and thus were not used for further analysis. The retrieved survey from the 276 questionnaires showed that 196 (71.0%) respondents were male while 80 (29.0%) were female. The educational qualifications of the respondents revealed that 21 (7.6%) had earned a National Diploma (ND). 55 (19.9%) of the respondents attained A Higher National Diploma (HND). 85 (30.8%) of respondents had earned a bachelor's degree in science or technology (B.SC/B.TECH). 27 (9.8%) of the respondents earned a master's degree in science or technology. Finally, 88 (31.9%) of the respondents had earned a Doctorate (PhD), the most significant percentage of educational qualifications. The findings also showed that 50 (18.1%) of the respondent’s profession is architecture, 106 (38.4%) of the respondents are builders, 47 (17,0%) of the respondents are quantity surveyors, 46 (16.7%) of the respondents are Engineers and 27 (9.8%) are in the other professions. The results also showed that 47 (17.0%) of respondents belong to QSRB professional qualification (body), 106 (38.4%) highest number of the respondents belong to the professional qualification body CORBON(NIOB), 50 (18.1%) of the respondents belong to ARCON, 46 (16.7) of the respondents belong to COREN, and 27 (9.8%) to other bodies. Many of the respondents are affiliated to CORBON(NIOB) from the results. The result also showed that 23 (8.3%) of the respondents have less than five years of working experience, 90 (32.6%) of the respondents have 5-10 years of work experience, which is the highest period of working experience, 64 (23.2%) of the respondents have 11-15 years working experience, 29 (10.5%) of the respondents have 16-20 years working experience, and 70 (25.4%) of the respondents have more than 20 years working experience. The respondents' background information reveals that they have enough professional qualifications, significant years of experience, and the knowledge to provide a professional opinion on the study's objective.

TABLE 4. 1 Background information of Respondents

`	**Categories**	**Frequency**	**Percent (%)**
Gender	Male	196	71.0
	Female	80	29.0
	TOTAL	**276**	**100.0**
Educational Qualification	ND	21	7.6
	HND	55	19.9
	B.sc /B. TECH	85	30.8
	M.sc/M. TECH	27	9.8
	Doctorate (PhD)	88	31.9
	Total	**276**	**100.0**
Profession	Architect	50	18.1
	Builder	106	38.4
	Quantity surveyor	47	17.0
	Engineer	46	16.7
	Others	27	9.8
	Total	**276**	**100.0**
Professional Qualification (Body)	QSRBN	47	17.0
	CORBON(NIOB)	106	38.4
	ARCON	50	18.1
	COREN	46	16.7
	Others	27	9.8
	Total	**276**	**100.0**
Professional Experience	Less than 5 years	23	8.3
	5-10 years	90	32.6
	11-15 years	64	23.2
	16-20 years	29	10.5
	More than 20 years	70	25.4
	Total	**276**	**100.0**

4.3 AWARENESS LEVEL OF SMART BUILDING CONCEPT

This section presented the finding on the awareness level of the smart building concept among construction professionals of Lagos State of the Nigerian construction industry. This section examined two significant aspects using Kruskal-Wallis Test and weighted means.

From Table 4.2, the professionals were asked about their awareness of the smart building concept; two hundred and seventy-six selected ‘Yes’ with 87.4%. At the same time, forty professionals selected ‘No’ with 12.6%. The selection also formed the basics of selecting the questionnaire for further analysis

TABLE 4. 2 Professionals Awareness level

Construct	**Response**	**F**	**Percentage (%)**
Are you aware of the smart building concept?	YES	276	87.4
	NO	40	12.6
	TOTAL	316	100

Source: Field Survey (2021)

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4.3.1 Kruskal-Wallis Test of Association between Tests of the relationship of awareness level against the profession

The result of the analysis from Table 4.3 showed no significant association in the awareness level of the smart building concept among professionals in the Nigerian construction industry in Lagos State. Since p= value > 0.005, the distribution $X^2 = 8.824$, P=0.066. A mean rank value of 160.13 suggested that the profession of builders has the highest awareness level of the practices of the smart building concept in the Lagos State chapter of the Nigerian construction industry. It could be because of the state's increase in the digitalization of building construction.

TABLE 4. 3 Kruskal-Wallis Test of Association between the relationship of awareness level against the profession

	Ranks			χ^2	df	Sig.
	PROFESSION	**N**	**Mean Rank**	8.824	4	0.066
AWARENESS OF SMART BUILDING	BUILDER	149	160.13			
	QUANTITY SURVEYOR	39	143.92			
	ENGINEER	38	142.41			
	ARCHITECT	34	134.42			
	OTHERS	16	109.79			
	Total	276				

4.3.2 Kruskal-Wallis Test of Association between Tests of the relationship of awareness level against EDUCATIONAL QUALIFICATION

The result of the analysis from Table 4.4 showed that there was no significant association between the awareness level of the smart building concept and the educational qualification distribution ($X^2 = 6.791$, P=0.061). since the p-value is > 0.5, a mean rank of 170.45 suggested that PhD holders have the highest knowledge of awareness of the practices of the smart building concept in the Lagos State chapter of the Nigerian construction industry. While ND holders have the slightest awareness knowledge with a mean value of 59.40.

TABLE 4. 4 Kruskal-Wallis Test of Association between Tests of the relationship of awareness level against Educational Qualification

	Ranks	N	Mean Rank	χ^2	Df	Sig.
EDUCATIONAL QUALIFICATION	ND	21	59.40	6.791	4	0.061
	HND	55	109.86			
	B.SC/B.TECH	85	145.85			
	M.SC/M.TECH	27	131.06			
	Ph. D	88	170.45			
	Total	276				

4.3.3 Kruskal-Wallis Test of Association between Tests of the relationship of awareness level against PROFESSIONAL EXPERIENCE

The result of the analysis from Table 4.5 showed that there was a significant association between the awareness level of the smart building concept and the Professional Experience distribution ($X^2 = 8.323$, P=0.000). A mean rank of 165.96 suggested that professional experience with more than 20 years have the highest knowledge of awareness of the practices of smart building concept in the Lagos State chapter of the Nigerian construction industry, while professional experiences with less than five years have the least knowledge of awareness with of mean value of 45.44.

TABLE 4. 5 Kruskal-Wallis Test of Association between Tests of the relationship of awareness level against Professional Experience

	Ranks	N	Mean Rank	χ^2	df	Sig.
	Less than 5 years	31	45.44	8.323	4	0.000
	5-10 years	104	148.90			
PROFESSIONAL EXPERIENCE	11-15 years	42	119.36			
	16-20 years	16	159.00			
	More than 20 years	83	165.96			
	Total	276				

Source: field survey (2021)

4.3.4 Kruskal-Wallis Test of Association between Tests of the relationship of awareness level against Gender

The result of the analysis from Table 4.6 showed that there was no significant association between the awareness level of the smart building concept and the Professional Experience distribution ($X^2 = 10.876$, P=0.212). Since the p-value is > 0.5, a mean rank of 146.99 suggested that males have a higher awareness of the practice of the smart building concept in the Lagos State chapter of the Nigerian construction industry than the females with a mean rank value of 117.70.

TABLE 4. 6 Kruskal-Wallis Test of Association between Tests of the relationship of awareness level against Gender

	Ranks	N	Mean Rank	χ^2	df	Sig.
GENDER	Male	196	146.99	10.876	1	0.212
	Female	80	117.70			
	Total	276				

4.3.5 Component to Measure Smart Building Concept

Table 4.7 shows respondents' responses on the component to measure the smart building concept, using the 5-point Likert scale of 1= very low; 2= low; 3= average; 4=high; 5=very high. The result showed that the energy management system (M=4.46, SD= 0.678, Ranked first), IT network connectivity (M=4.34, SD=0.813, Ranked second), Safety and Security Management System (M=4.18, SD=0.567 Ranked third) Building Automation System (M=4.05, SD=0.956 Ranked fourth) Building Control System (M=3.97, SD=1.019, Ranked fifth), Green Building Construction (M=3.90, SD=0.706 Ranked sixth), Enterprise Management System (M=3.48, SD=0.760, Ranked seventh)

TABLE 4. 7 Component to Measure Smart Building Concept

Component to Measure Smart Buildings	Very low	low	Average	High	Very high	Mean	SD	RANK
Energy Management System		2(0.7)	23(8.3)	98(35.5)	153(55.4)	4.46	0.678	1
IT Network Connectivity	2(0.7)	8(2.9)	23(8.3)	98(35.5)	145(52.5)	4.34	0.813	2
Safety and Security Management System		2(0.7)	18(6.5)	185(67.0)	71(25.7)	4.18	0.567	3
Building Automation System		14(5.1)	77(27.9)	66(23.9)	119(43.1)	4.05	0.956	4
Building Control System		24(8.7)	75(27.2)	62(22.5)	115(41.7)	3.97	1.019	5
Green Building Construction		14(5.1)	42(15.2)	178(64.5)	42(15.2)	3.90	0.706	6
Enterprise Management System	4(1.4)	11(4.0)	131(47.5)	108(39.1)	22(8.0)	3.48	0.760	7

Source: field survey (2021)

4.4 FACTORS THAT ENHANCE THE LEVEL 0F AWARENESS OF SBCs AMONG CONSTRUCTION PROFESSIONALS IN THE NIGERIAN CONSTRUCTION INDUSTRY

This section reported the findings of an analysis of the factors that enhance SBCs awareness among Nigerian construction industry professionals.

4.4.1 Principal Component Analysis of The Factors Enhancing Awareness Level of SBCs Among Construction Professionals

The factors enhancing were subjected to principal component analysis (PCA). The adequacy of data for factor analysis was assessed prior to doing PCA. The Kaiser-Meyer-Olkin (KMO) sampling adequacy is a degree that indicates if the value distribution is adequate for factor analysis. A score of < 0.5 is unacceptable, > 0.5 is acceptable, > 0.6 is mediocre, > 0.7 is fair,

> 0.8 is commendable, and > 0.9 is excellent. The table revealed that the variables' correlation matrix is not an identity matrix, meaning that off-diagonal values are one rather than zero.

In Table 4. 8, the KMO data returned a value sampling adequacy of 0.774, more significant than the permitted limit of 0.5, which means the data will yield distinct and reliable factors adequately (Field, 2013). Bartlett's test of sphericity was performed to determine the principal's suitability of data for factors analysis. The result (chi-square = 2249.845, P=0.000), as presented in Table 4.8, showed that the correlation matrix of the variables is different from an identity matrix.

TABLE 4. 8 KMO and Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.774
	Approx. Chi-Square	2249.845
Bartlett's Test of Sphericity	Df	190
	Sig.	.000

4.4.2 Communalities Table

The communalities of the factor enhancing the awareness level of SBCs among construction professionals were established to determine the extent to which the underlying factors account for the variance of the 20 factors. The table showed that 18 variables had communalities greater than 0.4, implying that the 18 variables measure the underlying factors.

TABLE 4. 9 Communalities of Factors that Enhance Awareness Level

Communalities	Initial	Extraction
The availability of comprehensive educational training (Conference/seminar) for professionals, developers, and policymakers	1.000	**.734**
Improving occupants’ productivity /satisfaction	1.000	**.767**
creation of public awareness	1.000	**.705**
Availability of institutional facilities	1.000	**.641**
Promotion of successful smart building projects	1.000	**.622**
Availability of new smart building technologies	1.000	**.709**
Availability of smart building codes and regulations	1.000	**.661**
Smart building rating system and labelling	1.000	**.512**
Organizational commitment towards smart building	1.000	**.537**
Professional network to support smart building	1.000	**.560**
Newmarket opportunities	1.000	.443
Performance-based standards and contracts	1.000	**.703**
New kind of partnership and project stakeholders	1.000	**.737**
Ecology of smart building	1.000	.425
Security of the smart building	1.000	**.794**
Building wastes management	1.000	**.588**
Peer Firm Influence	1.000	**.517**
Educational programs for developers,	1.000	**.623**
Low-cost loans and subsidies from the government	1.000	**.567**
Availability of better information on cost and benefits	1.000	**.577**

Extraction Method: Principal Component Analysis.

4.4.3 Total Variance Explained

Table 4.10 shows the number of components enhancing awareness levels among construction professionals and their respective eigenvalues. The factors have eigenvalues that were not less than one and the rotation sum of square loading, which is between 1.324 and 3.539 (Table 4.10). This suggested that five components could be extracted to represent the underlying factors. The dominant one accounts for 27.268% of the observed variance with an eigenvalue of 5.454. The second component accounted for 14.44% of the observed with an eigenvalue of 2.889. The third component accounted for 7.793% of the observed variance with an eigenvalue of 1.559. The fourth component accounted for 6.910% of the observed variance with an eigenvalue of 1.382. Lastly, the fifth component accounted for 5.699% of the observed with an eigenvalue of 1.140.

TABLE 4. 10 Total Variance Explained for Factors Enhancing Awareness Level Among Construction Professionals

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.454	27.268	27.268	5.454	27.268	27.268	3.539	17.697	17.697
2	2.889	14.444	41.712	2.889	14.444	41.712	3.464	17.321	35.018
3	1.559	7.793	49.505	1.559	7.793	49.505	2.169	10.845	45.863
4	1.382	6.910	56.415	1.382	6.910	56.415	1.926	9.628	55.491
5	1.140	5.699	62.114	1.140	5.699	62.114	1.324	6.622	62.114
6	.945	4.723	66.836						
7	.895	4.474	71.310						
8	.792	3.962	75.272						
9	.696	3.481	78.754						
10	.632	3.159	81.913						
11	.571	2.856	84.770						
12	.526	2.628	87.397						
13	.490	2.449	89.846						
14	.428	2.141	91.987						
15	.349	1.747	93.734						
16	.312	1.558	95.292						
17	.284	1.421	96.712						
18	.275	1.374	98.086						
19	.203	1.017	99.103						
20	.179	.897	100.000						
Extraction Method: Principal Component Analysis.									

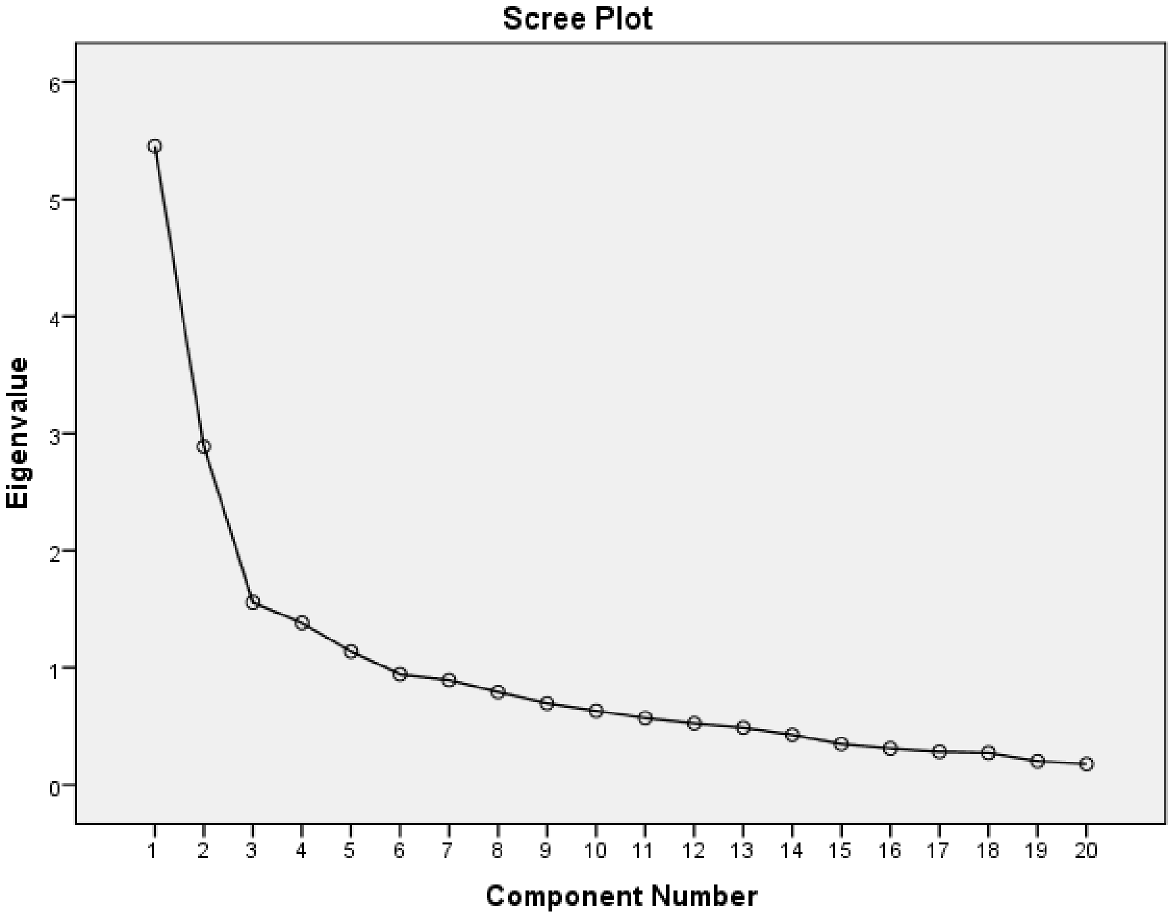

FIGURE 4. 1 Scree Plot for Factors Enhancing Awareness Level Among Construction Professionals

The components matrix in Table 4.11 shows the results of Pearson's correlation analysis between the components and the factors that enhance construction professionals' awareness levels. The criteria that are taken into account are divided into five components. Table 4 shows the result of a rotation performed with Varimax with the Kaiser Normalization method. The dominant factor loadings are shown in bold. After rotating the component matrix, twenty (20) factors were extracted and adopted for further analysis because their factor loading was not less than 0. 5. However, the availability of comprehensive educational training

(Conference/seminar) for professionals, developers, and policymakers (0.559), creation of public awareness (0.690), availability of institutional facilities (0.695), availability of new smart building technologies (0.774), availability of smart building codes and regulations (0.754), new kind of partnership and project stakeholders (0.776), were factors loaded into the first component. Building wastes management (0.652), peer firm influence (0.710), educational programs for developers (0.752), low-cost loans and subsidies from the government (0.652), availability of better information on cost and benefits (0.658) were loaded in component two. Professional network to support smart building (0.639), ecology of the smart building (0.527), performance-based standard, and contracts (0.833) were loaded into component three. The availability of comprehensive educational training (conference/seminar) for professionals, developers, and policymakers (0.602), improving occupants' productivity/satisfaction (0.571), promotion of successful smart building projects (0.731), organizational commitment towards smart building (0.567) were loaded component four lastly, security of the smart building (0.856). The results implied that variables in components 1, 2, 3, 4, and 5 were adequately correlated with the underlying factors represented by each component.

TABLE 4. 11 Component Matrix of correlation between component and factors enhancing awareness level of SBCs among construction professionals

Factors	Component				
	1	2	3	4	5
The availability of comprehensive educational training (Conference/ seminar) for professionals, developers, and policy makers	.407	-.524	.372	-.310	.245
Improving occupants' productivity /satisfaction	.171	.651	.442	-.232	.256
creation of public awareness	.637	-.478	.237	-.117	.022
Availability of institutional facilities	.320	-.624	.210	.295	-.135
Promotion of successful smart building projects	.375	.039	.560	-.375	-.159
Availability of new smart building technologies	.627	-.494	-.266	-.005	.002
Availability of smart building codes and regulations	.587	-.519	-.014	-.047	-.214
Smart building rating system and labelling	.613	.182	-.067	.037	-.311
Organizational commitment towards smart building	.554	.113	.460	-.008	.080
Professional network to support smart building	.518	.221	.188	.442	.109
New market opportunities	.538	.054	-.120	-.247	.275
Performance based standard and contracts	.401	.255	.301	.592	-.190
New kind of partnership and project stakeholders	.559	-.534	-.333	.089	.143
Ecology of smart building	.513	.279	.035	.248	-.144
Security of smart building	.334	.131	-.079	.362	.727
Building wastes management	.550	.413	-.133	-.022	-.311
Peer Firm Influence	.436	.388	-.275	-.313	-.050
Educational programs for developers,	.647	.265	-.231	-.284	.026
Low-cost loans and subsidy from government	.639	.233	-.293	-.012	.133
Availability of better information on cost and benefits	.682	.265	-.179	.011	-.103

Extraction Method: Principal Component Analysis.

a. five components extracted.

TABLE 4. 12 Rotated Component Matrix of The Correlation Between Component And Factors Enhancing Awareness Level Of SBCs Among Construction Professionals

Factors	Component				
	1	2	3	4	5
The availability of comprehensive educational training (Conference/ seminar) for professionals, developers, and policy makers	**.559**	-.065	-.171	**.602**	.162
Improving occupants' productivity /satisfaction	-.551	.254	.157	**.571**	.220
creation of public awareness	**.690**	.126	.098	.447	.060
Availability of institutional facilities	**.695**	-.266	.274	.099	-.051
Promotion of successful smart building projects	.074	.150	.105	**.731**	-.220
Availability of new smart building technologies	**.774**	.312	.016	-.018	.112
Availability of smart building codes and regulations	**.754**	.194	.102	.162	-.134
Smart building rating system and labeling	.202	**.536**	.392	.090	-.148
Organizational commitment towards smart building	.127	.189	.377	**.567**	.147
Professional network to support smart building	.084	.178	**.639**	.129	.312
New market opportunities	.210	.491	-.069	.235	.314
Performance based standard and contracts	.016	.043	**.833**	.069	.038
New kind of partnership and project stakeholders	**.776**	.231	-.013	-.121	.258
Ecology of smart building	.059	.372	**.527**	.064	.041
Security of smart building	.045	.103	.220	-.026	**.856**
Building wastes management	-.020	**.652**	.368	.050	-.154
Peer Firm Influence	-.083	**.710**	-.024	.073	.007
Educational programs for developers,	.120	**.752**	.041	.170	.115
Low-cost loans and subsidy from government	.163	**.652**	.184	.002	.286
Availability of better information on cost and benefits	.164	**.658**	.330	.065	.070

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 7 iterations.

Source: field survey 2021

The factors loaded in components one to five in Table 4.12 were regrouped into four components to assign unique names, as shown in Table 4.13. Factors loaded to component one are named administration factors, component two named educational factors, component three named organizational factors, and component four named environmental factors.

TABLE 4. 13 Shows the Principal Components with their unique names

Component factors	Factors (interpretation)
	Administration factors
Low-cost loans and subsidies from the government	
Peer Firm Influence	
Availability of better information on cost and benefits	
Building wastes management	
Availability of smart building codes and regulations	
Smart building rating system and labelling	
	Educational factor
creation of public awareness	
Availability of institutional facilities	
Educational programs for developers,	
The availability of comprehensive educational training (Conference/ seminar) for professionals, developers, and policymakers	
	Organizational factor
Organizational commitment towards smart building	
Promotion of successful smart building projects	
Professional network to support smart building	
New kind of partnership and project stakeholders	
Performance-based standards and contracts	
Availability of new smart building technologies	
	Environmental factors
Security of the smart building	
Improving occupants' productivity /satisfaction	

4.5 CRITICAL FACTORS FOR THE ADOPTION OF SBCs

This section presented the analysis results on the factors influencing the adoption of smart building concepts among construction professionals. Two aspects were considered in this section and examined: do professionals support the adoption of the smart building concept and the critical factors influencing the adoption of smart building concepts in the Nigerian construction industry.

4.5.1 The Professionals support the Adoption of SBCs in the Nigerian Construction Industry.

Table 4.14 shows the percentage of respondents of the professionals in support of adopting SBCs. 87.4% of the respondents support adopting SBCs, while 12.6% do not support adopting SBCs in the Nigerian construction industry. These figures indicate that professionals are ready to adopt smart building concepts in the construction industry. According to Owusu-Manu et al. (2021), before adopting SBCs, it is critical to understand the current state of professionals' opinions on the topic. In this scenario, knowing the amount of support for SBCs, and adoption is critical before identifying the significant factors that can influence the choice to adopt SBCs.

TABLE 4. 14 Professionals in support of adopting SBCs

Construct	Response	Percentage (%)
Professional support in adopting SBCs in the Nigerian construction industry	Yes	87.4
	No	12.6

Source: field survey 2021.

4.5.2 Factors influencing the adoption of smart building

Table 4.15 showed the respondent ranking of the factors significant in influencing the adoption of SBCs in the Nigerian construction industry, using the 5-point Likert scale 1= not significant, 2= rarely significant, 3= neutral, 4=significant; 5=highly significant. Table 4.15 showed that "Participation and collaboration" (M=4.66,SD=0.476), "Energy and cost-saving" (M=4.37,SD=0.672), "Stakeholders' computer" (M=4.30,SD=0.930), "Data management" (M=4.21,SD=0.906), "Job creation" (M=4.21,SD=0.906), "Viable funding strategy"(M=4.05,SD=0.923), "Interoperability" (M=3.86,SD=0.946), "Health care" (M=3.83,SD=0.960), "IT professional support"(M=3.83,SD=0.960), "Connection with professional" (M=3.83,SD =0.946), "Top management support" (M=3.80,SD=0.946), "Protection environment"(M=3.80,SD=0.946), "Stakeholders' engagement" (M=3.73,SD=1.027), "Comfortability of users" (M=3.64,SD=0.857) were the major significant factors influencing the adoption of the smart building concepts in the Nigerian construction industry.

TABLE 4. 15 Factors Influencing the Adoption of Smart Building Concepts

	Factors	S.DIS	DIS	N	AGR	S.AD	MNS	SD	Rank
BSC 11	Participation and collaboration				95(34.4)	181(65.6)	4.66	0.476	1
BSC 14	Energy and cost-saving		5(1.8)	15(5.4)	130(47.1)	126(45.7)	4.37	0.672	2
BSC 9	Stakeholders' computer	6(2.2)	11(4.0)	22(8.0)	92(33.3)	145(52.5)	4.30	0.934	3
BSC 4	Data management	6(2.2)	6(2.2)	36(13.0)	104(37.7)	124(44.9)	4.21	0.906	4
BSC15	Job creation	6(2.2)	6(2.2)	36(10.6)	104(37.7)	124(44.9)	4.21	0.906	4

	Factors	S.DIS	DIS	N	AGR	S.AD	MNS	SD	Rank
BSC 8	Viable funding strategy	5(1.8)	11(4.0)	48(17.4)	114(41.3)	98(35.5)	4.05	0.923	5
BSC 3	Interoperability	9(3.3)	7(2.5)	71(25.7)	117(42.4)	72(26.1)	3.86	0.946	6
BSC17	Health care	9(3.3)	10(3.6)	71(25.7)	116(42.0)	70(20.6)	3.83	0.960	7
BSC 6	IT professional support	9(3.3)	10(3.6)	71(25.7)	116(42.0)	70(25.4)	3.83	0.960	7
BSC 2	Connection with professional	9(3.3)	7(2.5)	75(27.2)	115(41.7)	70(25.4)	3.83	0.946	8
BSC 7	Top management support	9(3.3)	9(3.3)	75(27.2)	118(42.8)	65(23.6)	3.80	0.946	9
BSC18	Protection environment	9(3.3)	9(3.3)	75(27.2)	118(42.8)	65(23.6)	3.80	0.946	9
BSC 10	Stakeholders' engagement	10(3.6)	25(9.1)	57(20.7)	121(43.8)	63(22.8)	3.73	1.027	10
BSC 12	Comfortability of users		26(9.4)	91(3.0)	116(42.0)	43(15.6)	3.64	0.857	11
BSC 5	Privacy of users	37(13.4)	79(28.6)	68(24.6)	45(16.3)	47(17.0)	2.95	1.292	12
BSC16	Safety and security	37(13.4)	79(28.6)	68(24.6)	45(16.3)	47(13.8)	2.95	1.292	12
BSC 1	Instrumentation and control	38(13.8)	81(29.3)	70(25.4)	41(14.9)	46(16.7)	2.91	1.288	13
BSC 13	Conservation of resource	35(12.7)	77(27.9)	83(30.1)	47(17.0)	34(12.3)	2.88	1.200	14

Source: field survey, 2021.

4.5.3 Critical Factors Influencing Adoption of SBCs

The factors were further subjected to binary regression analysis to determine the critical factors influencing the adoption of the smart building concept.

4.5.4 Omnibus Test of Models Coefficients

The tests indicate how well the model performed to support the assumption of the factors influencing the adoption. It is also called the goodness of fit test. Table 4.16 shows the significant value that determines the usefulness of the developed model. According to Pallant (2016), if the significant value(sig) is < 0.05, the model is better. The table shows that the p-value for the test is 0,000, which is less than 0.005 p<0.05, and a chi-square value of 315.91 with 18 degrees of freedom(df). The results indicate that the model can be used to support the assumption of all respondents on the factors influencing the adoption of the smart building concept in the Nigerian construction industry (x^2 =315.912 df=18 p< 0.05).

TABLE 4. 16 Omnibus test of model's coefficients

`	Test	Chi-square	DF	Sig.
Step1	Step	315.912	18	.000
	Block	315.912	18	.000
	Model	315.912	18	.000

Source: field survey 2021

4.5.5 Hosmer and Lemeshow Test

Table 4.17 supports the model as being functional. Hosmer and Lemeshow's test is the most reliable test of model fit. It is interpreted very differently from the omnibus test. For the Hosmer-Lemeshow Goodness of Fit Test, the poor fit is indicated by a significance value of less than 0.05. in supporting the model built in the study, the p-value must be greater than 0.05 (Pallant, 2016). The p-value shown in the table is 0.709(p>0.05), indicating that the model building has a good model fit.

TABLE 4. 17 Hosmer and Lemeshow Test

Step	Chi-square	Df	Sig.
1	5.442	8	.709

Source field survey 2021

4.5.6 Model Summary

Table 4.18, the -2 LogLikelihood statistics is 302.981a, with a parameter estimated change of less than 0.001; therefore, it can be concluded that the model coefficients are not 0.000, and the model is useful (Awang and Alimin, 2016). Therefore, the model is used to determine the critical factors influencing the adoption of SBCs. Table 4.18 also shows the Cox and Snell R^2 and Nagelkerke $R^{2,}$ which provide the amount of variation in the dependent variable explained by the model (Pallant, 2016). Table 4.18 shows that the value of Cox and Snell R^2 is 0.652 and Nagelkerke R^2 is 0.831, suggesting that 65% and 81%, which is half and more than half of the variation in the outcome variable, respectively, can be explained by the logistic regression model. Therefore, the Nagelkerke R^2 test was more acceptable and preferable for the model built as it shows that more than half of the overall data (81%) was represented in the model.

TABLE 4. 18 Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	302.981[a]	.652	.831

a. Estimation terminated at iteration number 5 because parameter estimates changed by less than .001.

TABLE 4. 19 Binary logistic regression output

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1	BSC1	-.068	.412	.028	1	.548	1.565	.364	6.733
	BSC2	.448	.745	.361	1	.659	.768	.237	2.486
	BSC3	-.264	.599	.195	1	.093	1.743	.912	3.333
	BSC4	.556	.331	2.824	1	.239	1.570	.741	3.326
	BSC5	.451	.383	1.388	1	.465	.649	.204	2.069
	BSC6	-.432	.591	.533	1	.867	1.083	.425	2.765
	BSC7	.080	.478	.028	1	.421	.751	.374	1.509
	BSC8	-.286	.356	.646	1	.578	1.088	.808	1.465
	BSC9	.084	.152	.309	1	.436	1.125	.836	1.514
	BSC10	.118	.152	.607	1	.146	1.555	.857	2.819
	BSC11	.441	.304	2.113	1	.171	.762	.516	1.124
	BSC12	-.272	.199	1.876	1	.507	.748	.316	1.767
	BSC13	-.291	.439	.439	1	.234	1.301	.843	2.007
	BSC14	.263	.221	1.415	1	.041	.898	.852	2.634
	BSC15	-.404	.288	1.969	1	.030	.812	.534	1.234
	BSC16	.428	.254	.950	1	.029	2.236	1.084	4.614
	BSC17	.805	.370	4.742	1	.033	1.021	.821	1.269
	BSC18	.021	.111	.034	1	.228	.065		
	Constant	-2.729	2.266	1.451					

a. Variable(s) entered in step 1: BSC1 instrumentation and control, BSC2 connection with professionals, BSC3 interoperability, BSC4 data management, BSC5 privacy of users, BSC6 IT professional support, BSC7 top management support, BSC8 viable funding strategy, BSC9 stakeholders' computer, BSC10 stakeholders' engagement, BSC11 participation and collaboration, BSC12 comfortability of users, BSC13 conservation of resource, BSC14 energy, and cost-saving, BSC15 job creation, BSC16 safety and security, BSC17 health care, BSC 18 and protection environment.

The result of binary logistic regression with the significance and impact of each explanatory variable on the response variable is presented in Table 4.19. The significant value of the Wald statistics for each independent variable indicates the contribution or importance of each predictor variable ($P<0.05$). The logistic regression in this study contained eighteen independent variables. From Table 4.19, column six (6) determines the independent variables that contribute significantly to the model's predictive ability at a 0.05 level of significance. Four of the independent variables made a unique, statistically significant contribution to the model, which determines the critical factors influencing the adoption of SBCs. (energy and cost-saving, job creation, safety and security, health care). Further, instrumentation and control, connection with professionals, interoperability, data management, the privacy of users, IT professional support, top management support, viable funding strategy, stakeholders' computer, stakeholders' engagement, participation and collaboration, comfortability of users, conservation of the resource, and protected environment, did not contribute significantly to the model.

The B values (coefficient) show the direction of the relationship between the dependent and independent variables. B values (coefficient) could be negative or positive values, denoting which factors are critical in influencing or not influencing the adoption of SBCs. B value of seven of the independent variables in the model is negative. This indicates that a unit increase in the independent variable score will decrease the probability of the case recording a score of 1 in the dependent variable. Thus, BSC 1 -068, BSC3-264, BSC6-432, BSC8-286, BSC12-272, BSC13-291, BSC15-404 are less likely to influence the adoption of the smart building concept.

The EXP (B) is the exponential of the logistic coefficient. The EXP (B) column presents how raising the corresponding measure by one unit influences the odds ratio.

Energy and cost-saving have an EXP (B) value of .898; this indicates that when energy and cost-saving are increased by 1 unit, adopting SBCs is .898 times higher for the factors not influencing the adoption of SBCs.

Safety and security have an EXP (2.236). When safety and security are raised by 1 unit, the chance of the factors being selected is 2.236 times higher for influencing the adoption of SBCs than not influencing the adoption. Health care has an EXP (B) value of 1. 021. Hence, when a unit raises the health care, the odds ratio is 1.021 times higher, and therefore, health care is likely to influence the adoption of SBCs.

Job creation has an EXP (B) value of approximately 1. This value shows that the probability of a job creation being selected is higher for factors influencing a job creation than a factor not influencing the adoption of SBCs.

4.6 THE BARRIER TO SMART BUILDING CONCEPT IN THE NIGERIAN CONSTRUCTION INDUSTRY

This section presented the barriers to adopting the smart building concept in the Nigerian construction industry. Mean item scores and agreement analysis techniques have been used for the barriers. Data were gathered using a well-structured questionnaire. a 5-point Likert scale was utilized to rank the barrier to the adoption of the smart building concept in the Nigeria construction industry

Table 4.20 shows the barriers to smart building concept adoption in Nigeria's construction industry. Table 4.20 showed that all the barriers are significant to the adoption of SBCs: 'High cost of Smart building materials' (4.54); 'Inadequate power supply'(4.41); 'Resistance to change from the use of traditional technology'(4.41); "Poor maintenance culture"(4.40); 'Poor knowledge of SBT' (4.38); 'Inadequate well-trained labour'(4.38); 'Inadequate finance schemes' (4.38); 'Inconsistent government policy (4.37); 'Lack of local institutional facilities for research' (4.36); 'Low enforcement of building laws'(4.31); 'Fear of Inflation' (4,29); 'Lack of SBCs database and Information'(4.25); 'High cost of SB equipment'(4.12); 'A limited number of SB suppliers'(4.10); 'Lack of interest from clients'(4.08) and 'Low market demand'(4.01).

TABLE 4. 20 The Barriers to Smart Building Concept Adoption

Barriers	Mean	Rank
High cost of SB materials	4.54	1
Inadequate power supply	4.41	2
Resistance to change from the use of traditional technology	4.41	2

Barriers	Mean	Rank
Poor maintenance culture	4.40	3
Poor knowledge of SBT	4.38	4
Inadequate well-trained labour	4.38	4
Inadequate finance schemes	4.38	4
Inconsistent government policy	4.37	5
Lack of local institutional facilities for research	4.36	6
Low enforcement of building laws	4.31	7
Fear of Inflation	4.29	8
Lack of SBCs database &Information	4.25	9
High cost of SB equipment	4.12	10
A limited number of SB suppliers	4.10	11
Lack of interest from clients	4.08	12
Low market demand	4.01	13
Lack of govt incentives	3.87	14
Use of traditional procurement methods	3.83	15
Lack of promotion	3.57	16
Risk and uncertainties involved in implementing new technology	3.39	17
Extension of project schedules	3.34	18

Source: field survey 2021

The barriers were further subjected to the agreement analysis technique.

4.6.1 Agreement analysis technique

Table 4.21 show the hypothesis of the agreement analysis test.

According to Siegel and Castellan (1988), if Kendall's W value generated from the test is at a low significance (significance level ≤0.001), the null hypothesis can be rejected, and the conclusion is that some degree of agreement exists among the respondents. Based on the above statement, this study rejects the null hypothesis since the significance is 0.000 ≤0.001.

TABLE 4. 21 shows the agreement analysis of the barriers.

Sn	Null Hypothesis	Test	Sig	Decision
	The distribution of BSM1, BSM2, BSM3 , BSM4, BSM5, BSM6, BSM7, BSM8, BSM8, BSM9, BSM10, BSM11, BSM12, BSM13, BSM14, BSM15, BSM16, BSM17, BSM18, BSM19, BSM20, BSM21, BSM22,	Related-Samples Kendal Coefficient Of concordance	0.000	Reject the null hypothesis
	Asymptotic significance is displayed			Kendall's coefficient concordance.
	The significance at 0.05			

Source: survey field 2021

Table 4.22 shows Kendal's W value for ranking the 22 barriers was 0.018, and the significant level of Kendall's W was 0.000, which indicates that a significant agreement exists among all the respondents.

TABLE 4. 22 Kendal's W value

Test Statistics	
N	276
Kendall's W[a]	.018
Chi-Square	102.646
df	21
Asymp. Sig.	.000
a. Kendall's Coefficient of Concordance	

Source: survey field 2021

4.7 Summary

This chapter has presented the research finding and has interpreted the data analysis of the data collected. The study highlighted that construction professionals are highly aware of the smart building concept. Furthermore, it discovered that all the parameters are vital to measuring smart buildings. In understanding the barriers associated with smart building, the study highlighted that the professionals agreed to the barriers. The critical factors influencing were also discovered. The next will discuss the finding in full detail.

CHAPTER FIVE

DISCUSSION OF FINDINGS

5.1 INTRODUCTION

In this chapter, the findings from the data analysis were explored in-depth with the research questions and objectives. This study's findings are linked to the contents of the literature review to validate the findings of the fourth chapter of this research, which answers all of the research questions raised in Chapter One and listed below

5.2 BACKGROUND INFORMATION

The survey report from the two-hundred and seventy-six questionnaires showed that a total of 196 professionals were male, representing 71.0% of the total population of the respondents, and eighty were female professionals, representing 29.0% of the total population of respondents.

The educational qualifications of the respondents from the background information show that twenty-one respondents have ND, representing 7.6% of the total population. Fifty-five respondents have HND, which equals 19.9% of the total population. Eighty-five respondents have B.Sc or B. Tech degrees, representing 30.8% of the total population of the respondents. Twenty-seven respondents have a master's degree in science or technology, representing 9.8% of the total population of the respondents. Finally, eighty-eight respondents have a PhD, representing 31.9% of the total population. According to Ghansah et al. (2020), the education qualification of the respondents indicates the respondent's development skills and ability to think critically. This variety of education qualifications demonstrates that the respondent is intellectually inclined, enhancing the credibility of the data collected.

In terms of professions, fifty respondents who are architects formed 18.1% of the total population. One hundred and six respondents are builders, constituting 38.4% of the population. Forty-seven respondents are quantity surveyors, comprising 17.0% of the total population, 46 respondents are engineers, forming 16.7% of the population. The result also shows other professions which were not in the initial sample population: 27 respondents, who formed 9.8% of the total population of the respondents.

Furthermore, in terms of the Professions Qualification Body, 50 respondents belong to ARCON, which represents 18.1% of the total population, 106 respondents belong to CORBON(NIOB), which represents 38.4% of the population, 47 respondents belong to QSRB, which represents 17.0% of the total population, 46 respondents belong to COREN which represents 16.7% of the population. Other 27 of the respondents represented 9.8% of the total population.

Finally, years of experience, the survey result shows that twenty-three respondents have less than five years of working experience, which forms 8.3% of the population. Ninety respondents have 5-10 years of working experience, including 32.6% of the population. Sixty-three respondents have 11-15 years of working experience, constituting 23.2% of the population, 29 respondents have 16-20 years of working experience, which forms 10.5% of the population, and 70 respondents have more than 20 years working experience, which constitutes 25.4% of the population. The respondents' background information on their years of experience and professional qualifications indicates the adequacy of the respondent's opinions regarding the objective of this study.

5.3 DISCUSSION OF THE FINDINGS OF RESEARCH OBJECTIVE ONE

RO1: To investigate the awareness level of registered construction professionals to adopt the smart building concept (SBCs) in the Nigerian construction industry.

5.3.1 Awareness level among construction professionals to adopt smart building concepts in the Nigerian construction industry.

The awareness level of smart building concepts among construction professionals showed that construction professionals are generally aware of the concept. The findings suggest no statistically significant variation in awareness levels among construction professions. However, the results indicate that the construction profession is not ignorant about smart building concepts in the Nigerian construction industry, as previously observed by Ogunde et al. (2018) and Oyewole, Araloyin, and Oyewole (2019). The result of the analysis of the respondents on the component to measure the smart building concept showed that the components listed to measure the smart building concept were all relevant and vital in measuring the smart building concept.

However, with a mean score of 4.46, Energy Management System is ranked first. IT network connection comes in second with a mean score of 4.34. With a mean score of 4.18, the Safety and Security Management System ranked third. Building Automation System with a mean score of 4.05 ranked fourth. Building Control System has the second highest mean score of 3.97, Green Building Construction has the third-highest mean score of 3.90, and Enterprise Management System has the lowest score of 3.48. These imply that all the components are essential in measuring the smart building concept for adoption in the Nigerian construction industry. They were supported by Yuliastri and Amani (2017) and Ghansah et al. (2020), the

Indonesian construction industry, and Ghana's construction industry. This finding agrees with their study that the following component is vital to the smart building concept for adoption.

5.4 DISCUSSION OF FINDING ON RESEARCH OBJECTIVE TWO (RO2)

RO2: Investigate the factors that can enhance the level of awareness of smart building concepts among construction professionals in the Nigerian construction industry

5.4.1 Factors that Enhance the Level of Awareness of SBCs

Exploratory factor analysis was used to achieve the results of research objective two on the factors that enhance the level of awareness of the smart building concept.

The identified factors that enhance awareness were subjected to principal component analysis (PCA) using SPSS version 26 software. Four factors emerged from the factor analysis of the identified factors to improve the awareness of SBCs.

5.4.1.1 Factor 1: Administration factors

This factor was named "administration factors" because it contained an item that addresses information that enhances the awareness level of SBCs in the construction industry. Under this factor, the six-item enhancing awareness was the availability of smart building codes and regulations; peer firm influence; availability of better information on cost and benefits; low-cost loans and subsidies from the government; building wastes management; and smart building rating system and labelling. The respective factor loading for these variables was 0.754, 0.710,0.658, 0.652,0.652 and 0.536, respectively. Since these factors are information-related, therefore named administration.

Effective communication among all relevant professionals in the construction industry is essential in enhancing the awareness of the smart building concept for adoption. Better information on the cost and benefits of the practice of smart building must be communicated to the relevant professional at every stage to encourage the practice. For the successful adoption of a smart building, all the professionals must fully understand the smart building rating system and labelling for the effective performance of the features of the building, such as real-time monitoring. Al Dakheel et al. (2020) suggested that real-time monitoring is related to data collection, analysis, and storage, an important feature of a smart building. Further explained that information collected is used to monitor the behavior of the building and allow for predictive maintenance.

Smart building codes and regulations need to be considered because the government is the most influential stakeholder in developed and developing countries (Osabutey and Croucher, 2018). Thereby policy and finance assist in increasing its awareness and adoption for the construction professionals in the federal and state ministry of work and labor to engage in smart building technologies in executing their building projects.

According to Caerteling, Halman, and Dorée (2008) and Ghansah et al. (2021), the successful adoption of new technologies such as the smart building concept depends on the government's policy, promoting the adoption or hindering the adoption of the new technology. Osabutey and Croucher (2018) revealed that the government policy supports the development of awareness by providing financial support for the new technology, significantly enhancing the awareness and chance to be adopted.

5.4.1.2 Factor 2: Education factor

This factor comprises four items, namely, educational programs for developers; availability of institutional facilities; creation of public awareness; and availability of comprehensive educational training (conference/seminar) for professionals, developers, and policymakers, and their factor loading were 0.752,0.695,0.690, and 0.559 respectively, this factor was labelled "education factor" because it included an item that related to education.

Training professionals is vital to increasing the awareness of smart building concepts in the construction industry. Developing programs such as workshops and CPD are necessary to create awareness of SBCs and encourage their usage. The training program provides direct knowledge for the professionals in the Nigerian construction industry because the effort put into adopting new technology, such as smart building concepts, depends on the knowledge and understanding of the professional and the client to adopt and enjoy the benefit of the concept. Given this, the professionals, government, and the public must be educated on the benefit of smart building technology straight out of school, which will go a long way in enhancing the awareness of the smart building concept. According to Oyewole, Araloyin, and Oyewole (2019), sensitizing government authorities, professionals, and property users, in particular, is critical for enhancing the awareness level and comprehension of the smart building concept in the Nigerian construction industry, which can be done through educating all parties involved. The study also aligns with Al-Emran and Shaalan (2017) findings that educational factors increase awareness and attitudes toward adopting and utilizing smart building concepts. Lin and Ho (2011) found that using smart practices can add complexity to the process and necessitate a high level of learning and training to keep up with technological trends, thereby increasing the awareness of smart building concepts.

5.4.1.3 Factor three: Organizational factor

The six items assembled under this factor were performance-based standards and contracts, new kinds of partnership and project stakeholders, availability of new smart building technologies, promotion of successful smart building projects, professional network to support smart building, and organizational commitment towards the smart building. The respective factors loading for these variables was 0.833,0.776,0.775,0.731,0.639,0.567, respectively. Since these items are organization-specific, the factors were, therefore, named organizational factors.

Promoting the awareness of smart building is considered enormous for a single body of professionals to undertake. Therefore, the awareness involves all the stakeholders in the organizations to enlighten the general public about the importance of engaging in smart building technology practices in achieving sustainability in the construction industry. There is also a need to carry out further commitment actions in areas in the organization that must show a willingness to devote the necessary resources to make the smart building survive and successfully be implemented in the construction industry.

These groups of professionals are coming together as an organization to promote the awareness of smart building as a direct contribution to the benefit of the economy and the advancement of the technology level of the country's development. Furthermore, the organization's support for the smart building has long been considered important in distinguishing between their ultimate failure and success. Renwick et al. (2013) confirmed that organizational factors play a significant role in adopting and implementing new technologies, such as SBCs. Likewise, Ghansah et al. (2021) regarded organizational factors as significant to enhance the adoption and implementation of innovative technologies such as SBCs. Therefore, the results from the study also showed that the organizational factor plays a vital role in the awareness of the smart building concept within their workforce to ensure that workers have a basic knowledge and understanding of SBCs. Doing so helps to improve and develop the organization and the professionals.

5.4.1.4 Factor four: Environmental factors

This factor comprises three items: smart building security, improving occupants' productivity/satisfaction, and the ecology of a smart building. Moreover, their factors loadings were 0.856,0.571, and 0.527, respectively. This factor was labelled "environment" because it includes an item related to physical presence.

Improving the physical environment of the human being has a certain role in the awareness and adoption of the smart building. According to Včelák et al. (2017), buildings are an essential component of human life. Further explained that the average man spends 90% of his time indoors in the civilized world. Therefore, it is important to consider smart buildings as part of the technology adopted in the construction industry. The integrating features of monitoring and intelligent control systems directly into the buildings and information/data to improve the building's energy efficiency and the users' living comfort and safety aspects. As a result, the indoor environment impacts human health, mood, and behaviors. Juhasova and Senitkova (2019) revealed that The environmental element identified in the study as one of the aspects that significantly increase professional knowledge of SBCs optimizing, and environmental safety could be enhanced, encouraging SBC awareness through the advantage that the property owner drives.

5.5 DISCUSSION OF FINDINGS ON RESEARCH OBJECTIVE THREE (RO3)

RO3: To assess the factors that influence the adoption of SBCs among professionals in the Nigerian construction industry

The study assessed the professionals adopting the smart building concept in the Nigerian construction industry. Before adopting innovations like the smart building concept, construction professionals need to assess the critical factors influencing the adoption of SBCs in the Nigerian construction industry. The result shows that the construction professionals highly support adopting smart building concepts in the Nigerian construction industry.

The current research indicates the most significant factors influencing the adoption of smart building concepts in the Nigerian construction industry are participation and collaboration, energy and cost-saving, stakeholders' computer, data management, job creation, viable funding strategy, interoperability, health care, IT professional support, connection with professional, top management support, environmental protection, stakeholders' engagement, and comfortability of users. The study is supported by the studies of (Mohammed, Ibrahim, and Ithnin, 2016; Dewi et al., 2018; Owusu-Manu et al., 2021).

The factors were further analyzed to determine the critical factor for successfully adopting the smart building concept in the Nigerian construction industry. The result shows that energy and cost-saving, job creation, safety and security, and health care are critical factors in adopting the smart building concept by construction professionals in the Nigerian construction industry.

The study shows that the most significant drivers influencing the adoption of smart building technology in the Nigerian construction industry are participation and collaboration, energy and cost-saving, stakeholder's computer, data management, job creation, viable funding strategy, interoperability, health care, IT professional support, connection with professional, top management support, environmental protection, Stakeholder's engagement, and Comfortability of users, which is in line with other studies(Mohammed, Ibrahim, and Ithnin 2016, Dewi et al. 2018, Owusu-Manu et al. 2021).

The critical factors for successfully adopting SBCs in Nigerians are energy and cost-saving, job creation, safety and security, and health care. From the result, energy and cost-saving can be achieved when SBCs are adequately adopted in the built environment, reducing energy use and improving sustainability. The finding is similar to Ruzzelli (Ruzzelli 2010), who reported a 10% to 15% increase in energy-saving if SBC is fully adopted. Also, from the result, it was discovered that improved health and safety could be derived from the successful adoption of SBCs(Yap, Lee, and Wang 2021). Various infrastructures and technological innovations of SBCs can be used to improve the health of individuals to create a novel and richer ubiquitous concept of smart health in society. This will help provide health services by using the concept of network sensing infrastructures of smart cities. In addition, it optimized disease management and prevention. The adoption of SBCs will create job opportunities in society which will help to improve the economic status of a nation.

5.6 DISCUSSION OF FINDING ON RESEARCH OBJECTIVE FOUR (RO4)

RO4: To identify the barriers to the adoption of SBCs in construction projects in the Nigerian construction industry

5.6.1 Findings on the barriers to smart building concept adoption

The research result in the Table 4.20 discovered the high cost of smart building materials, inadequate power supply, resistance to change from the use of traditional technology, poor maintenance culture, poor knowledge of smart building technology, inadequate well-trained labour in the practice of smart building construction and inadequate finance schemes. Other challenges include inconsistent government policy and a lack of local institutional facilities for research, which are significant barriers to adopting the smart building concept in the Nigerian construction industry. This discovery was in line with the study by Iwuagwu and Iwuagwu (2014); Adenle, Azadi and Arbiol (2015), and Oyewole, Araloyin and Oyewole (2019). Therefore, construction professionals must devote more time and effort to educating clients about the importance of smart building technologies in the construction business and the benefits.

Also, construction professionals need to increase the awareness and knowledge of smart building practices among the general public and government to sensitize policymakers on the importance of smart buildings in society. According to Govindan, Shaw, and Majumdar (2021), any effort put into action, and the adoption of the smart building concept is contingent on professionals' awareness, knowledge, and understanding. In addition, the developer and the government should work together to plan and allocate sufficient funds to construction professionals. Furthermore, the case of inadequate power supply in the country is another area.

The government should provide a solution to increase and encourage the practice of smart building technology in the country. Maintaining a consistent electricity supply is critical because smart building technologies rely on it. If this is not the case, there will be a significant barrier to adopting smart building technology. The current amount of electricity produced by all power plants is insufficient to meet the current demand (Iwuagwu and Iwuagwu 2014).

In Nigeria, poor maintenance culture is the main issue, with smart buildings lacking maintenance (Iwuagwu, and Iwuagwu 2014; Chigozie 2018). The smart building technology is still in its infancy stage and poses a difficult challenge as newer and more advanced devices are released in quick succession that the technology used in Nigeria becomes obsolete within months. Finding spare components to keep it in working order becomes challenging when equipment becomes obsolete. Moreover, resistance to change from traditional technology is one of the barriers hindering the adoption of the smart building concept due to the inability of aging and young construction professionals to change from the old practice to the modern, sophisticated technology that involves the use of smart building practices. This study is supported by Ghansah et al. (2021b), who mentions that resistance to change from traditional practice hinders the project manager's adoption of smart building technology in the Ghanaian construction industry.

5.7 SUMMARY

This chapter presented the discussion and summarised the research finding concerning the study's aim and objective, therefore accomplishing the main aim of the study. This provides a platform for professionals to be informed about the current trends in technology development, such as smart buildings.

Chapter Six

CONCLUSION AND RECOMMENDATION

6.1 INTRODUCTION

The study was conducted to identify and investigate the critical factors influencing the successful adoption of smart building concepts in the Nigerian construction industry. This chapter discusses and presents this research's objective conclusion and recommendations to relate to the set objective evaluated in this study.

6.2 CONCLUSION

The objective of this research was to investigate construction professionals' awareness level to adopt the smart building concept (SBCs) in the Nigerian construction industry; to investigate the factors that can enhance the level of awareness of smart building concepts among construction professionals in the Nigerian construction industry; to assess the factors that influence the adoption of SBCs among professionals in the Nigerian construction industry, and finally, to identify the barriers to the adoption of SBCs in construction projects in the Nigerian construction industry. The following conclusion was drawn from the research study.

The study concludes that the awareness level of the smart building concept is generally above-average level. As a result, some construction professionals such as architects, builders (mechanical, electrical, and structural), engineers, and quantity surveyors are more aware of the practice of smart building. The study disapproves of the claim that construction professionals are ignorant of the smart building concept.

The study concludes that the smart building concept awareness is enhanced significantly by political, educational, organizational, and environmental factors among the construction professionals of the Nigerian construction industry. The enhanced factors may help increase the awareness and practice of the smart building concept among professionals in the Lagos construction industry.

The importance of adopting the smart building concept in the Nigerian construction industry cannot be overemphasized, as smart buildings appear to represent the future of the construction industry's housing sector. As a result, it is vital to examine the critical success factors in adopting the smart building concepts in the Nigerian construction industry. the study discovered that the construction professionals support the smart building concept adoption in the construction industry. The study concludes that the following factors have a critical influence in adopting the smart building concept in the Lagos construction industry: energy and cost-saving, job creation, safety and security, and health care are the most critical factors propagating the adoption of the smart building concept among construction professionals.

The study discovered that all the barriers are predominant to adopting the smart building concept in the Lagos state construction industry. Note that this study is limited to the Lagos state construction industry. Therefore, further study can be conducted in other construction tends states in Nigeria.

6.3 RECOMMENDATION

This research has examined the critical factor for the successful adoption of smart building concepts in the Nigerian construction industry. The study aimed to identify the level of awareness about smart buildings, the factors that enhance the awareness, the critical factors of the successful adoption of smart buildings, and the barriers to adopting the smart building concept among construction professionals in the Nigerian construction industry. Therefore, based on the conclusion drawn from the study, the following recommendations were proposed:

1. Construction professionals and individuals should be educated about smart building concepts through training programs such as conference programs, workshop seminars, and television/radio programs to boost and encourage professionals' understanding and knowledge of smart building concepts.

2. Construction professionals should engage more in the practice of smart building concepts, propagating the awareness and development of smart building construction in the country

3. Smart building practice should be promoted by government policy and regulatory guidance, which will help to enhance the practice among professionals and organizations.

4. The government should establish a common platform for collaboration of all professionals, the research community, and relevant stakeholders in the construction industry by policymaking and providing research and development funds to implement these smart technologies. It will go a long way for employment creation and better improve the economy of the country

6.4 RECOMMENDATION FOR FURTHER RESEARCH

1. Examination of the discovered barriers in another state in Nigerian construction to have a general view of the barriers

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2. An assessement of the competence skill required by the professionals to perform the technological function of the smart building.

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APPENDIX

APPENDIX 1

DURBAN UNIVERSITY OF TECHNOLOGY
INYUVESI YASETHEKWINI YEZOBUCHWEPHESHE

QUESTIONNAIRE SURVEY ON AN APPRAISAL OF CRITICAL FACTORS FOR THE SUCCESSFUL ADOPTION OF THE SMART BUILDING CONCEPT IN THE NIGERIAN CONSTRUCTION INDUSTRY

I am Cyril Chinonso Ejidike, a Master's student in the Department of Construction Management and Quantity Surveying, Durban University of Technology, Steve Biko Campus, Durban, South Africa. I am currently researching ***Appraisal of Critical Factors for The Successful Adoption of Smart Building Concept in The Nigerian Construction Industry***. The aim of this research is to examine the critical factors for the successful adoption of smart building concept, with a view to identifying the factors influencing the decision to adopt and implement smart building concept in the Nigerian construction industry. To achieve this aim, the objectives are set to;

i. To investigate the awareness level of construction professionals to the adoption of the smart building concept (SBCs) in the Nigerian construction industry
ii. Investigate the factors that can enhance the level of awareness of smart building concept among construction professionals in the Nigerian construction industry.
iii. Assess the factors that influence the adoption of SBCs among professionals in the Nigerian construction industry
iv. Examine the barriers associated with the adoption of SBCs in construction projects in the Nigerian construction industry.

SECTION A: BACKGROUND INFORMATION

This section of the questionnaire is designed to collect the necessary background information of respondents. Please note that your response will remain anonymous. Your co-operation is appreciated. Tick the correct description as applicable in the question.

1. Gender: Male [ ]   Female [ ]

2. Kindly indicate your highest educational qualification completed

a) ND [ ] (b) HND [ ] (c) B.Sc./B.Tech [ ] (d) M.SC /M.Tech [ ] (e) Ph. D [ ]

(f) Others please specify ……….................

3. Please indicate your profession? (a) Architect [ ] (b) Builder [ ] (c) Quantity surveyor [ ] (d) Engineer [ ] others please specify…………….

4. Please indicate your professional qualification? (a) QSRBN [ ] (b) CORBON [ ] (c) ARCON [ ] (d) COREN [ ] others please specify………………………………

5. Kindly indicate the year of professional experience?a) Less than 5 year [ ] (b) 5 - 10years [ ] (c) 11 - 15 years [ ] (d) 16 - 20 years [ ] (e) More than 20 years [ ]

Section B Awareness of smart building concept

Objective 1. Level of awareness of SBCs among construction professionals in the Nigerian construction industry

6). Are you aware of smart building concept?

(a) Yes ( ) (b) No ( )

If yes, kindly indicate your level of awareness of the components to measure smart building concept

using a 5-point Likert's scale

S/N	**Component of Smart Buildings**	1	2	3	4	5
COM1	Building Control System					
COM2	Building Automation System					

COM3	Enterprise Management System					
COM4	Green Building Construction					
COM5	IT Network Connectivity					
COM6	Safety and Security Management System					
COM7	Energy Management System					

SECTION C Factors that enhance awareness

Objective 2. Investigate the factors that enhance the level of awareness of smart building concept among construction professionals in the Nigerian construction industry.

1=Not significant; 2=; Rarely Significant 3= neutral; 4= Significant; 5= highly significant

S/N	Factors that Enhance the Awareness of Smart Buildings	1	2	3	4	5
AWR1	The availability of comprehensive educational training (Conference/ seminar) for professionals, developers, and policy makers					
AWR2	Improving occupants' productivity /satisfaction					
AWR 3	creation of public awareness					
AWR 4	Availability of institutional facilities					
AWR 5	Promotion of successful smart building projects					
AWR 6	Availability of new smart building technologies					
AWR 7	Availability of smart building codes and regulations					
AWR 8	Smart building rating system and labeling					
AWR 9	Organizational commitment towards smart building					
AWR 10	Professional network to support smart building					
AWR 11	New market opportunities					
AWR 12	Performance based standard and contracts					
AWR 13	New kind of partnership and project stakeholders					
AWR 14	Ecology of smart building					
AWR 15	Security of smart building					
AWR 16	Building wastes management					
AWR 17	Peer Firm Influence					

AWR18	Educational programs for developers, contractors, and policy makers related to SBCs					
AWR19	Low-cost loans and subsidy from government					
AWR20	Availability of better information on cost and benefits					

SECTION D Critical factors for successful adoption of SBCs

Objective 3; as a professional in Nigerian construction industry, do you support the adoption of SBCs in Nigerian construction industry?

Yes ☐ No ☐

Kindly identify the factors that influence your adoption of SBCs in order of significance using the following 5-point scale rating scale:

1=Not significant; 2=; Rarely Significant 3= neutral; 4= Significant; 5= highly significant.

S/N	Factors	1	2	3	4	5
BSC 1	Instrumentation and control					
BSC 2	Connection with professional					
BSC 3	Interoperability					
BSC 4	Data management					
BSC 5	Privacy of users					
BSC 6	IT professional support					
BSC 7	Top management support					
BSC 8	Viable funding strategy					
BSC 9	Stakeholders' computer					
BSC 10	Stakeholders' engagement					
BSC 11	Participation and collaboration					
BSC 12	Comfortability of users					
BSC 13	Conservation of resource					
BSC 14	Energy and cost saving					
BSC15	Job creation					
BSC16	Safety and security					

BSC17	Health care					
BSC18	Protection environment					

SECTION E Barriers to adoption of SBCs

Objective 4. The following factors has been identified as some of the barriers associated with the adoption of SBCs in construction projects in the Nigerian construction industry. Kindly rank in order of importance using the following 5-point scale rating scale; 1=strongly disagree; 2= disagree; 3= neutral; 4= agree; 5= strongly agree.

S/N	**BARRIERS TO SMART BUILDING CONCEPTS** **Barriers to the adoption of SBCs**	**1**	**2**	**3**	**4**	**5**
BSM1	Lack of promotion of SBCs practice					
BSM2	Poor knowledge of smart building technology					
BSM3	Inadequate of well-trained labour					
BSM4	Lack of SBCs databases and information					
BSM5	Lack of government incentive					
BSM6	Low Market demand					
BSM7	Lack of interest from clients					
BSM8	Extension of project schedules					
BSM9	High cost of smart building equipment					
BSM10	High cost of smart building material					
BSM11	Resistance to change from the use of traditional technologies					
BSM12	Poor Maintenance Culture					
BSM13	Use of traditional procurement method(s)					
BSM14	Limited number of smart building suppliers					
BSM15	Risk and uncertainties involved in implementing new technologies					
BSM16	Fear of inflation					
BSM17	Lack of local institutional facilities for research					
BSM18	Lack of SBCs training for professionals					
BSM19	Inconsistent Government policy					

BSM20	Low enforcement of building laws					
BSM21	Inadequate finance schemes					
BSM22	Inadequate power supply					

Kindly provide any additional comments

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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Thank you for your time in completing this questionnaire. Highly appreciated

Appendix 2: Proposal Approval: Cyril Ejidike, Student number: 22175606

DUT
DURBAN
UNIVERSITY OF
TECHNOLOGY

FACULTY OF
ENGINEERING
& THE BUILT
ENVIRONMENT

08 August 2021

Reference: Proposal Approval: Cyril Ejidike, Student number: 22175606

Dear Mr Cyril Ejidike

MBE: Construction Management and Quantity Surveying

This serves to confirm the approval of your research proposal by the Faculty Research Committee, at its meeting on 19 July 2021, as follows:

Research proposal and provisional dissertation title:

An Appraisal of critical factors for the successful adoption of smart Building concept in the Nigerian Construction Industry

Supervisor: Dr MC Mewomo

Please note that any proposed changes in the dissertation title require the approval of your supervisor/s, the Faculty Research Committee, as well as ratification thereof by the Higher Degrees Committee.

Research budget to the amount of R10 000.00

Please note that this funding is not a scholarship or bursary and is therefore not paid directly to you, but is controlled by your supervisor. Any proposed changes to the use of this funding allocation require the approval of your supervisor and the Faculty Research Committee.

The Institutional Research Committee has stipulated that:

(a) This University retains the ownership of any Intellectual Property (patent, design, etc.) registered in respect of the results of your Masters/Doctors Degree studies as a result of the award and the provisions of the above Act;

(b) Should you find any of the terms above not acceptable then you are given the option to decline the Research budget award to your project in writing.

May we remind you that in terms of Rule G25(2)(b), if you fail to obtain the Masters/Doctors degree within the maximum time period allowed after first registering for the qualification, Senate may refuse to renew your registration or may impose any conditions it deems fit. You may apply to the Faculty Research Committee for an extension.

Please note that you are required to re-register each year.

Should you experience any problems relating to your research, your supervisor must be informed of the matter as soon as possible. If the difficulties persist, you should then approach your Head of Department and thereafter the Executive Dean of the Faculty.

Please refer to the 2021 General Rule Book concerning the rules relating to postgraduate studies, which include *inter alia* acceptable minimum and maximum timeframes, submission of thesis/dissertations, etc. You are also advised to read the Postgraduate Students' Guide which is available on the DUT website.

Please do not hesitate to contact this office for any assistance. We wish you success in your studies.

Kind regards,

Prof S Rathilal
FRC Chairperson: Faculty of Engineering and the Built Environment