REBIRTHING HOUSING DELIVERY FOR END-USERS IN NIGERIA AND THE PIVOTAL ROLE OF ARTIFICIAL INTELLIGENCE

Olanrewaju I. Abiola

[a] qasim73@yahoo.com

Abstract

The floor area we occupy is expected to double by 2060, with most of this growth occurring in residential construction. Population growth and urbanisation in emerging markets will mean expanding cities and rising demand for new urban housing in urban areas and the world (Saberi and Menes, 2020). The trends represent an enormous opportunity to design, build and operate the homes of tomorrow in intelligent ways that minimise energy consumption and carbon emissions (against the backdrop of climate change concerns, advocacy, and justice), and lower building and home ownership costs and capital value. Nigeria has an estimated 28 million housing deficit as of 2023 and circa N21 trillion to fill this deficit (National Bureau of Statistics, 2023). Artificial Intelligence is expected to play a pivotal role in this area using data- including performance, resource consumption, reduced outgoings from service charge administration, drive cost efficiency and increased residents' comfort. Artificial intelligence will also use data sets from this research to improve residential housing development conceptualisation, design, and construction and shape policy actions by the government and other actors in the housing value chain around spatial planning and development control. The research aims to critically examine how artificial intelligence will shape the future of residential housing development in terms of energy efficiency and affordability for residential end-users in Nigeria. The research is still ongoing.

Keywords: urban housing, artificial intelligence, resource optimisation, energy consumption, housing value chain

JEL Classification: Q55, R31, O18

1. INTRODUCTION

When homes are not appropriately planned, they are said to waste energy and use more water. This is especially difficult in underdeveloped countries where resources are few and utility prices are relatively high in comparison to incomes (Saberi and Menes, 2020). Even in energy-efficient homes, habits can raise energy and water consumption. Increased bills might have a detrimental influence on a homeowner's capacity to make monthly mortgage payments. The interaction of artificial intelligence (AI) and human behaviour holds promise of a solution.

Smart meters put in residential buildings can help people make better judgments about their daily energy consumption. Smart meters, which record data on utility usage and indoor temperature, can signal for action and provide insights into more efficient energy use. Although the concept is still in its early stages, smart meter data can be gathered, processed, and shared to help different stakeholders make better decisions. With the use of smart meters and AI, homes might become the ultimate example of biomimicry, growing and protecting each other through interconnected roots (Saberi and Menes, 2020).

The implementation of Advanced Metering Infrastructure (AMI) in the domestic water supply sector is part of the UK's commitment to reducing water use, as stated in the DEFRA Environmental Improvement Plan (DEFRA, 2023a) and the UK Water Efficiency Strategy (Waterwise, 2022). AMI's comparable international roll-out means that over 6.2 million AMI-enabled meters have been deployed in the residential water supply sector (Newing et al., 2023). AMI typically involves the installation of a 'smart meter' on a dwelling's water supply pipe, providing consumers with near-real-time information on the volume and cost of their water consumption. Meters may be read remotely in near real-time, enabling broader benefits, including more accurate consumer billing and lower cost of metering.

Although the science of artificial intelligence was founded over 50 years ago, technological improvements have hastened its progress. AI is primarily owing to the advancement of machine learning, as well as advances in computing power, data storage, and communication networks. In this sense, artificial intelligence might be defined as the science and engineering of developing intelligent machines, namely intelligent computer programs (Woschnak et al., 2020). AI is a collection of technologies that can study their surroundings and use intelligent behaviour to achieve specific goals.

The notion of smart houses is not new, but new technologies are gaining favour among homeowners, promising greater control over energy and water usage (Sinclair, 2019). Amazon's Echo, Google Home, and Apple's Siri have all made strides in voice interaction, with Google Nest leading the way with its smart thermostat (ibid). Smartphone-enabled technology can remotely manage hot water tank temperature, identify leaks, and track water usage peaks.

Advanced technologies have been developed to meet consumers' energy, water, security, and environmental needs. However, these technologies have yet to be linked together to create a more complete solution. In the future, these technologies will grow more intelligent and networked, requiring minimum human intervention. AI-powered technologies will enable intelligent interrelationship of a building's design solutions to improve occupant comfort.

These systems will manage window openings, blinds, lighting, insulation, cooling, heating, and hot water systems. For example, AI-powered devices could cool a home by opening a window when the outside temperature is appropriate, and the air quality is satisfactory. AI could also start a ceiling fan, shade windows to prevent glare, and cycle the air conditioning to attain the appropriate temperature based on the occupants' location and persona-based approach pertaining to their behaviour and past preferences (Saberi and Menes, 2020).

To achieve intelligent buildings, we must first implement smart meters. These meters enable consumers to take advantage of time-of-day pricing, which is directly related to energy loads in the home. When situated in a visible area, smart meters serve as reminders and motivators for households to track their energy consumption. This leads to a reduction in consumption peaks. In South Africa, International Housing Solutions leases and sells quality affordable homes while educating customers on using pre-installed smart meters. They show how prudent behaviour results in savings equal to one month's rent every year. As smart meters grow more complex, they can be set to maximise efficiency for consumer benefit and relieve grid pressure (Saberi and Menes, 2020).

The field of resource-efficient design, which is inextricably linked to human behaviour, is predicted to grow more agile, detailed, and sophisticated soon. AI-powered robots and algorithms will analyse enormous amounts of data and generate reasoning to assist humans in making educated decisions. The potential for these robots to learn is boundless if they are programmed to spot patterns and constantly improve their predictions and conclusions.

Progress has already been made in applying AI-based models in the commercial building space, where companies use data-collecting sensors and the Internet of Things (IoT) to study and improve building performance and resource consumption. Small sensors are installed on systems or mounted on ceilings, creating a "nervous system" with inter-relating data points. The data collected is then sent to the cloud for interpretation by platforms such as Siemens' MindSphere or Schneider Electric's EcoStruxure, which allow engineers to control utility usage and

Tech companies that create construction management software, such as PlanGrid and Procore, have also made progress toward machine learning, with an eye to prioritising tasks, preventing injuries at the construction site, and maintaining equipment. However, the construction of a building is only a snapshot in time, providing little value to the architect who designs it beforehand, the banks that invest in the project, the building manager who needs to control operational costs or the occupants who eventually make it their residence or workplace costs.

IHS, Vinte, and several other builders certify their homes with IFC's EDGE, a green-building certification system for nearly 160 countries. A core component of EDGE is its software, which provides a foundation of bio-climatic data while eliminating silos among its categories of energy, water, and embodied energy in materials, serving up Whether EDGE evolves rapidly enough to become the ideal platform or a better solution emerges, exciting opportunities exist to develop artificial intelligence in the real estate industry.

Other applications for such machines include overlaying data for certified green buildings with evidence of investment performance. Providing proof of whether a certified building rents or sells faster or at a higher value could be a condition of incentivised financing and/or preferred insurance rates. How about insisting on carbon emission read-outs? Local and national governments could gain a better understanding as to whether they're on track with climate commitments if they could obtain this information from the building sector. Artificial intelligence would then play a role in helping banks decide whether they should even offer conventional financing.

Algorithms could be built to identify developers with lower risk profiles and determine their preferential rates. Governments could use this information to design incentives to minimise carbon emissions. As the building and construction industries adopt these technologies, the hope is that manufacturers will also eventually compete to produce the most ideal systems and materials.

Consumers may also compete for the lowest-priced green mortgage or drastically reduce their energy consumption, resulting in more pleasant homes that cost substantially less to heat, light, and power. Once energy consumption falls and pro-environmental building methods become more popular, resource-intensive homes will be a thing of the past, with AI likely playing a key part. When that happens, we'll recollect and recall how it all began with a smart meter placed on the wall, sparkling with the potential to alter the world.

2. LITERATURE REVIEW

Smart homes' success is primarily contingent on people adopting and using them in their daily lives.

The primary goal of this research is to use x-ray user-centred experience to create a comprehensive picture of households and communities that encourage affordability and energy efficiency through technology design, installation, and use.

Information and communication technologies (ICTs), the Internet of Things (IoT), big data, and artificial intelligence (AI) have just begun to transform people's daily lives.

Computing and information processing are spreading into daily life since these are increasingly being embedded in environments and artefacts invisibly. A new paradigm of human-computer interaction (HCI) is the integration of humans and humans, humans and objects, and objects and objects, and organically connecting them. This new technological paradigm is expected to cause significant changes in various fields, but it is predicted that the future information technology (IT) environment will be developed around the home (De Silva et al., 2012; Krishna and Verma, 2016; Borsekova et al., 2017; Noury et al., 2013). Numerous research projects have implemented a variety of prototypes of smart systems, which include sensors, algorithms, and intelligent devices (Das et al., 2002; Mihailidis et al., 2008; Krishna and Verma, 2016).

Existing smart home research has focused on technology development related to intelligent housing that can demonstrate new possibilities for the use of advanced technologies. These studies initially focused on home automation and networking technologies that facilitate remote control of electrical, lighting, and heating appliances (Arunvivek et al., 2015). Intelligence has recently become augmented and pervasive (Ricqueborg et al., 2006). Current research on smart homes has emphasised the collection of contextual information about the domestic environment and its residents and the provision of customised, automated supports (Singh et al., 2014). These studies focus on technology adoption and emphasise the need to provide user-friendly interfaces but regard the user as a passive agent and are essentially not focused on the user perspective. In other words, technology adoption was not based on clear user-centred understanding. For example, a home telehealth service, which incorporates ICT into the medical industry, will save medical costs for seniors who need chronic disease and health care and ensure independent living. Users perceived it as potentially useful, but in practice, they often refuse biosignal measurements and daily life monitoring through various sensing systems, such as cameras (Peek et al., 2014; Cimperman et al., 2016). This phenomenon is due to the introduction of technology without an in-depth understanding of its users.

Recently, the necessity of conducting smart home research in a more user-centred manner has been suggested, on realising that technology development cannot achieve substantial results in other IT fields without a user-centred vision. The overall success of smart homes is fundamentally dependent on people's adoption and use of this concept in the context of everyday life, regardless of the eventual form in which they adopt it.

Berlo and Allen (1999) described a smart home as ‘a working environment which includes the technology to allow the devices and systems to be controlled automatically’. Emphasis is placed on intelligent dwellings with automatic control, including lighting, climate, appliances, and security systems, such as access control and alarm systems. As home networking has developed with the availability of high-speed internet technology, such as asymmetrical digital subscriber line technology (ADSL), the smart home concept has been expanded by installing sensors in objects used daily and by enabling interworking with mobile devices.

Recently, Balta-Ozkan et al. (2013) defined a smart home as ‘a residence equipped with a high-tech network, sensors and devices, and features that can be remotely monitored, controlled, and provide services that respond to the needs of its inhabitants’. The key to smart dwellings is the ability to control dwelling facilities and devices from outside the dwellings automatically. New technologies such as AI and the IoT can analyse the living patterns of residents and enable communication and information collection between smart devices, objects, and humans (Orwat et al., 2008; Arunvivek, 2015). Many of the new technologies that use various sensing systems, such as motion sensors and video cameras, are being developed to the extent that they can automatically support the user’s contextual awareness without the need to directly manipulate devices (Mann et al., 2001; De Silva et al 2012).

Research on smart homes has been conducted in various fields, but thus far, most of these are in engineering and technical sciences domain, Wilson et al. (2015). For these studies, the goal of smart homes is to improve the quality of life of residents through automated devices, to enable them to live a safe, healthy, comfortable life independently (Gracanin et al., 2011).

Technology developers and researchers claim that advanced, applied knowledge will make our lives more comfortable. Their purpose is to support the daily lives of residents through technologies, such as those for energy management, security, monitoring, and detecting incidents (Yu-Ju et al, 2002; Gracanin et al., 2011). Despite this broad range of potential and assumed benefits of technology adoption, if we focus only on technological features, the technology can disappear before they are even incorporated into our lives (Cook, 2012). To successfully realise smart homes, it is critical to understand the factors that potential users consider important and necessary and then decide on acceptable technologies and functions rather than being concerned with technological performance in isolation (Fisk, 2008).

It is the age of ubiquitous and pervasive computing. The use of ICT is essential for smart dwellings because it changes daily lives in residences in meaningful, fundamental ways. ICT distributed in rooms, devices, and systems (i.e., lighting, heating, and ventilation) is aware of people’s activities and needs. This dimension has three categories: ubiquitous computing, AI, and IoT. IoT connects sensors, devices, actuators, radio frequency identification tags, laptops, and mobile phones to share network resources in conjunction with each other (Krishna and Verma, 2016). The technology helps in energy management systems and supports access to devices and remote monitoring of embedded devices

(Chatzigiannakis et al., 2015; Li et al., 2016). Advanced AI collects occupants' data and applies visual and sensory-based tracking systems to identify them based on facial expressions and emotion recognition (Mann et al., 2016). Visual-based tracking systems, such as cameras, can monitor the status of occupants in the smart home. An AI-based IoT framework provides a continuous monitoring system of the living patterns of residents through various sensors attached to the human body and in the environment to avoid health hazards and provide customised healthcare services accordingly (Mann et al., 2011).

3. IDIOSYNCRASIES AND THE FUTURE OF SMART HOMES IN NIGERIA

In recent years, smart home technology has emerged as one of the most fascinating innovations in everyday life. The Internet of Things (IoT) is transforming traditional household appliances, although in ways that alienate many people.

The concept of a smart home may seem like an aspiration or wishful thinking for the average Nigerian end-user household. Nonetheless, the intriguing traits and prospects for small-scale deployment in the immediate future warrant further investigation.

It goes without saying that a smart home requires a reliable Internet connection and smart products to work. Another prerequisite is a conducive housing construction. Smart dwellings flourish in environments that allow for easy integration and cable connectivity.

The location of a house or apartment is not often a big consideration, especially if the preceding components exist. However, in Nigeria, location is essential. Modern structures in highbrow Ikoyi, Abuja, Victoria Island, and the Lekki corridor are ideal for smart house designs due to their modernism.

There are several factors that prevent smart housing from being incorporated into the average Nigerian home. These include insufficient power supply, restricted earning power, the cost and quality of Internet services, the cost and accessibility of access to smart equipment, and poor accommodation architecture best suited for smart houses in Nigeria.

Poor Power Supply

The comatose power supply in Nigeria cannot be overstated. A smart house cannot work efficiently in the face of unpredictable power supply, electricity distribution, the supplier value chain, and frequent national grid outages. Switching to a prepaid metering system does little to alleviate this problem because the quality rarely matches the money paid.

Estates and upscale regions, in general, may not be as heavily impacted by this issue. However, the average Nigerian household in the average Nigerian local government is significantly disadvantaged.

Purchasing Power Parity and Disposable Income

Electricity bills must be paid, and smart appliances must be purchased. Unfortunately, electricity expenses in Nigeria can be high, and smart equipment is expensive. Considering the cost of periodic maintenance, smart home technology is fundamentally a luxury that the average Nigerian household cannot afford. In Nigeria, the minimum salary is insufficient to cover basic living expenditures. Even in households where at least two people earn far more than the minimum salary, smart housing remains prohibitively expensive.

Cost and Quality of Internet Services

Very few love-hate stories are more compelling than that of Nigerians and their Internet service providers. The same issues are complained of, whether the service provider is one in the strict sense or a telecommunications company. Nigeria is also Operating a smart house, which would require money to be spent on data plans. In a country where these plans are deemed costly for daily use, smart house technology is reinforced as unrealistic. Nigeria has yet to fully embrace 5G technology.

Cost of Acquisition and Ease of Access to Smart Devices

The issue of poor architectural design affects both old and new buildings in Nigeria. Old buildings do not allow for easy installation and usually do not allow for integration. Ironically, as revealed by pictures taken by house hunters, many new buildings also lack room for integration, especially in areas that require gentrification.

Cost of living crisis, Access to foreign exchange and pervasive inflation

The Nigerian state is currently witnessing a cost-of-living crisis occasioned by fuel subsidy removal; this has made the cost of goods and services witness an upward spiral. With headline inflation as of February 2024 in the region of 32.7% (National Bureau of Statistics, 2024) and the ripple effect of a fluctuating exchange rate that continuously affects imported technological gadgets and building materials, the application and sustainability of smart home concepts have been further limited by the day.

4. CONCLUSION

In a country like Nigeria, where energy management is crucial, smart home automation provides significant benefits in terms of energy efficiency. Smart thermostats allow homeowners to regulate their heating and cooling systems intelligently, optimising energy consumption. Automated lighting systems can be programmed to turn off when rooms are unoccupied, reducing unnecessary energy usage. These energy-saving features contribute to a greener environment and lead to cost savings on utility bills.

The future of housing delivery in Nigeria can be transformed by the incredible potential of smart home automation. With enhanced convenience, increased energy efficiency, improved security, streamlined entertainment, remote accessibility, and the potential for integration, homeowners are embracing the benefits of smart home automation. By incorporating these advancements into their living spaces, Nigerians are improving their quality of life and preparing their homes for the connected world of tomorrow. Smart home automation can shape the future of home living in Nigeria, and its transformative power could revolutionise the way we experience and interact with our homes.

This research study is still ongoing, and the research findings will be published when fully completed.

REFERENCES

1. Balta-Ozkan N., Amerighi O., Boteler B. (2014). A comparison of consumer perceptions towards smart homes in the UK, Germany, and Italy: reflections for policy and future research. *Technol. Anal. Strateg. Manag.,* 26, pp. 1176–1195.
2. Balta-Ozkan N., Davidson R., Bicket M., Whitmarsh L. (2013). Social barriers to the adoption of smart homes. *Energy Policy,* 63, pp. 363–374.
3. Berlo A. V., Allen B. (1999). *Design Guidelines on Smart Homes: A COST 219bis Guidebook.* Brussels: COST, Commission of European Communities.
4. Bersekova, K., Kourtit, K. and Nijkamp, P. (2017). Smart development, spatial sustainability, and environmental quality. Habitat International, 68, pp. 1-2.
5. Chatzigiannakis I., Amaxilatis D. and Livathinos S. (2015). "A collective awareness platform for energy efficient smart buildings," in *Proceedings of the 19th Panhellenic Conference on Informatics*, Athens.
6. Cimperman, M., Brenčič, M. M., Trkman, P. and Stanonik, M. D. L. (2013). Older Adults' perceptions of home telehealth services. Telemedicine journal and e-health, 19(10), pp. 786–790.
7. Cook D. J. (2012). How smart is your home? *Science,* 335, pp. 1579–1581.
8. Das, S. K., Cook, D. J., Battacharya, A., Heierman, E. O., and Tze-Yun, L. (2002). The role of prediction algorithms in the MavHome smart home architecture. *IEEE Wire. Communic.,* 9, pp. 77–84.
9. De Silva L. C., Morikawa C. and Petra I. M. (2012). State of the art of smart homes. *Eng. Appl. Artif. Intellig.,* 25, pp. 1313–1321.
10. Fisk M. J. (1998). Telecare at home: factors influencing technology choices and user acceptance. *J. Telemed. Telecare,* 4, pp. 80–83.
11. Gračanin D., Mccrickard D. S., Billingsley A., Cooper R., Gatling T., Irvin-Williams E. J., et al. (2011). "Mobile interfaces for better living: supporting awareness in a smart home environment". In: Stephanidis, C. (ed.) *Universal Access in Human-Computer Interaction. Context Diversity*, Berlin: Springer, pp. 163–172.
12. Krishna M. B. and Verma A. (2016). "A framework of smart homes connected devices using Internet of Things". In: *Proceedings of the 2nd International Conference on Contemporary Computing and Informatics (IC3I)*, Greater Noida, India, pp. 810-815.
13. Mihailidis A., Cockburn A., Longley C. and Boger J. (2008). The acceptability of home monitoring technology among community-dwelling older adults and baby boomers. *Assist. Technol.,* 20, pp. 1–12.
14. Newing, A., Hibbert, O., Van-Alwon, J., Ellaway, S. and Smith, A. (2023). Smart water metering as a non-invasive tool to infer dwelling type and occupancy – implications for the collection of neighbourhood-level housing and tourism statistics. *Computers, Environment and Urban Systems*, 105, p. 102028.
15. Peek S. T., Woutersa E. J., Hoofc J. V., Luijkxb K. G., Boeijed H. R. and Vrijhoefb H. J. (2014). Factors influencing acceptance of technology for aging in place: a systematic review. *International Journal of Medical Informatics,* 83(4), pp. 235–248.
16. Ricquebourg V., Menga D., Durand D., Marhic B., Delahoche L. and Loge C. (2006). "The smart home concept: our immediate future". In: *Proceedings of the 1ST IEEE International Conference on E-Learning in Industrial Electronics*, Hammamet.
17. Ricquebourg V., Menga D., Durand D., Marhic B., Delahoche L. and Loge C. (2006). "The smart home concept: our immediate future". In: Proceedings of the 1ST IEEE International Conference on E-Learning in Industrial Electronics, Hammamet.
18. Saberi, O. and Menes, R. (2020). Artificial Intelligence and the Future for Smart Homes. World Bank Publications - Reports 33615: The World Bank Group.
19. Sinclair, K. (2019). For Smart Buildings, Artificial Intelligence Is Still a journey. Facilitiesnet, available from: https://www.facilitiesnet.com/buildingautomation/contributed/For-Smart-Buildings-Artificial-Intelligence-Is-Still-a-Journey--43437.

20. Singh D., Tripathi G., Jara A. J. (2014). "A survey of Internet-of-Things: future vision, architecture, challenges and services". In: Proceedings of the IEEE World Forum on Internet of Things (WF-IoT), Seoul.
21. Waterwise (2020). UK water efficient strategy to 2030 published. Available from: https://www.waterwise.org.uk/strategy2030/.
22. Wilson C., Hargreaves T. and Hauxwell-Baldwin R. (2015). Smart homes and their users: a systematic analysis and key challenges. *Personal and Ubiquitous Computing*, 19(2), pp. 463-476.
23. Woschank. M., Rauch. E. and Zsifkovits, H. (2020). A Review of Further Directions for Artificial Intelligence, Machine Learning, and Deep Learning in Smart Logistics. *Sustainability*, 12(9), p. 3760.
24. Yu-Ju L., Latchman H. A., Minkyu L. and Katar S. (2002). A power line communication network infrastructure for the smart home. *IEEE Wireless Communications,* 9(6), pp. 104–111.