ISSN 2720 - 9644 (print)
ISSN 2721 - 0871 (online)
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INTERNATIONAL JOURNAL OF ENVIRONMENTAL, SUSTAINABILITY AND SOCIAL SCIENCE
Indexed By :

A COMPARATIVE ANALYSIS OF BUILDING ORIENTATION AND INDOOR THERMAL CONDITION OF SOME BUILDINGS IN BENIN CITY, NIGERIA

Volume: 6
Number: 6
Page: 1324 – 1337

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Article History:
Received: 2025-09-12
Revised: 2025-10-16
Accepted: 2025-11-15

Abstract:
The study focuses attention on the orientation of buildings as a significant design consideration due to its influence on improving the indoor thermal comfort. The aim of the study is to comparatively analysis the effect of building orientation on the indoor thermal condition of buildings in the study area. To achieve the aim of the study, a field survey was carried out in five neighbourhoods using 550 administered questionnaires. Secondly, buildings relatively oriented longitudinally in the East-West direction and buildings oriented longitudinally in the North-south direction were identified for comparison in their indoor thermal condition. Thirdly, the indoor thermal condition of buildings in relation to building orientation in the study area is measured. Data obtained was analysed with the aid of analyses of variants to determine the influence of building orientation on the indoor thermal conditions of buildings. The result shows no significant relationship between building orientation and indoor thermal condition among the buildings assessed, as the p-value equals 0.792. This result contrasts with most related research works, being that most buildings were built with foreign building materials, with one window in their functional spaces. No adequate building's setbacks, high wall fence, and most buildings occupied more than 50% of the total plot size, which may have resulted in the distortion of air circulation around such buildings and an increase in air temperature. The study therefore recommends a strict monitoring of physical developments by the relevant agency, and proposed development must incorporate passive design strategies that work with the local climate to maintain a comfortable temperature indoors.

Keywords: Building Orientation, Indoor Thermal Condition, Thermal Comfort, Buildings in Benin City.

INTRODUCTION

Building orientation refers to the way a building is situated on a site and the positioning of windows; it is a significant design consideration mainly with regard to solar radiation and wind direction so as to minimise solar gain and maximise natural ventilation to create thermal comfort indoors. It is significant to determine the energy needed for cooling or heating, depending on the weather conditions. Primarily, the sun, as a major source of energy on earth, is also inadvertently a major problem in buildings, particularly in hot climate regions of the world like the study area. The sun drives the energy of the earth and makes life possible; conversely, it is a problem to man's comfort in buildings, observably due to man's activities of transforming the natural vegetation of an area to residential, commercial, industrial and transportation uses for urbanization without due regard to the natural environment. Inevitably, these urban infrastructural materials are good receptors and heat storage, thus significantly increasing the heat being experience in most cities of

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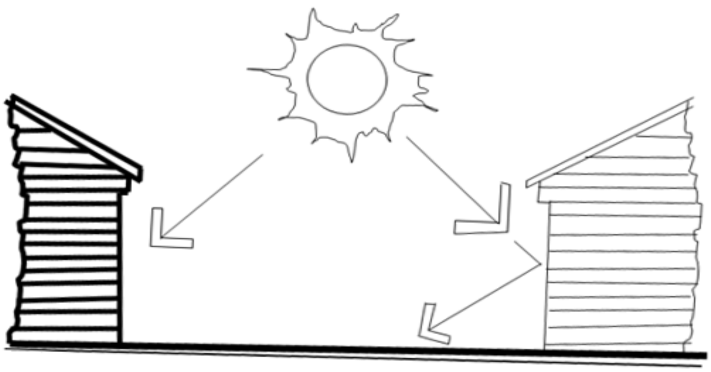
the world (Okhakhu, 2010). Therefore, to minimize heat being experienced in the building, it is important to consider sun shadow analysis for the purpose of avoiding large areas of building surfaces exposed to direct sunlight, especially in hot climate regions like Benin City. By sun shadow analysis, a building can be properly oriented in relation to the sun and with the immediate environment, thus minimise heat exchange between the building and the environment (Alatayneh, Alterman, Page & Moghtaderi, 2018), creating an indoor thermal comfort for building occupants.

In Nigeria, in particular Benin City, there is a poor supply of electricity couple with regular increase in fuel pump price due to fuel subsidy removal by the government, energy consumption for lighting and cooling buildings is also increasing by the day at a phenomenal rate due to increase in the nation's population (Efe &Eyefia, 2014). The demand for energy to light and cool buildings for human comfort continues to increase, mostly because of poor building orientation and non-climate responsive building designs, especially in the study area, while the general concern for the environment has been neglected (Mike & Olumide, 2012). As energy demand continues to increase, it is necessary to minimise heat transfer and maximise natural ventilation through proper orientation of buildings in relation to the shadow patterns of the sun, adopting climate-responsive building design, and the use of vegetation around buildings to shade building surfaces from direct sunlight. These steps would greatly minimise heat exchange between buildings and the environment, maximising ventilation, thus helping building users to cut down energy use in their homes for thermal comfort (Alamah, 2012; Alamah, 2018).

Building Orientation. The sun influences the climate the most, and must be considered in design, because buildings are in one way or the other affected by direct sunlight and by the process of its indirect transmission. The main form of entry for solar radiation into buildings is through windows (Paula, David & Jaime, 2018) because of the high transmittance of the window's glass, which allows the short-wave radiation from the sun to pass through it, providing energy to the existing elements in the interiors (Al-rawi, 2008). Those elements absorb and store a considerable amount of energy, which raises the room air temperature. Likewise, construction materials that are often dark in colour have a higher capacity to absorb and store heat energy than light-coloured materials (figure 1; Haque, Tai, Ham, 2004). Consequently, after sunset, the absorbed energy in a room is release as long-wave radiation into the atmosphere (Kieron & Tony, 2013) and inadvertently raises the air temperature, especially when there is a cloud cover which does not allow heat to escape. Therefore, building orientation is an imperative design consideration for mitigating heat gain and maximising wind flow in hot climate regions.



Source: Haque, Tai, Ham, (2004).

Figure 1. Dark Elements Absorb Heat. Conversely, Light Surfaces Reflect Heat

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Generally, sunlight falling on a building raises the indoor temperature of a building in two different ways. First, by indirect radiation or re-radiated solar radiation when it falls on external surfaces of a building, which causes heat to be conducted inward through the wall, roofs and openings to the interior. Secondly, by direct radiation, whereby solar radiation falls on an opening and passes directly into the interior (Agboola, 2011). To mitigate this effect, the orientation of buildings has been considered as a significant design principle to minimise solar gain and maximise wind flow in buildings. (Akeel, 2015). The way a building is situated on a site with respect to sun direction, and the positioning of windows with respect to wind direction, play an important role in natural ventilation as a means of removing heat in buildings, as wind moves, it carries heat along with it.

Collaborating this assertion, Al-Tamimi, Sharifah and Wan (2011) carried out a study in a predominant hot, humid region of Malaysia, which receives sunlight all year round. Their study found that buildings oriented in a proper context to the environment minimise solar gain and maximise natural ventilation, which effectively removes heat and reduces energy consumption in cooling buildings. Similarly, Lawal and Ojo(2011) conducted a study in Ibadan Oyo Stateand the result revealed the moderation of indoor climate to include the choice of proper site of the buildings, developing proper shape and size for the buildings, proper orientation of the buildings to providing adequate ventilation, providing adequate window sizes for natural ventilation, providing appropriate vegetation and selecting adequate building fabrics. These are passive energy techniques that building designers should follow to moderate the indoor climate.

Another study conducted by Odunfa, Dare, Adeaga and Babalola (2013) observed in most Nigerian metropolis, a sizeable percentage of buildings were placed longitudinally in the North-South direction (Figure 2), implying that a larger portion of the building surfaces are being exposed to solar radiation, consequently, more energy may have to be expended in cooling the interior of these buildings. Buildings placed longitudinally East-West direction (Figure 3) gain less heat from the sun, implying that a smaller portion of the building surfaces is being affected by solar radiation than those placed longitudinally North-South direction.

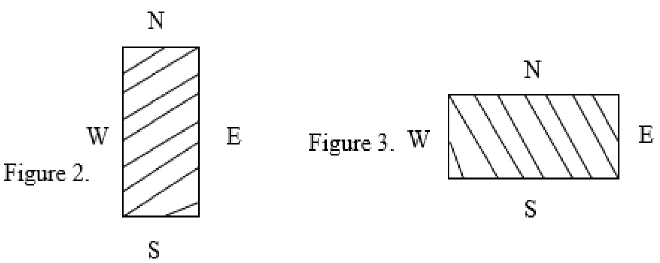

Figure 2. Buildings placed longitudinally in the North-South direction maximize solar gain.
Figure 3. Buildings placed longitudinally in the West-East direction minimize solar gain.

All buildings in one way or the other are affected by solar beams, and a proper building orientation and road network planning will reduce heat gain while cutting down energy consumption in cooling the interior of buildings (Odunfa et al, 2013). Most building designers, in particular Architects, can achieve a solar passive design by studying the sun shadow pattern while applying bioclimatic architecture design features and taking advantage of the existing natural resources on the site. The Solar passive design strategy varies from one climate to another, in which case, buildings can function independent of mechanical systems when there is a power failure, because they are well lit by natural daylight and thermally comfortable (Paula, David & Jaime, 2018).

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For instance, those living in cold climate regions could take advantage of solar energy from the sun by orienting their buildings longitudinally North-South, while those living in the hot-climate regions should orient their buildings and road planning longitudinally to East-West direction to avoid larger building surfaces from direct solar gain.

The orientation of a building in a hot climate is important in two respects: to minimise solar gain and to maximise wind flow in buildings. Buildings in the tropics should be placed longitudinally in the West-East direction to minimise solar gain, thereby reducing energy cost in cooling the interiors. In the event buildings could not be oriented in the recommended West-East longitudinally, this constraint can be offset by using trees, shrubs and other vegetal cover to improve the microclimate of such buildings at the same time enhancing their aesthetic value (Anumah&Anumah, 2017). Likewise, heat in buildings can be offset by design consideration of building materials that are not affected by the solar radiation and relative humidity (Akeel, 2015). The transparent part of the building (windows) also plays an additional role in heat exchange. It permits solar radiation transmission into the building envelope and prevents its reflection out of the inner environment when it becomes long wave; the transmitted solar radiation across window glass is able to increase the air thermal temperature of the inner environment to high values, more than external air temperature known as, "Greenhouse effect" (Al-rawi, 2008). It can also be offset by design and strategic use of vegetation. For a cold climate, the internal heat gain across window glass is welcome as it contributes to the heating of the building, whereas for a warm climate, the internal heat gain must be minimised since an additional heating of the building is undesirable. It underscores the main consideration of this study as it concerns the study area–a humid tropical urban settlement, Benin City, Nigeria.

Heat Flow/Air Temperature. Throughout the history of architecture and growth of cities, the building industry has always played a key role in shaping them, and this comes with a lot of associated environmental issues, primarily the problems and issues related to heat (Kannamma, 2012; Kanaan, Sevostianova, Donaldson &Sevostianor, 2021). Heat flow in buildings can occur in one, two or three dimensions. In almost all real situations, heat flow occurs in three dimensions or three primary mechanisms acting alone or in some combination of Radiation, Conduction and Convection (Straube, 2011; Aqilah, Rijal & Zaki, 2022). Heat flow in buildings can be mitigated through certain design considerations, which include building orientation, landscaping, site planning of appropriate use of adequate building air space (setbacks) and the use of building materials of low thermal conductivity, thus, facilitating temperature moderation in buildings. These design considerations enhance the building's thermal performance as an effective sustainable way of cooling buildings.

Relative to the study area, the value of air temperature is what necessitates the need to moderate heat flow in buildings, and the main factors that determine air temperature are: season, latitude, and the amount of cloud cover from the sun (Keenigsberger, Ingersoll, Mayhaw, and Szokolay, 1980). During the daytime, the coldest air temperature is just before sunrise and is desirable in buildings, while the hottest air temperature is two hours after noon and is the most undesirable in buildings. The air temperature then starts to decrease and continues to fall throughout the night. It is also the most noticeable characteristic of climate and the most important factor in determining heating and cooling energy use in buildings (Krisgger& Dorsi, 2004). At night, the heat absorbed and stored by surfaces is release back into the environment (Kieron & Tony, 2013) and is inadvertently prevented from escape into the atmosphere by the cloud cover, thereby raising the micro temperature, which in turn affects air temperature in buildings, necessitating cooling at night. To determine how cold or hot the air temperature is, a thermometer is usually placed at 1.2

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meters above the ground surface (Fondriest, 2010) and readings are taken. A properly exposed thermometer establishes the average temperature of air during a given period of time, usually a day, month or year; but the value of one year gives a reasonable accurate temperature of air.

METHODS

The Study Area. The study area is Benin City, and it is the administrative headquarters of Edo State (Figure 4). Benin-City lies roughly within latitudes 6020'N and 6058'N of the Equator and longitude 5035'E and 5041'E of the Prime Meridian (Okhakhu, 2010; Eseigbe, 2011). According to Buchanan and Pugh (1955), Benin City lies in the southernmost corner of a dissected margin: a prominent topographical unit which lies north of the Niger-Delta, west of the lower valley, and south of the western plains and ranges. Benin-City comprises three local government areas. Namely: – Oredo, Egor and Ikpoba-Okha. Benin-City occupies approximately an area of 607.48sqkm with an average elevation of 77.8m above mean sea level (Okhakhu, 2010; Ministry of Lands and Surveys, Benin-City, 2008). There are two notable prevailing air masses that are dominant in Benin City. These air masses, commonly called northeasterly trade wind (northeast trades) in the northern hemisphere, are undesirable in buildings and while the south easterly trade wind (southeast trade) in the southern hemisphere is desirable in buildings. The northeasterly trade wind is characterized by a moderately harsh harmattan, which lasts from December to January, while the arrival of the southeasterly trade wind comes with rainfall in the city region, bringing relief to the urban residents from the harsh harmattan weather (Agboola & Hodder, 1979; Agboola, 2011). The south-easterly trade wind in the southern hemisphere around the tropical city of Benin is being considered as it relates to the thermal performance of housing, vis-à-vis building orientation.

Urbanization is one of the several anthropogenic factors that result in land use and land cover changes. The increase in population growth, especially in the developing countries of the world, has brought about an increase in the rate of urbanization and a concomitant growth in cities around the world (Adeoye, 2012; Odjugo, Enaruvbe & Isibor, 2015). This activity has resulted in uncontrolled urban growth. According to the 2006 national population census, Benin City has a population of 1,147,188 with a projected population of 1.479 million by 2013 at an 8.66% growth rate (Taju & Andrew, 2017); and has also experienced land use and land cover changes due to an increase in population growth. This rapid territorial expansion of Benin City was mainly due to rural-urban migration, which influenced the siting of public institutions, such as schools, hospitals, government offices and industries (Odjugo, et al., 2015)

Edo State was created in 1991 out of the then Bendel State of Nigeria and subsequently divided into Edo and Delta states (UNDP on Human Development Reports-2003-2004). According to the USAID Strategic Plan (2004-2009), Edo State was estimated to have a population of 2.86 million in 2002, and in 1991, it had a population of 2.1 million, of which 64.47% lived in Benin City. This rapid population growth no doubt reflects a dynamic urban centre with lots of pressure on housing and different human activities. According to Akintola (1994), it includes industrial, commercial, agricultural, recreational, communication, sports and health services. The different Education, Transportation, Sanitation and Waste management services also constitute these modern urban characteristics (Okhakhu, 2010).

Rapid urban growth, as examined by Odjugo et al., 2015; Skole and Tucker, 1993; Lambin, Turner, Geist, Agbola, Angelsen, Bruce and Xu, 2001 and Perkin, 2013 is the leading cause of social, economic and environmental challenges, including loss of biodiversity, forest and agricultural resources, climate change and other issue related to the concentration of human activities. Akintola (1994) observed that urbanization has been a major process through which the physical landscape

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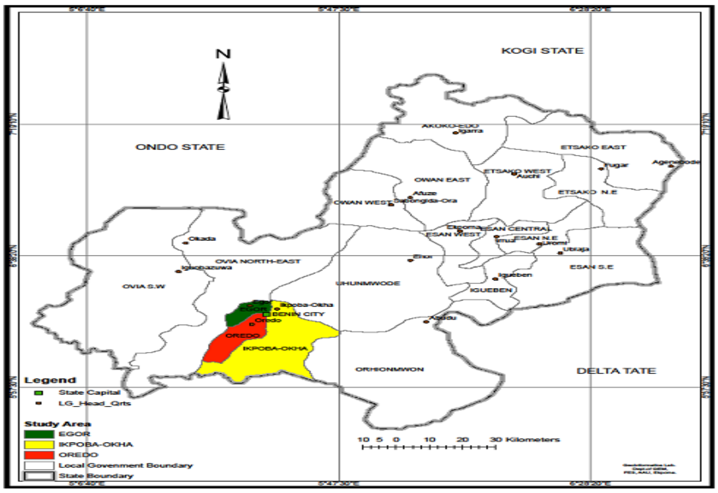
of most areas of the world has been altered. The process of urbanization, according to Akintola (1994), involves the clearing of natural forest for construction of houses and farming, leveling of the topography for infrastructural construction, planned transfer of soil for reclaiming swamps and filling up areas of weak soils alteration in the natural drainage pattern, as well as different land-use practices over the un-built areas of the city and the disposal of waste on various parts of the landscape. Okhakhu (2010) asserts that these human activities exert a strong influence on the natural climate cycle of the urban areas in such a broad dimension that peculiar urban climate characteristics, such as UHI, are produced permanently.

The survey was carried out in five neighbourhoods of the city: Ikpoba Hill, Government Reservation Areas (G.R.A), Ekehuan, Uselu and Ugbowo (Figure 5), which were selected on purpose. The study adopted a cross-sectional design to survey households in the study area. It stemmed from a multi-stage sampling technique where the research work progressed from the three local government areas of the city to the neighbourhood level, down to the ward level; from the ward level to the street level, and from the street level to the households of the respondents. In administering questionnaires, the convenience sampling technique was use in selecting respondents. A total of five hundred and fifty (550) structured questionnaires representing eleven percent (11%) of the population size of 5,000 across the five neighbourhoods (Table 1) were directly administered within the study area. In each of the five neighbourhoods, a total of 110 structured questionnaires representing eleven percent (11%) of a population size of 1,000 per neighbourhood was administered.

The population size was based on Convenience sampling, where two wards were selected per neighbourhood on purpose. Data on the estimated population size of the study was based on the registered 500 voters per ward, sourced from the Independent National Electoral Commission (INEC) of 2019-year general election in Edo State, and was adopted. The field survey was subjectively carried out by physical identification of buildings within the same locations; those buildings oriented longitudinally in the West-East direction and the nearest buildings oriented longitudinally in the North-South direction were used to compare their indoor temperature. To determine the influence of building orientation on indoor thermal conditions of buildings, data was analysis with the aid of ANOVA (F-Test), which allows test of multiple variables or components through a significant test.



Source: Department of Geography and Environmental Management, Ambrose Alli University, Ekpoma, Edo State, Nigeria (2017).

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Figure 4. Map of Edo State: Location of Oredo, Ikpoba-Okha and Egor Local Government Areas of Benin City

Source: Department of Geography and Environmental Management, Ambrose Alli University, Ekpoma, Edo State, Nigeria (2017).

Figure 5. Map of The Study Areas: Location of Ikpoba Hill, GRA, Uselu, Ugbowo and Ekehuan

RESULT AND DISCUSSION

Table 1 shows that 550 questionnaires were administered across five neighbourhoods. The percentage rate of retrieved questionnaires from respective neighbourhoods are; approximately 91% in Ikpoba Hill, 80% in GRA, approximately 96% in Uselu: in Ugbowo, approximately 82% and Ekehuan, approximately 95%. It indicated a successful mark of approximately 89% in the retrieval of administered questionnaires.

Table 1. Administered Across Five Neighbourhoods

Neighbourhood	Administered Questionnaires	Completed & Retrieved Questionnaires	Percentage of Retrieved (%) Questionnaires
Ikpoba Hill	110	100	90.91
GRA	110	88	80.00
Uselu	110	106	96.36
Ugbowo	110	90	81.82
Ekehuan	110	105	95.45
Total	**550**	**489**	**88.91**

Source: Author's field survey, 2020.

The study identified buildings based on their orientation. Figure 6 shows that only 58.3% of houses had their buildings oriented longitudinally in the North-South direction, indicating the longer side was facing sunrise and sunset.

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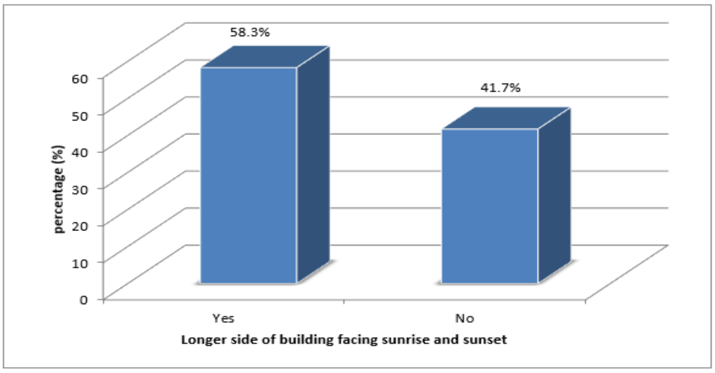

Source: Author's Field Survey, 2020.
Figure 6. Longer Side of Building Facing Sunrise and Sunset.

Table 2 shows a relationship Between Building Orientation and Indoor Temperature, which was tested with analysis of variance ANOVA with a coefficient of 0.070 in their relationship. The relationship was not statistically significant with a p-value equal to 0.792.

Table 2. Relationship Between Building Orientation nd Indoor Temperature

The longer side of the building faces sunrise and sunset	Indoor temperatures		Statistics
	Mean	**Std. Deviation**	
Yes	27.167	.7106	*F= 0.070
No	27.218	.7620	**Sig.= 0.792**
Total	**27.185**	**.7236**	

In Conclusion, there was no significant relationship between building orientation and indoor thermal condition among the buildings assessed in the study area.

Table 3 shows that Ikpoba and Ugbowo have the largest proportions of houses occupying more than 50% of the plot to be 53.0% and 44.4% respectively. The difference was significant (X2= 122.359, df= 12, p<0.001).

Table 3. Proportions of Houses Occupying

Zone	Percent of building area of the total plot				Total	Statistics
	30%	**40%**	**50%**	**Above 50%**		
Ikpoba	6	17	24	53	100	X^2= 122.359
	6.0%	17.0%	24.0%	53.0%	100.0%	df= 12
GRA	2	23	38	25	88	P< 0.001
	2.3%	26.1%	43.2%	28.4%	100.0%	
Uselu	18	30	49	9	106	
	17.0%	28.3%	46.2%	8.5%	100.0%	
Ugbowo	1	17	32	40	90	
	1.1%	18.9%	35.6%	44.4%	100.0%	
Ekehuan	8	35	61	1	105	
	7.6%	33.3%	58.1%	1.0%	100.0%	
Total			**240**	**128**		

Source: Author's field survey, 2020.

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As shown in Figure 7, only 20.2% of the buildings assessed were older than 20 years. The building age Mean was 13 (±8.9) years.

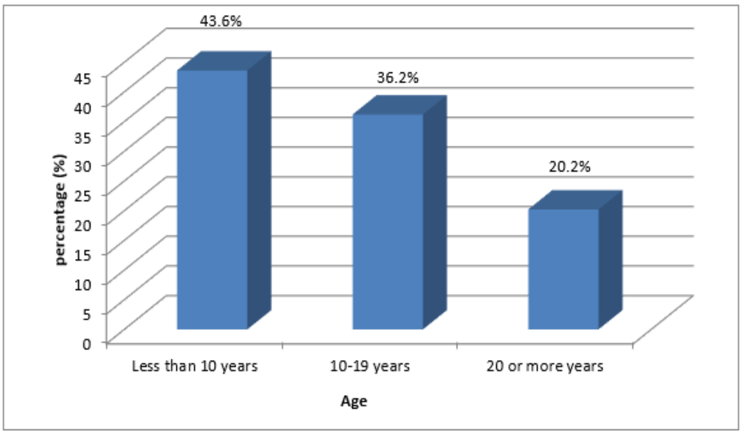

Figure 7. Age Of Buildings

Table 4 shows Building Features, Space and type of wall. The table indicates that one window per room was found in 63.2% of houses surveyed, while 19.8% were built as courtyard houses. The majority of the houses (76.7%) were built with sand screed, solid block walls.

Table 4. Building Features, Space and type of wall

Variable	Frequency (N= 489)	Percent (%)
Number of windows in each room		
one	309	63.2
two	152	31.1
above two	28	5.7
Minimum size of bedroom (Metre)		
2.4X3.0	58	11.9
3.0x3.0	124	25.4
3.0x3.6	273	55.8
3.6X4.2	29	5.9
4.2X4.8	5	1.0
Building with Courtyard		
Courtyard	97	19.8
Not courtyard	392	80.2
Type of wall		
Bricks	39	8.0
Sand screed hollowed block	74	15.1
Sand screed solid block	375	76.7
Earth walls	1	.2

Source: Author's field Survey, 2020.

Table 5 shows the cooling Practices of respondents outdoor. The table indicates the majority of the respondents (80.6%) sit outside to cool themselves, while 55.2% of respondents practice using a hand fan sitting outside the house to cool themselves, which is more when sitting in the verandah.

Table 5. Cooling Practices of Respondents Outdoor

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Variable	Frequency (N= 489)	Percent
Sit outside to cool self		
Yes	394	80.6
No	95	19.4
Use a hand fan to cool oneself when outside		
Yes	270	55.2
No	219	44.8
Use of a hand fan when in the verandah		
Yes	312	63.8
No	177	36.2

Source: Author's field survey, 2020.

Table 6 shows the surrounding buildings ' space distance to the neighbour and distance to the perimeter wall fence. The table indicates majority of the houses (70.6%) had a distance of 3 – 6 metres between neighbouring houses. A distance of 0.9 –1.2 metres between buildings and fence was observed in 56% of the assessed houses.

Table 6. The Surrounding Building's Space

Space Distance of building to the wall fence	Frequency (N= 489)	Percent
0.3 – 1.2m	274	56.0
1.5 – 1.8m	85	17.4
2.1 – 2.4m	64	13.1
2.7 – 3.0m	33	6.7
Above 3.0m	33	6.7

Source: Author's field survey, 2020.

The administered 550 questionnaires show approximately 89% were successfully retrieved, as shown in Table 1. Having assessed the effect of orientation on a building's indoor temperature as shown in Table 2, the result revealed a correlation that is not statistically significant (p= 0.792). From the table, it is observed that even in buildings that are properly oriented, there is no significant correlation between orientation and indoor temperature. This result could be explained by these factors.

1. From Table 3, out of the 489 sampled houses, 332 developed 50% or above of their plot area in the quest to maximise space to meet their need. It may have resulted in inadequate setbacks from the property wall fence, hence affecting air circulation around such buildings. It clearly revealed that a high number of buildings studied did not comply with the existing Town Planning Laws and Regulations for Building areas to develop less than 50% of the total plot size, and this is mostly observed in high-density areas of Ikpoba and Ugbowo. This practice always has a clear implication of nonconformity with the recommended North-South orientation of buildings, which is a major factor for energy consumption in cooling building interiors due to larger building surfaces absorbing and transmitting heat to the interiors, as well as reducing wind flow in buildings.
2. In Table 4, 63.2% of the 489 houses sampled have only one window in each room of their buildings. It may not allow cross ventilation to be possible as a natural way to ventilate a building and may make orientation ineffective for the tropical maritime airmass (south-west

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trade wind). Advertently, the majority of the respondents, 63.8% (Table 5), use various means like hand fans to cool their bodies when sitting in the verandah. It may be the consequence of not having more than one window in each functional space, responsible in a lack no air movement in and out of their buildings. Hence, the use of a hand fan to generate air movement even while sitting outside in the verandah.

3. Furthermore, Table 4 shows 76.7% of the houses were built with sandcrete solid block walls, while Figure 4.3 revealed only 20.2% of the buildings assessed were older than 20 years, with a mean building age of 13 (±8.9) years. It clearly shows that most of the buildings constructed are less than 10 years old, hence, are constructed from foreign building materials (sand screed blocks, metals and glass), making them more receptive to solar radiation and storage (Okhakhu, 2010). At sunset, the stored radiation is being re-emitted back to the environment, thereby undermining the effect of orientation in minimising the effect of heat absorption by surfaces and maximizing natural ventilation in buildings that would require low energy cost in cooling these buildings for human comfort.
4. Likewise, of the 489 houses assessed, Table 6 shows 56% have between 0.9 – 1 2 metre setbacks between their building's perimeter wall fence. This result implies that the majority of the houses do not have the minimum required setback of 3.0 metres from their party walls for air space, hence affecting adequate ventilation in their respective houses with increasing energy demand in cooling their buildings. It may have arisen from the fact that most of them built on or more than 50% of their plot size (Table 3), hence no adequate space to maintain the minimum required setback, thus impeding air circulation around buildings in such locations. Consequently, building orientation is ineffective for ventilation too.

Summarily, the natural method of cooling buildings relies on wind to force cool air into the buildings through inlets like wall louvres, a gable or open windows— at the same time, outlets allow warm interior air to go outside through vents via higher or opposite window openings. However, when buildings are not appropriately oriented, longer facades on East-West and windows are not toward the wind direction, coupled with inadequate air spaces (setbacks) and no outlet vents or windows, inhibiting cross ventilation in those buildings. Furthermore, buildings with one window in functional spaces make ventilation not effective, as reflected in Table 5, revealing, 394 out of the 489 (80.6%) respondents have to sit outside using a hand fan to cool themselves.

In contrast, this result negates the findings of Jackson and Jackson (1997); Al-Tamimi, Sharifah and Wan (2011); Odunfa, Dare, Adeaga, and Babalola (2013); Anumah and Anumah (2017) in their findings of building orientation as a strategy in energy lost in buildings in hot, humid regions.

CONCLUSION

The general result revealed that there was no significant relationship between building orientation and the indoor thermal condition of buildings. It being that, greater proportions of respondents had their buildings with longer sides facing sunrise and sunset, while at the same time majority of these buildings (76.7%) were built with sand screed solid block, which made them more receptive to solar radiation. In addition, very few of the respondents, 37.2% indicated their buildings were designed by an architect and in most cases, more than half of the respondents, 67.9% have their buildings occupying 50% or more of the total plot size. These sharp practices of designs done by non-professionals lack most basic design principles, which may increase the indoor thermal condition of the building, resulting from the distortion of air circulation. In other cases, it is observed that some building owners are adopting imported designs that do not response to the tropical

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climate, thereby making them thermal receptors. This result has also shown that majority of the houses do not have adequate setbacks for air flow/moment in and out of their buildings, ignoring or unaware of the problems of overheating in buildings being experienced in the tropical countries, rather most people rely mostly on the use of mechanical systems which seems to be a form of status symbol, neglecting the passive strategies in cooling buildings. These cumulatively resulted in high demand for energy to cool buildings, incurring high cost of electricity in the midst of epileptic power supply in Nigeria. Based on the findings of this study, the building development approval process should consider proposed designed buildings that integrate vegetation, appropriately orient buildings within the context of the environment with longer facades on North-South with adequate building setback, for wind flow in buildings, only.

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