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Adaptation to Heat Stress within Housing Estates in Akure, Nigeria

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Abstract: Adaptation to heat stress, human behavior and heat resistant characteristics of the residential environment are critical to achieving resilient human settlements. Through a survey of households in mass-developed housing in Akure (Nigeria), complemented by semi-structured interviews, this study identifies behavioural responses to heat and housing adaptations made to deal with heat stress. Top behavioural responses by the residents include using fans, keeping themselves hydrated, changing to lighter clothes and relocating to shaded space. The common post-occupancy adaptation measures include installing cooling devices, using light curtains and installing nets for windows and entrance doors. Heat resistant features that residents would want to be part of future housing development also came to the fore. These findings show that mass housing development should consciously incorporate heat resistance features while also promoting lifestyle approaches in adapting to heat.

Keywords: Adaptation; Housing; Heat Stress; Retrofitting; Thermal Comfort

1. Introduction

Nigeria is regarded as a hot country, and it is getting hotter with the changing climate. Persistently high temperature and extreme heat with the accompanying physical and health impacts are becoming a common experience in urban areas (Nigerian Meteorological Agency, 2017). The impacts can be physiologically and psychologically or otherwise. Omonijo et al. (2011) analysis of climatic data for the whole of Ondo State for 11 consecutive years (1998–2008) shows that 32.6% out of the study period was under strong heat stress - 36 – 42 degrees. This condition makes people prone to heat-related ailments and deaths. In their study of meteorological data from weather station on a university campus in Kano State, Alhaji and Ahmed (2013) revealed that thermal discomfort index (DI) values were 24.5, 26.5, 28.5 and 20 during the hot-dry, warm-wet, warm-dry and cool dry seasons respectively. These imply vulnerability to severe discomfort conditions, especially during the hot and humid season and in the afternoon when temperature is at peak. This potentially affects teaching and learning in the university. Morakinyo et al.'s (2016) study show that the period of consistently high temperature can affect occupational performance. Daniel (2015) have shown a positive significant relationship between increased monthly temperature and occurrence of heat rash in a Nigerian city.

Adaptation to heat stress, human behavioral responses and the heat resistant characteristics of the residential environment are critical to achieving resilient human settlements in Nigeria and beyond. Although human behavioral aspects are crucial to thermal regulation and adaptation during heat stress, it has received less attention in local and international literature compared with structural, institutional and technological mechanisms (Sawka et al., 2002; Zuo et al., 2015). Additionally, characteristics of the built environment, at home and elsewhere, affects adaptation to heat stress (Wilby, 2007) but is understudied in the Nigerian context.

There is knowledge gap in terms of the relationship between heat resistance features in housing and the built environment at large and adaptive capacity in Nigerian cities. Because of this, housing development is not substantively informed by adequate consideration for heat stress resistance in building (re)design, construction and management. This paper considers the behavioural responses and housing adaptations to heat stress. It is based on a study conducted in houses developed through government's mass housing scheme in Akure, Nigeria. The aim is to identify means of adapting to heat stress within mass-developed housing environment, thus providing insights for achieving thermal comfort in the context of increasing temperature associated with changing climate.

2. Bottom-up Adaptation, Human Behaviour and Heat Resistance in Housing

Increasing temperature and the associated impacts highlight the place of adaptation strategies. Some scholars explain that adaptation has generally utilized a top-down approach (Yeh, 2015; Mikulewicz, 2018). Government at different levels, at times together with some NGOs and consultants develop mitigation and adaptation strategies, without adequate attention paid to understanding what enhances individual and community resilience at the local level. This situation precludes the fact that approaches to coping with heat stress and other climate problems in Nigeria are largely individualised (Eludoyin, 2015). As Taiwo et al., (2012) argues, local knowledge based on perceptions, exposures and adjustments to seasonal heat waves can provide valid inputs into adaptation assessments. Hintz et al., (2018) analysed solutions to urban heat waves across some countries and covering different geographical context. Their review-based study 'emphasizes the importance of inhabitants as well as local governments as essential actors for adaptation to urban heat waves' (ibid:). Adaptation rooted in local knowledge within cities can be pursued at different spatial scales, starting from the building scale.

Human behaviour is critical in understanding adaptation at the building scale. People take different adaptive actions and exhibit thermal considerations in the use of space. Adebamowo and Olusanya (2012) identified behaviours that occupants within a student housing in Abeokuta, Nigeria adopt in response to heat. Opening windows and taking cold drink were the top two behavioural responses to heat. Going to the building's atrium, taking bath, changing cloth and switching on the air conditioner were other behavioural responses identified. Taiwo et al (2012) also found that switching on fans and/or air conditioner are the top responses in their study in Ibadan, Nigeria. Opening windows and doors as well as sleeping outside till late night are the least practiced responses. Similar studies conducted in the context of residential buildings outside Nigeria – in Australia (Soebarto and Bennetts, 2014; Hatvani-Kovacs et al., 2016), Taiwan (Hwang et al., 2009) and Japan (Rijal et al., 2015) also presents similar range of behavioural responses which include: doing nothing, wearing a sunhat, planning the day ahead, opening windows and/or doors to turning on the fans and/or air-conditioners.

Behavioral response to heat affects the use of different kinds of spaces – both indoor and outdoor, confirming that physiological comfort and the associated perceptions involve spatial and temporal variations (Eludoyin, 2015). This shows why Adunola and Ajibola (2016) found a correlation between the most thermally comfortable spaces and the most used spaces within the house at different periods of the day in their study of residential buildings in Ibadan. Hwang et al.'s (2009) work show that residents' choice of thermal adaptation behavior is generally influenced by their effectiveness, availability, cost among other factors.

Heat resistance features in housing and the built environment is also crucial to understanding adaptive capacity. This should start with the design approach for the residential building and its neighbourhood. In doing this however, Hatvani-Kovacs et al (2018) cautions that energy efficient design does not necessarily increase heat stress resistance in buildings. Conscious efforts are needed to shape the building form, its colour, orientation, furniture and fixtures, construction materials and methods as a means of resisting or adapting to heat stress. Literature includes some examples. In the tropics, it is common knowledge that ceiling insulation prevents excessive heat gain. In Nigeria, people living in houses without ceilings are subject to and complain of excessive heat (Muoghalu, 1984; Taiwo et al., 2012). Reflective and light-coloured materials for roofs and facades are more effective than darker colours in terms of reducing heat gain (Abimaje and Akingbohungbe, 2013). Furthermore, building orientation, walling type and materials affects thermal mass and has thermal comfort implications on the occupants (Ajibola, 2001; Akande, 2010). Vegetation, including trees, grasses, shrubs either indoor or outdoor are also useful at reducing ambient temperature and consequently dealing with heat stress (Akande 2010; Adedeji et al., 2010; Morakinyo et al., 2013).

Existing buildings that do not have the appropriate heat resistant features can be retrofitted or remodelled to improve their thermal performance (Akande and Olagunju, 2016; Abdulkareem et al., 2018). In the case of mass developed housing, owners may undertake post-occupancy changes in their dwellings to personalise the way they deal with persistently high temperature. Nnodu et al.'s (2017) study in Abuja suggests that residents are interested in such retrofits, especially incorporating the goal of energy-efficiency.

3. Study Area and Research Approach

Akure is the capital city of Ondo State, Nigeria. It is located on latitude 7'25°N and longitude 5'20°E, lying about 250m above sea level. According to the National Population Census, the city contains around 484,798 people in 2006, which is projected to have grown beyond 588,000 at present (National Population Commission, 2006). The mean annual relative humidity is about 77.1%, based on 1980-2007 data from the Nigerian Meteorological Agency. Average rainfall is about 1500mm per annum (Balogun et al., 2012).

Residential and territorial expansions associated with the rapid growth pattern affects the local climate. The medium sized city is notable for its high temperature – though not the highest nationally. Temperatures range averagely between 21.4 and 34.19°C, but this could be higher in built up areas due to urban heat island (Alaigba et al., 2018). Akindode et al.'s (2008) analysis of temperature and relative humidity data for Akure from 1992 to 2001 shows that daytime urban heat island intensity ranged between 0.5 and 2.5 °C within the study period. The characteristics of the urban heat island and heat stress in Akure, investigated by Balogun et al. (2010), indicates higher frequencies of high temperatures towards the city centre, which suggests a significant health risk and possibilities of physiological disorderliness. Ogunrayi et al.'s (2016) recent analysis of temperature trends in the city builds on these earlier studies. There is clear evidence of increase that indicates warming throughout the year.

To understand adaptation to heat stress through local eyes, data for this study was collected through a survey conducted in October and November 2017 – two of the hottest months in the year. Questionnaires were administered to households in two housing estates. Each of the estate contains housing typologies mass-developed, from 2006, through the federal or state government's public-private partnership housing programme. Seven of such mass-housing developments had taken place in Akure within the last decade (Adegun and Taiwo, 2011). Two of these were chosen due to their level of completion and high percentage of occupation as well as ease of conducting survey within the estates.

The questionnaire contained four sections which solicited for information about the respondents, the housing characteristics, personal responses to heat stress and heat resistant features in the built environment. 150 questionnaires were administered to randomly selected households in the estates. The household head or adult in the randomly selected households completed the questionnaire. Only 145 questionnaires were returned and used for analysis presented in this paper. To follow-up on the survey, semi-structured interviews were conducted with 3 residents in the estate. Result of the survey was briefly presented in course of the interviews. This helped to generate relevant nuances and complement the earlier findings.

4. Results and Discussion

Information about the age and level of education of those who responded to the survey is presented in figure 1. Of the 145 respondents, 27% were aged between 25 and 34 years while 30% were between the ages of 35 and 44 years. There is no one less than 18 years. Only 14 (10%) respondents were older than 55 years. Majority of the respondents (69%) were educated up to the tertiary level. There is no respondent without any form of formal education.

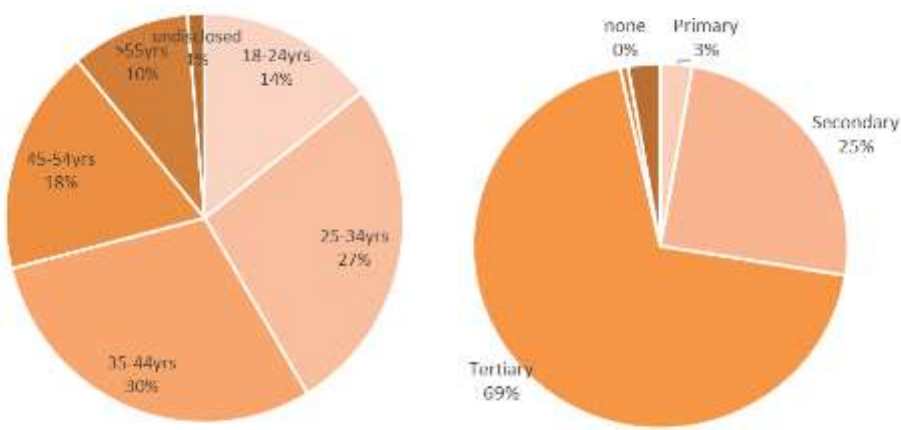

Figure 1. Age and educational level of respondents.

Housing Characteristics

The survey sought to understand the material character of the respondents' dwellings and their contents. Table 1 shows the material characteristics, and colour, of houses where the respondents live. The external walls are majorly made from hollow sandcrete blocks, being the common wall construction material in Nigeria while the roofs are majorly covered with corrugated aluminium/iron sheets (See Table 1). Pink, red and brown, at 26.2%, 21.4% and 16.6% respectively, are the top three colours for the roof covering. Most of the houses are sealed, with asbestos sheets (32.4%), PVC boards (32.4%) and POP (23.4%) being the top three materials used. Altogether, about 88% of the houses use these materials. Over half of the internal walls have a light colour – white (47.5%) and yellow (10.3%). Ceramic tile is the popular flooring material as majority (70.3%) of the houses are covered with it (See Table 1).

As stated earlier, housing construction materials are crucial factors in the heat resistance capacity of residential buildings (Akande, 2010; Hatvani-Kovacs et al., 2016a). The popular use of ceramic tiles is good in coping with heat because of the cold sensation they give to the bare feet. Light colours in the internal walls are good for reflection. Ceilings prevent excessive heat gain thus improving indoor temperature. The colours of the mostly aluminium/iron roofing sheet are not so light, and this is not good for heat reflection. These show that the housing features were not completely heat resistant. Their choices in course of architectural design must have been influenced by several factors, of which heat resistance is one and not necessarily a priority.

Table 1. Characteristics of the Respondents' Dwellings

	Types	**No**	**Percent**
Material of External Walls	Sandcrete blocks	132	91.0%
	Bricks	9	6.3%
	Others	4	2.7%
Colour of Internal Walls	White	69	47.5%
	Blue	27	18.6%
	Red	7	4.8%
	Green	13	9.0%
	Yellow	15	10.3%
	Purple	3	2.1%
	Brown	5	3.4%
	Others	2	1.4%
Roof Material	Iron sheet	135	93.1%
	Tiles	3	2.1%
	Concrete	1	0.8%
Roof Colour	White	8	5.5%
	Black	6	4.1%
	Blue	16	11.0%
	Red	31	21.4%
	Brown	24	16.6%
	Pink	38	26.2%
	Others	17	11.7%
	Undisclosed	5	3.4%

Flooring Material	Ceramic tiles	102	70.3%
	Mortar	14	9.7%
	Timber	6	4.1%
	Terrazzo	7	4.8%
	PVC tiles	1	0.7%
	Others	15	10.3%
Ceiling Type	Timber boards	12	8.3%
	POP	34	23.4%
	PVC boards	47	32.4%
	Asbestos	47	32.4%
	Undisclosed	5	3.4%
Material of Key Furniture	Cotton	64	44.1%
	Plastic	15	10.3%
	Furry fabric	53	36.6%
	Non-furry fabric	10	6.9%
	Undisclosed	3	2.1%
	GRAND TOTAL	**145**	**100**

Behavioural responses to heat

To understand personal adaptation, respondents answered questions about their behavioural responses, within and/or around the house, when persistently high temperature leads to heat stress. They chose from a list of responses presented in the questionnaire. Using a fan (electric or manual - by hand), hydration (drinking fluids), changing to lighter clothes and relocating to a shaded space outside the house are the top four behavioural responses (See Table 2). Putting on lighter clothes aids sweat evaporation and allows air flow into the skin. Hydration reduces excessive loss of body fluids. The top responses from this survey are similar to what Taiwo et al., (2012) and Adebamowo and Olusanya (2012) found out from their studies in two other Nigerian cities. These top responses are generally included in the list of tips publicised about dealing with extreme heat from government agencies such as the National Emergency Management Agency (NEMA, 2013) and Nigerian Meteorological Agency (NIMET, 2017).

Behavioural responses mentioned during the follow-up interviews concur with those emanating from the survey. An interviewee acknowledged that occupants in the same room/building will not respond in the same ways due to differences in physiological make-up and human experiences (personal communication, Ms W, August 2018). The statement ‘I don’t feel hot … though my wife enters the rooms and says she is feeling hot’ by another interviewee (personal communication, Mr J, August 2018) confirms the earlier point on physiological differences in response to heat. Behavioural responses to heat also vary across the two seasons (wet and dry) in Nigeria.

The rarest forms of responses include doing nothing, searching for information from books or online(internet), listening to the weather forecast and asking for help from others (See Table 2). In a study conducted in Adelaide, Australia, asking help from others was also one of the least things people do in response to heat stress (Hatvani-Kovacs et al., 2016b). Although majority of the respondents are educated up to tertiary (69%) and secondary levels (25%) (see figure 1), the study could not ascertain what is responsible for the situation where most of them do not search or seek for information from relevant sources indicated. Answers in this section show that behavioural responses to persistently high temperature are largely reactionary rather than proactive. The respondents would rather adjust to the heat – doing something when it comes - than anticipating and making adequately informed preparations to prevent the negative experience.

Table 2. Behavioural Responses to Heat Stress

Responses	**Yes**	**No**	**N/Applicable**	**Undisclosed**
Use fan (ceiling, pedestal)	133	11	2	0
Drink plenty of water/fluid	132	11	-	2
Wear light or loose clothing	131	11	-	3
Seek/spend time in the shade	124	19	1	1
Fan yourself by hand/manually	124	11	9	1
Open doors/windows/curtains	117	19	8	1
Move outdoors	113	27	2	3
Go to shower	111	21	12	1
Avoid/reduce activities	110	28	6	1
Use natural ventilation at night	108	27	7	3
Draw curtains	104	36	3	2
Move to cooler room in the house	101	32	10	2
Use air conditioner	95	40	9	1
Go to sleep	75	63	6	1
Plan the day to stay out of heat	47	42	55	1
Go to swimming pool	46	66	32	1
Wear a hat/cover head	45	69	30	1
Apply sunscreen (sun cream)	39	56	49	1
Check/Listen to weather forecast	31	52	61	1
Ask for help from others	31	45	68	1
Search for coping information online or in books	26	57	61	1
Do Nothing	20	43	80	2

Heat resistant features in housing

This study investigated what might be considered as heat resistant features in and around the respondents' dwellings. Being mass housing typologies, one assumes that each of the buildings have similar features. Notwithstanding the survey checked what was available before respondents occupied the dwelling and captured features that were later installed or alterations made to the dwelling to provide heat resistance or help to cope during heat stress. The results are presented in Table 3.

Although the houses occupied included design features for some form of passive cooling/thermal control, this wasn't enough as respondents made structural alterations primarily targeted at heat resistance. Based on the survey, residents majorly install and use different kinds of mechanical (e.g. air-conditioners, table/wall/ceiling fans) and non-mechanical cooling (e.g. hand fans) devices when there is persistently high temperature (See Table 3). Using lighter curtains and window/entrance door nets were also top on the list. Entrance doors and windows were installed with nets to keep away mosquitoes and other insects whenever the doors or windows are opened for improved air flow (ventilation). Painting internal walls with light colours is another notable post-occupancy measure. As earlier pointed out in literature (Abimaje and Akingbohungbe, 2013), the light colours are good for heat reflection, thus keeping it away rather than absorbing it. Double walling and insulated walling were largely not applicable, given the geographical context in Akure and Nigeria. It was observed that ceiling materials are also replaced to improve thermal insulation.

Features	Available before occupation	Implemented after occupation	Not applicable	Undisclosed
Light coloured roof	110	21	13	1
Roof insulation	64	22	57	2
Roof Ceiling	82	50	11	2
Double walling	14	21	106	1
Insulated walling	25	25	91	4
Light coloured internal walls	53	78	11	3
Ceramic floor/wall tiles	54	60	28	3
Glazing	42	47	54	2
Air Conditioner	29	87	26	3
Ceiling/Wall fans	33	99	10	4
Standing/Table Fans	10	111	21	3
Outdoor shady plants in the garden	47	52	45	1
Solar panels	39	56	46	4
Verandah/balcony	56	46	40	3
Awning	75	35	33	2
External blinds or shade clothes	51	30	60	4
Pergolas/Outdoor living areas	36	54	51	4
Building orientation	55	41	46	3
Using energy saving bulbs	97	35	10	3
Lighter curtain material	27	112	4	2
Entrance nets	21	104	18	2
Window nets	63	76	4	2

Through the interviews, residents identified and suggested what they consider crucial in making their houses more heat-resistant and possibly for future mass housing projects. These include vegetation (especially trees around the houses), plastering internal walls with POP

(Plaster of Paris), ceramic tiles and not just ordinary mortar, generous headroom (enough floor to ceiling height). In a notable situation, expressing his sentiment on generous headroom, an interviewee said 'I don't open windows. That cannot stop the house from being hot. For the room not to be hot, the height between floor and ceiling must be high' (personal communication, Mr J, August 2018). Others include using high quality construction materials, incorporating shading elements (e.g. terraces, longer eaves), proper building orientation, installing cooling devices (e.g. fans, air conditioners) and optimal internal arrangement.

These suggestions concur with known measures for passive and active thermal control for buildings in the tropics. That they are being mentioned by lay people shows that their incorporation in the design of individual and prototypical residential buildings need to improve and probably be enforced. Architects and allied professionals have a role to play in this regard.

4. Conclusion

Through the case of mass housing estates in Akure (Nigeria), this study shows what the residents have been doing themselves and what they think should be done in terms of adaptation to heat. These further understanding about adaptation to heat stress at the household level through local eyes. Material characteristics of housing in the study area and how they contribute to coping with persistently high temperature was shown. It became clear that negative impact of heat stress prompts post-occupancy alterations in the houses. These point to possible means of retrofitting existing housing stock to enhance capacity for heat resistance, as well as improving thermal comfort.

From the findings on behavioural responses taken to cope with heat stress, it can be inferred that lifestyle approach to adaptation can be enhanced, especially promoting preventive rather reactionary approaches. Additionally, housing design and development needs to incorporate more heat resistance features, so that occupants are saved the burden of making additional features later. This should take place at the design stage and architects have a role to play in this regard. Heat impact assessment can be carried in housing estates to comprehensively understand the effect of heat stress and how to further tackle it. Overall, coping with heat stress at the local level should receive more attention from residents and relevant stakeholders.

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