integrity Research Journals

Global Journal of Earth and Environmental Science
Volume 10(1), pages 8-18, February 2025
Article Number: 4722ED252
ISSN: 2636-6002
https://doi.org/10.31248/GJEES2024.174
https://integrityresjournals.org/journal/GJEES

Full Length Research

Comparative studies of changing temperatures on buildings structures in Asaba and Okwe

OGBOGO, Rosemary[1], OJOH, C. Oghenekome[2] and BOYITIE, Paul Odiyin[3]*

[1]Department of Estate Management, Dennis Osadebay University, Asaba, Delta State, Nigeria.
[2]Department of Urban and Regional Planning, Dennis Osadebay University, Asaba, Delta State, Nigeria.
[3]Department of Meteorology and Climate Change, Nigeria Maritime University, Okerenkoko, Delta State, Nigeria.

*Corresponding author. Email: paul.boyitie@nmu.edu.ng

Received 11th December 2024; Accepted 6th February 2025

ABSTRACT: This study investigates the impact of changing temperatures on building structures in Asaba and Okwe, Nigeria. Utilizing primary data from temperature readings and secondary meteorological records spanning 30 years, the study reveals a clear trend of rising temperatures in both areas, with Asaba experiencing consistently higher temperatures than Okwe, largely due to the urban heat island effect. The research highlights the vulnerability of building materials, particularly zinc roofs and walls, to temperature-induced stresses such as thermal expansion and contraction, leading to cracks and structural degradation. Statistical analysis, including regression and ANOVA tests, demonstrates a moderate positive relationship between temperature fluctuations and the extent of building damage. These results highlight how urgently better building techniques, environmentally friendly urban design, and climate-adaptive measures are needed. To ensure long-term resilience and sustainability, this study offers Asaba and Okwe's urban planners and policymakers some important insights on how to effectively adapt to the difficulties presented by urbanisation and climate change.

Keywords: Building structure, Nigeria, Okwe, structure integrity, temperatures.

INTRODUCTION

Climate change research is a complex and contentious field due to system complexities and modelling uncertainties (Malla *et al*., 2022). Future changes to weather patterns include warmer and drier summers, milder and wetter winters, rising sea levels, and extreme events such as increased hot days (Met Office, 2021), more intense periods of rain, and greater frequency of storms. Buildings are systemic structures with many interacting systems and subsystems. In Nigeria, many structural failures have occurred in recent years, almost in all areas of the built environment owing to the vagaries of weather and climate (Ede, 2010; Akinyemi *et al*., 2016). Regular one-day non-stop rainfall held the entire Lagos State in Nigeria to a standstill due to failed drainages and flooded-potholed roads (Kalu, 2024). Of the 65 cases of building collapse around Lagos and its environs, 384 human casualties were reported, while the number of injured was numerous (Windapo and Rotimi, 2012; Aliyu, 2024). Climate factors, including temperature, wind speed, solar radiation, and daylight hours, significantly influence building energy performance in the Nigerian built environment (Bett and Thornton, 2015).

Building performance and structures can be influenced in direct and indirect ways, and to make an effective estimation of the impact of climate on overall energy (Ahmadian *et al.,* 2023), the selection of climate element collection should be based on the combined integrated impacts of the climatic elements (Radhi, 2008; Lutz *et al*., 2016). The lifecycle cost of a building is about 60 to 85 percent, with design and construction accounting for five to ten percent (Lewis *et al*., 2011; Sanodiya and Rathore, 2024). Nigerian buildings often lack climate adjustment, affecting comfort, health, efficiency, and sustainability over their lifespan (Li *et al*., 2020; Rostam and Abbasi, 2023). Acquisition, renewal, and disposal costs account for 5-35% of total life cycle costs (The Federal Facilities Council AD HOC Task Group, 2001).

The Asaba and Okwe episodes are exacerbated by the heavy presence of paved surfaces with varying albedos and heavy vehicular movement, which contribute to the warming of the area (Sanodiya and Rathore, 2024). Currently, the most widely accepted climate change scenarios predict increases of between 1 and 3.5°C for the global annual average temperatures. In Asaba and Okwe, environmental challenges are exacerbated by extensive paved surfaces with low albedo and heavy vehicular movement, contributing to urban heat retention and pollution. Global climate change scenarios predicting temperature increases of 1 to 3.5°C further underscore the urgency of addressing these impacts.

While this study focuses on the influence of rising temperatures on building structures in Asaba and Okwe, it is important to acknowledge that the quality of building materials, construction designs, and workmanship significantly influence structural integrity. These factors, although critical, were beyond the scope of this investigation and were not directly examined. By comparing temperature-related impacts on buildings in these regions, the study aims to provide actionable insights for policymakers and urban planners. The findings will guide the Ministry of Lands, urban development agencies, and town planning boards in implementing best practices to mitigate the effects of temperature changes, highlighting the importance of material selection and urban design in adapting to local climate conditions.

Conceptual issues

Temperature increases atom kinetic energy, leading to increased atom separation and thermal expansion (Liu *et al*., 2017). Modern urbanisation has resulted in the growth of super-high-rise structures, which encounter issues in complicated surroundings, such as thermal expansion (Mostafavi *et al*., 2021). As the height and volume of structures rise, this effect has an impact on their stability and safety, particularly for concrete (Feng *et al*., 2024). Thermal expansion effects and control methods are crucial for improving building design, ensuring long-term stability and service life, and reducing maintenance. The concept presented in this paper indicates that the thermal contraction can be directly predicted on the building materials to expand or contract potentially leading to structure issues (see Figure 1). Thermal expansion is a crucial aspect of building design and maintenance in the construction industry (Medved, 2021).

If anchors or fixed locations are used to prevent this expansion, the stress forces seen in the above picture can exceed 10,000 pounds (see Figure 1). This stress can cause bending, distortion, or even failure of linked components if it is not adequately managed. Thermal contraction happens when materials are exposed to low temperatures, causing their particles to lose kinetic energy and migrate closer together (Figure 1). This shrinkage can cause structural damage such as fractures, joint failure, or the catastrophic breaking of the anchored ends. Thermal stresses are important to consider in building design and maintenance because they can cause cracking of walls, beams, or other load-bearing structures, misalignment or failure of rigidly fixed joints and connections, and accelerated material fatigue, all of which weaken the building over time.

In Asaba, Nigeria, the city's hot temperatures and high humidity levels can significantly impact building structures, causing them to expand and contract. The challenges of thermal expansion theory include the potential for structural damage, differential expansion between materials, and energy efficiency. Structural damage can result from the expansion of materials like concrete, steel, and wood, putting stress on the structure. If not managed properly, it can lead to cracks, warping, and other damage that compromises the building's integrity. Different materials have varying coefficients of thermal expansion, causing gaps to form between them, and compromising the building's structural integrity. Energy efficiency can also be affected by thermal expansion, leading to gaps and cracks in the building envelope, reducing energy efficiency and increasing heating and cooling costs. Lastly, thermal expansion can affect the overall stability of a building structure, putting stress on the foundation and other structural elements. Understanding the impacts of thermal expansion on building structures will assist in guaranteeing that they can resist the harsh temperatures and climatic conditions in Asaba and Okwe.

MATERIAL AND METHODS

Asaba and Okwe are situated in the Oshimili South Local Government Area of Delta (see Figure 2). The area is characterized by a tropical equatorial climate, influenced by two seasonal winds: tropical maritime (mT) and tropical continental (cT). The climate has a 9-10 months annual rainfall, with temperatures ranging from 31 to 31°C. In Asaba and Okwe, the interaction of environmental factors such as temperature, precipitation, wind, and relative humidity impacts building performance. The basin fill is made up of three formations: Akata, Agbada, and Benin Formations. The Amilimocha and Niger rivers drain the region, with the latter notable for its meanders, sandbars, and marsh. The drainage, geology, and terrain features of the research region all have a substantial influence on how well structures function under climate change. The tropical rainforest zones of Asaba and Okwe are evergreen forests

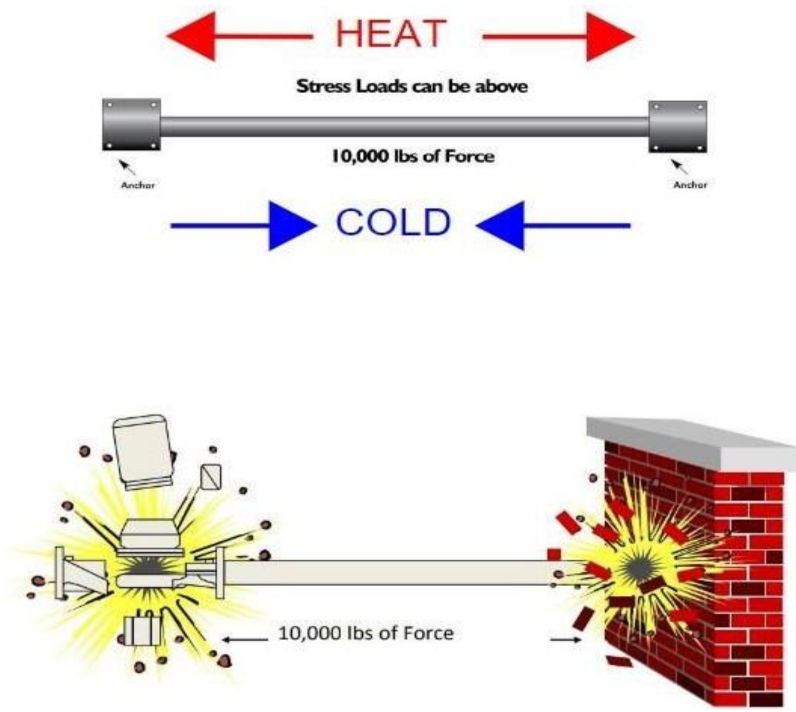

Figure 1. Thermal expansion on building material.

Table 1. Existing quarters in Asaba and Okwe.

Zones	Asaba	Okwe
A	Cable Point	Umunu
B	Umuaji	Unuofor
C	Umuagu	Old Oko Road
D	Umuezei	Todachi
E	Anwai Road	Nzediegwu
F	DLA	Iyasele
G	West End	Akuatua-egwu

Source: Fieldwork (2023).

with three tree canopies. The main trees along the riverside are Iroko, Obeche, and White Mahogany. Most plant species that would have served as wind-shade in the area have been cut down for construction purposes, so heavy wind storms due to climate change pose a danger to building performance.

The study examined the comparative differences in changing temperatures on building structures in Asaba and Okwe. The stratified sample approach was used, with the region divided into seven zones based on the existing major quarters in the research area (Table 1). The information utilised was gathered from both primary and secondary sources, including field data and personal observations. Secondary data comprised archive meteorological data from Nigerian Meteorological Agencies (NIMET) for 30 years. The researchers hired several field assistants who are well-versed in such metrics to help them take records. A hands-free temperature digital meter was used to take temperature measurements once a week for August and September. The choice of August and September for data collection was strategic to capture the seasonal variations in temperature that are typical of the region. These months generally reflect a transition in the local climate, with August often marking the peak of the wet season and September beginning to show signs of the transition towards drier conditions. This seasonal shift is crucial for understanding temperature fluctuations and the impact of both rain and humidity on the environment. Additionally, selecting these months allowed the research team to capture temperature dynamics that could differ significantly from the more extreme seasonal variations observed at other times of the year, thus providing a more balanced view of the temperature trends in Oshimili South. Every month, the temperature values were averaged. To track changes in the damages, information on the surface area of the damaged structures was gathered once a month. The researcher employed extrapolation to account for discrepancies in the required data. On-site measurements were taken to document the level of damage sustained in all areas. The data included damages to walls and roofs, which were utilised as indicators of a building structure.

The choice of data, including damages to walls and roofs, was essential as these elements serve as critical

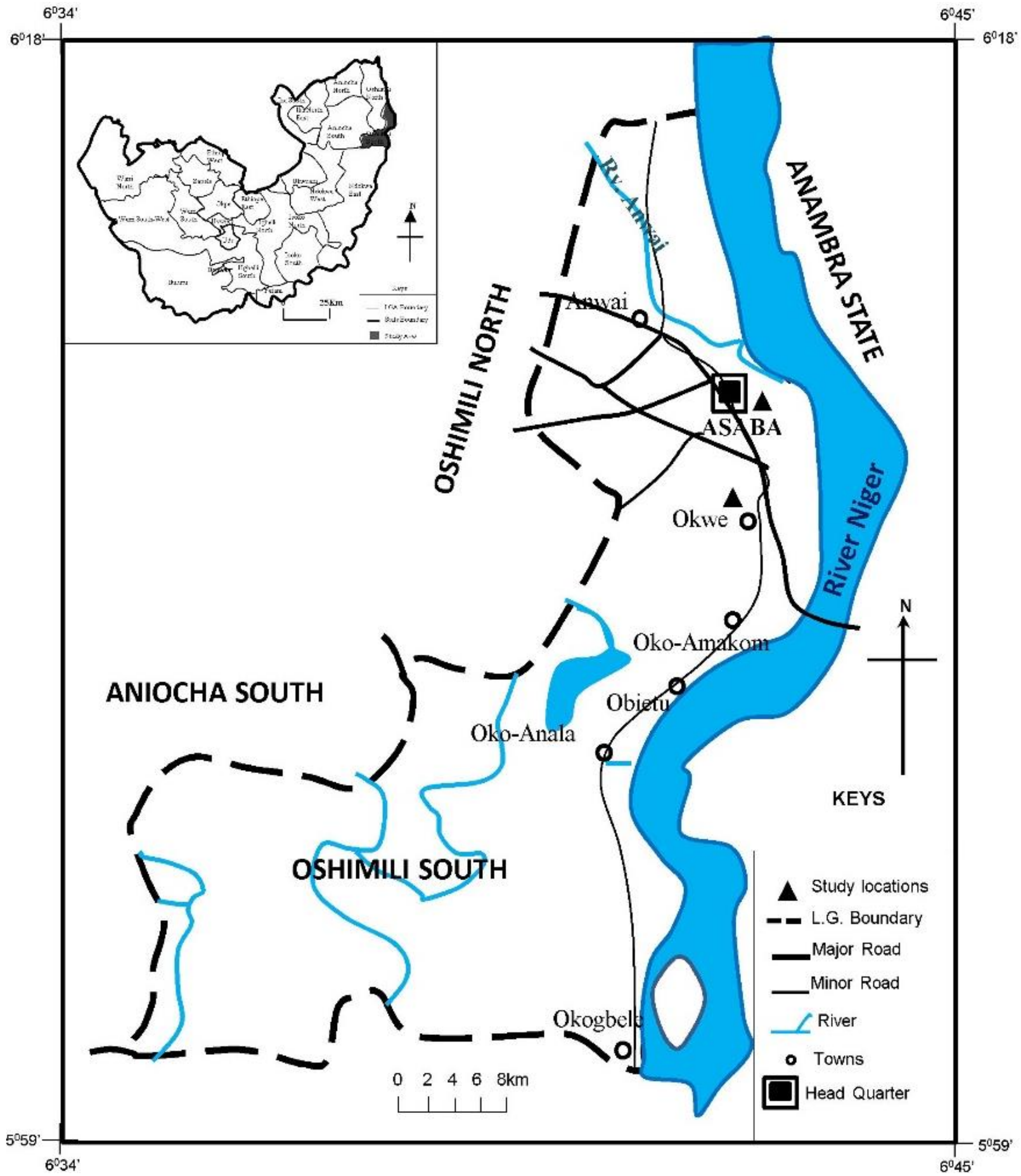

Figure 2. Map of Oshimilli South showing study area.

indicators of a building's structural integrity. Walls and roofs are directly exposed to environmental factors such as temperature fluctuations, making them particularly vulnerable to thermal stress and other climate-related impacts. In the context of the study, focusing on these components provided a practical and measurable way to assess the effects of changing temperatures on building structures in Asaba and Okwe. This method made it possible to compare how different climates affect structural performance, identifying potential weaknesses unique to each site and providing information on the wider effects of climate dynamics on built environments (Dharmarathne *et al*., 2024; Okoli and Abraham, 2024). Damaged walls and roofs were estimated using a measuring tape to determine the length and width of the affected regions. In doing this, the surface areas of the damages associated with temperature were determined using the following formula:

Surface Area (SA) = Length (L) x Width (W).

A preliminary investigation was conducted to identify buildings impacted by weather vagaries. Two buildings

Plate 1a. Decaying fence (Okwe).

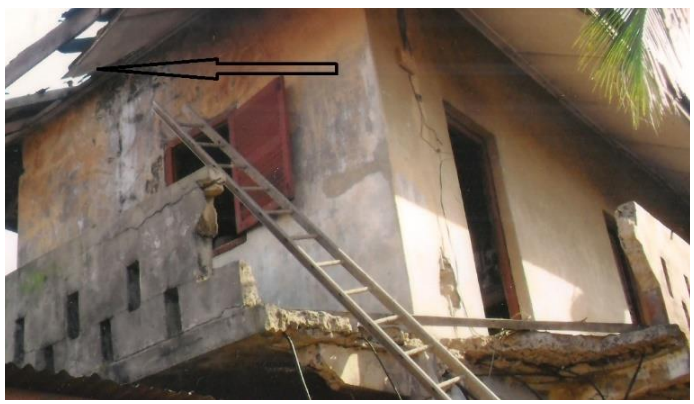

Plate 1b. Ruined balcony of a story building (Asaba).

were chosen from each zone, for a total of fourteen (14) affected structures. The Plate 1a and b depicts images of some of the impacted structures.

The results of the study were evaluated and presented using statistical diagrams. Multiple regression analysis (stepwise approach) was used to determine the association between temperature and building walls and roofs. The data was tested using the Statistical Package for Social Sciences (SPSS) version 22 stepwise regression and Analysis of Variance (ANOVA) function (Mitra, 2023).

Table 2. Mean decadal temperature trend in Oshimili South (Asaba and Okwe Area).

Decadal years	Decadal average temperature °C
1994-2003	32.73
2004-2013	32.89
2014-2023	34.15
Average	32.25

Source: Nigeria Meteorological Station (NIMET).

RESULTS AND DISCUSSION

Table 2 shows the "Mean Decadal Temperature Trend in Oshimili South (Asaba and Okwe Area)" and provides a comprehensive analysis of average temperatures over three decades. The data shows a distinct warming trend in the area, with temperatures rising steadily every ten years. The sharp increase in the most recent decade is concerning, likely driven by urbanization, climate change, and environmental degradation. In Asaba and Okwe, urbanization may intensify the "urban heat island" effect, while global climate change and local environmental degradation contribute to increased heat retention. This rising temperature trend has significant implications for the region, threatening agriculture, public health, and energy

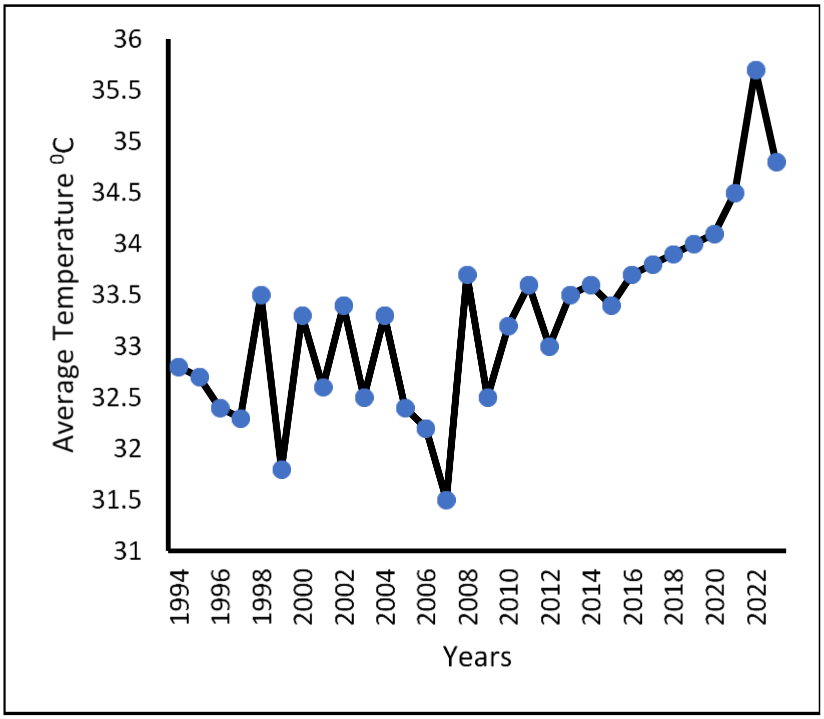

Figure 3. Average temperature change from 1994 to 2023 in Oshimili South.

demands. As a key agricultural area, the warming could jeopardize crop yields and exacerbate heat-related health issues. The data emphasises the necessity of coordinated measures to solve this issue, ranging from supporting sustainable urban development and green initiatives to reducing the effects of climate change (Ripple *et al.,* 2024).

The average temperature change from 1994 to 2023 is shown in Figure 3, which shows both oscillations and a distinct rising trend. The graph shows steady temperatures in the lower range at the beginning and a discernible rise in subsequent years. One of the lowest periods of temperature in the timeline was a precipitous decline in 2008. The gradual increase (2009-2018) saw a steady upward trajectory, with temperatures consistently rising, indicating a shift towards a warming trend. The recent spike (2019-2023) saw a rapid acceleration in temperature increases, peaking at 35.5°C in 2022, the highest point on the chart (see Figure 3). This graph serves as a wake-up call, reminding us of the importance of addressing environmental changes to mitigate their impact on the environment and our future.

These findings highlight a significant warming trend in the Oshimili South region (Asaba and Okwe Area) over the past three decades. The steady rise in average temperatures, coupled with recent sharp increases, underscores the influence of factors such as urbanization, climate change, and environmental degradation. These trends are more than just data points—they signify a pressing challenge for the region, with profound implications for agriculture, public health, and energy demand. The observed warming, illustrated by the marked increase to a peak of 35.5°C in 2022, demands urgent attention. Sustainable urban planning, climate adaptation strategies, and green initiatives are critical to mitigating these impacts and safeguarding the region's future. This study serves as a call to action, emphasizing the need for coordinated efforts to address the drivers of climate change and promote resilience in vulnerable regions like Oshimili South.

Table 3 presents a detailed analysis of ambient temperature data collected in August from two areas, Asaba and Okwe, with measurements. According to statistics on ambient temperatures gathered in August from Asaba and Okwe, Asaba sees greater afternoon and evening temperatures but lower morning temperatures. On the other hand, Okwe experiences colder temperatures all day long, with afternoon highs of no more than 36.3°C. Asaba consistently records higher temperatures, with peak afternoon temperatures reaching 38.4°C at Cable Point, the hottest area in the region. Average morning temperatures in Asaba are around 29°C, compared to 27°C in Okwe, and afternoon averages exceed 33°C in Asaba, while Okwe remains around 30°C. The urban heat island effect, driven by denser infrastructure and vehicular activity, likely explains Asaba's higher temperatures, while Okwe's cooler climate may be influenced by vegetation and nearby water bodies. The urban heat island effect suggests that Asaba, with denser infrastructure and

Table 3. On-site ambient temperature recorded in Asaba and Okwe areas (August).

Location	Time	0600 hr			1200 hr			1800 hr			2400 hr		
	Areas	Temp. (°C)		Av. Temp.	Temp. (°C)		Av. Temp.	Temp. (°C)		Av. Temp.	Temp. (°C)		Av. Temp.
		Dry	Wet		Dry	Wet		Dry	Wet		Dry	Wet	
Asaba	Cable Point	30.4	28.5	29.5	34.5	32.5	33.5	38.4	36.5	37.5	31.0	28.5	29.8
	Umuaji	30.1	28.0	29.1	34.0	32.1	33.1	38.0	36.2	37.1	31.0	28.0	29.5
	Umuagu	30.0	27.7	28.9	33.9	30.0	32.0	38.0	36.5	37.3	32.0	27.0	29.5
	Umuezei	30.0	26.9	28.5	34.4	32.0	33.2	37.5	36.0	36.8	31.5	28.0	29.8
	Anwai Road	30.4	28.0	29.2	35.0	33.5	34.3	38.0	36.0	37.0	31.2	28.0	29.6
	DLA	30.5	28.5	29.5	34.0	32.0	33.0	38.0	36.1	37.1	32.0	27.5	29.8
	West End	30.2	28.2	29.2	34.5	32.5	33.5	38.0	36.2	37.1	32.0	27.0	29.5
Okwe	Umunu	28.5	26.3	27.4	31.0	28.3	29.7	36.3	34.0	35.2	28.5	26.0	27.3
	Unuofor	28.0	26.0	27.0	32.0	28.0	30.0	35.4	33.0	34.2	28.0	26.0	27.0
	Old Oko Road	28.2	26.1	27.2	31.6	28.5	30.1	35.0	33.1	34.1	27.9	25.1	26.5
	Todachi	27.5	25.8	26.7	31.5	28.3	29.9	36.0	34.2	35.1	28.0	26.0	27.0
	Nzediegwu	27.5	26.0	26.8	31.0	28.0	29.5	35.0	33.1	34.1	28.5	26.0	27.3
	Iyasele	28.0	27.0	27.5	32.0	28.0	30.0	35.5	33.0	34.3	28.0	26.1	27.1
	Akuatua-egwu	29.2	27.4	28.3	31.0	27.5	29.3	36.0	34.1	35.1	28.0	26.3	27.2

Source: Fieldwork (2023).

possibly more vehicular activity, experiences higher temperatures (Mohajerani *et al*., 2017). The table emphasizes the importance of localized environmental data in planning and resource management (Oliveira and Meyfroidt, 2021).

The findings reveal a significant temperature disparity between Asaba and Okwe, with Asaba consistently recording higher temperatures, particularly during the afternoon hours. This variation highlights the influence of urbanization and infrastructure density, as seen in the urban heat island effect, which likely drives the warmer conditions in Asaba. These results demonstrate the importance of local environmental data in understanding temperature dynamics and their implications for urban development and resource management. By tackling the urban heat island effect in Asaba through sustainable development strategies, such as increasing green spaces, it may be feasible to decrease the observed temperature discrepancies and improve overall urban resilience.

Table 4 presents ambient temperature data for September in Asaba and Okwe, measured at four times of the day (0600, 1200, 1800, and 2400 hr). The ambient temperature data for September reveals clear temperature differences between Asaba and Okwe, measured at four times of the day. Both locations had colder early morning temperatures, and values for the wet and dry bulbs are near to one another, suggesting significant humidity. In the afternoon, Asaba sees a noticeable temperature increase, with dry bulb temperatures peaking at 34.5°C, while Okwe remains slightly cooler. The evening temperatures in Asaba remain high, especially in areas like Anwai Road and West End, where dry bulb temperatures exceed 38°C. Okwe, on the other hand, has cooler evening temperatures around 35°C. At midnight, temperatures drop in both areas, with averages between 26°C and 29.8°C. Throughout the day, Asaba locations consistently record higher temperatures than Okwe, with West End having the highest evening temperatures. Okwe locations such as Umunu, Unuofor, and Todachi remain cooler, especially in the morning and at midnight. Urban heat retention causes temperatures to rise in some parts of Asaba, such as West End and Anwai Road, whereas Todachi and Nzediegwu in Okwe retain more consistent, mild temperatures all day long. Possible influencing factors include urbanization, vegetation and water bodies, and seasonal weather patterns. Asaba's higher temperatures underline the need for urban cooling strategies. These findings emphasize the critical role of localized data in planning for sustainable development and adapting to environmental challenges (Elias and de Albuquerque, 2022).

The findings reveal distinct temporal and spatial temperature variations in Asaba and Okwe during September, highlighting the impact of urbanization and environmental factors on localized climate patterns. Spatially, Asaba consistently records higher temperatures than Okwe, with urban heat retention likely contributing to this disparity. Okwe's cooler temperatures, especially in areas like Todachi and Nzediegwu, may result from vegetation and water bodies that mitigate heat. These findings underscore the critical influence of urbanization, environmental features, and seasonal patterns on temperature dynamics. The higher temperatures in Asaba,

Table 4. On-site ambient temperature recorded in Asaba and Okwe Areas (September).

Location	Time	0600 hr			1200 hr			1800 hr			2400 hr		
	Areas	Temp. (°C)		Av. Temp.	Temp. (°C)		Av. Temp.	Temp. (°C)		Av. Temp.	Temp. (°C)		Av. Temp.
		Dry	Wet		Dry	Wet		Dry	Wet		Dry	Wet	
Asaba	Cable Point	30.4	28.5	29.5	34.5	32.5	33.5	38.1	36.3	37.2	31.0	28.5	29.8
	Umuaji	30.1	28.5	29.3	34.5	32.5	33.5	37.8	36.1	37.0	31.0	28.0	29.5
	Umuagu	30.0	28.0	29.0	34.0	32.1	33.1	38.2	36.5	37.4	31.0	27.0	29.0
	Umuezei	30.0	27.7	28.9	33.9	30.0	32.0	37.5	36.0	36.8	31.5	28.0	29.8
	Anwai Road	30.4	26.9	28.7	34.4	32.0	33.2	38.3	36.0	37.2	31.2	28.0	29.6
	DLA	30.5	28.0	29.3	35.0	33.5	34.3	38.0	36.1	37.1	32.0	27.5	29.8
	West End	30.2	28.5	29.4	34.0	32.0	33.0	38.4	36.2	37.3	32.0	27.0	29.5
Okwe	Umunu	28.5	28.2	28.4	34.5	32.5	33.5	36.3	34.2	35.3	28.1	25.5	26.8
	Unuofor	28.0	26.3	27.2	31.0	28.3	29.7	36.4	33.0	34.7	28.0	26.0	27.0
	Old Oko Road	28.2	26.0	27.1	32.0	28.0	30.0	36.4	33.2	34.8	27.2	25.1	26.2
	Todachi	27.5	26.1	26.8	31.6	28.5	30.1	36.0	34.2	35.1	28.0	26.0	27.0
	Nzediegwu	27.5	25.8	26.7	31.5	28.3	29.9	35.0	33.1	34.1	28.5	25.9	27.2
	Iyasele	28.0	26.0	27.0	31.0	28.0	29.5	35.5	33.0	34.3	27.4	25.1	26.3
	Akuatua-egwu	29.2	27.0	28.1	32.0	28.0	30.0	36.0	34.1	35.1	27.3	25.3	26.3

Source: Fieldwork (2023).

Table 5. Indices of affected building.

Parts of the building	Measured affected areas for worst hit building			
	Asaba	SLA (m^2)	Okwe	SLA (m^2)
Zinc/Roof	Cable Point	600	Umunu	320
	Umuaji	700	Unuofor	120
	Umuagu	770	Old Oko Road	240
	Umuezei	200	Todachi	320
	Anwai Road	960	Nzediegwu	200
	DLA	640	Iyasele	760
	West End	800	Akuatua-egwu	640
Fence/Walls (0-5m above ground level)	Cable Point	124	Umunu	130
	Umuaji	164	Unuofor	120
	Umuagu	770	Old Oko Road	240
	Umuezei	840	Todachi	320
	Anwai Road	520	Nzediegwu	120
	DLA	365	Iyasele	60
	West End	180	Akuatua-egwu	40

Source: Fieldwork (2023).

particularly in densely developed areas, highlight the pressing need for urban cooling strategies, such as increasing green spaces and promoting sustainable urban planning. These localized insights are essential for addressing environmental challenges and fostering sustainable development in Delta State.

Table 5 presents indices of affected buildings in parts of Asaba and Okwe, focusing on the surface areas (SLA) of zinc roofs and fences/walls for the worst-hit buildings. The data reflects structural vulnerabilities in these areas, offering insight into the impact of environmental or man-made factors such as weather, erosion, or construction quality. The study shows that Zinc/Roof Damage is the highest recorded affected area in Asaba, likely reflecting

Table 6. Regression on the relationship between temperature and building structure indices.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	0.583[a]	0.339	.284	1.1351	0.339	6.163	1	12	0.029

a. Predictors: (Constant), Surface area of Zinc/Roof buildings affected.
Source: SPSS Computation.

Table 7. Coefficient's analysis relationship between temperature and building structure indices.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations		
		B	Std. Error	Beta			Zero-order	Partial	Part
1	(Constant)	29.503	0.667		44.199	0.000			
	Surface area of Zinc/Roof buildings affected	0.003	0.001	0.583	2.483	0.029	0.583	0.583	0.583

a. Dependent Variable: ambient Average Temperature.
Source: SPSS Computation.

significant roof surface exposure and vulnerability. Other notable locations include West End (800 m²) and Umuagu (770 m²), which could indicate either extensive building sizes or severe damage from storms, wear, or inadequate materials. Smaller affected areas, such as Umuezei (200 m²), suggest relatively minor damage, possibly due to better maintenance or smaller roof sizes. Okwe has the largest affected areas, possibly due to larger structures or higher susceptibility to damage. Other locations, such as Unuofor (120 m²) and Old Oko Road (240 m²), indicate less extensive impact, likely linked to smaller roof spans or better resilience to environmental stressors. Fence/Wall Damage is also evident in Asaba, with Asaba showing more severe damage overall. For example, Umuezei reports 840 m² of affected walls compared to Todachi's 320 m² in Okwe. Okwe's lesser impact may indicate lower fence heights, less wall usage, or better adaptation to local environmental challenges.

Possible causes of damage in Asaba include heavy rainfall/ flooding, erosion, poor construction quality, urbanization and maintenance, and flood and erosion control. The data underscores the need for improved construction standards, particularly in Asaba, where the affected areas for both roofs and walls are substantially higher. Okwe's lesser damage points to the benefits of smaller structures and possibly better planning against environmental challenges. Investing in drainage systems and erosion prevention measures is critical, particularly in locations like Umuezei and Todachi, where significant wall damage is observed. This table highlights the importance of understanding building vulnerabilities to inform better construction practices and urban planning. Addressing these issues can help reduce structural damage, enhance safety, and improve long-term sustainability in Asaba and Okwe. The findings highlight significant structural vulnerabilities in buildings across Asaba and Okwe, with zinc roofs and fences/walls being the most affected areas. The disparities suggest that Asaba's larger and more exposed structures face greater environmental stressors, while Okwe benefits from localized resilience strategies. These findings emphasize the urgent need to improve construction standards, invest in drainage and erosion control, and adopt sustainable urban planning practices.

Table 6 shows the regression analysis that examines the relationship between temperature and building structure indices, specifically the surface area of zinc/roof buildings affected. The correlation between the surface area of affected zinc roofs and temperature shows a moderate positive relationship, with a correlation coefficient (R) of 0.583. The temperature change accounts for 33.9% of the surface area of the impacted structures change, according to the R2 value of 0.339. The F-statistic of 6.163 and p-value of 0.029 shows that the association is statistically significant and that temperature had a substantial influence on the surface area of the affected roofs. Although the surface area of the impacted zinc/roof structures is significantly influenced by temperature variance, the findings suggest that other factors should be taken into account in order to fully comprehend the intricate dynamics at work. In order to create more thorough models, it is crucial that future research incorporate wider environmental and structural aspects.

The surface area of the impacted zinc/roof structures and the ambient average temperature are compared using a linear regression analysis in Table 7. A statistically significant association ($p < 0.05$) is found in the analysis, suggesting that temperature is a useful indicator of the surface area. The standard error of the coefficient is 0.001,

Table 8. ANOVA tests of differences in "building structure indices," associated with temperature.

Source	Tests of Between-Subjects Effects					
	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	3819202.224	1	3819202.224	103.091	0.002	0.972
ambient	869316.500	10	86931.650	2.347	0.261	0.887
Error	111140.250	3	37046.750			

Source: SPSS Computation.

indicating little estimation error, and the zero-order correlation between the two variables is 0.583. The regression shows a positive correlation, with a 0.003°C increase in temperature for every 1 m² increase in the surface area of the impacted roofs. This relationship is statistically significant ($p = 0.029$), meaning this predictor reliably explains some temperature variation. The findings show that for every 1 m² of surface area of the affected roofs, the ambient temperature is predicted to rise by 0.003°C. The change in ambient temperature is a significant predictor of the surface area of impacted zinc/roof structures, illustrating how structural weaknesses can be affected by regional climatic conditions. Although some temperature variance may be explained by this predictor, the relationship's modest strength indicates that more research into other factors affecting building structure is necessary. These results highlight how crucial it is to address structural vulnerabilities in order to lessen their negative effects from the environment.

Table 8 shows an ANOVA test to examine the relationship between temperature variations and differences in building structure indices, such as roof and wall surface areas. The results showed that the baseline model was highly significant, explaining variations in the average structural indices. However, the relationship between temperature and building structure indices was not statistically significant, with the temperature contributing 869,316.500 to the total variance. The Partial Eta Squared value of 0.887 indicated that temperature explains a substantial proportion (88.7%) of the variance in building structure indices, suggesting a potentially meaningful relationship. The remaining unexplained variation was 111,140.250, with a mean square of 37,046.750. The study suggests that temperature variations may not reliably explain differences in building structure indices like roof and wall areas. However, the high Partial Eta Squared (88.7%) implies that temperature still explains a large share of the variance, though the results were not conclusive. Further research or more data would be needed to confirm this relationship. These results suggest a complex dynamic where temperature might play a meaningful but not independently sufficient role in shaping building structures. The study emphasises the necessity of more investigation or data to bolster and elucidate the observed link, opening the door to more complex understandings of the ways in which environmental elements impact architectural design and construction.

With notable temperature rises in the most recent decade, the three-decade study clearly shows a warming trend. Because of greater infrastructure, less greenery, and urban heat island effects, Asaba experiences warmer temperatures than Okwe. Okwe, with its cooler temperatures, benefits from vegetation and water bodies that moderate heat. Okwe's relatively smaller and less exposed structures show lower damage levels, highlighting resilience factors like better maintenance and planning. The surface area of the impacted zinc/roof structures and temperature have a somewhat favourable association, according to the regression analysis. It is anticipated that the ambient temperature will increase by 0.003°C for every 1 m² increase in the affected roof area. This emphasises how temperature may be used to anticipate structural weaknesses in a significant but limited way. While temperature explains a substantial portion of the variance in building structure indices, however, the involvement of other additional factors influences structural dynamics.

Conclusion

The study reveals a significant rise in decadal average temperatures in Oshimili South (Asaba and Okwe) from 1994 to 2023, driven largely by urbanization. This warming trend poses an urgent environmental and infrastructural challenge for Oshimili South. The sharp increase in temperatures, combined with structural vulnerabilities in Asaba, underscores the need for targeted and coordinated interventions. Sustainable urban planning, the expansion of green spaces, enhanced construction standards, and investments in erosion and flood control are essential to mitigating environmental impacts and fostering resilience. The observed correlation between rising temperatures and structural damage highlights the intricate relationship between climate and infrastructure. However, the presence of unexplained variances underscores the complexity of these dynamics and the need for further research to account for broader environmental and structural factors. Policymakers, engineers, urban planners, and other stakeholders must work together to address these issues. Policymakers must prioritize the strengthe-ning of climate policy frameworks, adopt region-specific policies to combat urban heat islands and establish robust environmental monitoring systems. Engineers should focus on implementing climate-responsive designs, utilizing reflective roofing materials, and enhancing the structural resilience of buildings. Town planners need to encourage sustainable urban growth, incorporate parks, green spaces, and water features, enforce zoning laws, and ensure the development of efficient drainage systems. The use of predictive models to assess the impact of future temperature trends on both urban and rural areas is also critical. This study serves as a call to action, emphasizing the need for integrated strategies that address urban heat, climate adaptation, and structural resilience. By adopting these sustainable approaches, Oshimili South can better safeguard its future and create a more resilient and sustainable environment for its communities.

CONFLICT OF INTEREST

The authors declare they have no conflict of interest.

REFERENCES

Ahmadian, E., Elnokaly, A., Sodagar, B., Verhaert, I. (2023). Impact of climate on building energy performance, urban built form and urban geometry. In: Littlewood, J., Howlett, R.J., Jain, L.C. (eds.). *Sustainability in energy and buildings 2022*. *SEB 2022. Smart Innovation, Systems and Technologies*, vol 336. Springer, Singapore.

Akinyemi, A., Dare, G., Anthony, A., & Dabara, D. I. (2016, May). Building collapse in Nigeria: Issues and challenges. In *Conference of the International Journal of Arts & Sciences, CD-ROM.* 9(1), 99-108.

Aliyu, A. (2024, August 31). Daily Trust. *Daily Trust*. https://dailytrust.com/building-collapse-over-90-die-in-incidents-in-one-year/

Bett, P. E., & Thornton, H. E. (2015). The climatological relationships between wind and solar energy supply in Britain. *Renewable Energy*, *87*(part 1), 96-110.

Dharmarathne, G., Waduge, A., Bogahawaththa, M., Rathnayake, U., & Meddage, D. (2024). Adapting cities to the surge: A comprehensive review of climate-induced urban flooding. *Results in Engineering*, *22*, 102123.

Ede, A. N. (2010, July). Structural stability in Nigeria and worsening environmental disorder: The way forward. In *The West Africa Built Environment Research Conference Accra Ghana* (pp. 489-498).

Elias, P., & de Albuquerque, J. P. (2022). Data and the localization of sustainable development goals in Africa: The case of SDG 11 in Lagos and Accra. In: Croese, S., & Parnell, S. (eds.). *Localizing the SDGs in African cities* (pp. 115-131). Sustainable Development Goals Series. Springer, Cham.

Feng, D. C., Ding, J. Y., Xie, S. C., Li, Y., Akiyama, M., Lu, Y., Beer, M., & Li, J. (2024). Climate change impacts on the risk assessment of concrete civil infrastructures. *ASCE OPEN: Multidisciplinary Journal of Civil Engineering*, *2*(1), 03124001.

Kalu, C. (2024, July 4). *Lagos floods: Floodwater slow to recede due to high tide.* Environment Commissioner Wahab. Arise News. Retrieved from https://www.arise.tv/lagos-floods-rainwater-slow-to-recede-due-to-high-tide-says-environment-commissioner-wahab/

Lewis, A., Elmualim, A., & Riley, D. (2011). Linking energy and maintenance management for sustainability through three American case studies. *Facilities*, *29*(5/6), 243-254.

Li, Y., Schubert, S., Kropp, J. P., & Rybski, D. (2020). On the influence of density and morphology on the Urban Heat Island intensity. *11,* Article number: 2647.

Liu, Z. K., Shang, S. L., & Wang, Y. (2017). Fundamentals of thermal expansion and thermal contraction. *Materials*, *10*(4), 410.

Lutz, A. F., Ter Maat, H. W., Biemans, H., Shrestha, A. B., Wester, P., & Immerzeel, W. W. (2016). Selecting representative climate models for climate change impact studies: an advanced envelope-based selection approach. *International Journal of Climatology*, *36*(12), 3988-4005.

Malla, F. A., Mushtaq, A., Bandh, S. A., Qayoom, I., Hoang, A. T., Shahid-e-Murtaza N. (2022). Understanding climate change: Scientific opinion and public perspective. In: Bandh, S. A. (ed.). *Climate change* (pp. 1-20). Springer, Cham.

Medved, S. (2022). Heat transfer in buildings structures and thermal comfort in buildings. In: *Building Physics* (1-143). Springer Tracts in Civil Engineering. Springer, Cham.

Met Office (2021). *UK and Global extreme events – Heatwaves*. Retrieved 8th November 2021 from https://www.metoffice.gov.uk/research/climate/understanding-climate/uk-and-global-extreme-events-heatwaves

Mostafavi, F., Tahsildoost, M., & Zomorodian, Z. (2021). Energy efficiency and carbon emission in high-rise buildings: A review (2005-2020). *Building and Environment*, *206*, 108329.

Okoli, P., & Abraham, E. (2024). In search of a sustainable future: A comparative assessment of climate change regimes in Nigeria and Kenya. *Review of European Comparative & International Environmental Law*, *33*(2), 276-290.

Oliveira, E., & Meyfroidt, P. (2021). Strategic land-use planning instruments in tropical regions: state of the art and future research. *Journal of Land Use Science*, *16*(5–6), 479-497.

Radhi, H. (2008). A comparison of the accuracy of building energy analysis in Bahrain using data from different weather periods. *Renewable Energy*, *34*(3), 869-875.

Ripple, W. J., Wolf, C., Gregg, J. W., Rockström, J., Mann, M. E., Oreskes, N., Lenton, T. M., Rahmstorf, S., Newsome, T. M., Xu, C., Svenning, J., Pereira, C. C., Law, B. E., & Crowther, T. W. (2024), The 2024 state of the climate report: Perilous times on planet Earth, *BioScience*, *74*(12), 812-824

Rostam, M. G., & Abbasi, A. (2023). Dynamic climate-adaptive design: A key to realizing future-proof energy efficiency in building sector. *Applied Energy*, *341*, 121146.

Sanodiya, J. S., & Rathore, H. (2024). Estimating the life cycle cost of a structures–case study. In: Pathak, K. K., Bandara, J. M. S. J., Agrawal, R. (eds.). *Latest developments in civil engineering* (vol 352, pp. 241-244). RACE 2022. Lecture Notes in Civil Engineering. Springer, Singapore.

The Federal Facilities Council AD HOC Task Group (2001). *Sustainable Federal Facilities: A Guide to Integrating Value Engineering, Life-Cycle Costing, and Sustainable Development*. National Academies Press.

Windapo, A. O., & Rotimi, J. O. (2012). Contemporary issues in building collapse and its implications for sustainable development. *Buildings*, *2*(3), 283-299.