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ASSESSMENT OF LAND SURFACE TEMPERATURE IN ABUJA MUNICIPAL AREA COUNCIL BETWEEN 2002 AND 2023

ABSTRACT

Rapid Urbanization and improper urban planning results to increase in the land Surface Temperature (LST) of a particular area. The change in land use land cover (LULC) contributes tremendously in the rise of land surface temperature. Higher LST in urban areas decreases human thermal comfort for the city dwellers and affects the urban environment and ecosystem. A comprehensive

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Introduction

Urbanization is a worldwide phenomenon and a key driver of environmental degradation and climate change. Grimmond (2007); Rahman (2020). An urban environment can generally be defined as an area containing an aggregation of infrastructure, buildings, and open spaces that provide for the urban community's socio-economic functions. Živković (2020). It has been established that morphological modification of the urban landscape results in rising urban temperatures and the urban heat island (UHI) phenomenon. Ayanlade (2016). When there is significant alteration such as the replacement of vegetation and evaporating

study is needed to evaluate the impact of land use land cover change on the LST. Remote Sensing (RS) and Geographic Information System (GIS) techniques were used for the detailed derivation of the land surface temperature in Abuja municipal area council, Federal capital Territory (FCT), Nigeria. Landsat satellite imageries; Enhanced Thematic mapper plus (ETM+) of 2002, 2012 and Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) of 2023 were used to carry out supervised image classification using maximum likelihood algorithm. The thermal bands of the imagery were used to analyze LST of the study area at different epochs using semi-classification plug-in algorithm in QGIS. The Imagery used covered a span of 21 years. The results show that there is significant increase of built-up from 341.97 km^2 to 1310.35 km^2 between 2002 and 2023, decrease in water body from 1.25 km^2 to 0.69 km^2 and bare land from 732.04 km^2 to 220.51 km^2. There is also sharp decrement in vegetation from 510.26 km^2 to 53.98 km^2 between 2002 and 2023. There is substantial rise in surface temperature from 2002 to 2023. The maximum and minimum temperatures between 2002 and 2023 were 48.93°C, 10.61°C and 43.51°C, 31.05°C respectively. Built up, contributed most to surface temperature. The methodology developed in this study can be adapted to other cities in Nigeria. The research emphasizes the significance of implementing effective land use planning and management strategies to address the adverse effects of urban heat and improve the urban microclimate. The findings offer valuable guidance for policymakers, urban planners, and environmental experts, assisting them in making data driven decisions for sustainable urban development and enhancing the quality of life for residents in AMAC, Abuja, FCT.

Keyword: Remote sensing, GIS, land use land cover, land surface temperature.

surfaces with impervious surfaces, the surface energy budget experiences fluxes which lead to warming at the local scale. Y. Feng et.al (2019); Q. Weng et.al (2008). Urban growth is driven by several factors, including population growth, migration, industrialization, and modernization. The critical need for monitoring natural resources has increased over time because of many factors, including rapid growth in population and climate change, Jhariya, et.al (2022). Land Surface Temperature (LST) is a fundamental aspect of climate and biology, affecting organisms and ecosystems from local to global scales. LST is an important climate indicator that shows the relationship between the atmosphere and land. It is the radiative skin temperature of the land derived from solar radiation. LST measures the emission of thermal radiance from the land surface where the incoming solar energy interacts with and heats the ground, or the surface of the canopy in vegetated areas. LST is a mixture of vegetation and bare soil temperatures. This quality makes LST a good indicator of energy partitioning at the land surface–atmosphere boundary and sensitive to changing surface conditions. (Nemani et al., 1996). LST retrieved from several remotely sensed data is widely used in the detection of urban heat island and ecological comfort zone. Weng et.al, (2009). Different types of LULC response differently in TIR band and consequently LST largely varies in an urban environment. Shigeto (1994). The Land Use Land Cover (LULC) types are mainly changed by land conversion process. Guha (2020). Thus, time is an important factor in LST monitoring. These spatial and temporal data of LST is also varied with the seasonal changes as sun elevation and sun azimuth are changed with seasons. Hence, the seasonal variation of LST is quite important in any LULC related study. The study of the temperature through Remote Sensing is focused on the electromagnetic radiation emitted by the earth's surface in the wavelength around 10,000 nm, located in the Thermal Infrared (TIR) domain (Hillel, 2004). Sensors that operate in this spectrum region capture the energy emittance, from which products such as the land surface temperature can be derived. (Sabins, 1996). The LST obtained through satellite sensors has been applied in many environmental studies, such as monitoring of fires, soils and geology (Bonn and O'Neill, 1993; Li et al., 2013, Sayão et al., 2018). The knowledge of LST is important to a range of issues and themes in earth sciences central to urban climatology, global environmental change, and human-environment interactions. Javed, et al. (2008). Satellite data are very useful in various fields like, astronomy, atmospheric studies, earth observation, communications, navigation, search and rescue. LST is an important parameter in atmospheric sciences as it combines the result of all surface-atmosphere interaction and energy fluxes between the ground and the atmosphere and is, therefore, a good indicator of the energy balance at the Earth's surface. Prasad, (2013). Moreover, data about environmental changes (in land use and land coverage) can now be collected and analysed within a short period of time due to the development of diverse technologies such as Geographic Information System (GIS) and Remote Sensing (RS) technology. Parece, et.al (2019). Adebayo, (1999), stated that surface temperature controls the surface heat and water exchange with the atmosphere which affects climatic change in the region. Owing to the business nature and the population density of the AMAC, FCT, the knowledge of land surface temperature is very important. The current study aims to derive and assess the land surface temperature in Abuja Municipal Area Council between 2002 and 2023. The objectives of this study are:

I. Assess land use/ land cover of the study area between 2002, 2012 and 2023.
II. Determine the land surface temperature of the epochs through spatiotemporal assessments.
III. Analyse the impacts of land use/ land cover on the derived land surface temperature of the study area.

Study Area

Abuja Municipal Area Council (AMAC) is a Local Government Area in Abuja, Federal capital Territory (FCT) in Nigeria. It is located between Latitude 8°22'54"N - 9°31'40"N and Longitude 7°30'55"E -7°34'00"E. Abuja Municipal Area Council was created on October, 1984. It is located on the eastern wing of the Federal Capital Territory and comprise of twelve wards namely, City Centre (Central Business District), Garki, Gui, Gwagwa, Gwarimpa, Jiwa, Karshi, Kabusa, Karu, Nyanya, Orozo and Wuse. The study area falls in Universal Transverse Mercator (UTM) Zone 32N. It is bound to the north by Bwari Local Government Area (LGA), to the east by Karu LGA, to the south by Kuje LGA, to the west by Gwagwalada LGA, and southwest by Nasarawa LGA in Nasarawa State. This region has an area of approximately 1586 km^2. It is regarded as the Capital City and also the centre of most commercial and governmental agencies. The area contains the following districts and satellite towns; Maitama, Asokoro, Wuse, Lugbe etc. The study area is characterized by a variety of agricultural fields, residential areas, bare surface and water body.

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The Köppen climate classification for Abuja features a tropical wet and dry climate. The weather conditions include a warm, humid rainy season and a blistering dry season. The period of rain starts in April and ends in October, when daytime temperatures range between 28 °C to 30 °C and the night time temperatures from 22 °C to 23 °C. During the dry season, the daytime temperatures can be as high as 40 °C and night-time temperatures can be as low as 12 °C.

The demographic survey conducted by the FCT and National Population Commission in 1993 confirms that the population of FCT was in the region of 409,000 before 1991, but rose significantly to about 700, 000 after the movement of Ministries, parastatals, departments and agencies to the capital city (National Population Commission, 1991). This resulted in overstretching the few existing facilities and influenced an increase in demand for housing, infrastructure and services which were insufficient and costly. According to Oyetunji et al., (2021).

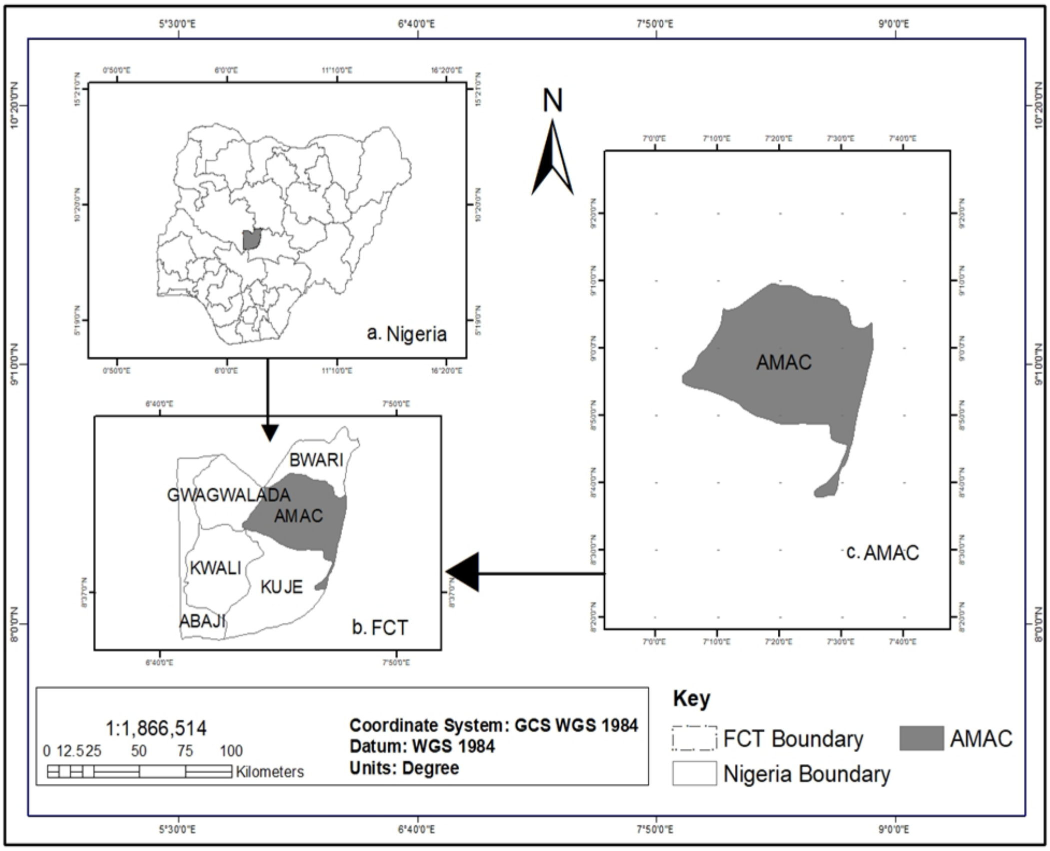

Figure 1. Abuja Municipal Area Council (AMAC), Abuja-FCT, Nigeria. Source: Author, 2024.

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Methodology

Data Acquisition and Source

The datasets used for this study were secondary data sources. They include: Landsat imageries of 2002, 2012 and 2023 and the administrative map of Nigeria which defined the boundary of the study area. The administrative map was derived from the Office of the Surveyor General of the Federation (OSGoF), Abuja-FCT, Nigeria. The Enhance Thematic Mapper plus (ETM+) imageries of Landsat 7 was downloaded for the years, 30th of December, 2002 and 23rd of November, 2012, while the Operational Land Imager (OLI) of Landsat 8 was downloaded for 15th February, 2023. The Landsat imageries were downloaded from United States Geological Survey (USGS). http://www.earthexplorer.usgs.gov/ at the spatial resolution of 30m. The Landsat imageries were used for image classification and generation of land surface temperature.

Data Processing

Pre-processing steps for satellite images were implemented. For Landsat 7 & and 8 data, band 2, band 3, band 4 and band 5 were layer stacked and then clipped to the shape of the study area. Area. ETM+ image of 2012 contained stripes and it was removed using focal analysis algorithm in Erdas imagine software.

Supervised Image Classification

Four general LULC classes including water body, built-up, bare-land and vegetation were derived in this study through pixel-based classification using the maximum likelihood algorithm in Erdas Imagine software. For each LULC class, at least 5 samples were collected and used for the classification of 2002, 2012 and 2023 imageries.

Derivation of Land Surface Temperature (LST) from Landsat Imageries

The single-window algorithm method was adopted to retrieve the LST from the imageries selected for this study. The Landsat imageries, ETM+ band 6L

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(10.31 - 12.36 µm) and TIRS bands 10 and 11 (10.60 - 11.19 µm) have a spatial resolution of 30m, 15m for panchromatic band and 100m for TIRS band respectively, which is considered suitable as shown by many literatures for capturing the multifaceted intra-urban temperature differences thus making it effective for urban climate analysis. Unfortunately, due to the calibration uncertainties in band 11, it is not recommended that band 11 be used for the split-window technique USGS-Landsat Mission. (2017); Nugraha et al 2019, which is why single-channel algorithms (also called MW algorithms) using band 10 are more appropriate for surface temperature estimation. The determine of LST include the following steps:

I. Conversion of Digital Numbers (DN) of the Bands to Spectral Radiance

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

where, LMAX = the spectral radiance that is scaled to QCALMAX in W/ (m2 * sr * µm); LMIN = the spectral radiance that is scaled to QCALMIN in W/(m2 * sr * µm); QCALMAX = the maximum quantized calibrated pixel value (corresponding to LMAX) in DN = 255; QCALMIN = the minimum quantized calibrated pixel value (corresponding to LMIN) in DN = 1.

II. Conversion from Spectral Radiance to At-Satellite Brightness Temperature

$$T = \frac{K_2}{In\left(\frac{K_1}{L_\lambda} + 1\right)} - 273.15 \quad (2)$$

where, T = At-satellite brightness temperature; Ll = Spectral radiance (gotten from equations -and-); K1 = Band specific thermal conversion constant from the metadata, x is the thermal band number); K2 = Band specific thermal conversion constant from the metadata; −273.15 = Constant

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for conversion from Kelvin to Degrees Celsius as shown in Awuh., et.al (2018).

III. Correcting for Land Surface Emissivity (LSE)

e PV = + 0.004 0.986 (3)

where, e = Land Surface Emissivity; 0.004 and 0.986 = Constants for emissivity estimation; PV = Proportion of vegetation. Awuh, M.E., et.al (2018), given by the equation

$$P_V\left(\frac{NDVI - NDVI_{\min}}{NDVI_{\max} - NDVI_{\min}}\right) \quad (4)$$

where, NDVI = Normalized Differential Vegetation Index as computed with Equation (1) for each of the years; NDVImin = Minimum value of NDVI for that year; NDVImax = Maximum value of NDVI for that year. Awuh, M.E., et.al (2018).

IV. Estimation of the Land Surface Temperature (LST)

$$LST = \frac{B_T}{1+W} \times \frac{B_T}{P} \times In(\Sigma) \quad (5)$$

Where, LST = Land Surface Temperature; BT = At-satellite brightness temperature; W = Wavelength of emitted radiance (μm) [Awuh, et.al (2018)] given as:

$$P = h \times \frac{c}{s}\left(1.438 \times 10^{-2}\ \mathrm{m \cdot K}\right) = 14380 \quad (6)$$

where, h = Planck’s constant (6.626 × 10−34 J/s); S = Boltzmann constant (1.38 × 10−23 J/K); C = Velocity of light (2.998 × 108 m/s); ε = LSE

Results and Discussion

Land Use Land Cover Classification

The analyses and results of this work was carried out from satellite imageries, for three epochs of different years in mapping and monitoring of surface temperature in Abuja Municipal Area Council. Figures 2, 3 and 4

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present land use and land cover maps of the study area in 2002, 2012 and 2023. Tables 1, 2 and 3 shows report of land use and land cover for different epochs for which surface temperature was measured, Tables 4,5 and 6 shows the accuracy assessment of the image classifications for the epochs and Figures 5, 6 and 7 present land surface temperature maps for 2002, 2012 and 2023 respectively.

The land use and land cover classes were derived using the maximum likelihood algorithm to generate four classes: waterbody, vegetation, built-up and bare land using the Landsat imageries of 2002, 2012 and 2023. The maps generated from the supervised image classification are shown in Figures 2-3. Between 2002 and 2023, Built-up areas increased significantly by 968.39 km^2 (61%), obviously due to expansion of residential area coupled with more anthropogenic activities over the region resulting from dynamic population growth that occurred between those years, and completion of development projects that were planned for that period. The class that contributed the most to this positive increase were bare surfaces as they lost about 511.53 km^2 (–32.30%) and vegetation lost about 456.28 km^2 (-28.8%) within twenty-one years. This drastic reduction was due to the increase in built-up areas. Most of the bare surfaces were replaced by the rapid development that occurred in Abuja through that period. This result agreed with Awuh et.al (2019), where between 1986 and 2001, built up areas increased significantly by 61.76 km^2 (4.4%), obviously due to expansion of residential area coupled with more anthropogenic activities over the region resulting from dynamic population growth that occurred between those years, and completion of development projects that were planned for that period. The result also agreed with Dissanayake et.al (2018), where Normalized Difference Building Index (NDBI) representing the built-up area and the spatial outline of city development in Lagos illustrated that Lagos City developed towards the northwest direction rather than the other areas, in 2002 and 2013. A large lagoon spreads close to the city midpoint in the eastern direction, and the southern portion of the city belongs to the coastal area. However, some part of the coastal area is occupied as an urban area where the harbour is located. The significant positive correlation between the LST and NDBI in both time points illustrates the influence of built-up areas for the expansion of high LST in Lagos.

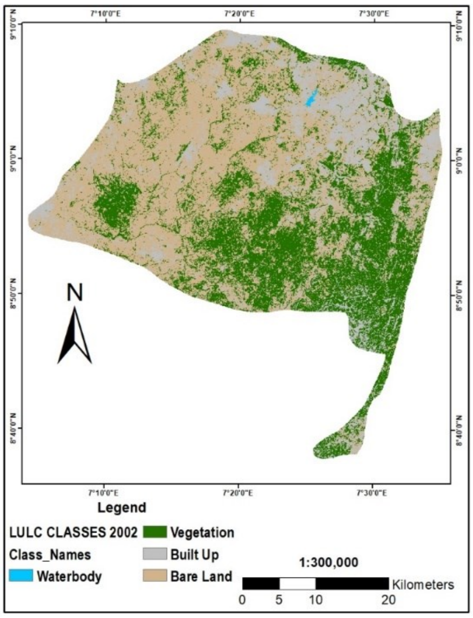

Figure 2: LULC 2002

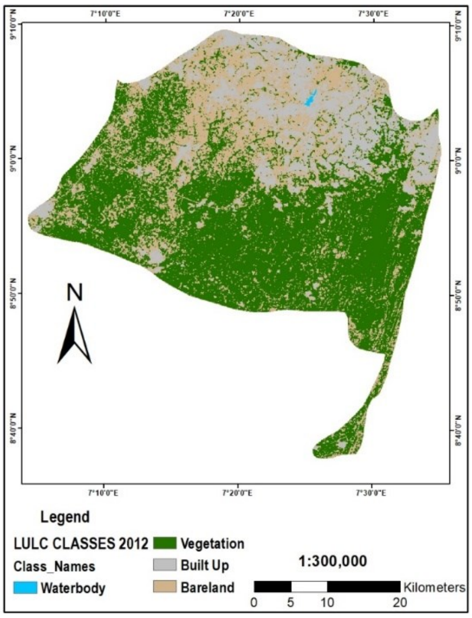

Figure 3: LULC 2012

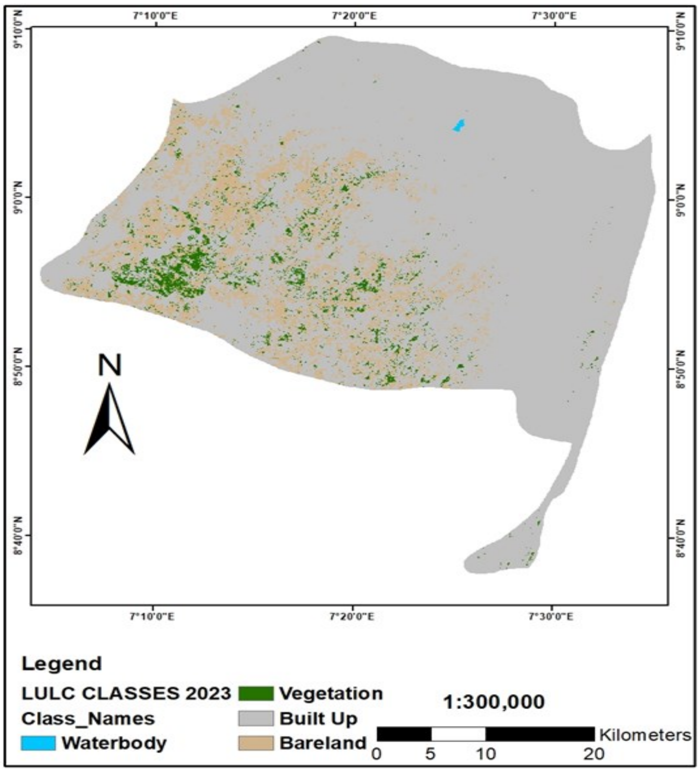

Figure 4: LULC 2023

For 2002 classification result, waterbody accounted, for 0.1% of total area, area covered by vegetation accounted 32.2 %, built up area accounted for 21.6 %, and the area covered by bare land accounted for 46.2%. For 2012 classification result, waterbody accounted, for 0.1% of total area, area covered by vegetation accounted 38.4 %, built up area accounted for 37.6 %, and the area covered by bare land accounted for 23.9%. For 2023 classification result, waterbody accounted, for 0.04% of total area, area covered by vegetation accounted 3.4%, built up area accounted for 82.6%, and the area covered by bare land accounted for 13.9%. The result from 2002 to 2023 shows that the built up activities in the study area increased significantly, while the vegetation decreased significantly, followed by the bare land. This result agreed with Suzana Binti Abu Bakar et.al (2016), between 2002 to 2015, from the observation, it was concluded that there was drastic change in built-up/roads, forest. Built-Up/ roads was increased by percentage from 4.746% to 8.297% and forest was decreased from 80.927% to 78.04% respectively. Total vegetation and cultivated land from the year 2002 with 11.421% were decreased by 9.527% corresponding to the loss of 61.782 km^2 to 51.537 km^2 respectively. The rapid changes were detected due to tourism factor and the conversion of vegetated and cultivated land to water due to soil digging activities in Langkawi Island. The increasing rate of built up classes both in areas and percentages as shown in tables 1,2 and 3 shows 3 shows the image classifications and the area changes in LULC classes between 2002-2023.

Table 1: 2002 Image Classification

Value	Class	Area (hectares)	Area (Km^2)	Percentage (%)
1	Built Up	34196.94	341.9694	21.6
2	Waterbody	124.56	1.2456	0.1
3	Vegetation	51026.04	510.2604	32.2
4	Bare Land	73204.11	732.0411	46.2

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Table 2: 2012 Image Classification

Value	Class	Area (hectares)	Area (Km²)	Percentage (%)
1	Built Up	59622.4177	596.224177	37.6
2	Vegetation	61028.48742	610.2848742	38.4
3	Bare land	37802.85658	378.0285658	23.9
4	Waterbody	97.370446	0.97370446	0.1

Table 3: 2023 Image Classification

Value	Class	Area (hectares)	Area (Km²)	Percentage (%)
1	Built Up	131034.96	1310.3496	82.6
3	Vegetation	5397.66	53.9766	3.4
4	Bare land	22050.63	220.5063	13.9
5	Waterbody	68.4	0.684	0.04

Source: Author (2024).

Image Classification Accuracy Assessment

After the classification, an accuracy assessment was carried out by generating 229 accuracy assessment points in ArcMap environment. The confusion matrix was computed to generate the accuracy assessment report and the Kappa statistics of (0.76), (0.53) and (0.56) and overall accuracy (80%), (70%) and (70%) for 2002, 2012 and 2023 respectively, as shown in tables 4, 5 and 6.

Table 4: 2012 Image Classification Accuracy Assessment

Object ID	Class Value	Built up	Waterbody	Vegetation	Bare Land	Total	User Accuracy	Kappa
1	Built up	12	0	2	6	20	0.6	0
2	Waterbody	0	10	0	0	10	1	0
3	Vegetation	0	0	17	2	19	0.894736842	0
4	Bare Land	0	0	2	28	30	0.933333333	0
5	Total	12	10	21	36	79	0	0
6	Producer Accuracy	1	1	0.80952381	0.777777778	0	0.848101266	0
7	Kappa	0	0	0	0	0	0	0.785617368

Overall Accuracy= (67/79) =0.8

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Table 5: 2012 Image Classification Accuracy Assessment

Object ID	Class Value	Waterbody	Built up	Vegetation	Bare Land	Total	User Accuracy	Kappa
1	Waterbody	10	0	0	0	10	1	0
2	Built up	0	11	8	11	30	0.366666667	0
3	Vegetation	0	1	15	4	20	0.75	0
4	Bare Land	0	0	4	16	20	0.8	0
5	Total	10	12	27	31	80	0	0
6	Producer Accuracy	1	0.916666667	0.555555556	0.516129032	0	0.65	0
7	Kappa	0	0	0	0	0	0	0.531380753

Overall Accuracy= (52/80) =0.7

Table 6: 2023 Image Classification Accuracy Assessment

Object ID	Class Value	Built up	Vegetation	Bare Land	Waterbody	Total	User Accuracy	Kappa
1	Built up	15	2	13	0	30	0.5	0
2	Vegetation	0	6	4	0	10	0.6	0
3	Bare Land	0	2	18	0	20	0.9	0
4	Waterbody	0	0	1	9	10	0.9	0
5	Total	15	10	36	9	70	0	0
6	Producer Accuracy	1	0.6	0.5	1	0	0.685714286	0
7	Kappa	0	0	0	0	0	0	0.564971751

Overall Accuracy= (48/70) =0.7

Source: Author (2024).

Land Surface Temperature of the Study Area

The Land Surface Temperature maps was derived using the semi-classification algorithm in QGIS software to generate the trend in LSTs that occurred between the epochs. According to table 4.8, in 2002 the values of the LSTs were 48.93°C, 31.2°C6 and 10.61°C for the highest, medium and low values respectively. In 2012, there were significant changes in the values of the LSTs to be 40.28°C, 30.73°C and 23.12°C for the highest, medium and low values respectively. It shows that there was a slight decrease in the highest and medium values of LST in 2012 by 8.65°C and 0.53°C, and a significant increase in the lowest value by 12.51°C. In 2023 there was an apparent increase in the LST values to be 43.51°C, 38.66°C and 31.05°C for the highest, medium and lowest values respectively. During this period, the mean land surface temperature increased by 6.89˚C from 32.31˚C to 39.2˚C, an increase that was due to the increased urbanization activity that went on during that period. This statement is backed by the results of the zonal statistics and correlation analyses between the LULC classes and the corresponding LST values. Built up areas were associated with average temperatures of 32.31˚C in 2002, 33.82°C in 2012 and 36.87˚C in 2023, further pointing to the strong relationship between LULC and LST and how surfaces with high albedo and low absorptivity reflect heat and contribute to the Urban Heat Island (UHI) development in an area. Surfaces like asphalt and concrete having Lower Albedo Effect (reflectivity), absorb more solar radiation than they reflect, prevent water infiltration, reducing cooling from groundwater evaporation. It prevents water from cooling the soil and surfaces naturally. Rock outcrop also contributes little to both spatial extent and total land use of the study area. Figures 5, 6 and 7.

Figure 8, shows the pattern of the increase in the Land Surface Temperatures between 2002 to 2023. It shows that developmental changes in the LULC classes increases the Land Surface Temperatures of the study area. These results agreed with Das et.al (2020), where the change of Land Surface Temperature in Asansol Subdivision, India was extracted for the year 1995 and 2018, a period of twenty-three (23) years, for summer and winter seasons. "Ibid", for the summer season of 1995, the maximum temperature was 41.7°C and the minimum temperature was 26.19°C. In 2018 surface temperature increased both in summer and winter season. In summer 2018 the maximum temperature was 45.26°C and the minimum temperature was 28.61°C. It showed that the maximum temperature during summer increased up to 3.56°C. The rate of change of temperature per year

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during summer and winter season between 1995 and 2018 was 0.12°C and 0.17°C respectively. At the micro-level, the climate has been changed with the changing of the LULC units. The rate of temperature change is very prominent at the impervious surface (Ranagalage et al., 2019).

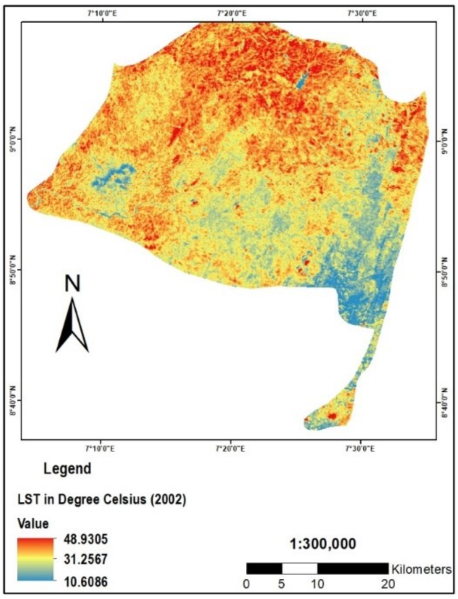

Figure 5: LST 2023.

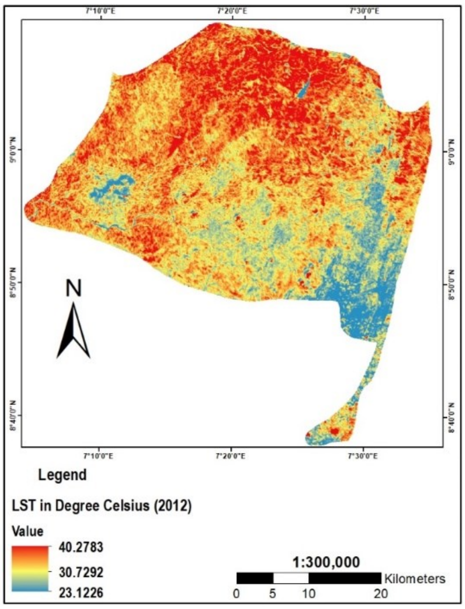

Figure 6: LST 2023.

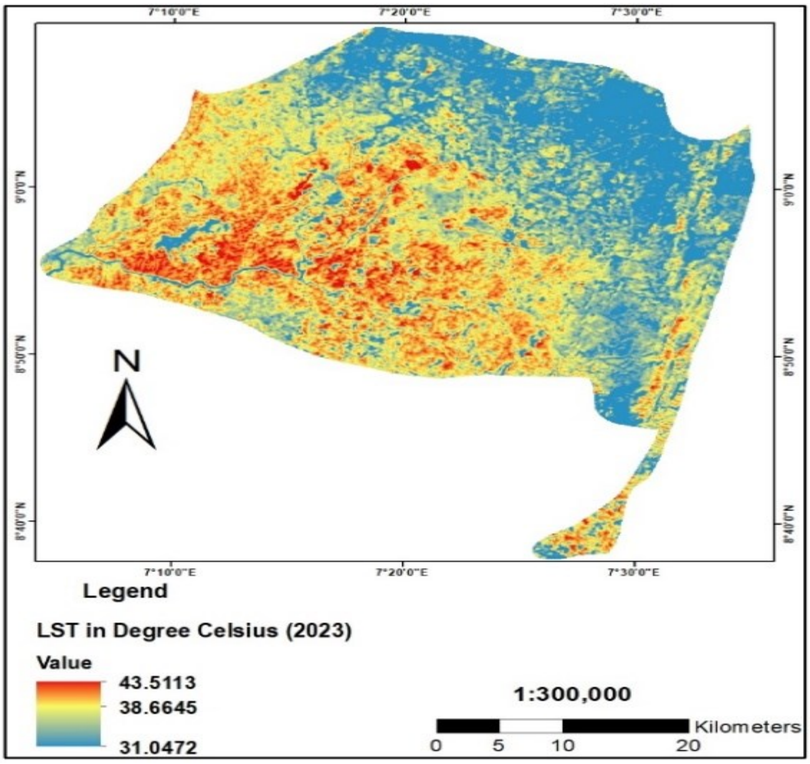

Figure 7: LST 2023. Source: Author (2024).

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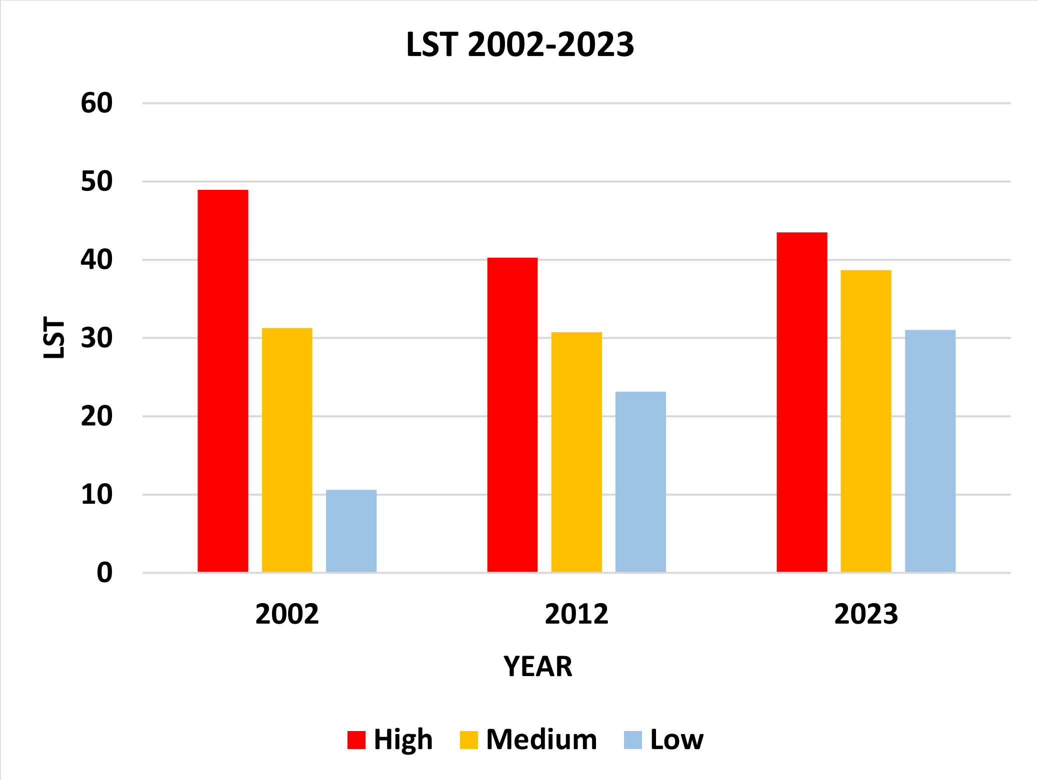

Figure 8: Land Surface Temperature Graph from 2002-2023. Source: Author (2024).

The impacts of Land Use/ Land Cover on the Derived Land Surface Temperature of the Study Area

Table 7, shows the summary of the variations in LST at sampled wards in AMAC between 2002 to 2023. The coordinates of the various wards were shown on the table displaying Latitudes and longitudes which defined each point location. From the table it is seen that the LST in Lugbe increased from 33.16°C to 35.78°C, Karu increased from 32.11°C to 34.20°C, Nyanya increased from 33.16°C to 35.76°C, Wuse increased from 33.16°C to 34.83°C, Gwarinpa increased from 33.94°C to 34.59°C, Gwagwa increased from 35.23°C to 36.63°C, Orozo increased from 31.06°C to 36.82°C, Karshi increased from 27.83°C to 39.40°C, Kurudu increased from 31.85°C to 35.99°C, Garki increased from 29.72°C to 33.35°C, Central Business District (CBD) increased from 31.59°C to 33.71°C, Uttako increased from 33.42°C to 35.48°C, Asokoro

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increased from 31.59℃ to 35.26℃, Guzape increased from 31.32℃ to 35.59℃ and Gui increased from 34.98℃ to 39.88℃ respectively.

The increase in the land surface temperature of these sampled points is due to urbanization, also known as urban sprawl, population influx and anthropogenic activities, as the expansion of built-up areas (new residential areas, industries, commercial centers) and infrastructure development leads to the replacement of natural vegetation and soil with impervious surfaces like asphalt and concrete. It contributes to the urban heat island effect, where built-up areas absorb and retain heat, causing temperatures to rise. Another factor is Land Use and Land Cover (LULC) changes where the conversion of natural habitats, such as forests and grasslands, to urban areas and agricultural land leads to changes in the local climate, causing increased temperatures. Areas with limited green spaces and vegetation tend to experience higher LST values, as vegetation helps regulate temperature through processes like transpiration (the process by which plants release water vapour into the air, cooling the surrounding environment) and shading.

The removal of trees for agriculture, construction, and fuel affects local microclimates. Trees provide shade and release moisture through transpiration, which helps cool the atmosphere. Garki is heavily urbanized, with a mix of residential, commercial, and government establishments, contributing to increased temperatures, characterized by higher foot traffic, leading to increased human activity and heat generation. Wuse is among the busiest places in the AMAC. The area is a key commercial center, playing host to the famous Wuse Market. Other prominent landmarks include Banex Plaza, City Park and Sheraton Hotel. Wuse is one of the most renowned districts in the FCT for recreational activities. Many of the city's best restaurants and relaxation places are located in the district. It can be accurately described as Abuja's most fun and popular district. Wuse is characterized for its high-rise buildings and commercial centers, these buildings can reduce air circulation by blocking wind flow, preventing natural cooling and allowing heat to accumulate in the area. Gwarinpa has

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experienced rapid urbanization, leading to increased built-up areas and corresponding temperature rises. City Centre, which is the Central Business District (CBD), is a predominantly commercial district with few residential areas. CBD is the primary business district in the FCT, housing the headquarters of many Nigerian and international organizations. CBD is expected to have higher temperatures due to the concentration of infrastructure and human activities, including high traffic flow.

Karshi is a fast-developing area in AMAC, lots of construction including roads, residential areas, markets and other anthropogenic activities are occurring there. The use of heat-absorbing materials, such as concrete and asphalt, in building construction has contributed to the increase in LST. In places like Gwagwa where there is augmented industrialization, increased greenhouse gas emissions can lead to higher temperatures and altered weather patterns due to global climate change. Industries release greenhouse gases (GHGs) such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) into the atmosphere. These gases trap heat in the Earth's atmosphere, leading to an overall warming effect. The increased GHG concentration can enhance the urban heat island effect, where built-up areas become significantly warmer than their rural surroundings. Industrial activities often emit particulate matter (PM), which can absorb and scatter sunlight. This leads to localized warming as the particles settle on land and surfaces, influencing the thermal properties of these areas. This can increase the land surface temperature directly and can also influence cloud formation and precipitation patterns, further impacting local temperatures. Many industrial processes produce waste heat as a by-product. This heat can directly increase the temperature of the surrounding environment. For example, facilities such as power plants, manufacturing plants, and other industrial operations may release significant amounts of heat into the atmosphere, contributing to the overall warming.

In Guzape, where roads, buildings, and other infrastructure are being developed, due to the rising population of the area, heat-absorbing materials like asphalt and concrete used in the construction often leads to increased energy consumption, which generates heat and contributes to

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higher LST. Places like Utako where there is Dense Crowding which results to high concentration of people and economic activities in commercial zones amplifies heat emissions. AMAC tend to have higher population densities, leading to increased human activity, energy consumption, and heat generation. In Gui ward, poor land management practices can lead to soil degradation, which reduces the land's ability to hold moisture. Dry and bare soil tends to absorb more heat, leading to higher surface temperatures. It is worthy to note that specific temperature values may vary depending on various factors, including time of day, season, and weather conditions.

Table 7: Summary of the variations in LST at sampled wards in AMAC between 2002-2023

S/NO	WARD	Lat	Long	LST (°C) 2002	LST (°C) 2023
1	Lugbe	8.964104	7.381373	33.16	35.78
2	Karu	9.01772	7.573398	32.11	34.20
3	Nyanya	9.0316	7.571108	33.16	35.76
4	Wuse	9.075241	7.476102	33.16	34.83
5	Gwarinpa	9.108851	7.411017	33.94	34.59
6	Gwagwa	9.075364	7.312196	35.23	36.63
7	Orozo	8.894216	7.54243	31.06	36.82
8	Karshi	8.8100712	7.523988	27.83	39.40
9	Kurudu	8.944935	7.548916	31.85	35.99
10	Garki	9.032288	7.48233	29.72	33.35
11	CBD	9.04417	7.478489	31.59	33.71
12	Utako	9.06856	7.445945	33.42	35.48
13	Asokoro	9.047904	7.515519	31.59	35.26
14	Guzape	9.01211	7.507768	31.32	35.92
15	Gui	8.986428	7.222143	34.98	39.88

Source: Author (2024). Generating using multivalues to point algorithm in ARCGIS Software.

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Conclusion

This study assessed LST and analysed the impact of LULC on the land surface temperature in Abuja Municipal Area Council from 2002 to 2023. This study shows that built-up areas are major drivers of the increase thermal reflectance in Abuja Municipal Area Council due to their reflective and absorptive capacity. Expansion of the urban area is highly related to the socio-economic and industrial potentials of the study area. To promote thermal comfort in the study area, urban planning, control of building patterns, the use of high albedo construction materials and maintaining sustainable building practices, tree-planting exercises were highly recommended. For 2002 classification result, waterbody accounted, for 0.1% of total area, area covered by vegetation accounted 32.2 %, built up area accounted for 21.6 %, and the area covered by bare land accounted for 46.2%. For 2012 classification result, waterbody accounted, for 0.1% of total area, area covered by vegetation accounted 38.4 %, built up area accounted for 37.6 %, and the area covered by bare land accounted for 23.9%. For 2023 classification result, waterbody accounted, for 0.04% of total area, area covered by vegetation accounted 3.4%, built up area accounted for 82.6%, and the area covered by bare land accounted for 13.9%. In 2002 the values of the LSTs were 48.93°C, 31.2°C6 and 10.61°C for the highest, medium and low values respectively. In 2012, there were significant changes in the values of the LSTs to be 40.28°C, 30.73°C and 23.12°C for the highest, medium and low values respectively. It shows that there was a slight decrease in the highest and medium values of LST in 2012 by 8.65°C and 0.53°C, and a significant increase in the lowest value by 12.51°C. In 2023 there was an apparent increase in the LST values to be 43.51°C, 38.66°C and 31.05°C for the highest, medium and lowest values respectively. During this period, the mean land surface temperature increased by 6.89˚C from 32.31˚C to 39.2˚C, an increase that was due to the increased urbanization activity that went on during that period. This statement is backed by the results of the zonal statistics and correlation analyses between the LULC classes and the

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corresponding LST values. Built up areas were associated with average temperatures of 32.31°C in 2002, 33.82°C in 2012 and 36.87°C in 2023.

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