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Towards sustainable residential architecture in rapidly Urbanizing Nigerian cities: Insights from Ozoro

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Abstract

In this study, the impact of sustainable design elements on city living in Ozoro which is rapidly becoming urban, is examined. Post-occupancy evaluation surveys were carried out with 650 residents to analyze the five parameters of thermal comfort, daylighting, acoustics, functionality and appearance of the housing. About 70% of the survey respondents said they felt too warm and 86% felt their homes were not well-lit. Furthermore, the majority of the feedback showed that people care most about improved function (88.92%) and visual appearance (91.07%). This shows that current designs for homes are not meeting the standards set by sustainable development. The research adds new evidence to revealed earlier that sustainable housing should be cooled passively, feature natural light, strong acoustic insulation, rooms that can be multi-functional and a pleasant outlook. It suggests that architects should keep both people and climate in mind when creating future designs. Adherence to global standards for sustainability can enhance both city lives for people and the environment in cities across Nigeria.

Keywords: Sustainable Architecture; Residential buildings; Thermal comfort; Energy efficiency; Urbanization

1. Introduction

Sustainable architecture is now considered very important around the world because of the challenges rapid urban growth creates for the environment, the energy sector and human health. Energy use in the global building sector accounts for almost 40%, while emissions from it take up 30% (UNEP, 2022). They also prove that we need to adopt building practices that decrease carbon emissions, support water and energy conservation and ensure more healthful interiors. People now regard sustainable urban development as incomplete without including energy-saving, green and human-centered designs in residential buildings (Shen et al., 2010; Kim et al., 2020). Besides, climate change has increased the chances of urban areas being affected by flooding, high temperatures and air pollution. Because of these risks, international organizations and governments are now encouraging the use of green codes and ensuring sustainability is considered during all stages of building a structure.

In Africa, building sustainably is something that must be done and is also not easy. In Sub-Saharan Africa, many cities are growing quickly and the urban population is expected to double by the year 2040 (UN-Habitat, 2022). Even so, African countries, including Nigeria, don't have enough guidelines, encouragement from policies or suitable expertise for adopting large-scale sustainable housing plans. Traditional materials and old ways of building in Nigeria usually explain why indoor air is of low quality and why the energy used to operate such buildings is often much higher (Silverman & Mydin, 2014). Due to unreliable power, most homes depend on rental generators for electricity, leading to more air pollution and increased carbon emissions in cities. With the emergence of energy and climate problems,

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both governments and private companies are now paying more attention to energy efficiency and sustainability (Jat & Mane, 2018; Nduka et al., 2021). Even so, turning policies into actions is not easy and the gap is especially wide in peri-urban and semi-urban areas because their regulations are difficult to apply.

For example, Ozoro in Delta State, just like other smaller towns in the country, is undergoing significant urban changes. With the establishment of the Southern Delta University, people have flocked there which has pushed up housing needs and resulted in an increase in construction projects. Despite the fast rise in building activity, there has not been a similar rise in sustainable building. Most houses in Ozoro provide only basic comfort, have confusing spatial designs and pay little attention to clean or low-energy living. People in these regions also have to face high energy bills, problems with accessing facilities provided by the city and a greater chance of heat- and flood-related risks, as such situations negatively affect their lives (De Silva et al., 2004; Nalewaik & Venters, 2008). Sustainable features of buildings are now recognized by developers and investors as leading to lower running costs and more content tenants, but there are not many studies of sustainability in towns such as Ozoro. As a result, this research aims to assess the sustainability of residential design in Ozoro, mainly based on how comfortable residents are, how much energy is used, how renewable the main materials are and how the urban environment is affected. Also, the study seeks to recommend local solutions for building and renovating homes in Nigerian cities that are growing quickly.

2. Literature Review

Building industry practitioners have begun to pay attention to controlling and correcting the environmental damage due to their activities. Architects, designers, engineers and others involved in the building process have a unique opportunity to reduce environmental impact through the implementation of sustainable strategies at the design development stage of a building project (Chime & Okafor, 2023; Ugwu et al., 2006).

2.1. Design for Residents' comfort

Needless to say, environmentally friendly homes should be designed to ensure that necessary spaces are healthful, useful and responsive, now and in the future, for their people. According to research worldwide, ensuring a good indoor environment and well-being while reducing our environmental impact is a crucial objective of sustainable construction (Alyami & Rezgui, 2020; Lin et al., 2023). Buildings are expected to support people's needs by offering the right temperature control, quality air, enough light, proper sounds, adequate space and fire protection. Per WHO (2021), almost all of our lives are spent indoors, so our health and job performance largely depend on the indoor environment. Even if structures are energy efficient, if they do not ensure good indoor environments, they cannot be considered sustainable (Sev, 2009). All these factors include when creating a building design ensure occupants gain physical benefits, cost-effectiveness and boost the community.

For any sustainable building, providing comfort and good health must start with the proper choice of building materials. Indoor air, noise levels, ventilation from nature, access to daylight and temperature affect how satisfied people are with their homes (Oral et al., 2004; Adgate et al., 2002; Afolabi et al., 2021). Ensuring thermal comfort goes a long way in satisfying the user. Many factors influence body temperature such as air temperature, humidity level, the intensity of light, airflow, as well as personal factors including the type of clothes worn and the activity level (as mentioned in Chime & Okafor's and Tettey et al.'s studies). Applying Low-E windows, reflective roofs and good building orientation is a good way to improve the comfort of a home. The acoustics in a venue are also important but are rarely considered. Sounds created by machines or originating from outside influence our mental health. You can provide comfort and stay sustainable by using walls and tiles that effectively absorb noise (Sev, 2009). Additionally, in places with sporadic electricity, research in tropical climates proves that using natural airflow instead of air conditioners is a better solution (Edwards, 2006; Olatunji & Adegun, 2021). Using the right window position and ventilating your home through different openings has helped to reduce pollutants indoors and save energy on heating and cooling.

Visual comfort is also very important for making our homes sustainable. With natural light in a room, people can use less energy for lighting, have a better mood, sleep schedule and productivity (Li et al., 2020; Lin et al., 2023). Appropriately facing the building, adding light shelves and adding both reflective materials and skylights can reduce glare and heat inside, letting in lots of natural light. Decor such as nature, soft textures and attractive design brings psychological benefits to people living in or using the environment (Kim et al., 2020). Besides, the features of a product should respond to future changes in user needs. Buildings should be sustainable, meaning they can be updated or enlarged conveniently, without causing significant construction damage (Olanrewaju & Abdul-Aziz, 2015; Olusola et al., 2024). Ozoro's rapid growth means function is critical for houses, since the city's infrastructure can't support everything that's needed. The final point to consider is how the selected materials can last for years without having to be replaced

or repaired often. Consequently, a sustainable house is safe for health, feels good inside, offers flexible and adaptable living and looks great.

2.2. Physical Resources

Ensuring the safety of our environment and buildings includes basing sustainable design on safeguarding adaptable and lasting physical resources. Today, buildings use hazard-controlling designs that ensure the property and its inhabitants remain secure and the structure can withstand damage. The main points of attention are fire protection, being prepared for natural disasters and safeguarding against crime. Because many rapidly growing cities are susceptible to causing great strain on their infrastructure, disaster planning against fires, floods, earthquakes and intruders is crucial during modern construction (Olanrewaju & Abdul-Aziz, 2015; Olusola et al., 2024). So, using hazard mitigation planning, architects can take the necessary steps to prevent risks during the initial planning process.

It is very important in resilient design to include fire protection at the earliest phase and address it using a systems approach. Since buildings are becoming more complex, effective passive fire protection is needed to protect the structure and keep occupants safe. Streams of heat, smoke and flames are delayed by using fire-resistant and fire-stopping methods and dividers inside buildings. The changes ensure that people who need to escape will be supported and also benefit firefighters. During renovation or building, materials that have passed fire tests should be installed to preserve the fire safety of the building for its lifetime (WHO, 2021). Such buildings should also be able to survive natural disasters, as problems like climate change and more people cities are bringing them closer to our towns and cities. To protect against floods, it is now usual to rise buildings in hazardous locations, make buildings waterproof and build levees around such areas (Edwards, 2006; Afolabi et al., 2021). Applying tie beams, ferro-cement sheathing and reinforcing building corners can make buildings stronger and less prone to damage if a disaster strikes.

Crime prevention through environmental design (CPTED) is another major part of physical resource protection. Properly designed architecture is known to discourage crimes and raise the sense of security within a community (Marzbali et al., 2011; Kim et al., 2020). According to CPTED, it helps to use territorial markers, ensure there are proper places for people to watch over and regulate who can enter each space. Territorial behaviour increases when buildings are separated from the public area with fences, porches and pathways. You can achieve natural surveillance in your home by adding or moving windows, lights and things that allow for clear vision. Traffic is regulated and unpermitted entry is blocked by gates, hedges, doors and signboards. As a result of using all of these features together, residents feel more ownership and the areas turn out to be safe, enjoyable for everyone and sustainable (Alyami & Rezgui, 2020; Lin et al., 2023). To support the growth of secure, sustainable and resilient communities in Nigerian and similar cities, integrative approaches are necessary.

3. Materials and Method

The researchers carried out the study in Ozoro, a town that lies in the warm-humid part of southern Nigeria. The focus was on how well sustainable residential design ensures the comfort of people using the buildings. In this work, both objective facts and subjective observations were gathered through comparing cases. A questionnaire was designed to gather primary information from residents of buildings randomly selected in every stratum. The survey was offered to every person living in the buildings. Multiple areas of indoor environmental quality, for example, thermal comfort, natural ventilation, amount of light during the day, proper acoustics, effectiveness and appeal were considered in the questionnaire. Those who participate were instructed to indicate by the ASHRAE 7-point thermal sensation scale how they feel, from feeling “cold” to feeling “hot.” To see which features were preferred, McIntyre’s 3-point scale was used on answers about both the brightness and functionality of the bulbs. Acoustics were evaluated on the basis of whether they were regarded as ‘acceptable’ or ‘not acceptable’.

It was also discovered from the questionnaire if residents changed what they did to feel comfortable and what changes they preferred in their environment. Since natural ventilation and good lighting are basic for passive heating and cooling, we made sure they were effective. The personal survey involved giving out questionnaires, while figure 1–6 include several pictures of the buildings being monitored. The responses from 650 people were analysed using descriptive statistics. Sixty-four point nine two percent of respondents were too warm and seventy point six one percent felt hot, hinting that they felt uncomfortable with heat levels. Almost 86% noted that the building was badly lit and over 86% considered the acoustics to be unsatisfactory. Still, the survey found that better design and increased functionality were the top priorities for 91.07% and 88.92% of people, respectively. This proves that higher attention to comfort during design is required in regional homes.

Figure 1 Three-bedroom block flats in the study area

Figure 2 Two-bedroom block flats in the study area

Figure 3 Six-bedroom duplex in the study area

Figure 4 5-bedroom bungalow in the study area

Figure 5 Two-bedroom bungalow in the study area

Figure 6 A room self-contain bungalow in the study area

Figure 7 Google map shewing aerial view of the study area

4. Data Presentation

The contents of the questionnaire were developed from previous research on post-occupant evaluation.

4.1. Question 1: How the residents feel with the natural ventilation

This question was asked to know how the respondents feel with the natural ventilation. Figure 8, shows how the residents feel with the natural ventilation. The result has shown that about 4.30% of the respondents feel cold, 1.84% feel cool, 6.00% feel slightly cool, 2.00% feel neutral, 46.15% feel slightly warm, 10.92% feel warm and 70.61% feel hot. This shows that more of the respondents feel hot as shown in Figure 8.

Table 1 Occupant feeling with the indoor temperature

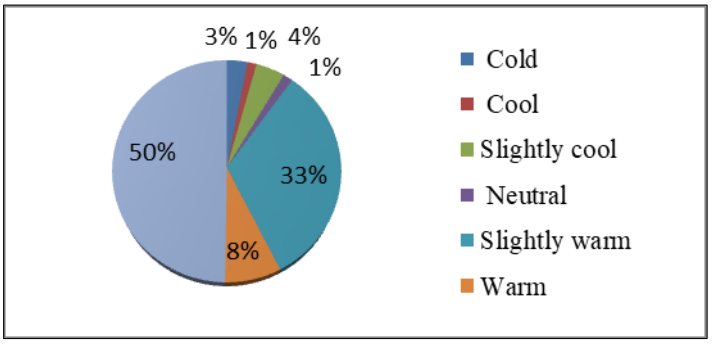

Figure 8 Resident feeling with the natural ventilation (Field work 2024)

4.2. Question 2: Resident thermal comfort level

This question was asked for respondents to indicate their level of thermal comfort. Figure 9 shows the thermal comfort level distribution of the respondents. The result has shown that about 0.92% of respondents were much too cool, 3.54% too cool, 2.00% cool, 4.76% ok, 18.92% warm, 64.92% too warm and 5.07% much tool warm. This shows that more of the respondents are feeling too warm as shown in Figure 9.

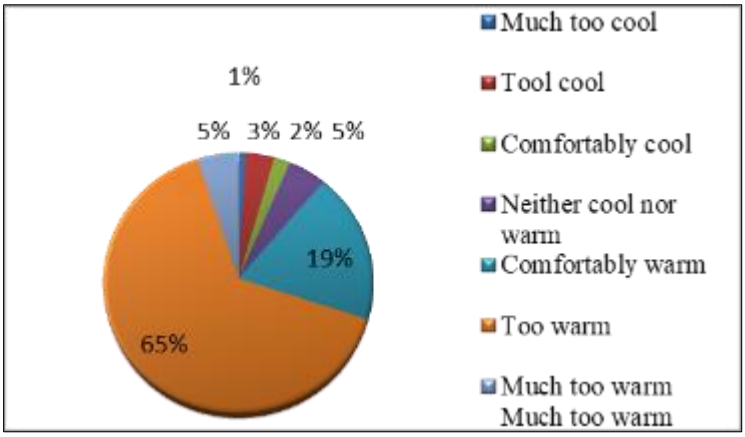

Figure 9 Thermal comfort level distribution (Field work 2024)

4.3. Question 3: Resident preference of the building day lighting, (how would you like to be?)

This question was asked to know the distribution of how respondent would like to be. Figure 10 shows the resident preference of day lighting. The result has shown that about 85.69% of respondents were badly lit, 8.15% no change, 6.15% well lit. This shows that more of the respondents prefer to have well lit interior as shown in Figure 10.

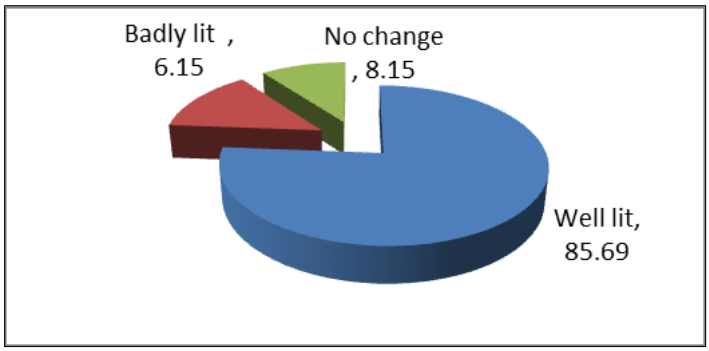

Figure 10 Resident preference distribution of the building day lighting (Field work 2024)

4.4. Question 4: resident acceptability of the building acoustics

This question was asked to know the distribution of respondent's acceptability of the acoustics. Figure 11 shows the acoustics acceptability distribution of the respondents. The result has shown that about 13.53% of the respondents accepted it while 86.46% of the respondents did not accept the acoustics. This shows that more of the respondents did not accept the acoustics as shown in Figure 11.

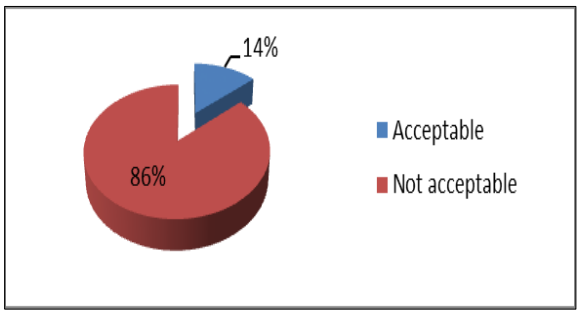

Figure 11: Acoustics acceptability distribution (Field work 2024)

4.5. Question 5: Resident preference of building functionality, (how would you like to have the functionality).

This question was asked to know the distribution of how respondent would like to be. Figure 12 shows the resident preference of functionality. The result has shown that about 88.92% of respondents prefer good functionality, 6.30% exactly how it is now, and 4.76% prefer poor functionality. This shows that more of the respondents prefer good functionality as shown in Figure 12.

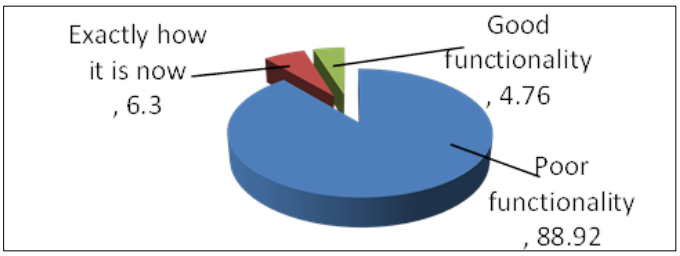

Figure 12 Resident preference distribution of building functionality (Field work 2024)

4.6. Question 6: Resident perception of building aesthetics

This question was asked to know the distribution of how respondent feel about building aesthetics. Figure 13 shows the resident preference of aesthetics. The result has shown that about 3.53% of respondents prefer poor aesthetics, 5.38% exactly how it is now, and 91.07% prefer good aesthetics. This shows that more of the respondents prefer good aesthetics as shown in Figure 13.

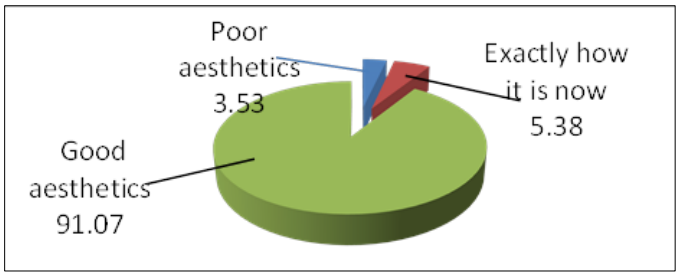

Figure 13 Resident preference distribution of building aesthetics (Field work 2024)

5. Discussion

According to the research data, thermal comfort, the look of the space, sound design and how the space is useful are essential for sustainable homes. Nearly all survey respondents felt uncomfortable, as 70.61% mentioned being hot and 64.92% described being too warm, showing the homes in Ozoro lack proper ventilation. This is the same conclusion reached by Chime and Okafor (2023) and Tettey et al. (2022) about tropical residential buildings that do not apply passive design. Since the area is quite uncomfortable in terms of temperature, it is necessary to add better ventilation, glazing, roofs with high solar reflectance and orient buildings correctly for better comfort, as documented by Edwards (2006) and Olatunji & Adegun (2021) in regions with a mixed power supply. Moreover, the fact that 85.69% of people said their indoor lighting was not good enough suggests city planners are not effectively using daylight in their designs. These studies conducted by Lin et al. (2023) and Li et al. (2020) point out that not having enough daylight reduces the building's energy efficiency and comfort of occupants, so it is necessary to bring in more sunlight using skylights, light shelves and reflective surfaces.

As acoustics were unacceptable to most residents (86.46%), this demonstrates another key sustainability issue being ignored. In the same year, Snav (2009) noted that the quality of sound is vital for our minds and using soundproof materials can enhance the noise level in any space. Almost 90% of respondents supported the idea that a sustainable urban design should include enhanced functions to help with spatial adaptability. As a result, it shows that flexible design and planning buildings around users support long-term sustainability. Moreover, many participants said they wanted enhanced visuals, supporting claims by Kim et al. (2020) and Olusola et al. (2024) that appearance boosts users' satisfaction, connection to the game and their sense of value. Many architects today are concerned with aesthetics which hints at a need to feel linked to nature by seeing it in their homes and offices. Moreover, these results suggest that many people seek healthy, comfortable and flexible homes which follows the announced recommendations from the WHO (2021) that homes should address health and support good productivity. Therefore, Nigerian architects and urban planners should reassess their styles to fit global standards for sustainability and the special needs of the locals in Ozoro.

6. Conclusion

Experts found that the buildings being used in Ozoro don't support the main points of sustainable building principles. Many residents have mentioned that the building lacks proper thermal comfort, daylight, good sound control, works well and has an appealing design. The research results are in line with studies worldwide claiming that to be sustainable; a home must be properly heated, well-lit, have effective soundproofing and be both practical and attractive. Evidently, urbanizing cities in Nigeria must have buildings updated or improved to fit the new challenges faced by residents but not at the expense of the environment. Thus, architects and those in the building industry should include natural cooling, boost natural light, choose materials that are both soundproof and fireproof and design spaces that can be easily rearranged during planning stages. Taking this approach will ease present physical issues and also benefit the environment, people and future generations. Local officials ought to establish policies that ensure buildings are centered on people and that offer support for learning about sustainable architecture. Studies could investigate interesting and cheap ways to upgrade buildings currently used by poor urban populations. To ensure all can benefit from sustainable housing in Nigeria, we must improve these homes through actual design that meets the needs and interests of the people.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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