Cite this article
Adegun OB (2024)
Strategies for addressing exposure to extreme heat in a slum community.
Proceedings of the Institution of Civil Engineers – Municipal Engineer **177(2)**: 53–63,
https://doi.org/10.1680/jmuen.23.00022

Research Article
Paper 2300022
Received 31/05/2023;
Accepted 04/12/2023;
First published online 19/12/2023

Municipal Engineer

Strategies for addressing exposure to extreme heat in a slum community

Olumuyiwa Bayode Adegun PhD
Senior Lecturer, Department of Architecture, Federal University of Technology, Akure, Nigeria; Visiting Senior Lecturer, School of Architecture and Planning, University of the Witwatersrand, Johannesburg, South Africa
(Orcid:0000-0003-1045-4447) (muyiwaadegun@yahoo.co.uk)

Climate change is resulting in higher temperatures and the problem of heat stress, which significantly affects urban population. Poor households living within low-income urban communities are disproportionately affected by these problems. This paper reports an investigation of coping strategies among residents in a low-income community within Lagos, Nigeria. The study utilised a mixed-method approach – community survey (sample size = 300 residents) and semi-structured interviews with 15 purposively selected residents. The survey data were analysed statistically, whereas content analysis was carried out on the interview transcripts. The findings indicate a range of personal/behavioural preventive and reactive strategies and building-related measures were utilised to address the challenge of increasing heat within the community. Notably, greening-related practices (for planting trees, cultivating gardens) did not rank high among the residents. They are willing to pay a modest amount towards greening and environmental features but not as much as housing modifications to enhance thermal comfort in the face of extreme heat. The study contributes to evidence of local coping strategies for heat exposure among disadvantaged urban residents, providing a pedestal on which heat adaptation initiatives can be developed.

Keywords: buildings, structures & design/climate change/temperature effects/UN SDG 11: Sustainable cities and communities/UN SDG 13: Climate action

1. Introduction

The intensity, frequency and duration of extreme temperatures are increasing due to climate change. The unfolding exposure to heat is putting more people at risk. This is specially a concern for countries where the living conditions are poor. Of the estimated 2 billion people who could face dangerous extreme heat in the coming decades, over 600 million are from India and over 300 million from Nigeria (Lenton *et al.*, 2023). The others are mainly from developing countries; these are the poorer people on the planet, living in some poorest communities of the world, especially within urban centres. Over 50% of urban residents are estimated to live in such areas categorised as slums and informal settlements within sub-Saharan Africa (UN Habitat, 2012).

The ongoing and projected challenge of heat exposure poses a significant concern for higher heat-related morbidities and mortalities. Most heat-related morbidity and mortality should be preventable with improved preparedness especially those which are based on good understanding of heat adaptation strategies (Ebi *et al.*, 2021). It is therefore important to consider, from various dimensions (e.g. infrastructural, behavioural), how people respond or will respond to heat stress, especially in the context of low-income informal urban communities that dominate African cities. This article reports a study undertaken within a low-income slum community in Lagos, Nigeria. It starts by reviewing the existing body of knowledge on extreme heat and the range of coping strategies within informal, low-income urban settings across developing countries. The study area and method were described before presentation and discussion of the findings.

2. Literature review

Although heat stress is a notable global urban problem, a growing body of literature shows a local dimension within cities. Studies have established that heat exposure within informal, low-income urban settlements in developing countries is significant. The emerging consensus within existing body of knowledge is that residents of informal, low-income urban communities within tropical countries experience higher temperature and prolonged heat stress year-round.

Experimental studies, involving climate data logging and simulation, have been carried out to establish high exposure and vulnerability to higher temperatures within informal and low-income areas. Temperatures were measured within three informal neighbourhoods (Kibera, Mathare and Mukuru) in Nairobi, Kenya during a very hot summer in the city (Scott *et al.*, 2017). The study shows that temperature within the informal areas regularly exceeds the temperature at the central, non-slum monitoring station by several degrees. In the same vein, Ramsay *et al.* (2021) monitored indoor and outdoor thermal conditions at home across 12 informal settlements in Makassar, Indonesia. They found that the residents experience chronic heat stress conditions, which are underestimated by measurements at weather stations. Another example comes from a study that monitored indoor environments (temperature) within informal settlements in Pretoria, South Africa (Hugo and Sonnendecker, 2023). The informal dwellings perform poorly in terms of thermal properties. The residents experience 6–10 h daily extreme heat stress conditions at the peak of summer. The general knowledge is that housing construction material is usually a notable contributor to indoor temperature and heat stress conditions (Jay *et al.*, 2021).

In comparative terms, residents in informal settlements experience higher heat exposure when compared with people within formal and middle-to-high-income neighbourhoods. This is affirmed by a few studies. For example, a survey across two socio-economically different neighbourhoods in Akure, Nigeria (Adegun and Ayoola, 2022) and geographic information system-enabled estimation of city-wide land surface temperatures across different areas in Mumbai, India (Mehrotra *et al.*, 2018) both affirm that poor urban households living within informal areas are more vulnerable and disproportionately affected by extreme heat.

It is important to note that exposure to higher temperature leads to health challenges. Heat-health challenges often experienced by the informal settlement residents include headache, malaria, skin rashes, heat stroke, high blood pressure, sleep impairment, anger/aggression, typhoid and diarrhoea, as reported in Tanzania (Adegun *et al.*, 2022; Pasquini *et al.*, 2020), Nigeria (Adegebo, 2022) and other African countries (Hambrecht *et al.*, 2022; Laue *et al.*, 2022). Health problems are further complicated by poor access to adequate and affordable health care.

Different strategies have been deployed to facilitate adaptation to heat stress within informal urban settlements. Some of the strategies are physical – that is, they involve changes in the residential building and/or its immediate built environment. Many scholars and practitioners have advocated the need to improve heat resilience of dwellings within low-income urban areas through investment in the physical and natural environment. Strategies proposed include building retrofits, developing vegetation and green spaces and incremental slum upgrading (see e.g. Akinwolemiwa *et al.*, 2018; Laue *et al.*, 2022; Loggia *et al.*, 2015).

Among the possible building-related coping measures, alteration of building envelope (especially changes on the roof) appears to hold potential for significant benefits. Nutkiewicz *et al.* (2022) argue that up to 98% of annual heat stress exposure in informal settlements within the tropics can be mitigated by improving the building envelope. Through simulations they found that cool roofs, as a universal solution, can reduce up to 91% of annual heat stress exposure in cities within the tropical setting. The implementation of thermocol insulation and solar reflective white paint on roof surfaces in houses within a slum in Ahmedabad (India) effectively reduced indoor temperature (Vellingiri *et al.*, 2020). Similarly, a simulation study by Hugo (2023) for the Pretoria geography shows that 'cool roof paints can currently lower excessive heat stress conditions by 42–63% when applied to high thermal mass dwellings with poorly insulated lightweight corrugated sheeting roofing'. The effectiveness of cool roof paints in the future 2100 climate scenarios reduces. It might only lower heat stress conditions by 12–17%.

Greening is a notable strategy useful in addressing heat exposure. Studies that have dealt with greening within slums and informal settlements generally show that home gardens, trees, parks and other forms of informal green open spaces can offer services that meet human needs in relation to regulation of the local neighbourhood climate and indoor temperature (Adegun, 2017). An experimental project on vertical greening within a low-income neighbourhood in Lagos is exemplary (Akinwolemiwa *et al.*, 2018). Vertical greening prototypes constructed using bamboo and high-density polyethylene were installed on the blank walls of some dwellings. After monitoring for 5 months (across wet and dry seasons), the greening interventions provided average 2.3°C reduction in indoor air temperature, thus enhancing thermal comfort.

Apart from measures related to changes and interventions in built and natural environments, people often undertake individual initiatives to cope with during heat stress conditions. These are largelybehavioural responses, which have been identified by some scholars. Adebamowo and Olusanya (2012) and Taiwo *et al.* (2012) show some of these behaviours through studies in Abeokuta and Ibadan, Nigeria. They identified responses such as opening windows, having cold drinks and using fans as the notable among residents. Their studies were however not delineated to the context of low-income urban communities.

Behavioural responses by residents within informal settlements have been reported by a few scholars. In the survey of 405 residents in Keko Machungwa neighbourhood in Dar es Salaam, Tanzania, Adegun *et al.* (2022) found that taking a shower/bath; wearing light clothing; having cold drinks (hydration) and opening doors and windows were the most popular responses to heat stress conditions. The rarest responses are swimming and contributing to savings. A study within a Kolkata slum shows that using a fan, resting, drinking water (hydration) and moving to a cooler room were identified to be the most practiced heat-coping strategies (Mukhopadhyay and Weitz, 2022). The Kolkata study observed that there is no gender disparity, as both elderly men and women engaged in these responses in a similar pattern.

The kinds of responses made depend on several factors including available facilities, knowledge and resources. For instance, hydration through drinking water and other non-alcoholic beverages is common because these are easily within reach. Using air conditioners or swimming is rarely practiced because the poor households usually cannot afford such facility. More knowledge is needed about these responses, especially for people living within informal urban areas in the African setting.

3. Study area and research methods

This study was undertaken in Lagos – Nigeria's commercial capital, where increasing temperature and exposure to heat present a growing concern. Approximately 0.5°C monthly mean temperature increase was recorded in the period 1980–2018 in Lagos (Oppermann *et al*., 2021). Urban heat island (UHI) intensity in Lagos could be up to 7°C (Ojeh *et al*., 2016) with the areas over which ensemble-time-mean UHIs exceed 1°C sharply increasing from 254 km^2 in 1984 to 1572 km^2 in 2016 (Bassett *et al*., 2020). These temperature increases pose significant challenge to human health, especially for the notable population of low-income, socio-economically weak and disadvantaged residents (Borg *et al*., 2021; Laue *et al*., 2022).

A community known as Idi-Araba/Mosafejowo in Oworonshoki area of Lagos served as the case neighbourhood in this study. It was chosen given earlier smooth research engagements in the neighbourhood. The community leaders were welcoming of researchers that provided an easy access to participants. The emergence of the community is traced back to the 1980s, when it evolved as a small fishing settlement. It has grown over years such that by 2015, it contained 188 houses and 516 households (Lagos State Government, 2015). It consisted mostly young people – 88% are aged 21–40; 67% work in the informal sector, whereas 67% had junior secondary education. There are 59 and 39% households with sizes of 1–4 and 5–9, respectively (Lagos State Government, 2021). A 2019 enumeration shows there are ~2456 persons within 709 households, with males representing 50.91% of population in the community (Lagos Urban Studies Group, 2019). These are comparable with the findings from the current study, shown in Table 1.

This study, part of a larger work on climate adaptation, follows a mixed-method approach involving two sequential activities. First, semi-structured interviews and second a survey of residents. Through purposive sampling, 15 residents were selected and interviewed. The selection criterion is that all the interviewees were adults who had lived in the community for a minimum of 12 years. This length of stay meant the interviewees can make well-informed comments on climatic issues based on experience. The community leadership team facilitated selection (based on the stated criterion) and access to the residents interviewed. The participation of residents was voluntary, and they gave clear verbal consent to participate in the study and be audio-recorded before interview started. The selected residents were questioned about their experiences of extreme temperature within the community and how they cope with. Most of the interviews were conducted by the author in the Yoruba vernacular language for easy understanding. Audio-recording of the interview session was allowed by 14 out of the 15 interviewees. The recordings were later transcribed/translated before coding and content analysis.

Table 1. Socio-economic characteristics of the respondents

Attribute	Characteristics	Frequency, *N* = 247	%
Age	18–24	21	8.5
	25–34	55	22.2
	35–44	69	27.8
	45–60	62	25.0
	Above 60	31	12.5
Level of formal education	None	34	13.7
	Primary	79	31.9
	Secondary	69	27.8
	Tertiary	40	16.1
Household size	1	30	12.1
	2–4	69	27.8
	5–8	75	30.2
	Over 8	64	25.8
Employment status	Self-employed	121	48.8
	Employed by others	82	33.1
	Not employed at all	17	6.9
	Retired	12	4.8
Monthly household income	Below ₦30 000 (US$ 79)	112	45.2
	₦31 000–75 000 (US$ 198)	79	31.9
	₦76 000–150 000 (US$ 396)	12	4.8
	₦151 000–250 000 (US$ 660)	8	3.2
	₦251 000–500 000 (US$ 1319)	3	1.2

A survey followed the interviews. Some issues emanating from the interviews and from literature informed design of questionnaire used in the survey. On the basis of the formula of Krejcie and Morgan (1970), a sample size of 333 was derived from the ~2456 estimated settlement population. This was scaled down to 300, given time and resource constraints in the study. Five residents were recruited and trained to assist with questionnaire administration. The field assistants conducted the survey by interviewing each resident (the respondent) and filling answers in the hard copy questionnaire or dropped it (and returned to collect) for those who wanted to complete the questionnaire themselves. Of the 300 questionnaires administered in total, 270

Table 2. Housing characteristics of the respondents

Characteristics	Description	% ($n = 247$)
Tenure status	Owned/landlord	38.8
	Rented	37.6
	Family house	23.2
	Others	0.4
Monthly rent	Less than ₦5000 (Less than $13.89)	28.1
	₦5001–15 000 ($13.89–41.67)	43.7
	₦15 001–25 000 ($41.67–69.44	23.7
	₦25 001–50 000 ($69.44–138.89)	3.0
	Over ₦50 000 (Over $138.89)	1.5
Source of water	Municipal pipe-borne water	34.0
	Community/private borehole	32.4
	Well	5.8
	Tanker delivery	2.9
	River/ocean	5.0
	Sachet/bottled water	19.9
Sanitation	Water closet within the house	32.2
	Water closet outside the house	45.9
	Community toilet	5.2
	Pit latrine	10.3
	Open defecation	6.4
Source(s) of electricity	Grid only	25.5
	Grid + private generator	62.5
	Generator only	8.9
	Grid + generator + solar	2.1
	Solar only	0.5
	Others	0.5
External wall material of buildings	Raffia palm	2.1
	Mud	6.2
	Sandcrete block	60.1
	Iron sheets	0.4
	Timber/planks	13.6
	Tarpaulin	2.9
	Burnt bricks	1.6
	Concrete	12.3
	Expanded polystyrene	0.8
Roof covering	Zinc or aluminium sheets	82.6
	Others (e.g. tarpaulin, timber)	17.4
Roof covering colour	White	12.8
	Off-white	15.8
	Black	11.1
	Blue	11.5
	Red	5.1
	Brown	27.8
	Green	15.8
Floor finish	Ceramic tiles	14.0
	Cement mortar	27.2
	Timber	7.0
	PVC tiles	12.8
	Terrazzo	4.5
	Carpet	15.2
	Rug	19.3
Ceiling type	No ceiling	9.7
	Timber boards	4.2
	Plaster of paris	13.5
	PVC	33.3
	Asbestos	24.5
	Paper	10.1
	Fabric	2.1
	Others	2.5

were retrieved. After screening for completeness, only 248 were analysed and reported in the article. This return rate of the sample size meets minimum requirement for statistical analysis.

The field work activities (both interview and survey) were guided by ethical considerations. The study procedure was earlier subject to institutional ethical review at the Federal University of Technology, Akure, Nigeria. Confidentiality and anonymity of the information was promised to the participants and ensured during data collation and analysis. As indicated earlier, voluntary participation was also ensured by obtaining informed consent from the interviewee and survey participants.

4. Results and discussion

4.1 Residents and settlement characteristics

Information about socio-economic, housing and neighbourhood conditions in the settlement is shown in Tables 1 and 2. Among the residents who participated in the survey, 52.8% were male, 46.8% female – a ratio that aligned with what was reported in the 2020 Lagos State Household Survey Report. Around a quarter are 35–44 years (27.8%) as well as 25–34 years (22.2%). Around half (48.8%) are self-employed, whereas 6.9% are unemployed. The self-employment rate is close to 45% reported in the 2020 city-wide household survey report but the unemployment percentage is much lower than 29.9% reported in city-wide survey report (Lagos State Government, 2021). Majority are educated, as only 13.7% had no formal education. The highest proportion (45.2%) had a household income below ₦30 000 (approximately US$ 66), which is much lower than the national minimum wage or the global $2 per-person daily international poverty line. A few households (representing 1.2%) had over ₦250 000 (US$ 544) monthly income.

Information about housing characteristics of residents and other related conditions is presented in Table 2. The highest percentage of the respondents is landlords/homeowners (38.8%), followed by renters at 37.6%. Almost half (43.7%) of the renters pay between ₦5001 (US$ 13) and ₦15 000 (US$ 40) as monthly rent. About one-third (34%) of the respondents get water from pipe-borne municipal sources, usually by paying a small amount at communal tap points. Municipal water sources are not connected to the homes. Another 32.4% of the residents rely on community or private borehole, which are at times free to fetch but of lower quality compared with the one municipally supplied. In terms of sanitation, the majority uses the water closet, either located within (32.2%) or outside the house (45.9%). The settlement has formal electricity connection, with 88% having their houses connected to the electricity grid, and only 12% are not connected. From the 2020 Lagos Household Survey report, 90% of the respondents use electricity from the grid. Due to frequent power cuts, majority of the residents uses small power generators (62.5%) to complement

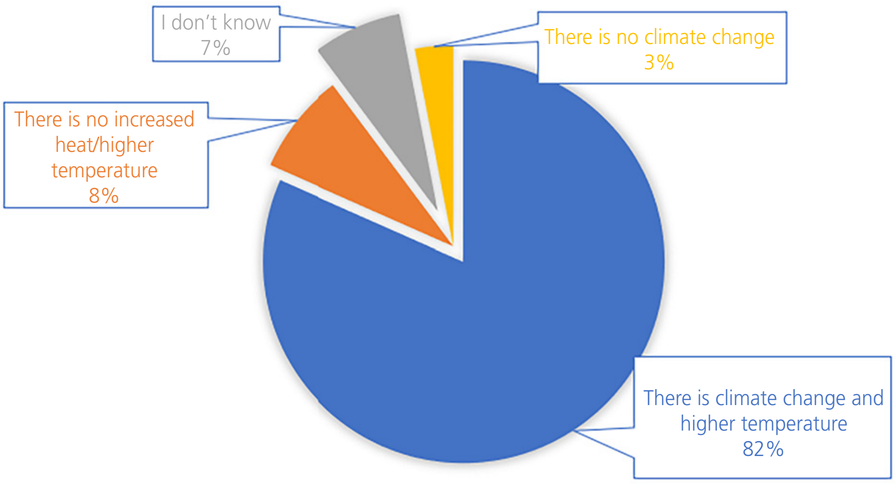

Figure 1. Perceptions of residents on climate change and heat

electricity from the grid. Only a very few (2.6%) get household electricity through solar systems.

The houses are majorly (60%) walled with hollow sandcrete blocks, which is the conventional and relatively cheap walling material in most parts of Nigeria. About 52.1% respondents indicated that the external walls are not plastered. The materials used to construct houses in the neighbourhood (shown in Table 2) possess varying, and largely poor, capacities in terms of providing thermal comfort. For example, 60% of the houses have their walls made from hollow sandcrete blocks. This material has very poor thermal properties both in wet and dry seasons (according to Muhammed *et al.*, 2022), thus predisposing the indoor environment to excessive heat.

Corrugated zinc or aluminium sheet is the dominant (82.6%) material for roof covering. They are available in a range of colours. Floors are usually finished or covered with materials such as cement mortar (27.2%), rug (19.3%), carpet (15.2%) and ceramic tiles (14%). The community also contains buildings with stilts located on the waterfront. The wall, floors and frame are usually made from timber. A few houses (representing 9.7%) are not ceiled. Asbestos and polyvinyl chloride (PVC) boards are the common ceiling materials. On the basis of the assessment of the respondents, 54.7% believe their buildings only need minor repairs, 18.7% think they are okay, whereas to some 1.6%, they are not habitable.

4.2 Perceptions of climate change and heat-related outcomes

The survey investigated the perception of the residents about climate change and the resulting problems of higher temperatures. From the results, illustrated in Figure 1, 80% of the residents agree that temperature has increased as a result of changes in the global climate system. On the contrary, a few persons (representing 2.8% of the respondents) do not believe there is climate change. Some 8% of the respondents do not believe there are higher temperatures, whether linked to climate change or not.

The survey result affirms notions expressed during the semi-structured interviews. In a lay manner, one of the residents explained that the 'climate is changing because the sun has increased beyond what it used to be. The heat has increased. The weather this time is too much, the house is hot, there is heat at night and in the morning, especially when there is no electricity' (personal communication, Interview 12, December 2019). Another description of the change (increase) in temperature is that 'if the rain fells nowadays there will still be heat, even more heat. The sun is more than the olden days. That people cry out that the sun is much even during rainy season which is not supposed to be' (personal communication, Interview 5, November 2019).

Apart from global climate change, the residents opine that housing development has reduced the quantity of green and open spaces within the community. The ensuing UHI phenomenon thereby alters the temperature conditions in the local climate. As explained by a resident, 'the heat has increased. Because when we first got here, everywhere was cool in this community. Houses were few then and breeze from the sea usually blows here. It was very cool than what it is now' (Interview 12, December 2019). Another resident observed that 'there are no trees here and it affects the temperature. So, we have higher temperature, hotter weather…when I moved in,

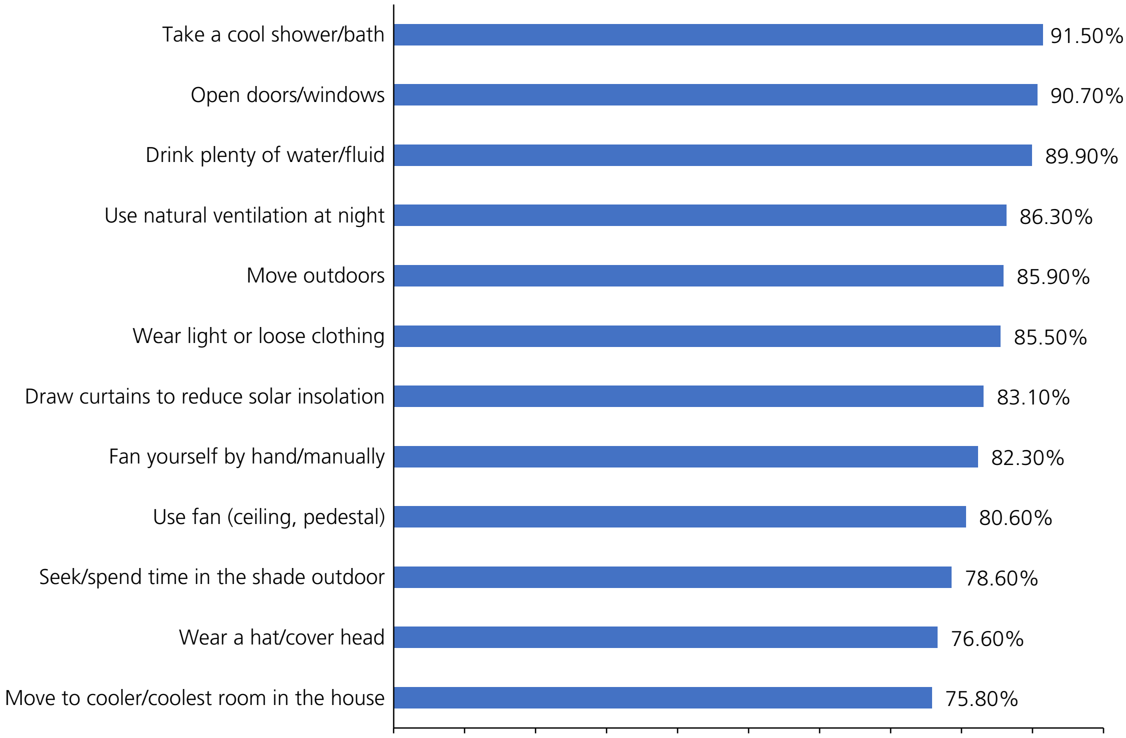

Figure 2. Most practiced individual responses to heat by residents

there was a tree there. Back then houses were not as many as this. Most of these places were bushy [and cooler]' (Interview 10, December 2019).

4.2.1 Behavioural responses to extreme heat

The human body manages heat stress through thermo-regulatory responses. Accompanying or supplementing these physiological responses are a range of personal actions. The interviews and survey in the study investigated the responses of the residents in terms of behavioural/personal actions and activities. These yielded some insights that are discussed later in the paper. The survey results, shown in Figures 2 and 3, capture the most and least practiced personal responses. Bathing/taking a cool shower and opening doors/windows were the most popular responses, followed by over 90% of the residents. Other top responses include drinking water/fluid (hydration), using natural ventilation at night and moving outdoor. Some other top-ranking responses include wearing light clothing, drawing curtains, use of fans, spending time in shaded outdoor space, covering the head and moving to cooler space (see Figure 2). The immediate insight here is that the top practices are linked to water (bathing, hydration) and features of house (doors, windows – openings generally).

On the contrary, some responses were least practiced. As shown by over half of the residents, activities such as doing nothing, seeking medical attention, asking for help from others and using sunscreen were seldom practiced. In this context, the high percentage (63.7%) who 'do nothing' means majority of the residents would make one or more responses when they experience extreme heat (See Table 3). As many 'do nothing', seeking medical attention that may not be easily accessible or affordable would not take place. Also, there would not be meaningful efforts to ask for help from others. All these indicate a possibly reticent attitude towards heat within the community.

The interviews corroborated the survey results and provide further insights on the practices. The first issue emerging is the active and passive cooling measures used by the residents. A resident explains that 'we use fan to protect heat…When NEPA [public electricity provider] brings light, and if there's no electricity supply, those who have generating set will use it to power their fan' (Interview 1, November 2019). Explaining how other measures are implemented, a resident show that 'the heat is too much. At times you'll stay outside for a long time. Sometimes you enter around 12 midnight, take shower, but you'll start feeling serious heat in less than 2 h again' (Interview 12, December 2019). Power cuts are common across

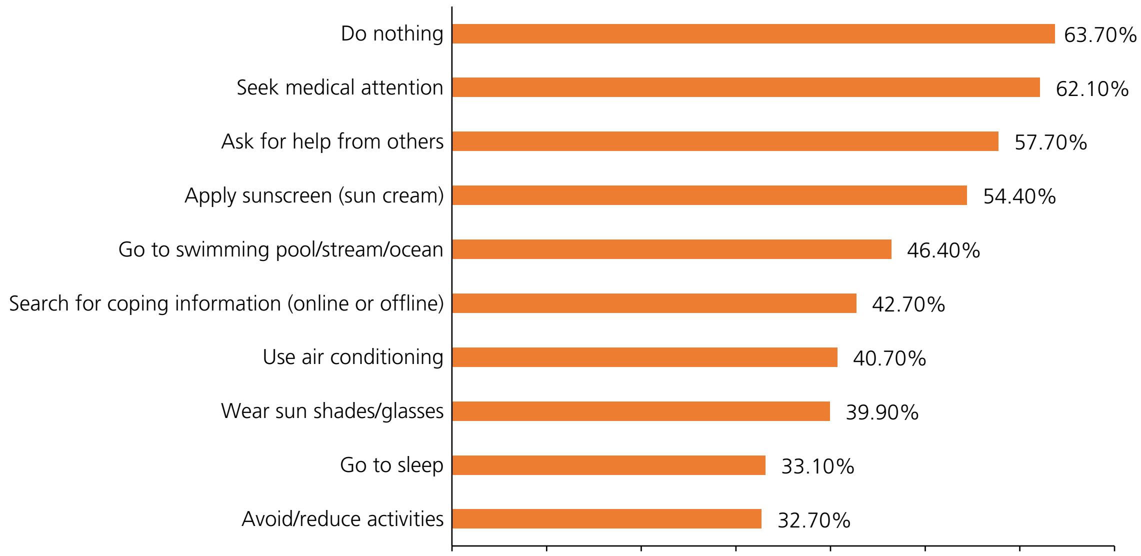

Figure 3. Least practiced individual responses to heat by residents

Table 3. Behavioural responses of the residents to extreme heat

	Yes	%	No	%	Not applicable	%
Drink plenty of water/fluid	223	89.9	24	9.7	0	0
Wear light or loose clothing	212	85.5	35	14.1	1	0.4
Wear a hat/cover head	190	76.6	54	21.8	3	1.2
Apply sunscreen (sun cream)	94	37.9	135	54.4	16	6.5
Wear sun shades/glasses	137	55.2	99	39.9	8	3.2
Take a cool shower/bath	227	91.5	17	6.9	1	0.4
Splash water on yourself	187	75.4	53	21.4	4	1.6
Go to swimming pool/stream/ocean	68	27.4	115	46.4	64	25.8
Go to sleep	150	60.5	82	33.1	16	6.5
Move to cooler/coolest room in the house	188	75.8	40	16.1	18	7.3
Move outdoors	213	85.9	24	9.7	8	3.2
Seek/spend time in the shade outdoor	195	78.6	40	16.1	10	4.0
Use natural ventilation at night	214	86.3	27	10.9	6	2.4
Open doors/windows	225	90.7	18	7.3	4	1.6
Draw curtains to reduce solar insolation	206	83.1	32	12.9	6	2.4
Use air conditioning	83	33.5	101	40.7	64	25.8
Use fan (ceiling, pedestal)	200	80.6	35	14.1	12	4.8
Fan yourself by hand/manually	204	82.3	40	16.1	4	1.6
Avoid/reduce activities	158	63.7	81	32.7	7	2.8
Check/listen to weather forecast	78	31.5	97	39.1	69	27.8
Search coping information (online or offline)	55	22.2	106	42.7	82	33.1
Plan the day to stay out of heat (outdoor)	130	52.4	96	38.7	19	7.7
Ask for help from others	86	34.7	143	57.7	18	7.3
Seek medical attention	65	26.2	154	62.1	28	11.3
Do nothing	58	23.4	158	63.7	24	9.7

Nigerian cities because electricity supply is grossly inadequate. Its cost (for maintenance of the infrastructure and tariff) also presents a challenge. Therefore, cooling through active measures is not always possible. Passive cooling measures are often used although usually less effective.

The challenges associated with electricity availability for cooling were highlighted in the interviews. Only ~72% of the residents have their homes connected to electricity or powered by alternatives such as solar panels or petrol generators. Among those having electricity supply, one person explained that

'NEPA should give us light as the weather is becoming hot, so that the impact of the heat will be minimal. They should make the electricity stable so that people won't complain about heat' (Interview 6, November 2019). Given that passive cooling measures are less effective, the residents make electricity a critical part of community-led initiatives to ensure relevant maintenance takes place. A resident explained that 'the community is making effort. Look at the poles, and the roads – they were made by the community without government's assistance…For instance, our electricity connection spoilt. I just returned from collecting money [from residents] to repair it. If we wait for the government, we will sleep in darkness, and heat will nearly kill us' (Interview 7, November 2019).

4.2.2 Environmental and building-related strategies

The survey investigated initiatives made in the indoor or outdoor built environment to deal with heat (see Table 4). A range of responses earlier identified through literature review and the interviews was presented, and residents were asked to choose those they had implemented to coping with extreme heat. Those they wished or planned to implement as well as those deemed not applicable were also indicated.

Within the list of responses shown in Table 4, installing window/door nets; ceiling the building and installing fans were the most popular. On the contrary, extending roof eaves; installing and/or upgrading air conditioners were the initiatives mostly aspired towards. These initiatives aspired to are regarded as good but the residents have not implemented them probably due to cost. The initiatives they wish or plan to are more expensive compared with the ones already implemented. Initiatives such as using double walling and installing awning were mostly observed as not applicable in tackling heat exposure for the setting in the neighbourhoods. Insulating floors and walls are rarely done and not observed as applicable in the dwellings. It appears high cost plays a significant role in the building-related initiatives observed as not applicable or rarely done. Also, initiatives such as double walling have limitations in its cooling effectiveness in the tropical climate within Lagos, Nigeria.

One might expect that, given the well-known micro-climate control benefits of vegetation, greening should emerge among the top responses. This was however not the case in this community. Over 41 and 44% respectively only plan/wish to have trees and shades outside the house and develop a garden. As cultivating vegetation takes some time and requires other resources, the tenure status (37% are renters) and busy nature of their (self)employment might discourage developing green spaces. With the absence of green infrastructure, spending time

Table 4. Heat adaptation strategies implemented in the built environment

	Yes	No	Plan/wish to	Not applicable
Install light-coloured roof covering	69 (27.8%)	42 (16.9%)	107 (43.1%)	30 (12.1%)
Add roof insulation	47 (19%)	62 (25%)	118 (47.6%)	21 (8.5%)
Extend roof eaves	55 (22.2%)	44 (17.7%)	129 (52%)	20 (8.1%)
Use double walling	39 (15.7%)	62 (25%)	103 (41.5%)	44 (17.7%)
Insulate walls	36 (14.5%)	64 (25.8%)	104 (41.9%)	44 (17.7%)
Change to lighter colour internally	65 (26.2%)	39 (15.7%)	114 (46.0%)	27 (10.3%)
Install ceramic floor/wall tiles	61 (24.6%)	56 (22.6%)	105 (42.3%)	25 (10.1%)
Install window/door nets	111 (44.8%)	16 (6.5%)	106 (42.7%)	14 (5.6%)
Use double glazing	48 (19.4%)	77 (31.0%)	91 (36.7%)	29 (11.7%)
Use lighter curtain material	84 (33.9%)	32 (12.9%)	119 (48.0%)	11 (4.4%)
Install ceiling	95 (38.3%)	37 (14.9%)	99 (39.9%)	16 (6.5%)
Insulate existing ceiling	48 (19.4%)	71 (28.6%)	103 (41.5%)	22 (8.9%)
Install vent/air extractor	45 (18.1%)	65 (26.2%)	114 (46.0%)	22 (8.9%)
Install air conditioner	53 (22.6%)	52 (21.0%)	127 (51.2%)	6.0 (2.0%)
Upgrade air conditioner	56 (37.1%)	55 (22.2%)	120 (48.4%)	15 (6.0%)
Install fans	92 (44.0%)	29 (11.7%)	118 (47.8%)	4 (1.6%)
Insulate floors	35 (19%)	101 (40.7%)	66 (26.6%)	43 (17.3%)
Plant vegetation in the house	47 (22.2%)	81 (32.7%)	77 (31%)	42 (10.9%)
Plant trees with shades outside	55 (21%)	55 (22.8%)	104 (41.9%)	32 (12.9%)
Develop a garden	52 (20.6%)	58 (23.4%)	110 (44.4%)	26 (10.5%)
Add pergolas/outdoor areas	51 (22.6%)	60 (24.2%)	107 (43.1%)	26 (10.5%)
Add veranda/balcony	56 (14.9%)	56 (22.6%)	115 (46.4%)	20 (8.1%)
Install awning	37 (25%)	70 (28.2%)	94 (37.9%)	45 (18.1%)
Install external blinds or shade clothes	62 (20.6%)	58 (23.4%)	104 (41.9%)	23 (9.3%)
(Re-)orient the building	51 (19%)	62 (25%)	98 (39.5%)	33 (13.3%)
Install solar panels for uninterrupted electricity	47 (22.2%)	58 (23.4%)	115 (46.4%)	27 (10.9%)
Use energy-saving, low heat-emitting bulb	89 (35.9%)	27 (10.9%)	114 (46.0%)	18 (7.3%)

Table 5. Willingness of the residents to pay for a range of greening initiatives

	None	$10 000–100 000	$100 001–250 000	$250 001–500 000	$500 001–1 000 000	Over $1 000 000
Tree planting	49 (19.8%)	43 (17.3%)	48 (19.4)	39 (15.7%)	32 (12.9%)	29 (11.7%)
Vertical greening	85 (34.3%)	37 (14.9%)	49 (19.8%)	38 (15.3%)	20 (8.1%)	14 (5.6%)
Water fountain	51 (20.6%)	54 (21.8%)	33 (13.3%)	50 (20.2%)	35 (14.1%)	18 (7.3%)
Green roof	87 (35.1%)	50 (20.3%)	34 (13.7%)	33 (13.3%)	24 (9.7%)	16 (6.5%)
Permeable paving	37 (14.9%)	42 (16.9%)	57 (23%)	49 (19.8%)	34 (13.7%)	23 (9.3%)
House modification	20 (18.1%)	55 (22.2%)	42 (16.9%)	33 (13.3%)	52 (21.0%)	42 (16.9%)

US$1 = 360 naira in December 2019 when the survey was undertaken

in the shade outdoor ranked low among behavioural responses. The next section presents their willingness to pay if the green infrastructure were to be developed by others.

5. Willingness to pay for heat-resistance initiatives

The study explored the willingness of the residents to pay for certain alterations that will enhance heat-resistant capacity of residents and built environment within the community. Table 5 shows a range of amount willing to pay for different initiatives. The highest proportion of unwillingness to pay any amount was recorded for vertical greening and green roofs. It is surprising, especially given that these two are notable examples of building-based green infrastructure. Probably low awareness and understanding about these initiatives might be reasons. This deserves to be further explored.

The highest amount willing to be committed goes to modifying or retrofitting the house to enhance its heat-resistant capacities. One can expect this based on the capital-intensive nature of housing construction. Modification of houses to improve their heat resistance attracts notable interest given that only 18.1% of the residents are not willing to pay anything for it.

6. Discussion

Some aspects of the findings in this study are notable. Some of these align with earlier issues from literature, others do not. First is the important role that services and infrastructure play in capacity to cope with heat stress. Water, electricity and sanitation are very crucial, as evident from the account of the residents. The settlement studied is underserviced. Water and electricity are available but inadequate, in quantitative and qualitative terms. Jay *et al.* (2021) recognise that poor water and sanitation situations combined with heat stress can indirectly increase the risk of water-borne diseases in informal settlements. Adegun *et al.* (2022) explain that availability of services and infrastructure either enables or constrains the kinds of heat adaptation strategy adopted within low-income neighbourhoods.

Apart from services, the housing material is another notable factor in heat exposure and adaptation. From onsite observation, buildings within the community are not durable given the quality of materials and methods used for their construction. The openings (windows, doors) are usually not adequate. There is an added challenge of low heat resistance properties for the construction materials, especially hollow sandcrete blocks which is the dominant walling material. Beyond walling material alone, there is a need to upgrade as well as retrofit the buildings to enhance their heat resistance capacities.

From the results, greening has not received an outstanding attention in addressing heat stress. For instance, spending time in the shade outdoor did not rank high among behavioural responses. So also are cultivating vegetation indoor or outdoor through trees and gardens. None of these are among the top environmental measures that the residents wish or plant to implement. Furthermore, there is no outstanding interest in developing green measures, based on aspects of the survey investigating the willingness to pay of the residents. The highest number (and percentage) of the respondents are not willing to pay anything for tree planting, vertical greening and green roof. This should be concerning given the ample evidence on the potentials of greening in addressing heat stress. Akinwolemiwa *et al.* (2018), Birtchnell *et al.* (2019) and Adegun *et al.* (2022) have shown how greening provides temperature moderation and other benefits within informal settlements in African cities.

The low practice and preference for greening in the case settlement, which wasn't the expectation, raises a couple of questions. The quantity of green spaces in the settlement is limited. Are the residents not interested in improving or merely do not see any value therein? Is it less cost-effective compared with other options or people think this should be done by government? Are there competing interests or experiences which relegate knowledge of, and value placed on greening within the community? The challenge is how might greening at the local level as part of municipal infrastructure be enhanced and entrenched. Although these questions might be addressed through future studies, deliberate policy and programmatic interventions are needed to catalyse interest in and uptake of greening within low-income informal urban settlements to make the residents and spaces resilient to heat stress in the context of climate change.

7. Conclusion

Realities accompanying climate change is increasing human exposure to extreme heat. Residents in informal urban communities are aware of and experiencing this challenge. The study has shown the pattern of responses to extreme temperature, from the individual and building scales, within their immediate environment. The findings highlight critical role of services, especially water and electricity, in personal and building-based cooling measures. Cost also influences which response strategy is used or not by the low-income residents. The low practice and preference for greening initiatives for cooling in community is notable, and the reasons deserve to be explored in future studies.

Clearly, more needs to be done to promote resilience within these deprived communities, promoting the right behaviour through awareness as well as facilitating building retrofits. External support from the state and non-state actors would be needed in actualising this. The value of this study lies in its illumination of local strategies that provide a pedestal towards heat adaptation in a poor urban setting. It not only contributes to knowledge but can also potentially inform heat action plans at the local community and municipal levels.

REFERENCES

Adebamowo MA and Olusanya O (2012) Energy savings in housing through enlightened occupants' behaviour and by breaking barriers to comfort: a case study of a hostel design in Nigeria. In *Proceedings of 7th Windsor Conference, UK*, pp. 12–14.

Adegebo B (2022) Urban thermal perception and self-reported health effects in Ibadan, Nigeria. *International Journal of Biometeorology* **66(2)**: 331–343.

Adegun OB (2017) Green infrastructure in relation to informal urban settlements. *Journal of Architecture and Urbanism* **41(1)**: 22–33.

Adegun OB and Ayoola HA (2022) Between the rich and poor: exposure and adaptation to heat stress across two urban neighbourhoods in Nigeria. *Environment, Development and Sustainability* **24(10)**: 11953–11968, https://doi.org/10.1007/s10668-021-01924-w.

Adegun OB, Mbuya EC and Njavike E (2022) Responses to heat stress within an unplanned settlement in Dar es Salaam, Tanzania. *Frontiers in Built Environment* **8**: 69, https://doi.org/10.3389/fbuil.2022.874751.

Akinwolemiwa OH, de Souza CB, De Luca LM and Gwilliam J (2018) Building community-driven vertical greening systems for people living on less than £1 a day: a case study in Nigeria. *Building and Environment* **131**: 277–287.

Bassett R, Young PJ, Blair GS, Samreen F and Simm W (2020) The megacity Lagos and three decades of urban heat island growth. *Journal of Applied Meteorology and Climatology* **59(12)**: 2041–2055.

Birtchnell T, Gill N and Sultana R (2019) Sleeper cells for urban green infrastructure: harnessing latent competence in greening Dhaka's slums. *Urban Forestry & Urban Greening* **40**: 93–104.

Borg FH, Greibe Andersen J, Karekezi C *et al.* (2021) Climate change and health in urban informal settlements in low-and middle-income countries – a scoping review of health impacts and adaptation strategies. *Global Health Action* **14(1)**: 1908064.

Ebi KL, Capon A, Berry P, *et al.* (2021) Hot weather and heat extremes: health risks. *The Lancet* **398(10301)**: 698–708.

Hambrecht E, Tolhurst R and Whittaker L (2022) Climate change and health in informal settlements: a narrative review of the health impacts of extreme weather events. *Environment and Urbanization* **34(1)**: 122–150.

Hugo JM (2023) Heat stress: adaptation measures in South African informal settlements. *Buildings and Cities* **4(1)**: 55–73, https://doi.org/10.5334/bc.269.

Hugo JM and Sonnendecker PW (2023) Ground-level documentation of heat stress exposure and response strategies in informal settlements in Tshwane, South Africa. *Smart and Sustainable Built Environment*, https://doi.org/10.1108/SASBE-10-2022-0229.

Jay O, Capon A, Berry P *et al.* (2021) Reducing the health effects of hot weather and heat extremes: from personal cooling strategies to green cities. *The Lancet* **398(10301)**: 709–724.

Krejcie RV and Morgan DW (1970) Determining sample size for research activities. *Educational and Psychological Measurement* **30(3)**: 607–610.

Lagos Urban Studies Group (2019) *Idi Araba Oworonshoki Community General Profile*. University of Lagos, Lagos, Nigeria.

Laue F, Adegun OB and Ley A (2022) Heat stress adaptation within informal, low-income urban settlements in Africa. *Sustainability* **14**: 8182, https://doi.org/10.3390/su14138182.

Lenton TM, Xu C, Abrams JF *et al.* (2023) Quantifying the human cost of global warming. *Nature Sustainability* **6(10)**: 1237–1247.

Loggia C, Tramontin V and Trois C (2015) Sustainable housing in developing countries: meeting social and environmental targets by 'greening' low-income settlements in South Africa. *International Journal of Sustainability Policy and Practice* **9(4)**: 1–12.

Lagos State Government (2015) *Baseline Assessment of Olubori-odun Ifa, Idi-araba and Mosafejo Communities in Kosofe Local Government Areas*. Lagos Bureau of Statistics, Lagos, Nigeria.

Lagos State Government (2021) *2020 Lagos State Household Survey Report*. Lagos State Nigeria. Lagos Bureau of Statistics, Lagos, Nigeria.

Mehrotra S, Bardhan R and Ramamritham K (2018) Urban informal housing and surface urban heat island intensity: exploring spatial association in the city of Mumbai. *Environment and Urbanization ASIA* **9(2)**: 158–177.

Muhammed A, Folorunso CO and Fadairo G (2022) Assessment of sandcrete hollow blocks' thermal performance as a walling material for tropical buildings in Lokoja, Nigeria. *International Journal of Building Pathology and Adaptation*, https://doi.org/10.1108/IJBPA-07-2021-0096.

Mukhopadhyay B and Weitz CA (2022) Heat exposure, heat-related symptoms and coping strategies among elderly residents of urban slums and rural villages in West Bengal, India. *International Journal of Environmental Research and Public Health* **19(19)**: 12446, https://doi.org/10.3390/ijerph191912446.

Nutkiewicz A, Mastrucci A, Rao ND and Jain RK (2022) Cool roofs can mitigate cooling energy demand for informal settlement dwellers. *Renewable and Sustainable Energy Reviews* **159**: 112183.

Ojeh VN, Balogun AA and Okhimamhe AA (2016) Urban–rural temperature differences in Lagos. *Climate* **4(2)**: 29.

Oppermann E, Kjellstrom T, Lemke B, Otto M and Lee JKW (2021) Establishing intensifying chronic exposure to extreme heat as a slow onset event with implications for health, wellbeing, productivity, society and economy. *Current Opinion in Environmental Sustainability* **50**: 225–235.

Pasquini L, van Aardenne L, Godsmark C, Lee J and Jack C (2020) Climate change-related public health challenges in Africa: case study of heat-health vulnerability of informal settlement residents in Dar es Salaam. *Science of Total Environment* **747**: 141355.

Ramsay EE, Fleming GM, Faber PA *et al.* (2021) Chronic heat stress in tropical urban informal settlements. *iScience* **24(11)**: 103248.

Scott AA, Misiani H, Okoth J *et al.* (2017) Temperature and heat in informal settlements in Nairobi. *PLoS ONE* **12(11)**: e0187300.

Taiwo OJ, Olaniran HD and Osayomi T (2012) Perceived causes, exposures and adjustments to seasonal heat in different residential areas in Ibadan, Nigeria. *The Environmentalist* **32(4)**: 405–414.

UN-Habitat (2012) *State of the World's Cities 2008/9: Harmonious Cities*. Routeledge, London, UK.

Vellingiri S, Dutta P, Singh S *et al.* (2020) Combating climate change-induced heat stress: assessing cool roofs and its impact on the indoor ambient temperature of the households in the urban slums of Ahmedabad. *Indian Journal of Occupational and Environmental Medicine* **24(1)**: 24–29.

How can you contribute?

To discuss this paper, please email up to 500 words to the editor at support@emerald.com. Your contribution will be forwarded to the author(s) for a reply and, if considered appropriate by the editorial board, it will be published as discussion in a future issue of the journal.

Proceedings journals rely entirely on contributions from the civil engineering profession (and allied disciplines). Information about how to submit your paper online is available at www.icevirtuallibrary.com/page/authors, where you will also find detailed author guidelines.