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SMART BUILDING PROJECTS IN NIGERIA - THE ROLE OF ARCHITECTS

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Abstract

In recent times, the term 'smart buildings and cities' have stimulated the interest of researchers across several disciplines thereby making the subject multi-disciplinary. Smart buildings as a major component of smart city help to save time, save energy, promotes health, enhance efficiency of systems and guarantee low-cost operations. It also enhances higher resource utilization, risk identification management and improves the quality of lives of occupants. The study was aimed at appraisal of the role of architects and ICT in development of smart buildings in Nigeria. Methodology of study is basically review of literatures, interviews and use of questionnaire survey. Questionnaires were employed to extract information from architects drawn from six States of the Niger Delta region of Nigeria, on their knowledge and involvement in smart building development. The retrieved data was analyzed using Cronbach's Alpha with Likert scores 1-3 and the results presented in tables and charts. The paper showed that although Nigerian architects have high level of awareness on smart building initiatives, but their involvement level in design and construction is low. The paper recommended among others that architects should become smart building compliant and creation of smart economy through provision of smart infrastructure in the country by the government.

Keywords: architect**,** design, ICT, intelligent buildings, smart buildings

Introduction

Technological advancements and innovations, in the 21st century, are changing constantly at an accelerated rate globally. These innovations and changes are also affecting the characteristics of buildings and other infrastructures in our cities. In the developed countries of the world, buildings are being automated and powered by ICT to become more responsive, service oriented, more sustainable and flexible thereby gradually replacing convectional buildings with intelligent or smart buildings.

The United Nations Environment Programme (UNEP, 2018) has estimated that about 70% of the global population will be living in the cities by the year 2050, that is, one-third rural and two-third urban, which is a reverse of the global rural-urban population distribution pattern in mid-twentieth century resulting in expansion of the urban environment. Thus, the urban population which is growing steadily has its attendant problems related to growth, performance, scarce resources, poor housing quality, traffic congestion, pollution, competitiveness and waste management resulting in deterioration of livability and health concerns of individuals (McKinsey, 2018).

One of the major solutions to the urbanization challenges especially that of climate change and excessive use of resources is the development of the concepts of smart buildings and smart cities. These concepts are multidisciplinary and tends to collate ideas, new technologies and innovations towards development of mutually beneficial interactions between the environment, resources, infrastructure and humans for the enhancement of quality of life which is one of the goals of sustainable development (Pucar, *et al.,* 2016).

However, one cannot discuss the concept of smart buildings without smart cities initiatives. Thus, smart city according to Mohanty, Choppali & Kougianos (2016), is a place where traditional networks and services are made more efficient, flexible and sustainable with the use of information and communication technologies to improve its operations for the benefit of city inhabitants. In other words, "A smart sustainable city is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operations and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social and environmental aspects" (Mardacany, 2014).

Moreover, it should be noted that smart buildings form the foundation of smart cities, thus smart cities is a combination of smart/intelligent buildings as well as smart people/users. Smart buildings on the other hand refer to building equipped with ICT features that "essentially programmes itself by monitoring the environment and sensing actions performed by the inhabitants (e.g., turning lights on and off, adjusting the thermostat), observing the occupancy and behavior patterns of the inhabitants and learning to predict future states of the house"(Batov, 2015). Smart buildings differ from the usual buildings; hence the designing process is also different. This is done to accommodate all the distinctive features of artificial intelligence for its performance. The benefits of smart buildings cannot be quantified ranging from time saving, comfort of occupants to improvement of the health of occupants.

Smart building and smart cities can only be anchored on innovative information and communication technology (ICT). The importance of ICT in achieving a smart sustainable city cannot be overemphasized. ICT has become the key to smart buildings which can be aggregated into neighborhoods, campuses, districts, cities and countries to provide a truly sustainable built environment (Rowte, 2017).

Most developing countries including Nigeria are yet to embrace the new phenomenal of smart buildings. Studies by Aghimien, *et al.* (2019), Eseosa & Temitope (2019) and Iwuagwu & Iwuagwu (2014), identified certain factors hindering the implementation of smart building and cities in Nigeria. The factors include poverty, terrorism (which scares away foreign investors), cyber insecurity and poor digital information safety, poor power supply, poor internet connectivity, poor maintenance culture, poor economy, lack of awareness and lack of technical know-how.

Therefore, this study is aimed at appraising the role of architects (who are the leaders of the built environment professionals) and ICT in development of smart buildings in Nigeria. Towards the realization of this aim, the study seeks to discuss the awareness level and

involvement of architects in the design and construction of smart building projects in Nigeria.

Theoretical underpinning

The terms smart buildings (intelligent buildings) and smart cities are increasingly being used in several sectors leading to numerous definitions in the literature by several authors and researchers. Whichever angle the meaning originates from, there is a consensus that for a city or building to be termed 'smart', there must be the use of ICT and sensor competences infused into the city infrastructure/building in order to enhance efficiency, electrical, energy, water, cost reduction and transportation-related as well as other daily logistical operations to improve quality of life (Chen, 2010). The United Nation has recently emphasized the need for cities to transit to smarter cities. This was established in the 11th UN Sustainable Development Goal (SDG), targeting on making cities more inclusive, safe, resilient and sustainable (UN, 2018). Therefore, some of the definitions and meanings of the various terms associated with smart cities and smart buildings are presented in this section.

Accordingly, smart city is defined as a city "connecting the physical infrastructure, the information-technology infrastructure, the social infrastructure, and the business infrastructure to leverage the collective intelligence of the city" (Mohanty, Choppali & Kougianos, 2016). Smart city is also defined as 'resilient and inclusive cities built collaboratively, that use different types of technology and data in order to achieve a better quality of life for all their residents' (Evergreen, 2018). However, a combined definition of two authors seems to give more comprehensive meaning of smart city that encompasses various aspects and components. Hence, smart city is viewed as a city with "certain intellectual ability whose "smartness" is embedded into the city operations based on the analysis, monitoring and optimization of urban, physical (energy, water, waste, transportation and others) and social (equity, governance, citizen participation) systems, through transparent and inclusive communication structures that addresses several innovative socio-technical and socio-economic aspects of growth including quality of life" (Zygiaris, 2013; ICLEI, 2017).

Conversely, smart buildings also known as intelligent buildings have been described by different authors. But, the context of the various definitions centres on the same core theme 'smartness'. Smart buildings among other benefits saves time; saves energy; promotes health and improves the quality of lives of occupants. Mozer (2005) described smart building as a building that fundamentally programme itself by monitoring the environment and sensing actions performed by the users or inhabitants (such as turning lights on and off, adjusting the thermostat), observing the occupancy and behaviour patterns of the inhabitants, as well as predicting future status of the building. Smart building is also defined as 'the combination of design, materials, systems, and technologies that offer users an interactive, flexible, productive, economic, integrated, and dynamic environment' (Albino, *et al*., 2015).

However, several studies have been carried out on the subject of smart or intelligent buildings around the globe. The concepts, meanings, importance and challenges have been stressed in those studies. Thus, the most relevant of the studies especially as it relates to the roles of architects and challenges to smart building adoption in developing countries of the world have been further analyzed and presented in this study.

On the implementation of smart building projects in Nigeria, Iwuagwu & Iwuagwu (2014) in their paper titled 'Adopting Intelligent Buildings in Nigeria: The Hopes and Fears', discussed the concepts and origin of intelligent buildings including the benefits. The paper expressed the fears that certain factors are hindering the adoption of intelligent building projects in Nigeria. These hindrances are poor maintenance culture; erratic electric power supply, lack of awareness; lack of technological know-how. Their contributions in terms of concepts, methodology, findings and recommendations are very relevant to the current study and it is adopted.

El-Motasem, Khodeir & Fathy Eid (2021) did a study on 'analysis of challenges facing smart buildings projects in Egypt'. The paper focused on the challenges of smart building projects in Egypt employing the use of literature review and questionnaire survey as methodology of study. The study compared the challenges of smart building projects in Egypt with the challenges of other developing countries which were extracted from the literature sources. The methodology and findings of the study are very important to this study and are therefore adopted.

Conversely, Cetkovic´ (2016) carried out a study on the challenges of designing without input from the end users of smart buildings asserting that this will undermine the smartness of the buildings. The author outlined the benefits of carrying the users along in the design process at every phase of the building project, opining that smartness of a building depends on how smart the users see the building. The author suggested the use of 'interactive or adaptive architecture' in place of smart building when used by architects. This research will adopt part of the study that emphasized the involvement of users in the design and construction of smart building projects.

Similarly, Belani, *et al*. (2014), focused on energy issues and its implication on our world. The study stressed the roles the building professional can play in finding solutions to the energy problems in buildings through the designs and construction of smart and energy efficient buildings. The study analyzed the concepts of smart buildings and benefits to both present and future users and how to tackle current and future energy challenges. It also carried out an analysis of the construction, operating and maintenance costs over the life cycle of building to arrive at the total cost of the building, opining that the operating cost of smart buildings are cheaper than the conventional buildings by 25% to 35%. The findings and concepts discussed in the study are relevant and adopted.

Methodology

The methodology of study involved both literature review, interviews and questionnaire survey. Literature review involves studying and summarizing the works of recognized authorities relevant to the present study. It helps to determine what has already been done relating to one's research problem, the research strategies used and eventually leads to what needs to be done in the chosen area of study (Akuezuilo, 1990, Chike-Okoli, 2004).

A comprehensive review of literature from scientific academic journals, documents and reports produced by organizations and government agencies, which was accessed online via Google Scholar, Science Direct and Elsevier's Scopus databases was carried out to understand basic concepts, meanings and features of smart buildings. Also, using purposive and expert sampling techniques,

questionnaires were distributed to some practicing architects across six Niger Delta States of Nigeria namely Akwa-Ibom (25), Bayelsa (20), Cross River (20), Edo (30), Delta (30) and Rivers State (30) respectively. A total of 155structured questionnaires covering respondents' knowledge, application, awareness, information dissemination forms the basis for the questions that were distributed. From the 155 questionnaires administered, 116 questionnaires representing 74.8% were retrieved and the data was analyzed using Cronbach's alpha with Linkert scores 1-3 namely (1= low, 2= fair, 3 = high) and the results presented in tables and charts.

Discussion

From the literature reviewed, the following subtitles were extracted for discussing for clearer understanding of the components of smart buildings/cities, importance of ICT and the roles of architects in smart building projects.

a. Components of Smart Cities

Smart city is made up of several components and core themes that makes it functional and account for its 'smartness'. These components include smart buildings (which forms the basis for this study), smart technology, smart infrastructure, smart energy, smart transportation, smart healthcare, smart education, smart governance and smart citizens. The smartness of these components depends on four core themes which are the environment, society, economy and governance (Mohanty, *et al*., 2016).

b. The Role of ICT in Smart Building Projects

Information and communication Technology (ICT) infrastructure is described as the bedrock and backbone of the smart infrastructure of smart cities and buildings. The ICT infrastructure includes communication infrastructure such as fiber optics, Wi-Fi networks, wireless hotspots as well as service-oriented information systems. The smart infrastructure will usually consist of physical infrastructure, sensors, firmware, software, and middleware as its overall components**.** One main features of the ICT as it relates with smart cities development is the 'Internet of Things' [IoT] (Mohanty, *et al.*, 2016).

However, the IoT framework consists of various components that makes it functional and enhance smartness. These includes electronics, networks, firmware, software and sensors. These components are grouped into four namely:

(i) The Thing: a sensor, embedded computing device or embedded system which can transmit and receive information over a network in order to control another device or interact with a user, examples include a micro-controller, temperature sensor, computers, smart phones, sensors, actuators, wearable devices, homes, buildings, structures, vehicles, and energy systems. (ii) The local area network (LAN), (iii) the Internet, and (iv) the cloud (Evans, 2011; Zanella, *et al*, 2014).

In summary, the role of ICT in the development of smart building project is anchored on its framework which are grouped into five categories of technology which include the following:

1. Tools for energy efficient design and production. These will create the building models necessary for providing model-based control.

2. Energy management from a building up the micro-grid level for connections to the national grid.

3. Intelligent building and community control with connections to utilities.

4. User awareness and decision support tools for decision-makers and smarter citizens.

5. Providing all the additional ICT integration requirements to make model-based control to work.

c. **Architects, Smart Buildings and Smart Cities**

The old conventional approach to design concept of buildings is changing drastically giving way to a new concept that is able to solve the challenges of the 21st Century with regards to the built environment. This new design concept entails eco-friendly, energy efficient and green architecture. It works in harmony with the natural environment without severe negative effects and is influencing the attitudinal change of professionals in the built environment especially architects in planning, designing and general practice of architecture (Pucar, *et al*, 2016).

The concept of smart cities development which is that of a complex relationship between buildings and the city, users and spaces, reduction in carbon emission, climate change mitigation, energy and water efficiencies and sustainable environment, certainly has undoubtedly introduced some challenging changes to the roles of architecture and urban planning in recent times. Thus, the recent advances in ICT, new materials with very high performances have revolutionized the concept of design and planning which must now be complex in order to meet up with not just the demands of the architecture profession, but also of investors, users, as well as the environment (Pucar, *et al*, 2016).

Smart building is one of the most essential components of smart cities today. According to Rowte (2017), there are two 'golden rules' that needs consideration in discussing the subject of smart cites. These rules are:

a. There can be no smart cities without smart citizens.

b. There can be no smart cities without smart buildings.

c. There can be no smart buildings without smart stakeholders. (This is the opinion of the study that there is need to add a third rule which accounts for the role of stakeholders including architects).

Accordingly, Clements-Croome (2013) describes an intelligent building as one that is responsive to the requirements of occupants, organizations and society. It is healthy in terms of well-being of the occupants and users, less polluting in terms of emissions and waste, sustainable in terms of energy and water conservations and functional to satisfy user needs. A smart building can have different hardware, software, sensors, and smart appliances, for different computerized operations such as data network, access control, power management, and lighting control/power management, video distribution, video surveillance and voice-over-IP [VoIP] (Buckman, *et al*., 2014; Clements-Croom, 2013).

Recent advancement in areas such as complexity modelling, data mining, deep learning, artificial intelligence (AI**)** and the internet of things (IoT) have boosted the creativity of the Architects through the determination to more efficient use of resources and the optimization of buildings and infrastructure serving the needs of people thereby creating opportunities for advancement (El-Hawary, 2014).

The key revolutions in the architecture profession includes the following:

i. the use of facades with smart materials to provide sophisticated forms of feedback, high level controls, regulating heat, air and light transmission.

ii. coating and embedding materials with nano-particles which helps to specify material properties much more easily (Pacheco-Torgal & Labrincha 2013).

iii. coating structures with zinc oxide nanoparticles help to accelerate heat dissipation while concrete matrix embedded with capsules of sodium silicate healing agent can repair cracks in buildings through the interaction of the sodium silicate with the calcium hydroxide to form a gel that seals the cracks (Pelletier, *et al*., 2011).

iv. energy-efficient LED light fixtures can be powered via Ethernet cables, which can also relay control and data information to the light fixtures (Castle, 2013).

v. occupancy sensors which use infrared, sound, or ultrasound to detect when a room is occupied or unoccupied. Also, constantly connected to lighting and ventilation systems to conserve energy when rooms are empty as well as function as part of a security system, giving notice of invaders to occupants (Agarwal, *et al*, 2010).

vi. building dashboards are publicly available websites that provide real-time data about how much energy a building is consuming and producing, how many occupants are in it, and other customizable data points

vii electro-chromic windows or "smart glass" comprises of thin films and an electrolyte sandwiched inside glass, thereby reducing glare and thermal transfer while allowing visible light to pass through the windows (Wallace, 2016).

viii. Indoor positioning systems which give users indoor location data on their mobile device to simplify way-finding and also have the ability to locate specific people within the building, using badges or cell phones (Schneider, 2013).

The advantages of the smart/intelligent buildings include the following: efficiency of systems (through data-driven decision-making), low-cost operations, flexibility, higher resource utilization, high quality service delivery, reduced capital and operational cost structure, resilience, risk identification management, and sustainability. However, smart buildings are also not without its challenges, thus, some of the disadvantages includes security concerns due to vulnerability of cyber-attack, high initial costs, fear of obsolescence, compromised privacy disruption of service due to poor internet services amongst others (Mohanty, *et al*, 2016; Worall, 2018).

Consequently, the creativity of the building designer-Architect in relation to the provision of smart buildings for the development of smart cities cannot be underrated. Therefore, for the Architects to be able to design smart buildings, the Architects must be smart by embracing the technology of 'smartness' which only ICT offers. This is why and where the roles of the Architects and ICT are complementary in the development of smart buildings. Thus, according to Rethinking the Future (2019), the renowned Hong Kong Architect, James Law summarized the relationship between and ICT by declaring that:

'*In the 21st Century,*
buildings will be different
from 20th Century. They are

no longer about concrete, steel and glass only, but also the new intangible materials of technology, multimedia, intelligence and interactivity. Only recognizing this will bring a new form of architecture to light, namely a Cybertecture'.

d. Table and Charts

Table 1: Respondents' Level of Awareness, Compliance, Involvement and Educating Clients

Variables:	**Low**	**Fair**	**High**	**Total**	**Results**
a. **Awareness**	12	34	70	116	
Percentage %	10.3	29.3	**60.4**	100	High
b. **Compliance**	52	36	28	116	
Percentage %	**44.8**	31.1	24.1	100	Low
c. **Project involvement**	50	46	20	106	
Percentage %	**43.1**	39.7	17.2	100	Low
d. **Educating Clients**	16	32	68	106	
Percentage %	13.8	27.6	**58.6**	100	High

Source: Authors' fieldwork, 2022.

From Table 1 above, four major parameters constituted the basis for the questionnaire namely awareness (on smart buildings), compliance level (in design), involvement (in project construction/supervision) and educating clients on the importance of smart building projects. This is further presented in pie chart for clearer understanding as follows:

On the issue of awareness, it is clear from Figure 1 below that respondents' level shows 60.4% for high awareness, 29.3% indicates fair awareness level while 10.3% indicates low awareness level. Thus, the highest percentage of 60.4 for high awareness clearly suggest that architects in Niger Delta States have high awareness level of smart buildings.

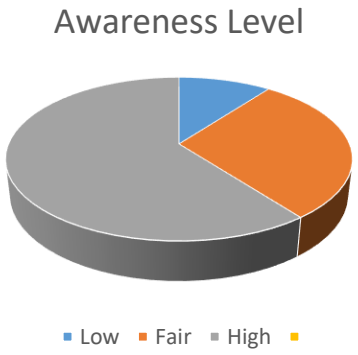

Fig.1: Awareness level of Respondents **Source**: Author's fieldwork

On the issue of compliance level of architects in the design of smart buildings, the study in Figure 2 below shows that high compliance level is 24.1%, respondents with fair level of compliance is 31.1%, while 44.8% have low level of compliance. Therefore, the study indicates that architect's level of compliance in smart building design is low.

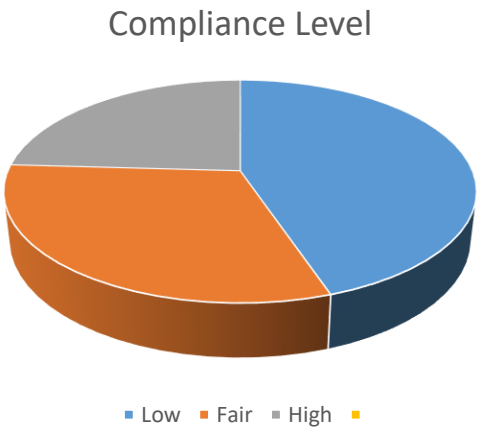

Fig. 2: Compliance level of Respondents. **Source**: Author's fieldwork

Similarly, on the involvement in project construction and supervision, respondents rating shows that 43.1% of respondents scored low, 39.7% shows fair involvement while only 17.2% constitutes those with high level of involvement. This indicates (from Figure 3) that architect's level of involvement in construction and supervision of smart building projects is low.

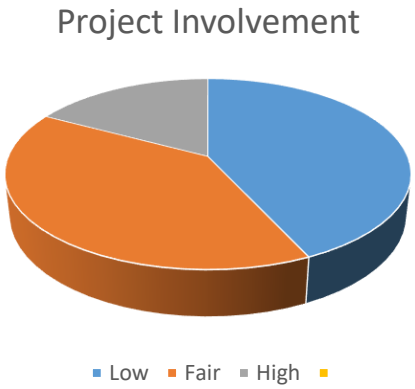

Fig.3: Project involvement level of respondents. **Source**: Author's fieldwork

Finally, on the issue of educating clients pertaining to the need and importance of smart building projects, respondents rating was high with 58.6%, fair with 27.6% and low with 13.8%. This suggests that architects in the study areas have been educating clients on the importance of smart building projects as in Figure 4.

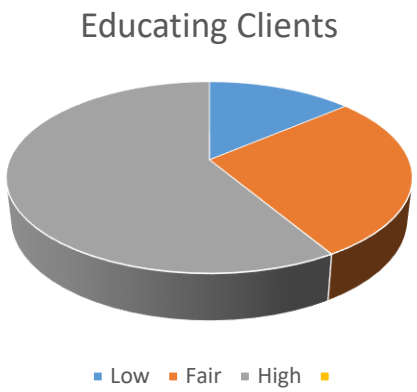

Fig. 4: Respondents' level of educating clients. **Source**: Author's fieldwork

Conversely, the analysis of the interviews conducted among individual project clients revealed certain reoccurring themes which centred on awareness, acceptance and cost implications. The interviews show that most of the respondents or clients displayed low level of awareness on smart building projects. Also, the level of acceptance of smart building projects among the clients was very poor with some reasons for non-acceptance. Further analysis of the interviews revealed that the respondents/ clients were quick to express their fear of high cost of construction of smart building projects as well as the issue of erratic power supply particularly in the study areas. Respondents gave some expressions such as "does that kind of building exist? Can average people like us afford such buildings? That kind of house will be very expensive to build, or where will you get electricity to run the building or power the building in this area or in this Nigeria?" This is in agreement with the findings of Iwuagwu & Iwuagwu (2014) in their study titled 'adopting intelligent buildings in Nigeria: the hopes and fears'.

The architects interviewed opined that since smart building features was not a requirement in the approval process of buildings, clients do not see any reason to accept it. In addition, some architects teaching in universities who were also interviewed expressed their high level of awareness of smart buildings but were worried about the non-inclusion of smart building and smart cities topics (although they seldom talk about it or teach the students) in the curriculum of architectural programmes taught in some higher institutions in Nigeria.

Conclusion

The study has been able to appraise the role of architects (as leaders of the built environment professionals) as well as that of ICT in the development of smart buildings in Nigeria thereby achieving the aim of the study. The study equally discussed the awareness level and involvement of architects in the design and construction of smart building projects in Nigeria through the methodology of questionnaire administration and interviews of architects in the study areas.

This study has undoubtedly proved that technological innovation with its effects on humans and the environment particularly in the design and construction of buildings (architecture practice) is a reality and is still changing. These changes have resulted in the development of smart and intelligent buildings today. Smart and intelligent buildings have been seen to adapt to both short and long term

needs of humans and users with the capacity to cope effectively with social and technological changes of the 21st Century. Smart building projects are quite achievable in Nigeria if the commitment and collaborative involvement of the different stake holders namely the government, the building owners, users, the technology providers, architects and other built environment professionals are fully harmonized.

As the study has shown, ICT has become the bedrock and the foundation for the development of smart buildings while the architects (the designer and planner of buildings) cannot neglect the new technological innovations but should embrace ICT to realize the dream of smart building development in Nigeria for the enhancement of the optimum living conditions and comfort of humans in particular and sustainable environment in general.

However, the study recommends the following: (a) that architects should be smart building compliant (b) creation of smart economy through provision of smart infrastructure in the country by the government(c) provision of steady electricity supply to power smart buildings and other infrastructure (d) implementation of government policy on smart city/building initiatives and (e) the inclusion of smart building courses in the curriculum of higher institution of learning that will drive the idea of sustainable smart building projects in Nigeria.

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