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Land Surface Temperature (LST) Distribution Across Ogbaru Local Government Area of Anambra State

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ABSTRAK
Tujuan – Suhu Permukaan Tanah (LST) adalah parameter kunci dalam memahami dinamika termal suatu wilayah, dan berfungsi sebagai indikator penting untuk menilai pulau panas perkotaan, perubahan iklim, dan pola penggunaan lahan. Studi ini menyelidiki distribusi LST di seluruh Wilayah Pemerintah Daerah (LGA) Ogbaru di Negara Bagian Anambra, Nigeria, dengan memanfaatkan teknologi penginderaan jauh dan Sistem Informasi Geografis (GIS) untuk menilai tren spasial dan temporal antara tahun 1986 dan 2020.
Metode – Data selanjutnya divalidasi melalui survei lapangan menggunakan GPS dan metode ground-truthing. Penelitian ini juga menggunakan Thematic Mapper (TM) LANDSAT, Enhanced Thematic Mapper Plus (ETM+), dan Operational Land Imager (OLI) untuk estimasi LST. Korelasi Product Moment Pearson diterapkan untuk menganalisis hubungan antara penggunaan/tutupan lahan dan LST di seluruh wilayah.
Hasil – Hasil penelitian menunjukkan peningkatan signifikan dalam LST selama periode penelitian, dengan suhu pada tahun 1986 berkisar antara 19,4°C hingga 33,3°C, meningkat menjadi suhu antara 22,3°C dan 38,7°C pada tahun 2002, dan mencapai 24,4°C hingga 34°C pada tahun 2020. Peningkatan suhu tersebut terutama disebabkan oleh urbanisasi, perubahan penggunaan lahan, dan perluasan permukaan kedap air, khususnya di daerah bagian utara dan perkotaan Ogbaru, termasuk kedekatannya dengan Onitsha.
Temuan – Studi ini juga menyoroti disparitas regional dalam LST, dengan suhu yang lebih tinggi di kawasan terbangun dan suhu yang lebih rendah di zona bervegetasi. Tren ini menekankan semakin besarnya pengaruh pembangunan perkotaan terhadap variasi suhu lokal dan menggarisbawahi pentingnya perencanaan penggunaan lahan berkelanjutan dan strategi adaptasi iklim untuk mengurangi dampak pulau panas perkotaan di LGA Ogbaru dan wilayah serupa.
Keywords: Suhu Permukaan Tanah, Penginderaan Jauh, GIS, Urban Heat Island, Ogbaru, Perubahan Penggunaan Lahan, Adaptasi Iklim

Sebaran Suhu Permukaan Tanah (LST) Di Wilayah Pemerintah Daerah Ogbaru Negara Bagian Anambra

ABSTRACT
Purpose *– Land Surface Temperature (LST) is a key parameter in understanding the thermal dynamics of any given area, serving as an important indicator for assessing urban heat islands, climate change, and land use patterns. This study investigates the distribution of LST across Ogbaru Local Government Area (LGA) of Anambra State, Nigeria, utilizing remote sensing technology and Geographic Information System (GIS) to assess spatial and temporal trends between 1986 and 2020. The research utilizes secondary data, including LANDSAT imagery from 1980, 2000, and 2020, shapefiles, and Google Earth maps for visual interpretation.*
Method - *Data was further validated through field surveys using GPS and ground-truthing methods. The study also used LANDSAT's Thematic Mapper (TM), Enhanced Thematic Mapper Plus (ETM+), and Operational Land Imager*

(OLI) for LST estimation Pearson's Product Moment Correlation was applied to analyze the relationship between land use/cover and LST across the region.
***Results -** The results reveal a significant rise in LST over the study period, with temperatures in 1986 ranging from 19.4°C to 33.3°C, increasing to temperatures between 22.3°C and 38.7°C by 2002, and reaching 24.4°C to 34°C by 2020. The increase in those temperatures was primarily attributed to urbanization, land use changes, and the expansion of impervious surfaces, particularly in the northern and urbanized parts of Ogbaru, including the proximity to Onitsha. The study also highlights the regional disparity in LST, with higher temperatures in built-up areas and lower temperatures in vegetated zones.*
***Findings -**These trends emphasize the growing influence of urban development on local temperature variations and underline the importance of sustainable land use planning and climate adaptation strategies to mitigate the effects of urban heat islands in Ogbaru LGA and similar areas.*
***Keywords**: Land Surface Temperature, Remote Sensing, GIS, Urban Heat Island, Ogbaru, Land Use Change, Climate Adaptation*

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INTRODUCTION

Land Surface Temperature (LST) refers to the temperature of the Earth's surface, playing a critical role in understanding various environmental and climatic phenomena. The distribution of LST is influenced by multiple factors, including urbanization, vegetation cover, surface albedo, and meteorological conditions (Adeyeri et al., 2024). Research on LST distribution has provided an understanding of Urban Heat Islands (UHIs), Land Use and Land Cover (LULC) changes, and their implications for sustainability and urban planning. Urbanization significantly affects LST distribution. Studies highlight that urban areas typically exhibit higher LST compared to surrounding rural regions due to increased impervious surfaces, reduced vegetation, and anthropogenic heat emissions (Athukorala & Murayama, 2020). This phenomenon, known as the UHI effect, is pronounced in densely populated cities, where concrete and asphalt surfaces retain heat, raising nighttime temperatures. Vegetation cover, including urban green spaces, is inversely related to LST, as plants regulate temperature through evapotranspiration, creating cooling effects (Fadipe et al., 2024). Surface albedo, or the reflectivity of surfaces, also influences LST. High-albedo materials reflect more solar radiation, reducing surface heating, while low-albedo surfaces absorb more heat, increasing LST (Dissanayake et al., 2018).

The impact of albedo is often integrated into urban design strategies, where reflective materials are used to mitigate this. Meteorological factors, including humidity, wind speed, and precipitation, further modulate LST. Regions with high humidity and frequent rainfall typically experience lower LST due to increased latent heat flux (Huang et al., 2019). LULC changes directly affect LST distribution by altering surface characteristics and energy balance. For instance, deforestation increases LST as vegetation removal reduces evapotranspiration and exposes bare soil, which absorbs more solar radiation (Seun et al., 2022). Conversely, afforestation and reforestation efforts lower LST by enhancing vegetation cover. Urban expansion often replaces natural landscapes with impervious surfaces, exacerbating LST disparities between urban and rural areas (Fashae et al., 2020). Remote sensing technology has been pivotal in assessing LULC changes and their impact on LST. Satellite data, such as those from Landsat and MODIS, enable a spatiotemporal analysis of LST distribution, offering a valuable understanding of regional and global trends. Integration of remote sensing with geographic information systems (GIS) has further enhanced the accuracy of LST mapping and its correlation with LULC dynamics (Du et al., 2022).

The implications of LST distribution extend to public health, energy consumption, and ecosystem sustainability. Elevated LST in urban areas contributes to heat stress, particularly during heatwaves, posing significant health risks to vulnerable populations (Delgado-Capel et al., 2024). Increased temperatures also drive higher energy demands for cooling, straining urban energy systems and contributing to greenhouse gas emissions. Understanding LST distribution is critical for developing adaptive strategies to mitigate these challenges. LST distribution impacts ecosystem sustainability by influencing soil moisture, vegetation growth, and biodiversity. Higher LST can lead to soil desiccation, reducing agricultural productivity and affecting food security (El-Kenawy et al., 2024). Urban planning incorporating green infrastructure, such as parks and green roofs, has been identified as a practical approach to counteract the adverse effects of elevated LST.

Emerging technologies, including machine learning and artificial intelligence, are being applied to enhance LST modeling and prediction. These technologies allow for the integration of diverse datasets, improving the precision of LST distribution analysis (Anupriya & Rubeena, 2024). In addition, interdisciplinary research combining climatology, urban planning, and public health perspectives is necessary to address the multifaceted challenges of LST distribution. Global initiatives, such as the Sustainable Development Goals (SDGs), emphasize the importance of managing LST in urban and rural settings. Goal 11, which focuses on sustainable cities, underscores the need for strategies that reduce UHIs and promote climate-resilient urban development (United Nations, 2023).

The study on Land Surface Temperature (LST) distribution across the Ogbaru Local Government Area of Anambra State is motivated by the critical role of LST in understanding environmental and urban dynamics. LST is a significant parameter for studying the effects of Surface Urban Heat Island (SUHI), as it modulates air temperatures and influences energy exchanges between the surface and the atmosphere. This interaction affects thermal comfort, particularly in urbanized areas. Ogbaru, with its diverse land cover types and rapid urbanization, provides a compelling case to investigate these dynamics (Egbueri, 2019). The temporal trends in LST, observed from 1986 to 2020, highlight a significant increase in surface temperatures, attributed to urbanization and changes in land use and cover. Understanding these trends is important for policymakers and urban planners to address the implications of rising temperatures, such as thermal discomfort, increased energy demand, and adverse health effects.

Spatial variations in LST, driven by land cover changes, further underscore the need for localized strategies to mitigate temperature rise. For instance, areas with higher vegetation cover in Ogbaru exhibited lower LST values, emphasizing the importance of green infrastructure in urban planning. Conversely, built-up and bare surfaces, particularly around Onitsha and along the River Niger, were associated with higher LST values due to their thermal properties. This understanding is crucial for designing interventions to reduce the heat island effect and promote sustainable urban development (Areh et al, 2020). Moreover, the study is driven by the need to evaluate the long-term impacts of urban expansion on the environment. The significant increase in the mean of LST values over 34 years underscores the urgency of understanding and managing the consequences of urban growth on local and regional climates. Analyzing how land cover transitions influence LST distribution will guide the study in providing data-driven recommendations to enhance climate resilience in the Ogbaru Local Government Area.

Objectives

1. To examine the temporal trends in Land Surface Temperature (LST) distribution in Ogbaru Local Government Area of Anambra State from 1986 to 2020.
2. To analyze the influence of land cover changes on the spatial distribution of Land Surface Temperature (LST) within Ogbaru Local Government Area of Anambra State across different periods.

METHOD

The study adopts an experimental research design, focusing on secondary data sources. Key variables include surface land use/cover and surface temperature characteristics. Required data for the research includes remotely sensed imagery from LANDSAT, vector shapefiles of Ogbaru Local Government Area in Anambra State, and a digital map or guide of the study area obtained from Google Earth. This map assists in the visual interpretation of land use classes and aids in ground-truthing efforts to validate the findings. These data sources are important for analyzing the land use and temperature dynamics in Ogbaru Local Government Area. Figure 1 shows the map of Nigeria, providing an overview of the country’s geographical layout. Figure 2 zooms in on the southwestern region, specifically highlighting Anambra State, and further locates Ogbaru Local Government Area within the state. Also, Figure 3 offers a detailed map of Ogbaru LGA itself, illustrating its specific boundaries and the towns it encompasses.

Ogbaru Local Government Area is situated in southwestern Anambra State, Nigeria, bounded by Onitsha South LGA to the north, Ihiala LGA to the east, Imo State to the south, and River Niger to the west. It is located between latitudes 6°38’0” N and 6°38’01” N and longitudes 5°49’01” N and 6°51’01” N. The area includes 15 towns, such as Atani, Akili-Ogidi, and Ogbakugba. The climate is tropical, with a long rainy season from March to October, and a shorter dry period from November to February. The region is predominantly a freshwater swamp forest, experiencing flooding at the end of the rainy season. Agriculture is the main economic activity in the drained areas, while fishing is prevalent in the swampy zones. Fertile alluvial soils support continuous cropping. The population of Ogbaru is 261,018 (2010, National Bureau of Statistics), with most residents being Igbo people, alongside others from Southeastern Nigeria and Delta State, who engage in trade. Geologically, Ogbaru is a low-lying sedimentary basin prone to annual flooding, which deposits mineral-rich sediments. Economic activities are largely agro-based, reflecting the area’s fertile land and abundant freshwater resources.

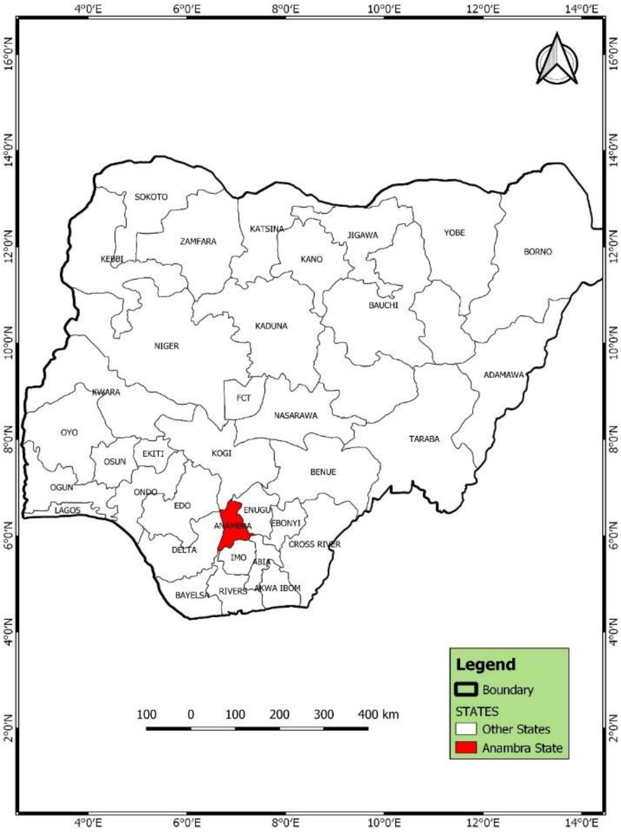

Figure 1: Map of Nigeria

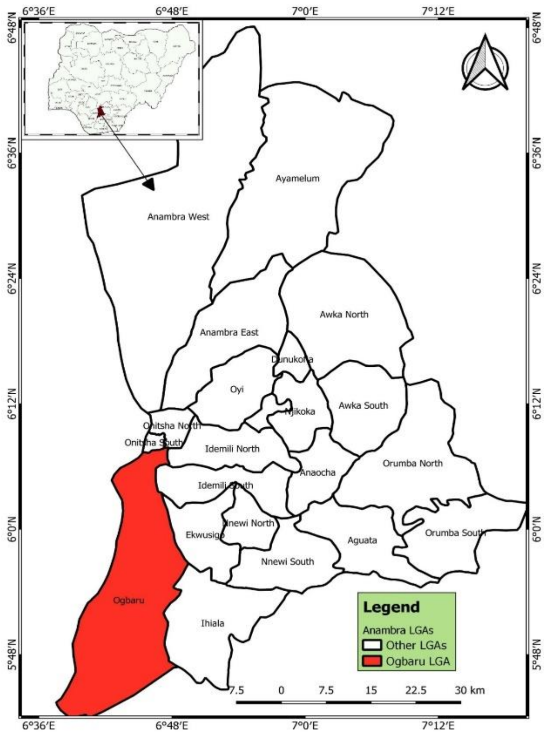

Figure 2: Map of Anambra showing Ogbaru

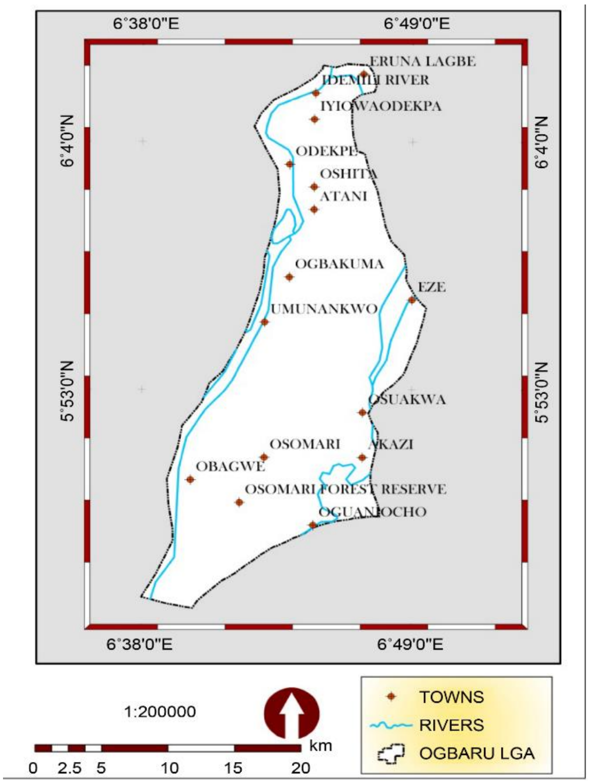

Figure 3: Map of Ogbaru Local Government Area of Anambra State

Primary data for the study were gathered through field surveys to establish the relationship between image signals and ground conditions. The surveys, using GPS to create ground control points, helped in ground-truthing and assisted in training data sets for land use and land cover classification. The data shown in Table 1 provided both quantitative and qualitative information on land use types. Secondary data included satellite imagery, journals, texts, and online articles. LANDSAT data, available at no cost, were used with imagery from December 6, 1980; December 27, 2000; and December 8, 2020. The vector shapefiles of Ogbaru LGA were sourced from NASRDA.

Table 1: Data Characteristics

S/N	Data	Sensor	Band	Spatial Resolution	Source	Year	Reference System
1	Landsat 5	Tm (Thematic Mapper)	2-5	30m	USGS Earth Explorer	1986	WGS 1984 UTM Zone 32n
2	Landsat 7	Etm+ (Enhanced Thematic Mapper Plus)	2-5	30m	USGS Earth Explorer	2003	WGS 1984 UTM Zone 32n
3	Landsat 8	OLI (Operational Land Imager)	3-9	30m	USGS Earth Explorer	2020	WGS 1984 UTM Zone 32n

The data analysis involved two main processes: land use/cover classification and Land Surface Temperature (LST) estimation. Data errors were corrected for image preprocessing, with the primary operation being the resampling of TM band 6 to 30m resolution. Land use/cover classification was performed using the supervised Maximum Likelihood Classification (MLC) method in ArcMap 10.4, where training data were used to classify image pixels. LST estimation employed the mono-window algorithm, using thermal bands from Landsat-5 TM, ETM+, and TIRS. These bands, with a spatial resolution of 30m, were used to calculate LST for Ogbaru LGA for 1980, 2000, and 2020.

Conversion of Digital Numbers (DN) of the bands to Spectral Radiance: The DN of the thermal bands of TM and ETM+ were converted into spectral radiance values for each of the investigated years using the following equation –

$$L_\lambda = \left(\frac{L_{MAX} - L_{MIN}}{Q_{CALMAX} - Q_{CALMIN}}\right) \times (DN - 1) + L_{MIN} \quad (1)$$

Where,

Ll = The spectral radiance at the sensor's aperture in $Wm^{-2}sr^{-1}\,\mu m^{-1}$

L_{MAX} = Spectral radiance scaled to Q_{CALMAX} in $Wm^{-2}sr^{-1}\,\mu m^{-1}$, available in the metadata

L_{MIN} = Spectral radiance scaled to Q_{CALMIN} in $Wm^{-2}sr^{-1}\,\mu m^{-1}$, available in the metadata

Q_{CALMAX} = Maximum quantized calibrated pixel value (corresponding to L_{MAX}) in DN = 255

Q_{CALMIN} = Minimum quantized calibrated pixel value (corresponding to L_{MIN}) in DN = 1

DN = Digital Number of the Band

For Landsat 8 with file data on Radiance Multiplier (M) and Radiance Add (B), the thermal infrared (TIR) band was converted into spectral radiance (Lλ) using the equation -

$$L\lambda = M_L Q_{CAL} + A_L \quad (2)$$

Where,

Ll = The spectral radiance at the sensor's aperture in $Wm^{-2}sr^{-1}\,\mu m^{-1}$

M_L = Band Specific Multiplicative Rescaling factor, gotten from the metadata of the image.

Q_{CAL} = Quantized and calibrated standard product pixel values (Digital Number)

A_L = Band Specific Additive Rescaling factor, gotten from the metadata of the image.

Conversion from Spectral Radiance to At-Satellite Brightness Temperature: Spectral radiance values for the bands were then converted to radiant surface temperature under an assumption of uniform emissivity using pre-launch calibration constants for the Landsat ETM+ sensor implemented into this equation:

$$T = \frac{K_2}{\ln\left(\frac{K_1}{L_\lambda} + 1\right)} - 273.15 \quad (3)$$

Where,

T = At-satellite brightness temperature in Degrees Celsius

L_l = Spectral radiance in $Wm^{-2}sr^{-1}\,\mu m^{-1}$ (gotten from equations 1 and 2)

K_1 = Band specific thermal conversion constant from the metadata (K1_CONSTANT_BAND_X, x is the thermal band number)

K_2	=	Band specific thermal conversion constant from the metadata (K2_CONSTANT_BAND_X, x is the thermal band number)
-273.15	=	Constant for conversion from Kelvin to Degrees Celsius

Correcting for Land Surface Emissivity (LSE): Normalized Differential Vegetative Index (NDVI) was used to estimate LSE for emissivity correction. The temperature values obtained using Equation (3) are referenced to a blackbody. Therefore, corrections for spectral emissivity (ε) became necessary according to the nature of land cover. This Equation was used:

$$e = 0.004P_v + 0.986 \quad (4)$$

Where,

e	=	Land Surface Emissivity
0.004 and 0.986	=	Constants for emissivity estimation
P_V	=	Proportion of vegetation given by the equation –

$$P_V = \left(\frac{NDVI - NDVI_{min}}{NDVI_{max} - NDVI_{min}}\right)^2 \quad (5)$$

Where,

NDVI	=	Normalized Differential Vegetation Index as computed with Equation (6) for each of the years
$NDVI_{min}$	=	Minimum value of NDVI for that year
$NDVI_{max}$	=	Maximum value of NDVI for that year

The Normalized Difference Vegetation Index (NDVI) is the most commonly used vegetation index for observing vegetation globally. Due to plants' high reflectance in the near-infrared (NIR) and high absorption in the red spectrum, these two bands were used to calculate NDVI so that the following formula gives Normalized Difference Vegetation Index (NDVI) -

$$NDVI = \frac{NIR - RED}{NIR + RED} \quad (6)$$

Where NIR and RED are the reflectances in the Near-Infrared and Red portions of the electromagnetic spectrum respectively.

For LANDSAT 5 TM and 7 ETM+,

$$NDVI = \frac{BAND\ 4 - BAND\ 3}{BAND\ 4 + BAND\ 3} \quad (7)$$

where Band 4 and Band 3 are the reflectances in the Near-Infrared and Red portion of the Electromagnetic spectrum of the Thematic Mapper and Enhanced Thematic Mapper Plus respectively.

For LANDSAT 8 OLI,

$$NDVI = \frac{BAND\ 5 - BAND\ 4}{BAND\ 5 + BAND\ 4} \quad (8)$$

Where Band 5 and Band 4 are the reflectance bands in the Near-Infrared and Red portions of the Electromagnetic spectrum of the Operation Land Imager (OLI) sensor of Landsat 8 respectively.

Estimation of the Land Surface Temperature: Finally, having corrected the emissivity in equation (4), the LST was estimated using the equation:

$$\mathrm{LST} = \frac{\mathrm{B_T}}{1+\mathrm{w}} \times \frac{\mathrm{B_T}}{\mathrm{P}} \times \ln(\mathcal{E}) \qquad (9)$$

Where,

LST = Land Surface Temperature in Degrees Celsius
B_T = At-satellite brightness temperature
W = Wavelength of emitted radiance (μm)

$$\mathrm{p} = \mathrm{h} \times \frac{\mathrm{c}}{\mathrm{s}}\ (1.438 \times 10^{-2}\mathrm{m\ K}) = 14380 \qquad (10)$$

Where,

H = Planck's constant ($6.626 \times 10^{-34}\mathrm{Js}$)
S = Boltzmann constant ($1.38 \times 10^{-23}\mathrm{J/K}$)
C = Velocity of light ($2.998 \times 10^{8}\mathrm{m/s}$)
e = LSE

Pearson's Product Moment Correlation: Pearson's Product Moment Correlation Analysis is a statistical method that tests the measures of linear association between two quantitative variables, with the linear association going from +1 to -1. Pearson's Product Moment Correlation analysis determined the relationship between land use/land cover and land surface temperature. This equation is given as:

$$\mathrm{r} = \frac{\Sigma \mathrm{XY} - \frac{(\Sigma \mathrm{X})(\Sigma \mathrm{Y})}{\mathrm{N}}}{(\Sigma \mathrm{X}^2 - \frac{(\Sigma \mathrm{X})^2}{\mathrm{N}})(\Sigma \mathrm{Y}^2 - \frac{(\Sigma \mathrm{Y})^2}{\mathrm{N}})} \qquad (11)$$

Where,

r = Correlation Coefficient
x = Independent variable, which is the Land use classes
y = Dependent variable, which is the land surface temperature readings associated with each class
n = Observations

To test the strength of the correlation, the coefficient of determination was used and given by:

$$C/D = r^2$$

Where,

C/D = Coefficient of determination
r^2 = correlation coefficient

RESULTS

Land Surface Temperature (LST) Distribution Across Ogbaru Local Government Area of Anambra State

Land surface temperature (LST) is the key parameter for studying Surface Urban Heat Islands, as it modulates the air temperature of lower layers, impacting energy exchanges between the surface and air and, therefore, influencing thermal comfort in the canopy layer. This study applied remote sensing technology and GIS in extracting the surface temperature to determine the spatial extents and temporal trends in the Ogbaru Local Government Area of Anambra State.

LST Distribution of Ogbaruin 1980

The LST assessment of Ogbaru Local Government Area of Anambra State revealed that the temperature values in 1986 ranged between 19.4°C and 33.3°C (Figure 4). The temperatures during this period were relatively low around Odekpe in the northeastern part of the Ogbaru Local Government Area of Anambra State and most of the southern part. This is related to the high amount of vegetative cover in these parts, which consists of the forested areas, within this period. The low urban development in 1986 contributed to the low temperature levels in these parts of Ogbaru. The relatively high temperatures identified in Ogbaru Local Government Area of Anambra State as of 1986, ranging from 25.8 to 33.3, were shown in Figure 4 to be in areas closer to the river Niger that consist mostly of bare surfaces, some of which are dominated by sandy sediments, deposited by the river. These temperature values were obtained due to high thermal reflectance and low absorption of their materials.

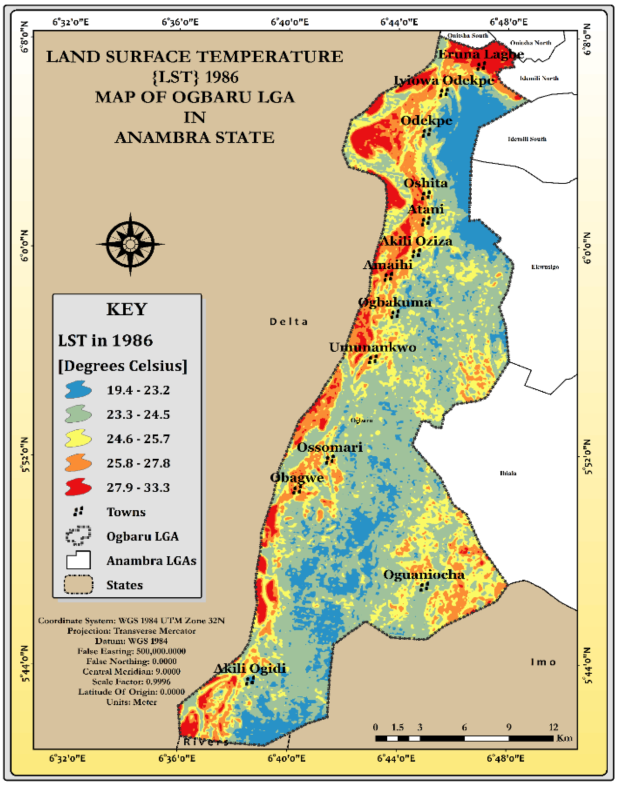

Figure 4: LST Distribution of Ogbaruin 1980

As observed in Figure 4, the regions associated with the highest temperatures are located towards the western side of Ogbaru Local Government Area of Anambra State with traces of built surfaces. In contrast, the lowest temperatures are found in the majorly rural areas towards the east, such as Oguaniocha and Akili Ogidi. The highest LST range values of 27.9 – 33.3°C are dominant within the urban surfaces in the northernmost part of Ogbaru Local Government Area of Anambra State, which is part of Onitsha urban, indicating that built–up and bare surfaces are the major drivers of LST intensity within Ogbaru Local Government Area of Anambra State in 1986.

LST Distribution of Ogbaru in 2002

By 2002, the LST values increased significantly, ranging between 22.3°C and 38.7°C over the area (Figure 5). This overall increase is likely due to the increased changes in landcover classes due to changing land use as observed from the LULC analysis, as the increase in impervious surfaces leads to a subsequent increase in temperatures in the area (Adebayo et al., 2017; Awuh & Japhets, 2018). The regions associated with the lowest values in 1986 have been shown to have an increase in temperatures by 2002. For example, Oguaniocha, an area previously with a temperature range of 23.3 to 24.5°C in 1986, has witnessed an increase in the temperature range of 24.9 to 29.2°C attributable to changing land use. This temperature change could be related to the massive transition of the land cover from forested areas in 1986 to more light vegetation in 2002. The highest temperature ranges of 31.8 to 38.7°C were still dominant in the northernmost part of the LGA and some parts of the eastern part of Ogbaru Local Government Area of Anambra State. The interesting development is that a greater part of the Ogbaru Local Government Area of Anambra State has witnessed a significant increase in LST across most parts of the Ogbaru Local Government Area of Anambra State. More so, the lowest temperature identified for Ogbaru Local Government Area of Anambra State in 2002 was 22.3, which is 2.9°C higher than the lowest LST values in 1986, showing an increase in surface temperature. The highest LST values in 1986 were 27.9 – 33.3°C while the highest determined LST values in 2002 were 31.8 – 38.7°C, showing a clear increase in the LST range of 3.9 – 5.4°C.

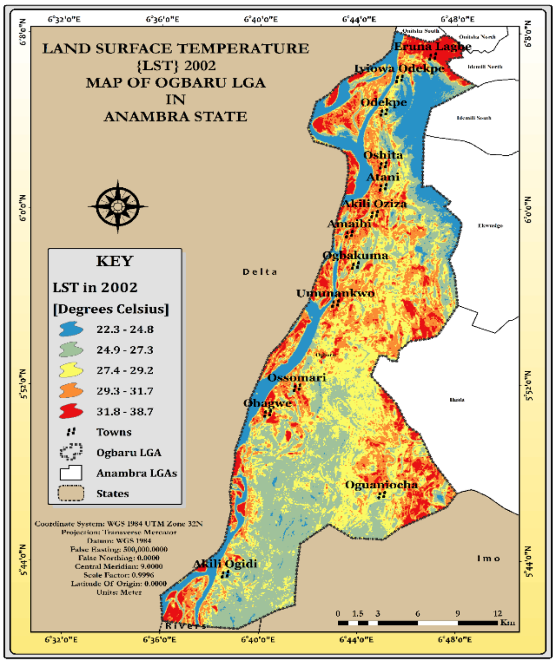

Figure 5: LST Distribution of Ogbaru in 2002

LST Distribution of Ogbaru in 2020

In Ogbaru Local Government Area of Anambra State, by 2020, the LST distribution increased considerably over the area, ranging between 24.4°C and 34°C (Figure 6). It is evident that the lowest LST value recorded in Ogbaru Local Government Area of Anambra State rose to 24.4°C from an initial value of 19.4°C in 1986 and 22.3°C in 2002 while the highest identified LST value dropped to 34°C in 2020 from 38.7°C in 2002 but still higher than the highest LST value of 33.3°C identified in 1986. Given the expansion of urban surfaces as depicted by the variations in the landcover characteristics, most parts of Ogbaru Local Government Area of Anambra State showed LST values above 27.4°C. The continued increase in artificial surfaces is a major driving factor in the overall spatial and numeric temperature readings. As the temperatures had risen over the Ogbaru Local Government Area of Anambra State, alongside the development and growth of urban surfaces, the regions with the highest spatial extent of the maximum temperatures were located towards the city of Onitsha.

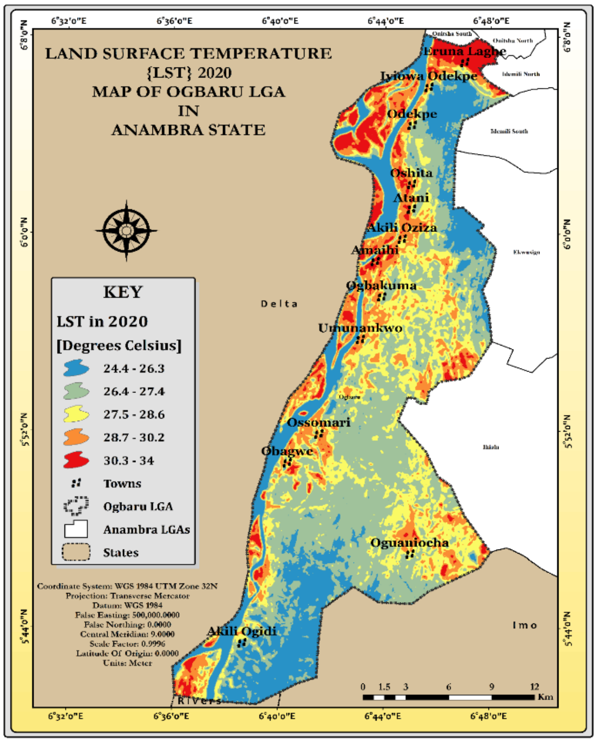

Figure 6: LST Distribution of Ogbaruin 2020

The analysis of the temporal trend of LST distribution in Ogbaru Local Government Area of Anambra State displays that each parameter has been increasing over time. The maximum temperatures increased from 33.3°C to 38.7°C in 2002 and maintained a maximum LST of 34 in 2020, while the minimum LST values increased from 19.4°C to 24.4°C between 1986 and 2020 (Figure 7). The mean temperatures grew from 24.4°C to 29.2°C between 1986 and 2020, indicating that the temperatures within Ogbaru Local Government Area of Anambra State are on an increasing trend. This implies that the average LST of Ogbaru Local Government Area of Anambra State increased by 4.8°C within 34 years.

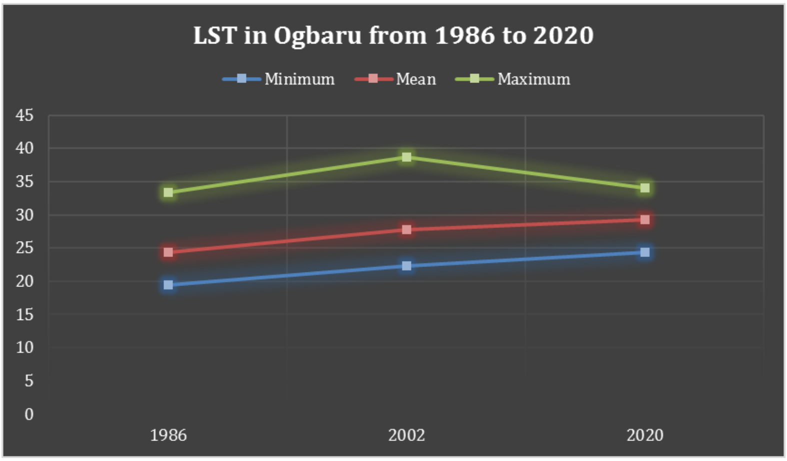

Figure 7: Temporal Trend of LST in Abakaliki from 1980 to 2020

DISCUSSION

The land surface temperature (LST) distribution across Ogbaru Local Government Area (LGA) of Anambra State has demonstrated a clear upward trend over the years, driven by urban expansion and changing land use patterns. The study utilized remote sensing technology and GIS to assess LST across three periods: 1986, 2002, and 2020. In 1986, the LST values in Ogbaru LGA ranged from 19.4°C to 33.3°C, with areas of lower temperatures concentrated in the northeastern and southern parts of the region, primarily due to the extensive vegetative cover. These cooler regions were dominated by forested areas, where the canopy helped maintain lower surface temperatures. In contrast, higher temperatures, ranging from 25.8°C to 33.3°C, were recorded in areas closer to the River Niger. This was due to the presence of bare surfaces and sandy sediments that had low thermal absorption. The highest LST values were found in the urban areas of Ogbaru, which include parts of Onitsha, where built-up surfaces contributed significantly to the elevated temperatures. This finding aligns with the research of Du et al. (2022), which identified urbanization as a significant factor driving the increase in surface temperature in similar regions.

By 2002, LST values had increased significantly, ranging from 22.3°C to 38.7°C. This increase could be attributed to changes in land cover as urbanization progressed and impervious surfaces expanded. The rise in LST was evident even in areas that had previously experienced lower temperatures in 1986, such as Oguaniocha. In this area, the temperature range increased from 23.3°C to 24.5°C in 1986 to 24.9°C to 29.2°C by 2002, reflecting the transition from forested to lighter vegetation cover. These changes align with the findings of Fashae et al. (2022), who observed similar patterns of increased surface temperature due to urbanization and land cover changes in Nigerian cities. The highest temperature values remained concentrated in the northernmost parts of Ogbaru LGA, particularly around Onitsha, where impervious surfaces like roads and buildings continued to dominate the landscape. In contrast, a study by Guo et al. (2022) of neighboring regions found that, while urbanization significantly contributed to LST increases, the impacts were not as pronounced as in Ogbaru, highlighting regional differences in the extent of urban development and its effect on surface temperatures. This variation could be attributed to the difference in urban expansion rates and the level of infrastructure development in the studied regions.

By 2020, the LST range in Ogbaru LGA had further increased, reaching between 24.4°C and 34°C. While the maximum LST values decreased slightly from 38.7°C in 2002 to 34°C in 2020, they were still higher than the 33.3°C recorded in 1986. The increase in the lowest recorded LSTs, from 19.4°C in 1986 to 24.4°C in 2020, reflected the continued expansion of urban areas, particularly near Onitsha. The continued rise in artificial surfaces, such as roads, buildings, and other urban infrastructure, was the primary factor behind this temperature rise. This finding is consistent with research by Li et al. (2017), who noted that as urban surfaces expand, LSTs tend to increase, especially in regions with significant urban growth. In addition, the findings of Dissanayake et al. (2018) in Lagos corroborate the idea that Urban Heat Islands (UHIs) intensify over time, particularly when urbanization outpaces natural vegetation restoration. Interestingly, while the highest temperature values declined slightly in 2020, the general trend still showed an upward movement in surface temperatures over time. This suggests that while Urban Heat Islands tend to peak at certain times, their overall impact continues to grow as urbanization progresses. A related study by Huang et al. (2019) also found that surface temperatures in major Nigerian cities, including Onitsha, have been steadily increasing over the years, with noticeable cooling during specific periods but a long-term upward trajectory due to increased built-up areas.

The temporal analysis of LST in Ogbaru revealed a steady temperature increase from 1986 to 2020. The maximum LST increased from 33.3°C to 38.7°C in 2002, then slightly dropped to 34°C in 2020. However, the overall trend demonstrated a 4.8°C increase in average LST over the 34 years. The mean temperatures grew from 24.4°C in 1986 to 29.2°C in 2020, indicating a significant shift towards higher average surface temperatures. This trend of increasing LST over time is consistent with studies in other urbanized regions of Nigeria and across Africa, where land use changes, particularly urbanization, have been linked to higher surface temperatures (Simwanda et al., 2019). In contrast, research by Athukorala and Murayama (2020) in parts of Ghana showed a slower rate of increase in LST, with only a 2°C rise over a similar time frame. This difference in findings underscores the varying impacts of urbanization in different African countries, which can be attributed to local factors such as vegetation cover, urban planning, and industrialization levels.

CONCLUSION

This study has successfully assessed the Land Surface Temperature (LST) distribution across Ogbaru Local Government Area (LGA) of Anambra State, using remote sensing technology and GIS to determine the spatial and temporal trends from 1986 to 2020. The findings reveal a clear and consistent increase in LST over the three decades, primarily driven by urbanization, land use changes, and the expansion of impervious surfaces. In 1986, the region experienced relatively low LST values, with cooler temperatures concentrated in areas with dense vegetative cover. However, by 2002, a significant increase in LST was observed, particularly in the northern part of Ogbaru, linked to the growth of urban areas such as Onitsha. The LST values continued to rise in 2020, despite a slight reduction in the maximum temperatures from 2002, suggesting an upward trend. This study highlights the significant impact of urban development, particularly in the northern regions, on the local microclimate, with the highest LST values consistently found in built-up areas. The results underscore the urgent need for effective urban planning strategies, such as increasing green spaces, improving vegetation cover, and implementing sustainable development practices to mitigate the adverse effects of Urban Heat Islands (UHI). The rise in LST has important implications for human health, energy consumption, and the local environment, emphasizing the necessity for targeted interventions to adapt and mitigate the effects of increasing surface temperatures in Ogbaru LGA and similar urbanized regions across Nigeria.

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