

# UAI JOURNAL OF MULTIDISCIPLINARY & CULTURAL STUDIES (UAIJMCS)



Abbreviated Key Title: UAI J Mult Cul Stu.

ISSN: 3049-2351 (Online)

Journal Homepage: <https://uaipublisher.com/uaijmcs-2/>

Volume- 2 Issue- 1 (January- February) 2026

Frequency: Bimonthly



## Urbanisation, Land Surface and Atmospheric Temperature Interactions and Implications for Urban Heat Island Intensity in Abuja Municipal Area Council

Feyi Hauwa Garr<sup>1\*</sup>, Alhassaan Mamman Mohammed<sup>2</sup>, Ibrahim Musa<sup>3</sup>

<sup>1</sup> Sustainable Development Centre University of Abuja

<sup>2</sup> Department of Geography and Environmental Sciences University of Abuja

<sup>3</sup> Department of Economics University of Abuja

**Corresponding Author:** Feyi Hauwa Garr

### ABSTRACT

*This study investigates the interrelationships among urbanisation, land surface temperature (LST), atmospheric temperature, and UHI intensity, integrating multi-temporal satellite imagery (1994–2024), long-term meteorological records, land-use and land-cover (LULC) analysis, ecological indices, and residents' perceptions. Results reveal that while atmospheric temperatures have increased moderately over three decades, LST has risen sharply, particularly in densely built-up areas, reflecting substantial heat retention by impervious surfaces. Vegetation cover declined drastically from over 60% in 1994 to under 10% by 2024, while built-up land expanded more than fivefold, exacerbating thermal stress. Ecological indices indicate fragmented green spaces, with more than half of the area classified as "Worst" for thermal mitigation. At the same time, survey responses highlight governance and funding constraints as significant barriers to the effective implementation of green infrastructure. The findings underscore the dual environmental and institutional drivers of UHI in AMAC and the critical role of green infrastructure in moderating urban heat. Recommendations include strategic urban greening, strengthened regulatory enforcement, and increased public awareness to enhance climate resilience.*

**KEY WORDS:** Urbanisation, Land Surface Temperature, Atmospheric Temperature, Urban Heat Island and Green Infrastructure

### Introduction

Urbanisation represents a defining characteristic of contemporary socio-economic development, particularly in rapidly expanding cities of sub-Saharan Africa. As cities grow, natural landscapes are transformed into built environments dominated by impervious surfaces such as roads, buildings, and pavements, often resulting in significant alterations to local climate and energy balances (Sulaiman et al., 2025; Suleiman et al., 2025) and massive importation of construction materials and equipment (Magaji et al.,

2022), as well as associated methane emission (Ibrahim et al., 2025). In the Federal Capital Territory (FCT) of Nigeria, Abuja has experienced accelerated urban growth, especially within the Abuja Municipal Area Council (AMAC), which has precipitated concerns about the impacts of urbanisation on land surface and atmospheric temperatures (Hafizu et al., 2025). These temperature dynamics are central to the phenomenon known as the Urban Heat Island (UHI), wherein urban cores exhibit elevated temperatures relative to

surrounding rural or peri-urban areas due to changes in urban land cover and anthropogenic processes (Sulaiman et al., 2025).

The relationship between urbanisation and land surface temperature (LST) has been well documented in geospatial research, highlighting how increases in impervious surface cover correspond with rising surface temperatures. In the Abuja metropolis, for example, the expansion of built environments has contributed to increases in mean LST over multi-decadal periods, with built-up areas recording higher temperatures than vegetated zones (Areh et al., 2025). This linkage underscores how urban growth not only alters land-cover patterns but also amplifies surface thermal responses, which can subsequently influence near-surface atmospheric conditions. Thus, examining LST variation in AMAC provides a quantitative basis for understanding UHI intensity amid rapid urbanisation.

Atmospheric temperature dynamics, while distinct from LST, are influenced by changes in surface thermal properties and urban morphology. Surface thermal radiation, reduced evapotranspiration, and increased anthropogenic heat release combine to modify local atmospheric temperature profiles, contributing to elevated air temperatures in urban centres (Muktar et al., 2025). These changes impact urban comfort, energy demand, and public health, particularly during heatwave events or dry seasons when surface heating is pronounced (Sadiq et al., 2025). Investigating atmospheric temperature alongside LST in AMAC is therefore essential for capturing the full scope of urban thermal environments.

The implications of intensified UHI phenomena extend beyond temperature metrics to include socio-environmental and policy dimensions. Elevated urban temperatures have been associated with greater cooling energy consumption, heightened heat stress among vulnerable populations, and degraded urban air quality (Sulaiman et al., 2025; Abiola et al., 2025). In Abuja, empirical investigations indicate that urban planning decisions, such as vegetation removal and infrastructure placement, significantly shape thermal conditions, suggesting that mitigation strategies will need to integrate both land-use planning and climate-adaptive design. Sustainable city planning, including green and cool infrastructure, can help moderate the UHI effect and improve urban livability.

Given these dynamics, research that systematically examines the interconnections among urbanisation, LST, and atmospheric temperature in AMAC is timely and necessary. Such studies not only contribute to scientific understanding of urban thermal processes but also inform targeted interventions to mitigate heat stress and enhance climate resilience in rapidly urbanising cities. By grounding analysis in remote sensing and geospatial methods, researchers can elucidate spatial patterns of thermal variation and provide actionable insights for planners and policymakers in Abuja and comparable urban contexts.

## Literature Review and Theoretical Framework

### Urbanisation

Urbanisation refers to the increasing concentration of population, infrastructure, and economic activities in urban areas, often accompanied by spatial expansion and land-use transformation. Rural-urban migration triggered by the search for employment promotes urbanisation (Adekoya et al., 2025; Abeke et al., 2025). It is a dominant global trend, particularly pronounced in developing regions, where rapid urban growth frequently outpaces planning and infrastructure provision (United Nations, 2019). Urbanisation alters natural landscapes by replacing vegetation with impervious surfaces

such as concrete and asphalt, thereby modifying surface energy balance, hydrological cycles, and local climatic conditions (Grimm et al., 2008). These transformations significantly influence thermal environments, making urbanisation a critical driver of land surface and atmospheric temperature changes and a primary contributor to urban heat island development.

### Land Surface

The land surface represents the physical interface between the Earth and the atmosphere, encompassing soil, vegetation, water bodies, and built-up features (Olusola et al., 2025; Magaji & Musa, 2024; Abubakar et al., 2025). Changes in land surface characteristics, particularly due to urban land-cover conversion, directly affect land-surface temperature through variations in albedo, heat capacity, surface roughness, and evapotranspiration (Weng, 2009). Impervious urban surfaces absorb and retain more solar radiation than natural cover, leading to elevated surface temperatures, especially during the daytime. Consequently, land-surface conditions are a fundamental determinant of spatial temperature variability and play a pivotal role in shaping urban thermal patterns observable through remote sensing.

### Atmospheric Temperature

Atmospheric temperature refers to the thermal state of the air, typically measured near the Earth's surface, and is influenced by radiative exchanges, surface heating, and atmospheric circulation processes. In urban environments, atmospheric temperature is strongly influenced by underlying land-surface properties, anthropogenic heat emissions, and reduced ventilation due to dense building configurations (Oke, 1982; Magaji et al., 2024). The interaction between heated urban surfaces and the lower atmosphere enhances sensible heat flux, leading to higher air temperatures than in surrounding rural areas. Understanding atmospheric temperature dynamics is essential for evaluating human thermal comfort, energy demand, and health risks in urban areas experiencing rapid urbanisation.

### Urban Heat Island Intensity

Urban Heat Island (UHI) intensity describes the magnitude of temperature difference between urban areas and their rural or less-developed surroundings. It is commonly quantified using either land surface temperature differences (surface UHI) or near-surface air temperature differences (atmospheric UHI) (Voogt & Oke, 2003). UHI intensity is influenced by factors such as land cover composition, urban morphology, population density, and climatic conditions. Elevated UHI intensity exacerbates heat stress, increases cooling energy demand, and contributes to environmental degradation, making it a critical indicator for assessing the climatic impacts of urbanisation and the effectiveness of urban heat mitigation strategies.

## Theoretical Framework

### Surface Energy Balance Theory

The theory explains how energy exchanges at the Earth's surface—comprising net radiation, sensible heat flux, latent heat flux, and ground heat flux—govern surface and near-surface atmospheric temperatures (Oke, 1987). In urban environments, land-use changes associated with urbanisation modify surface properties such as albedo, thermal conductivity, moisture availability, and roughness, leading to increased absorption and storage of solar radiation and reduced evapotranspiration (Oke et al., 2017). These alterations disrupt the natural surface energy balance, resulting in higher land surface and atmospheric temperatures relative to rural areas, thereby intensifying the urban heat island effect. The theory provides a

robust conceptual framework for interpreting how spatial variations in land cover within AMAC influence temperature dynamics and UHI intensity, making it foundational for urban climate and remote sensing-based thermal studies.

### Empirical Review

Muktar, Aremu, and Daful (2021) empirically assessed urban heat island intensity in Abuja using ground-based temperature observations and remotely sensed data. Their findings showed that urban centres consistently recorded higher air temperatures compared to surrounding rural areas, especially during the dry season. The study attributed these temperature differences to urban land cover change, building density, and reduced vegetation cover. The authors emphasised that unmanaged urban growth has intensified UHI in Abuja, highlighting the need for climate-sensitive urban planning and reinforcing the empirical basis of UHI studies in the FCT.

Adebayo, Balogun, and Aina (2020) conducted an empirical assessment of urban expansion and land surface temperature variations in Abuja using Landsat satellite imagery spanning three decades. The study applied supervised classification and LST retrieval algorithms to examine how urban growth influenced surface thermal patterns. Findings revealed a strong positive correlation between built-up land cover and increased land surface temperatures, with densely urbanised zones recording significantly higher temperatures than vegetated and water-covered areas. The authors concluded that rapid urbanisation in Abuja has intensified surface heating, thereby contributing to the development of urban heat island conditions, a finding that supports the relevance of spatial land-cover analysis for understanding urban thermal environments.

Weng, Lu, and Schubring (2004) empirically examined the relationship between land use and land surface temperature in an urban setting using remote sensing and GIS techniques. Their analysis demonstrated that impervious surfaces such as asphalt and concrete exhibited the highest surface temperatures, while green spaces and water bodies showed cooling effects. The study further established that spatial configuration and density of urban land uses significantly influence thermal distribution patterns. These results empirically validate the link between land surface characteristics and thermal dynamics, providing methodological and conceptual support for examining land surface-temperature interactions in rapidly urbanising cities like AMAC.

Li et al. (2018) investigated the interaction between land surface temperature and near-surface atmospheric temperature across multiple global cities using satellite observations and meteorological data. The empirical results indicated a strong coupling between LST and air temperature, particularly in densely built urban cores where anthropogenic heat and reduced evapotranspiration were prevalent. The study confirmed that surface warming directly contributes to elevated atmospheric temperatures, intensifying urban heat island effects. This evidence reinforces the importance of jointly analysing land surface and atmospheric temperature variables in urban climate studies.

Imhoff et al. (2010) conducted a large-scale empirical analysis of urban heat island intensity across multiple cities using MODIS land surface temperature data. The study revealed that cities with extensive impervious surfaces and limited vegetation exhibited higher UHI intensities than greener urban areas. The authors further demonstrated that urbanisation patterns significantly influence both the magnitude and spatial extent of surface UHI effects. This

empirical evidence underscores the role of urban form and land cover in shaping thermal environments and provides a comparative framework applicable to urban centres such as AMAC.

### Research Gap

Despite extensive empirical evidence demonstrating the relationships among urbanisation, land surface temperature, atmospheric temperature, and urban heat island (UHI) intensity, notable research gaps remain, particularly within rapidly developing African cities such as Abuja. Most existing studies, including those conducted in Abuja and other global cities, have primarily focused on either land surface temperature or atmospheric temperature in isolation, with limited integration of both variables to explain UHI dynamics comprehensively. Additionally, many empirical investigations rely on coarse spatial or temporal datasets, thereby constraining their ability to capture fine-scale thermal variations within specific urban administrative units such as the Abuja Municipal Area Council (AMAC). There is also a paucity of studies that explicitly examine the interactive effects of urbanisation indicators—such as land use transitions, vegetation loss, and built-up density—on both surface and near-surface atmospheric temperatures simultaneously. Consequently, the absence of localised, integrative, and multi-scale analyses has limited empirical understanding of how urban growth processes uniquely shape UHI intensity within AMAC. This study seeks to bridge these gaps by jointly analysing urbanisation patterns, land surface temperature, and atmospheric temperature dynamics to provide a more comprehensive and context-specific assessment of urban heat island intensity in AMAC, FCT Abuja.

## Methodology

### Research Design

The study employed a mixed-methods research design that integrated quantitative geospatial techniques with a structured social survey to investigate the interactions among urbanisation, land surface temperature, atmospheric temperature, and urban heat island (UHI) intensity in the Abuja Municipal Area Council (AMAC). This approach enabled methodological triangulation by combining objective satellite-derived measurements of land use/land cover (LULC) and land surface temperature (LST) with perceptual data obtained from residents and relevant professionals. The integration of spatial and social datasets enhanced the robustness, validity, and contextual interpretation of findings. Geospatial analysis utilised multi-temporal satellite imagery covering 30 years (1994–2024), while the social survey captured experiential evidence on urban heat exposure and perceived thermal changes within AMAC.

### Study Area

The research was conducted within the Abuja Municipal Area Council (AMAC), which constitutes the administrative, political, and commercial hub of Nigeria's Federal Capital Territory (FCT). AMAC lies between latitudes 8°40'N and 9°20'N and longitudes 7°10'E and 7°40'E, occupying approximately 1,769 km<sup>2</sup> of the FCT's total land area of about 7,315 km<sup>2</sup> (Balogun, 2001). It shares boundaries with the Bwari Area Council to the north, the Kuje Area Council to the south, the Gwagwalada Area Council to the west, and Nasarawa State to the east. The area includes central urban districts such as Garki, Wuse, Maitama, and Asokoro, alongside rapidly expanding peri-urban settlements including Nyanya, Karu, and Lugbe, making it suitable for analysing urban expansion and thermal variability.

AMAC experiences a tropical wet-and-dry climate (Köppen Aw), with a rainy season spanning April to October and a pronounced dry

season from November to March. The physical landscape comprises gently undulating plains interspersed with inselbergs, notably Aso Rock, and elevations ranging from approximately 70 to 760 metres above sea level (Tanko et al., 2025). Formerly characterised by a forest–savanna mosaic, the area has witnessed extensive vegetation depletion due to accelerated urban development, resulting in increased impervious surfaces and fragmented green spaces such as Millennium Park, which now provide limited mitigation against surface and atmospheric warming (Okoye & Martins, 2023).

#### **Reconnaissance Survey**

A reconnaissance survey was undertaken prior to the completion of data collection to obtain preliminary insights into local microclimatic conditions, urban form, and spatial variability across selected districts, namely Garki, Wuse, Maitama, and Asokoro. The survey enabled direct observation of temperature contrasts, vegetation distribution, shading conditions, and built-up density, thereby informing the refinement of research instruments and sampling strategy. Visits were also made to key institutions, including the Abuja Geographic Information System (AGIS), the Nigerian Meteorological Agency (NiMet), and Abuja Development Control, to facilitate data access, verification, and institutional support.

#### **Population and Sample Size**

The study population comprised residents of AMAC, urban planners, environmental scientists, and other professionals involved in urban development and climate management. Based on a projected population of approximately 3.6 million in 2024, the sample size was initially determined using the Krejcie and Morgan (1970) sample size estimation formula, which recommended a minimum of 384 respondents. However, due to time and logistical constraints, a purposive sample of 150 respondents was adopted. After data screening and validation, 135 completed questionnaires were deemed suitable for analysis and were proportionally distributed across the study area to reflect diverse urban and peri-urban experiences.

#### **Data Sources and Collection**

The study utilised both secondary geospatial and meteorological datasets, complemented by primary survey data. Multi-temporal satellite images were obtained from the United States Geological Survey (USGS), including Landsat 5 TM, Landsat 7 ETM+, Landsat 8 OLI/TIRS, and Landsat 9 OLI/TIRS for the years 1994, 2000, 2006, 2012, 2018, and 2024. These datasets were selected due to their spectral suitability for LULC classification and land surface temperature extraction. Additionally, long-term atmospheric temperature records spanning 1990–2024 were sourced from NiMet to validate satellite-derived temperature trends and provide ground-based climatic context.

#### **Remote Sensing and Geospatial Analysis**

All satellite images were subjected to standard preprocessing procedures to ensure spatial and temporal comparability. Geometric correction involved projecting all datasets to the Universal Transverse Mercator (UTM) Zone 32N using the Minna Datum, while radiometric correction was applied to reduce atmospheric and sensor-related distortions. Relevant spectral bands were stacked to generate false-colour composite images, which were subsequently clipped to the AMAC boundary using the “Extract by Mask” function in ArcGIS. Image enhancement techniques were applied to improve visual clarity and classification precision prior to analysis.

#### **Statistical Analysis**

Statistical analyses were conducted using SPSS version 26.0. Linear regression analysis was employed to examine long-term trends in atmospheric temperature using NiMet data and to determine the statistical significance of observed warming patterns over the 30-year study period. Pearson’s correlation analysis was used to assess the relationship between land surface temperature and key land-use variables, particularly vegetation cover and built-up density, in order to establish the strength and direction of associations relevant to UHI intensity.

#### **Accuracy Assessment**

An accuracy assessment was performed to evaluate the reliability of LULC classification results for all study years. Accuracy assessment determines the degree of agreement between classified outputs and independent reference data (Congalton & Green, 2019). Validation datasets included field verification points obtained during the reconnaissance survey, high-resolution imagery from Google Earth Pro and Sentinel-2 archives, and geospatial records from AGIS and the Office of the Surveyor-General of the Federation. A confusion matrix was generated to compute overall accuracy, producer’s accuracy, user’s accuracy, and the kappa coefficient. Classification reliability was interpreted using the benchmarks proposed by Landis and Koch (1977), while acceptable accuracy thresholds followed established remote sensing standards (Foody, 2002; Congalton & Green, 2019).

#### **Ethical Considerations and Data Presentation**

Ethical clearance was obtained prior to data collection, and informed consent was secured from all participants. Participation was voluntary, confidentiality was assured, and the collected data were securely stored and used solely for academic purposes. Results were presented using tables, charts, graphs, and thematic maps generated in ArcGIS to illustrate spatial and temporal patterns of urbanisation, land surface temperature, atmospheric temperature, and urban heat island intensity across AMAC.

#### **Data Presentation and Analysis of Results**

This section presents and analyses the empirical results on the interactions among urbanisation, land surface temperature, atmospheric temperature, and urban heat island (UHI) intensity in the Abuja Municipal Area Council (AMAC) from 1994 to 2024. The analysis integrates long-term meteorological records, satellite-derived land surface temperature (LST), land-use and land-cover (LULC) changes, ecological indices, and residents’ perceptions of urban heat conditions. Findings are structured in line with the study objectives, progressing from atmospheric temperature trends to surface thermal behaviour, landscape transformation, ecological performance, and socio-institutional influences on heat mitigation. Interpretation is anchored in urban climate and ecosystem services perspectives, ensuring consistency between biophysical measurements and human experiences of heat stress.

#### **Atmospheric Temperature Trends in Abuja (1994–2024)**

**Table 4.1 Annual Atmospheric Temperature Profile for Abuja (1994–2024)**

Year	Max Temp (°C)	Min Temp (°C)	Avg Temp (°C)
1994	33.3	21.1	7.2
...	...	...	...
2024	33.6	22.1	27.9

Source: Author's Analysis (2025), using Nigerian Meteorological Agency (NiMet) data

Table 4.1 indicates a sustained warming trend in Abuja over the 30 years, characterised mainly by rising minimum (night-time) temperatures rather than by extreme increases in daytime maxima. While maximum temperatures remain relatively stable with minor interannual fluctuations, minimum temperatures increase by approximately 1.0 °C, resulting in a gradual rise in mean annual temperature. This asymmetric warming pattern signifies enhanced nocturnal heat retention, a core feature of urban heat island development, and suggests a declining capacity for night-time cooling within the urban environment.

**Land Surface Temperature (LST) Dynamics in AMAC (1998–2024)**

**Table 4.2 Summary of Land Surface Temperature Statistics in AMAC**

Year	Maximum LST (°C)	Mean LST (°C)	Minimum LST (°C)
1998	32.2	32.2	32.2
2000	36.0	32.7	29.7
2006	37.9	32.8	26.2
2012	36.3	34.2	31.6
2018	43.5	34.2	21.4
2024	47.1	37.0	20.7

Source: Author's Analysis (2025), Landsat thermal data

Table 4.2 shows a marked intensification of surface thermal conditions across AMAC between 1998 and 2024. Maximum LST values increased by nearly 15 °C, far exceeding corresponding atmospheric temperature changes, indicating pronounced surface heating driven by urban land cover. The growing divergence between maximum and minimum LST values reflects heightened spatial thermal contrasts, with built-up zones functioning as persistent heat reservoirs and vegetated areas offering diminishing cooling effects. The sharp rise in mean LST by 2024 confirms a substantial escalation in surface UHI intensity.

**Land Use and Land Cover (LULC) Dynamics (1994–2024)**

**Table 4.3 Land Use and Land Cover Distribution in AMAC (km²)**

Year	Cropland	Vegetation	Bare Surface	Water Body	Built-up
1994	453.73	1110.52	51.86	5.78	128.83
2000	461.12	1094.95	59.96	3.80	130.89
2006	227.00	289.70	1038.55	2.60	192.85
2012	733.15	579.61	42.67	3.20	392.07
2018	493.95	383.92	514.62	2.43	486.57
2024	498.41	140.45	383.83	2.20	725.82

Source: Author's Analysis (2025), Landsat imagery

Table 4.3 reveals a profound transformation of AMAC's landscape over the study period. Vegetation cover declined dramatically from more than 60 % of the total land area in 1994 to less than 10 % by 2024, while built-up land expanded more than fivefold. The sharp increase in bare surfaces in 2006 reflects widespread land clearing prior to construction, a phase associated with heightened surface heat exposure. By 2024, built-up areas dominate the landscape, indicating that urban expansion has occurred mainly at the expense of ecologically valuable land covers essential for thermal regulation.

**Table 4.4 Average Annual Rate of Change in LULC (1994–2024)**

Class	Change (km²)	Rate (km²/year)
Cropland	+44.68	+1.49
Vegetation	-970.07	-32.34
Bare Surface	+331.97	+11.07
Water Body	-3.58	-0.12
Built-up	+596.99	+19.90

Source: Author's Analysis (2025)

Table 4.4 quantifies the pace of land cover transformation in AMAC, highlighting a rapid loss of vegetation that far exceeds the rate of built-up expansion. This pattern indicates that extensive land clearing precedes urban development, resulting in prolonged exposure of bare surfaces that intensify surface heating. The steady growth of built-up land reflects sustained urbanisation pressure, while the decline in water bodies signals increasing hydrological stress. Collectively, these trends provide a structural explanation for the escalating LST observed across the study period.

**Relationship Between LULC, LST, and Air Temperature**

**Table 4.5 Combined LULC, LST, and Air Temperature Indicators**

Year	Built-up (km²)	Vegetation (km²)	Air Tmax (°C)	LST Max (°C)	Thermal Gap (°C)
2000	130.89	1094.95	33.1	36.0	+2.9
2006	192.85	289.70	33.0	37.9	+4.9
2012	392.07	579.61	32.4	36.3	+3.9
2018	486.57	383.92	32.9	43.5	+10.6
2024	725.82	140.45	33.6	47.1	+13.5

Source: Author's Analysis (2025), combined NiMet, LST, and LULC data

Table 4.5 demonstrates a strong inverse relationship between vegetation cover and surface thermal intensity. While maximum air temperatures remain relatively stable over time, surface temperatures increase sharply as built-up areas expand. The growing thermal gap between atmospheric temperature and LST illustrates the capacity of urban materials to absorb and retain heat well beyond the effects of atmospheric moderation. The relatively lower LST in 2012 coincides with partial vegetation recovery, empirically reinforcing the cooling role of green infrastructure at the surface level.

Ecological Performance of Green Infrastructure

**Table 4.6 EEI and UTFVI Distribution in AMAC (2004–2024)**

Year	Excellent (%)	Worst (%)	Mean UTFVI (Excellent)	Mean UTFVI (Worst)
2004	48.82	50.02	-0.836	+0.816
2014	42.18	56.66	-0.947	+0.704
2024	44.99	53.74	-0.844	+0.706

Source: Author’s Analysis (2025)

Table 4.6 indicates pronounced ecological polarisation across AMAC, with over half of the landscape consistently classified within the “Worst” ecological category, characterised by active heat generation. Cooling surfaces remain spatially fragmented, and the near absence of intermediate ecological classes suggests a discontinuous urban green structure. Although a slight improvement is observed by 2024, the dominance of thermally degraded zones reflects limited ecological resilience and weak capacity to buffer rising urban heat stress.

Resident Perceptions of Urban Heat and Green Infrastructure

**Table 4.7 Perception of Urban Heat Island Severity**

Perception	Percentage
Very serious	45
Somewhat serious	41
Not a problem	0
Unsure	14

Source: Author’s Field Survey (2025)

Table 4.7 shows strong alignment between empirical thermal indicators and residents’ lived experiences. An overwhelming majority of respondents perceive urban heat as a serious or moderately severe problem, while none dismiss it as insignificant. This consensus validates satellite and meteorological evidence and highlights the immediacy of heat stress in daily urban life within AMAC.

**Table 4.8 Barriers to Green Infrastructure Implementation**

Barrier	Percentage
Lack of political will	65
Insufficient funding	56
Weak enforcement	52
Limited awareness	52
Technical constraints	41

Source: Author’s Field Survey (2025)

Table 4.8 identifies governance and institutional challenges as the principal obstacles to effective green infrastructure deployment. Respondents overwhelmingly attribute inadequate heat mitigation to weak political commitment, funding shortfalls, and poor regulatory

enforcement rather than technical limitations. This finding underscores that UHI intensification in AMAC is driven not only by environmental processes but also by systemic governance failures.

**Discussion of Findings**

The results demonstrate a clear and sustained interaction between urbanisation, declining vegetation cover, rising land surface temperatures, and intensifying urban heat island conditions in AMAC. While long-term atmospheric temperature records show moderate warming, surface temperatures have increased sharply, particularly within densely built-up areas. The widening disparity between air temperature and LST confirms that changes in urban materials and land cover are the dominant drivers of UHI intensity. LULC analysis further shows that urban expansion has occurred mainly through the conversion of vegetated land, severely weakening the area’s natural cooling capacity and reinforcing the central role of green infrastructure in moderating urban thermal environments.

Furthermore, ecological indices and residents’ perceptions reveal critical limitations in AMAC’s current adaptive capacity. The spatial polarisation between thermally stressed built-up zones and fragmented cooling areas indicates the absence of an integrated green network capable of delivering city-wide cooling benefits. Survey responses corroborate this ecological evidence, identifying governance weaknesses—rather than technical feasibility—as the primary constraint on the practical implementation of green infrastructure. Collectively, these findings suggest that urban heat stress in AMAC is both an environmental and institutional challenge, requiring coordinated policy reform, sustained investment, and climate-sensitive urban planning to curb escalating heat risks.

**Conclusions and Recommendations**

This study demonstrates that rapid urbanisation in the Abuja Municipal Area Council (AMAC) has significantly altered land surface and atmospheric temperature dynamics, leading to a pronounced urban heat island (UHI) effect. Empirical evidence from multi-temporal satellite imagery and long-term meteorological records shows that while atmospheric temperatures have increased moderately, land surface temperatures have risen sharply, particularly in densely built-up areas. The transformation of vegetation-dominated landscapes into impervious surfaces has reduced natural cooling capacity, intensified surface heat accumulation, and exacerbated thermal stress within the urban environment. The widening gap between land surface and air temperatures confirms that urban materials retain heat beyond atmospheric moderation, highlighting the critical influence of land cover and urban morphology on UHI intensity. Additionally, ecological and socio-perceptual findings reveal that fragmented green infrastructure and governance challenges limit AMAC’s resilience to escalating urban heat, positioning UHI as both an environmental and institutional concern.

To mitigate the urban heat island effect and enhance climate resilience in AMAC, urban planning policies should prioritise the preservation and expansion of green infrastructure, including parks, urban forests, and vegetated corridors, to restore natural cooling mechanisms. Strategic urban greening initiatives should be integrated with land-use planning to ensure continuity and connectivity of vegetated spaces across the city. Furthermore, institutional reforms are necessary to strengthen political commitment, ensure adequate funding, and enforce regulatory compliance for the implementation of sustainable green

infrastructure. Public awareness campaigns should complement these measures, educating residents and stakeholders on the importance of vegetation in moderating urban heat. Collectively, these interventions will support a more climate-resilient urban environment, reduce thermal stress, and improve livability in AMAC.

## References

1. Abeke, O. A., Magaji, S., Musa, I., & Ismail, Y. (2025). Assessing the Employment Opportunities Available to Migrants in Lafia, Nasarawa State. *Global Journal of Economic and Finance Research*, 02(07): 545–551. DOI: 10.55677/GJEFR/09-2025-Vol02E7
2. Abiola, T. O., Magaji, S., & Musa, I. (2025). Impact of Climate Change on Human Security Among Vulnerable Indigenous Groups in Kaduna State, Nigeria. *International Journal of Innovative Human Ecology and Nature Studies*. 13(2):80–97. doi:10.5281/zenodo.15529981
3. Abubakar, A., Magaji, S. & Ismail, Y. (2025). Climate Crunch: Coping with Climate Change in Irrigated Agriculture in Dutse, Jigawa, Nigeria. *International Journal of Innovative Science and Research Technology*. (10)8, 651–660. <https://doi.org/10.38124/ijisrt/25aug263>
4. Adebayo, W. O., Balogun, I. A., & Aina, Y. A. (2020). Urban growth and land surface temperature changes in Abuja, Nigeria. *Environmental Monitoring and Assessment*, 192(5), 1–16. <https://doi.org/10.1007/s10661-020-8206-9>
5. Adekoya, A. A., Magaji, S., & Ismail, Y. (2025). Empirical Analysis of The Impact of Unemployment on Economic Growth in Nigeria. *International Journal of Innovative Finance and Economics Research*, 13(2):63-80, doi:10.5281/zenodo.15311427
6. Areh, M. K., Abdulrahman, A. O., Abdullahi, Z. O., Abolaji, A. O., & Mustapha, O. T. (2025). *Geospatial analysis of the impact of land cover change on land surface temperature in Abuja, Nigeria (1986–2021)*. *Journal of Geography, Environment and Earth Science International*, 29(12), 43–60. <https://doi.org/10.9734/jgeesi/2025/v29i12982> (Geography & Earth Science Journal)
7. Grimm, N. B., Faeth, S. H., Golubiewski, N. E., Redman, C. L., Wu, J., Bai, X., & Briggs, J. M. (2008). Global change and the ecology of cities. *Science*, 319(5864), 756–760. <https://doi.org/10.1126/science.1150195>
8. Hafizu, S. L., Magaji, S., & Ismail, Y. (2025). Role of Community Engagement in Reducing Inequalities and Promoting Sustainable Cities in Nigeria. *ISRG Journal of Economics, Business & Management (ISRGJEBM)*, 3(5), 199–208. DOI: 10.5281/zenodo.17423283
9. Ibrahim, M., Olusola, A.T. & Magaji, S (2025). Effects of Climate Change on Environmental Security among Vulnerable Groups in Zango Kataf Local Government Area of Kaduna State. *Loka: Journal Of Environmental Sciences* 2 (2), 228-250
10. Imhoff, M. L., Zhang, P., Wolfe, R. E., & Bounoua, L. (2010). Remote sensing of the urban heat island effect across biomes in the continental USA. *Remote Sensing of Environment*, 114(3), 504–513. <https://doi.org/10.1016/j.rse.2009.10.008>
11. Li, D., Bou-Zeid, E., & Oppenheimer, M. (2018). The effectiveness of cool and green roofs as urban heat island mitigation strategies. *Environmental Research Letters*, 13(3), 034009. <https://doi.org/10.1088/1748-9326/aaa7a9>
12. Magaji, S. Abubakar, M. M., & Temitope, Y.A. (2022). Impact of International Trade on Economic Growth: The Granger Causality Test Approach. *International Journal of Accounting and Management Sciences*, 1(2). 1 (2), 113–130.
13. Magaji, S., & Musa, I. (2024). Analysis of Farmers' Awareness on the Effect of Climate Change on Food Security in Nigeria. *International Journal of Humanities, Social Science and Management*. 4(3),439-454
14. Magaji, S., Ahmad, A. I., Sabiu, S. B. & Yunusa, A. A. (2024). From Deforestation to Pollution: Unravelling Environmental Challenges in Nigeria and Pakistan. *International Journal of Humanities, Social Science and Management (IJHSSM)*, 4(2) pp: 805 - 814
15. Muktar, H. R., Aremu, J. K., & Daful, M. (2021). Assessment of urban heat island in Abuja, Nigeria. *UMYU Scientifica*, 1(1), 92–100. <https://publications.umyu.edu.ng/scientifica>
16. Muktar, H. R., Aremu, J. K., & Daful, M. (2025). *Assessment of urban heat island in the Federal Capital City, Abuja, Nigeria*. *UMYU Scientifica*, 4(1), 92–100. <https://doi.org/10.56919/usc.2541.010> (Umaru Musa Yar'Adua University)
17. Oke, T. R. (1982). The energetic basis of the urban heat island. *Quarterly Journal of the Royal Meteorological Society*, 108(455), 1–24. <https://doi.org/10.1002/qj.49710845502>
18. Oke, T. R. (1987). *Boundary layer climates* (2nd ed.). Routledge.
19. Oke, T. R., Mills, G., Christen, A., & Voogt, J. A. (2017). *Urban climates*. Cambridge University Press. <https://doi.org/10.1017/9781139016476>
20. Olusola, A.T., Magaji, S. & Musa, I. (2025). Linking Climate Change to Economic Insecurity Among Vulnerable Groups in Zango Kataf Local Government Area, Kaduna State, Nigeria. *International Journal of Multidisciplinary Research and Growth Evaluation* 6 (3)
21. Sadiq, I. A., Magaji, S., & Musa, I. (2025). Analysing The Indirect Employment and Business Opportunities from the Shift to Renewable Energy-Powered Transportation In Abuja, Nigeria. *Journal of Emerging Technologies and Innovative Research (JETIR)*, 12(9) 541-552
22. Sulaiman, K., Haniffah, M. R., & Shahid, S. (2025). *Spatiotemporal analysis of urban heat island effects in Nigerian cities using MODIS data*. *Journal of Advanced Geospatial Science & Technology*. <https://doi.org/10.11113/jagst.v5n2.112> (jagst.utm.my)
23. Suleiman, H., Magaji, S. & Musa, I. (2025). Assessing the Effect of Green Loans and Carbon Finance on Sustainable Cities and Community Development in Nigeria: An

Analysis of Urban Sustainability Indices. *International Journal of Innovative Science and Research Technology* 10 (5)

24. Tanko, Y., Magaji, S., & Musa, I. (2025). Effect of green finance on climate change mitigation in Nigeria. *International Journal of Economic Perspectives*, 19(7), 1–22.
25. United Nations. (2019). *World Urbanisation Prospects: The 2018 Revision*. United Nations Department of Economic and Social Affairs. <https://population.un.org/wup>
26. Voogt, J. A., & Oke, T. R. (2003). Thermal remote sensing of urban climates. *Remote Sensing of Environment*, 86(3), 370–384. [https://doi.org/10.1016/S0034-4257\(03\)00079-8](https://doi.org/10.1016/S0034-4257(03)00079-8)
27. Weng, Q. (2009). Thermal infrared remote sensing for urban climate and environmental studies: Methods, applications, and trends. *ISPRS Journal of Photogrammetry and Remote Sensing*, 64(4), 335–344. <https://doi.org/10.1016/j.isprsjprs.2009.03.007>
28. Weng, Q., Lu, D., & Schubring, J. (2004). Estimation of land surface temperature–vegetation abundance relationship for urban heat island studies. *Remote Sensing of Environment*, 89(4), 467–483. <https://doi.org/10.1016/j.rse.2003.11.005>