Int. j. adv. multidisc. res. stud. 2026; 6(2):1743-1749

Received: 02-03-2026
Accepted: 12-04-2026

International Journal of Advanced Multidisciplinary Research and Studies

ISSN: 2583-049X

Evaluation of the Effect of Landuse Growth on Land Surface Temperature Using Remote Sensing: A Case Study of Awka Capital Territory, Nigeria

[1] Njoku RE, [2] Baywood CC, [3] Igbokwe EC

[1, 2] Department of Surveying and Geoinformatics, Federal University of Science and Technology, Owerri, Imo State, Nigeria
[3] Department of Surveying and Geoinformatics, Nnamdi Azikiwe University Awka, Anambra State, Nigeria

DOI: https://doi.org/10.62225/2583049X.2026.6.2.6161
Corresponding Author: **Njoku RE**

Abstract

This study evaluated the effect of land use growth on land surface temperature of Awka Capital Territory, Nigeria using remote sensing. Its objectives were to examine the spatial dynamics of land surface temperature in regards to landuse change in the study area between 1990 and 2017 and to examine the relationship between land surface temperature and the respective landcover/landuse in Awka Capital Territory. The methodology involved the acquisition of Landsat images for 1990, 1999, 2008 and 2017, image preprocessing for the acquired images, image classification to determine the landcover/landuse extent in the study area and derivation of land surface temperature using the thermal band of the Landsat images. The results indicated that the mean surface temperature for areas cover by urban area increased from 33.25°C to 34.11°C between 1990 and 1999, while the mean temperature for areas covered by vegetation decreased from 25.31°C to 24.68°C. similarly areas covered by open space increased from 28.36°C to 28.47°C while areas covers by water body decreased from 25.16°C to 25.06°C, bringing the overall mean surface temperature between 1990 and 1999 from 30.2°C to 31.01°C. Between 1999 and 2008, the mean surface temperature for areas cover by urban area increased further from 34.11°C to 34.31°C while the mean temperature for areas covered by vegetation increased from 24.68°C to 24.76°C. Areas covered by open space decreased from 28.47°C to 27.85°C while areas covers by water body decreased from 25.06°C to 24.99°C, bringing the overall mean surface temperature between 1999 and 2008 from 31.01°C to 31.21°C. Then in the final epoch between 2008 and 2017 the mean surface temperature for areas cover by urban area increased further from 34.52°C to 35.96°C while the mean temperature for areas covered by vegetation increased from 24.76°C to 25.50°C. Areas covered by open space increased from 28.77°C to 30.08°C while areas covers by water body increased from 24.99°C to 24.74°C, bringing the overall mean surface temperature between 2008 and 2017 from 31.21°C to 31.82°C. this indicated a steady increase of urban area temperature between 1990 and 2017. To affirm the results, correlation coefficient was conducted and it gave a coefficient of 0.925 between LST and urban area, 0.730 between LST and open space and -0.22 and -0.73 between LST and vegetation and LST and water body respectively. The results obtained is significant as it can be used as a decision support system for Environmental planning and management in Awka Capital Territory.

Keywords: Thermal Dynamics, Landuse Growth, Remote Sensing, Land Surface Temperature

1. Introduction

Urban growth transforms the natural state of the landscape and thus affects the earth surface characteristics, one of the which, is land surface temperature (Mishraa *et al*., 2010, Manat *et al*, 2012 [7], Turner *et al*., 2007). Youneszadeh *et al*., 2015 defined land surface temperature (LST) as the temperature of the skin surface of a land which can be derived from the satellite information or direct measurements in the remote-sensing terminology.

Land surface temperature is very important to the study in terms of its effect on urban climates as noted by (Voogt and Oke, 2003) [13]. It changes the temperature of the atmospheric boundary layer and these change in land surface temperature can have significant effects on local weather and climate (Kalnay and Cai, 2003; Landsberg, 1981) [5, 6]. By natural landscape to anthropogenic landscapes, urban areas now experience higher solar radiation absorption and a greater thermal conductivity (Manat *et al*, 2012 [7], Ramachandra *et al*., 2012). This process leads to a temperature that is warmer in urban areas than the surrounding landcover/landuse classes. As the temperatures in urban areas increase, there is an increase in air conditioning demands thus raising pollution levels and a high chance of increase in greenhouse gases which in turn increases the temperature (Manat *et al*, 2012) [7]. Studies on the land surface temperature using land surface temperature (LST) derived measurements have long being carried out using NOAA AVHRR data (Streutker, 2002) [11] for regional-scale land surface temperature mapping. But recently, Landsat Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+) thermal infrared (TIR) data with 120 m and 60 m spatial resolutions, respectively, have also been utilized for local-scale studies of land surface temperature (Chen, Wang, and Li, 2002; Weng, 2001) [2, 15]. Research on LST showed that the partitioning of sensible and latent heat fluxes and thus surface radiant temperature response was a function of varying surface soil water content and vegetation cover (Owen *et al*., 1998). This finding encourages research on the relationship between LST and vegetation abundance or lack of (Weng, 2001) [15], as this is a growing trend in Awka Capital Territory with the trend of vegetation loss (Igbokwe *et al*., 2020).

The landcover transition trends occurring in the Awka Capital Territory has been documented by (Musa *et al*, (2017) [8], Nzomiwu *et al*, (2017) [9], the study area is rapidly developing and has caused spatial landuse and landcover changes. The migration into urban areas has resulted in the territory becoming a highly urbanized with 62% of its population living in urban areas (UN-HABITAT, 2009) [12]. The shift in urban migration has posed problems for Awka Capital Territory, infrastructure improvements, both physical and social, has lagged behind the growth in population (UN-HABITAT, 2009) [12]. There are problems in erosion, flooding due to unregulated building patterns, noise pollution and declining environmental conditions. There has been a noticeable surge of increasing surface temperature in recent years with insufficient data to correctly quantify the causes and prepare for possible solutions. It has therefore become necessary to analyze to see if there is a correlation between increasing land surface temperature trends and the results of environmental alterations as an after effect of urban growth. There's the need to examine how landcover transition affects the environment's temperature dynamics in Awka Capital Territory, in doing this, it is necessary to explore the connections between different types of land cover and surface temperature in the study area, so that planners will have enough data for informed decisions on urban climate management in the study area.

2. Material and Method

2.1 Study Area

Awka Capital Territory is located in Anambra State, South Eastern Nigeria (See fig. 2.0). It is located between latitude 6^0 5' N and 6^0 15' N and longitudes 7^0 0' E and 7^o 5' E. Awka capital territory covers a land mass of 400 square kilometres and comprises of six local government areas namely Anaocha. Awka North, Awka South, Dunukofia, Njikoka and Orumba North, in part or full (UN-HABITAT, 2009) [12].

The study area is predominantly a low-lying region on the western plain of the Mamu River with almost all parts at 333 meters above sea level. The major topographic feature in the region is two celestas (asymmetric ridges) with east facing escarpments each trending southward outside Awka urban to form part of Awka-Orlu upland. In a section of Agulu, the land rises above 333 meters or (1000ft) above mean sea level outside Awka urban but within the study area (Adeboboye *et al*, 2012).

The study area has rainforest vegetation with two seasonal climatic conditions. They are the rainy season and the dry season. The dry season also has a period called harmattan. The dryness of the climate tends to be discomforting during the hot period of February to May, while the wet period between June and September is very cold.

The harmattan which falls within December and February is a period of very cold weather when the atmosphere is generally dry with mist (Agada *et al*, 2014). Awka Capital Territory is characterized by the annual double maxima of rainfall with a slight drop in either July or August known as dry spell or (August break). The annual total rainfall is above 1.450mm concentrated mainly in eight months of the year with few months of relative drought. Climatologically records since 1978, show that ACT has a mean annual rainfall of about 1,524mm (UN-HABITAT, 2009) [12]. ACT has mean daily temperature of 27^0C, with daily minimum temperature of 18^0C. Annual minimum and maximum temperature ranges ace about 22^0C and 34^0C respectively. It has a relative humidity of 80% at dawn (Ada *et al*, 2014).

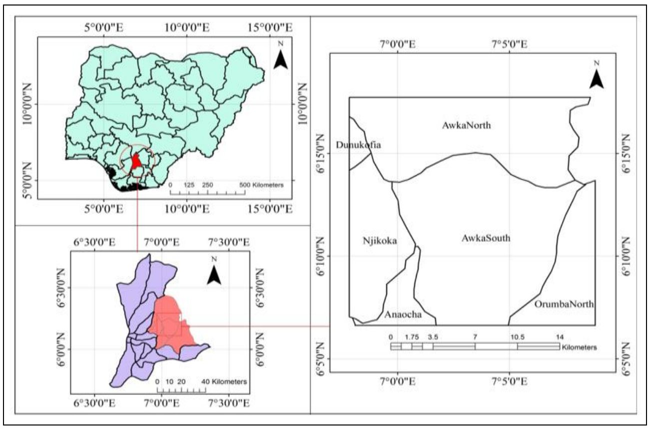

Fig 2: Map of Study area

2.2 Materials and Method

2.2.1 Materials

The study utilized secondary data to identify the effects of urban growth on urban LST in Awka Capital Territory. Landsat TM, ETM+ and OLI images were obtained from (USGS) http://earthexplorer.usgs.gov/ for 1990, 1999, 2008 and 2017 with a spatial resolution 30m. All of its bands were used for this study, and in particular Band 6 (thermal band) which is the most appropriate for detecting LST.

2.2.2 Method

i. Image Preprocessing

The Landsat 5 thematic mapper for the year 1990, Landsat 7 enhanced thematic mapper for 1999 and 2008 and Landsat 8 operational land imager for 2017 were radiometrically and geometrically corrected using the approach by Orimoloye *et al*, (2018) [10].

ii. Image Classification

In order to examine the urban growth, a land cover classification scheme by Anderson *et al*, (1967) was adopted, this resulted in the following class features: urban area, water body, vegetation and open space, using supervised image classification. Ground truthing was carried out to collect sample data for accuracy assessment using random sampling technique. Kappa statistics was used to assess the accuracy of the classified images.

iii. Derivation of Land Surface Temperature

In order to analyze the effect of urban growth on the thermal environment, land surface temperature of Awka capital territory was estimated from Landsat images. The calculation was done by:

a. Converting top of atmosphere (TOA) radiance:

Using the radiance rescaling factor, Thermal Infra-Red Digital Numbers was converted to TOA spectral radiance using the formula:

$$L\lambda = ML * Qcal + AL \quad (3.1)$$

Where:

$L\lambda$ = TOA spectral radiance

ML = Radiance multiplicative Band

AL= Radiance Add Band

Qcal = Quantized and calibrated standard product pixel values (DN)

b. Converting Top of Atmosphere (TOA) Brightness Temperature:

Spectral radiance data was converted to top of atmosphere brightness temperature using the thermal constant Values in Meta data file.

$$BT = K2 / \ln (k1 / L\lambda + 1) - 272.15 \quad (3.2)$$

Where:

BT = Top of atmosphere brightness temperature (°C)

$L\lambda$ = TOA spectral radiance

K1 = K1 Constant Band

K2 = K2 Constant Band

c. Calculating Normalized Differential Vegetation Index (NDVI):

The Normalized Differential Vegetation Index (NDVI) is a standardized vegetation index which was calculated using Near Infra-red and Red bands.

$$NDVI = (NIR - RED) / (NIR + RED) \quad (3.3)$$

Where:

RED= DN values from the RED band

NIR= DN values from Near-Infrared band

d. Calculating Land Surface Emissivity (LSE):

Land surface emissivity (LSE) is the average emissivity of an element of the surface of the Earth, this was firstly calculated from NDVI values to get Proportion of vegetation value.

$$PV = [(NDVI - NDVI\ min) / (NDVI\ max + NDVI\ min)]^2 \quad (3.4)$$

Where:

PV = Proportion of Vegetation

NDVI = DN values from NDVI Image

NDVI min = Minimum DN values from NDVI Image

NDVI max = Maximum DN values from NDVI Image

Then Land Surface Emissivity was calculated by

$$E = 0.004 * PV + 0.986 \quad (3.5)$$

Where:

E = Land Surface Emissivity

PV = Proportion of vegetation

3. Results

3.1 Analysis of Landcover/Landuse Transition

In 1990, urban area had 27.92 % and a coverage area of 12922.45 hectares. vegetation had 50% and an area of 23144.9 hectare, open space and water body had the lowest turnout with 12.82% and 9.26% with an area of 5936.22 and 4286.22 hectares respectively.

In 1999, vegetation, decreased from 50% to 46.73% to an area of about 21629.79 hectares. Urban area increased from 27.92% to 31.19 %, to area of 14437.68 hectares. Open space decreased from 12.82% to 12.30 to an area of 5693.72 hectares while water body increased from 9.26% to 9.78% to an area of 4528.6 hectares.

In 2008, vegetation decreased further from 46.73% to 44.46%, to an area of 20583.59 hectares. Urban area increased further from 31.19% to 33.67%, to an area of 15586.73 hectares while open space decreased from 12.30% to 12.07%, to an area of 5589.67 hectares. Water body increased slightly from 9.78% to 9.78% to an area of 4529.8 hectares.

In 2017, vegetation continued its gradual decrease from 44.46% to 41.29%, to an area of 19115.32 hectares, while urban area also increased from 33.67% to 37.24%, to an area of 17237.45 hectares. Open space continued decreasing from 12.07% to 11.52%, to an area of 5334.6 hectares while water body increased from 9.78% to 9.94%, to area coverage of 4601.35. This is further illustrated in table 3.1 and figure 3.1. Most of the urban expansion resulted from the conversion of vegetation and open spaces in the study area. Urban expansion impacts the environment by the modification of the properties of the environment, the replacement of natural surfaces by non-evapotranspirative urban surfaces through urban growth, results to the increase in land surface temperature. Natural surfaces are often composed of vegetation which utilize the absorbed radiation in the evapotranspiration process and release water vapour that contributes to cool the air in the environment.

Table 3.1: Landcover/Landuse Distribution for Awka Capital Territory between 1990 and 2017

Class Name	1990		1999		2008		2017	
	Area	%	Area	%	Area	%	Area	%
Urban area	12922.45	27.92	14437.68	31.19	15586.73	33.67	17237.45	37.24
Vegetation	23144.9	50.00	21629.79	46.73	20583.59	44.46	19115.32	41.29
Open space	5936.22	12.82	5693.72	12.30	5589.67	12.07	5334.67	11.52
Water body	4286.22	9.26	4528.6	9.78	4529.8	9.78	4602.35	9.94
Total	46289.79	100	46289.79	100	46289.79	100	46289.79	100

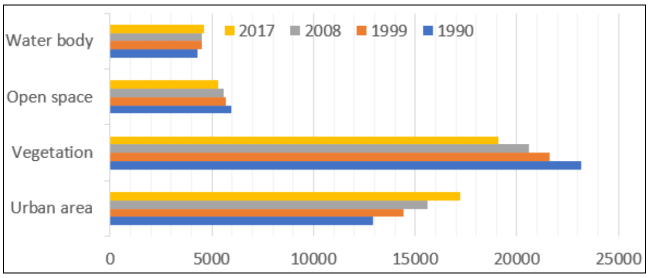

Fig 3.1: Histogram of landcover/landuse distribution of Awka Capital Territory between 1990 and 2018

3.2 Spatial-temporal analysis of the LST in Awka Capital Territory

3.2.1 Land Surface Temperature of Awka Capital Territory in 1990

The land surface temperature of Awka Capital Territory in 1990 as shown in figure 3.2 and table 3.2, revealed that the mean temperature in 1990 was 30.2°C while the min and max temperature was 24.23°C and 36.17°C respectively. The mean temperature for areas covered by vegetation was 25.31°C with a min and max temperature of 24.23°C and 26.39°C respectively. The mean temperature for areas covered by waterbody was given as 25.16°C with a min and max temperature of 24.44°C and 25.89°C respectively. The mean temperature of areas covered by open space was given as 28.36°C with a min and max temperature of 26.39°C and 30.33°C respectively while the mean temperature of areas covered by urban area is given as 33.25°C with a min and max temperature of 30.33°C and 36.17°C respectively. The areas covered by urban area had the highest temperature reading in the study area, followed by areas covered by open space with a moderate temperature reading, then areas covered by waterbody and vegetation had the lowest temperature readings in the study area.

Table 3.2: Land surface temperature distribution for 1990

Class Name	Min. Temp (°C)	Max. Temp (°C)	Mean Temp (°C)
Urban area	30.33	36.17	33.25
Vegetation	24.23	26.39	25.31
Open space	26.39	30.33	28.36
Water body	24.44	25.89	25.16
1990	24.23	36.17	30.2

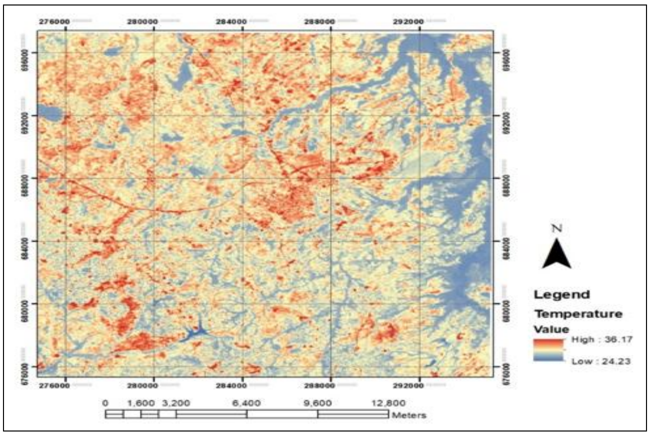

Fig 3.2: Land surface temperature of Awka Capital Territory 1990

3.2.2 Land Surface Temperature of Awka Capital Territory in 1999

The land surface temperature of Awka Capital Territory in 1999 as shown in figure 3.3 and table 3.3, revealed that the mean temperature in 1999 was 31.01°C while the min and max temperature was 24.02°C and 37.99°C respectively. The mean temperature for areas covered by vegetation was 24.68°C with a min and max temperature of 24.02°C and 25.24°C respectively. The mean temperature for areas covered by waterbody was given as 25.06°C with a min and max temperature of 24.30°C and 25.83°C respectively. The mean temperature of areas covered by open space was given as 29.97 with a min and max temperature of 27.59°C and 32.35°C respectively while the mean temperature of areas covered by urban area is given as 34.11°C with a min and max temperature of 30.23°C and 37.99°C respectively. In the same case as the temperature in 1990, the areas covered by urban area have the highest temperature reading in the study area, followed by areas covered by open space having a moderate temperature reading, then areas covered by waterbody and vegetation having the lowest temperature reading in the study area.

Table 3.3: Land surface temperature distribution for 1999

Class Name	Min. Temp (°C)	Max. Temp (°C)	Mean Temp (°C)
Urban area	30.23	37.99	34.11
Vegetation	24.02	25.24	24.68
Open space	27.59	29.35	28.47
Water body	24.30	25.83	25.06
1999	24.02	37.99	31.01

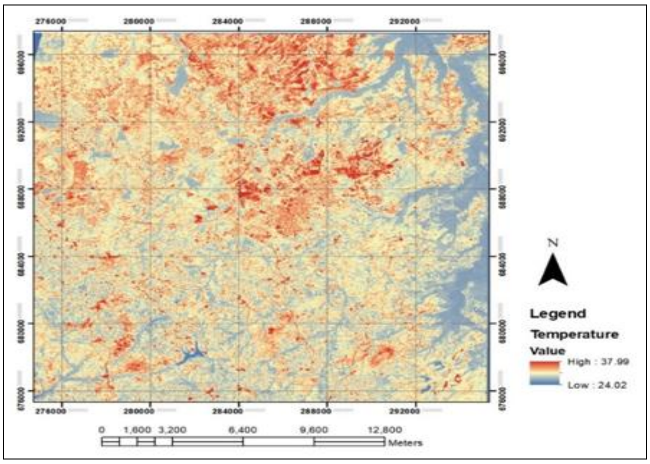

Fig 3.3: Land surface temperature of Awka Capital Territory 1999

Table 3.4: Change in land surface temperature between 1990 and 1999

Class Name	Mean Temp (°C) (1990)	Mean Temp (°C) (1999)	Change (°C)
Urban area	33.25	34.11	0.86
Vegetation	25.31	24.68	0.63
Open space	28.36	28.47	0.11
Water body	25.16	25.06	0.1
Mean Temp	30.2	31.01	0.81

From Table 3.4, it can be deduced that the mean surface temperature for areas cover by urban area increased from 33.25°C to 34.11°C between 1990 and 1999, while the mean temperature for areas covered by vegetation decreased from 25.31°C to 24.68°C. similarly areas covered by open space increased from 28.36°C to 28.47°C while areas covers by water body decreased from 25.16°C to 25.06°C, bringing the overall mean surface temperature between 1990 and 1999 from 30.2°C to 31.01°C. this indicates an increase in the surface temperature in Awka Capital Territory between

1990 and 1999 with urban area having the most change with an increase of 0.86°C.

3.2.3 Land surface temperature of Awka Capital Territory in 2008

The land surface temperature of Awka Capital Territory in 2008 as shown in figure 3.4 and table 3.5, revealed that the mean temperature in 2008 was 31.21°C while the min and max temperature was 24.18°C and 38.24°C respectively. The mean temperature for areas covered by vegetation was 24.76°C with a min and max temperature of 24.18°C and 25.35°C respectively. The mean temperature for areas covered by waterbody was given as 24.99°C with a min and max temperature of 24.26°C and 25.72°C respectively. The mean temperature of areas covered by open space was given as 27.85°C with a min and max temperature of 27.34°C and 28.37°C respectively while the mean temperature of areas covered by urban area is given as 34.31°C with a min and max temperature of 30.39°C and 38.24°C respectively. Similarly, in 1990 and 1999 the areas covered by urban area also had the highest temperature reading in the study area, followed by areas covered by open space with a moderate temperature reading, then areas covered by waterbody and vegetation had the lowest temperature reading in the study area.

Table 3.5: Land surface temperature distribution for 2008

Class Name	Min. Temp (°C)	Max. Temp (°C)	Mean Temp (°C)
Urban area	30.39	38.24	34.31
Vegetation	24.18	25.35	24.76
Open space	27.34	28.37	27.85
Water body	24.26	25.72	24.99
2008	24.18	38.24	31.21

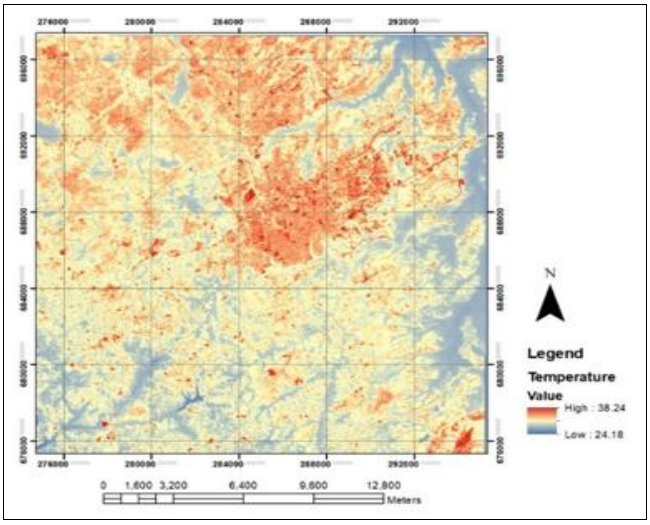

Fig 3.4: Land surface temperature of Awka Capital Territory 2008

Table 3.6: Change in land surface temperature between 1999 and 2008

Class Name	Mean Temp (°C) (1999)	Mean Temp (°C) 2008	Change (°C)
Urban area	34.11	34.31	0.2
Vegetation	24.68	24.76	0.08
Open space	28.47	27.85	0.3
Water body	25.06	24.99	0.07
Mean Temp for the year	31.01	31.21	0.2

From Table 3.6, it can also be deduced that the mean surface temperature for areas cover by urban area increased further from 34.11°C to 34.31°C between 1999 and 2008, while the mean temperature for areas covered by vegetation increased from 24.68°C to 24.76°C. Areas covered by open space decreased from 28.47°C to 27.85°C while areas covers by water body decreased from 25.06°C to 24.99°C, bringing the overall mean surface temperature between 1999 and 2008 from 31.01°C to 31.21°C. this indicates an increase in the surface temperature in Awka Capital Territory between 1999 and 2008 with a steady increase of urban area temperature as was in 1990, 1999 with a temperature change of 0.2°C in 2008.

3.2.4 Land surface temperature of Awka Capital Territory in 2017

The land surface temperature of Awka Capital Territory in 2017 as shown in figure 3.5 and table 3.7, revealed that the mean temperature in 2017 was 31.82°C while the min and max temperature was 24.29°C and 39.35°C respectively. The mean temperature for areas covered by vegetation was 25.50°C with a min and max temperature of 24.22°C and 26.77°C respectively. The mean temperature for areas covered by waterbody was given as 24.74°C with a min and max temperature of 24.26°C and 25.23°C respectively. The mean temperature of areas covered by open space was given as 30.08°C with a min and max temperature of 28.59°C and 31.57°C respectively while the mean temperature of areas covered by urban area is given as 35.96°C with a min and max temperature of 32.58°C and 39.35°C respectively. Similarly, in 1990, 1999 and 2008, the areas covered by urban area also had the highest temperature reading in the study area, followed by areas covered by open space with a moderate temperature reading, then areas covered by waterbody and vegetation had the lowest temperature reading in the study area.

Table 3.7: Land surface temperature for 2017

Class Name	Min. Temp (°C)	Max. Temp (°C)	Mean Temp (°C)
Urban area	32.58	39.35	35.96
Vegetation	24.22	26.77	25.50
Open space	28.59	31.57	30.08
Water body	24.26	25.23	24.74
2017	24.29	39.35	31.82

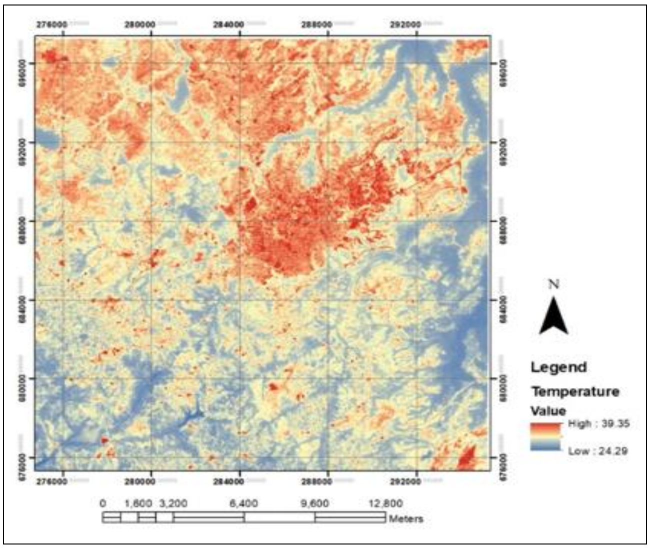

Fig 3.5: Land surface temperature of Awka Capital Territory 2017

Table 3.8: Change in land surface temperature between 2008 and 2017

Class Name	Mean Temp (°C) 2008	Mean Temp (°C) 2017	Change (°C)
Urban area	34.52	35.96	1.44
Vegetation	24.76	25.50	0.74
Open space	28.77	30.08	1.31
Water body	24.99	24.74	0.25
Mean Temp for the year	31.21	31.82	0.6

From Table 3.8, it can also be deduced that the mean surface temperature for areas cover by urban area increased further from 34.52°C to 35.96°C between 2008 and 2017, while the mean temperature for areas covered by vegetation increased from 24.76°C to 25.50°C. Areas covered by open space increased from 28.77°C to 30.08°C while areas covers by water body increased from 24.99°C to 24.74°C, bringing the overall mean surface temperature between 2008 and 2017 from 31.21°C to 31.82°C. this indicates an increase in the surface temperature in Awka Capital Territory between 2008 and 2017 with a steady increase of urban area temperature as was in 1990, 1999 and 2008 with a temperature change of 0.6°C in 2017.

3.3 Evaluating the relationship between landcover/Landuse and LST in Awka Capital Territory

In order to ascertain if there was a relationship between land surface temperature and each of the landcover class in the study area, a Pearson's correlation coefficient was conducted to test for the relationship between landcover/landuse and their mean surface temperatures in the study area between 1990 and 2017, the resulting scatter plots are shown in figure 3.6 and subsequently discussed.

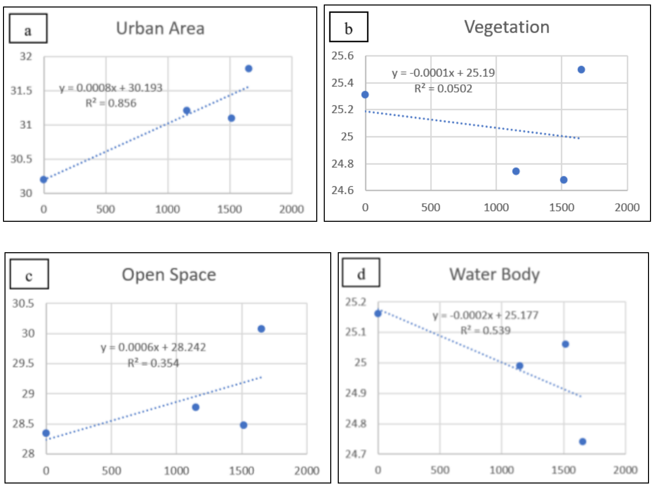

Fig 3.6: Scatter plot of the correlation between (a) LST and urban area, (b) LST and vegetation (c) LST and open space (d) LST and waterbody

From fig 3.6 (a), the test gave a correlation coefficient of 0.925 which indicated a strong consistent relationship between LST and urban area in the study area, this indicates that as urban area increases from 1990 to 2017, its land surface temperature was increasing as well and because urban development in Awka Capital Territory is going up, its urban surface temperature is increasing as a resultant effect of expansion into other landuse classes and the subsequent replacement of natural vegetation canopies that would have reduced surface temperature by surfaces such as bare land (soils), metal, tar, cemented buildings and concrete among others. The dry nature of these non-evapotranspirative materials in the urban environment is responsible for high variation of land surface temperature. More so, the removal of vegetation cover often leads to the adjustment in water balance because the interception role of the canopy is lost, evapotranspiration is changed and surface runoff is increased. This is observations were also reported by Nzomiwu *et al*, (2017) [9].

The result in figure 3.6 (c), with a correlation coefficient of 0.730 indicates that open spaces had high surface temperature as a result of the conversions of vegetation to open space, its openness with no natural vegetation to help reduce evaporation and transpiration in its surface lead to a high surface temperature.

From figure 4.6 (b) and (d), vegetation and waterbody had a correlation coefficient of -0.22 and -0.73 respectively, this indicates a negative relationship because unlike urban area and open space, vegetation canopies reduce surface temperature through transpiration and evaporation, while water body surface temperature changes much less rapidly than on land, so it will have relatively lower surface temperature. From the results, it is certain that there is indeed an effect of urban growth on urban thermal dynamics of Awka Capital Territory.

4. Conclusion

This study examined the effects of landcover/landuse transition on surface temperature of Awka Capital Territory, Anambra State, Nigeria using remote sensing. The study indicated that the mean surface temperature for areas cover by urban area increased from 33.25°C to 34.11°C between 1990 and 1999, while the mean temperature for areas covered by vegetation decreased from 25.31°C to 24.68°C. similarly areas covered by open space increased from 28.36°C to 28.47°C while areas covers by water body decreased from 25.16°C to 25.06°C, bringing the overall mean surface temperature between 1990 and 1999 from 30.2°C to 31.01°C. Between 1999 and 2008, the mean surface temperature for areas cover by urban area increased further from 34.11°C to 34.31°C while the mean temperature for areas covered by vegetation increased from 24.68°C to 24.76°C. Areas covered by open space decreased from 28.47°C to 27.85°C while areas covers by water body decreased from 25.06°C to 24.99°C, bringing the overall mean surface temperature between 1999 and 2008 from 31.01°C to 31.21°C. Then in the final epoch between 2008 and 2017 the mean surface temperature for areas cover by urban area increased further from 34.52°C to 35.96°C while the mean temperature for areas covered by vegetation increased from 24.76°C to 25.50°C. Areas covered by open space increased from 28.77°C to 30.08°C while areas covers by water body increased from 24.99°C to 24.74°C, bringing the overall mean surface temperature between 2008 and 2017 from 31.21°C to 31.82°C. This indicated a steady increase of urban area temperature between 1990 and 2017. To affirm the results, Pearson's correlation coefficient test was conducted and it gave a correlation coefficient of 0.925 between LST and urban area, this indicated a strong consistent relationship between LST and urban area in the study area, which means that as urban area increased from 1990 to 2017, its land surface temperature increased as well. The correlation test for the relationship between LST and open space also gave a coefficient of 0.730 which indicated that open spaces also had relatively high surface temperature perhaps due its openness with no natural vegetation to stop or reduce evaporation and transpiration in its surface. The correlation test for the relationship between LST and vegetation and waterbody had a correlation coefficient of -0.22 and -0.73 respectively, this indicated a negative relationship because unlike urban area and open space, vegetation canopies reduce surface temperature through transpiration and evaporation and water body surface temperature, changes much less rapidly than on land, so it will have relatively lower surface temperature. The results therefore is recommended as a decision support system for urban planning and management in Awka Capital Territory.

5. References

1. Anderson E. A Landuse and Landcover Classification System for Use with Remote Sensor Data. Geological Survey Professional Paper No. 964, U.S. Government Printing Office, Washington, D.C, 1976, p. 28.
2. Chen Yunhao, Wang Jie, Li Xiaobin. A study on urban thermal field in summer based on satellite remote sensing. Remote Sensing for Land and Resources. 2002; 4:55-59.
3. Gallo KP, Owen TW. Assessment of urban heat island: A multisensory perspective for the Dallas-Ft. Worth, USA region. Geocarto International. 1998a; 13:35-41.
4. Gallo KP, Owen TW. Satellite-based adjustments for the urban heat island temperature bias. Journal of Applied Meteorology. 1998b; 38:806-813.
5. Kalnay, Cai. Impact of urbanization and land-use change on climate, Nature. 2003; 423(29):528-531.
6. Landsberg. The urban climate, Academic Press, New York, 1981.
7. Manat S, Kazunori H, Vivarad P. Assessing the Impact of Urbanization on Urban Thermal Environment: A Case Study of Bangkok Metropolitan. International Journal of Applied Science and Technology. 2012; 2(7).
8. Musa SD, Onwuka S, Patrick E. Geospatial Analysis of Land Use/Cover Dynamics in Awka Metropolis, Nigeria: A Sub-pixel Approach. Journal of Geography, Environment and Earth Science International. 2017; 11:1-20. Doi: 10.9734/JGEESI/2017/35209.
9. Nzomiwu PC, Agulue EI, Mbah SC, Igbanugo CP. Impact of Landuse/Landcover Change on Surface Temperature Condition of Awka Town, Nigeria. Earth and Environmental Sciences, 2017, 763-776.
10. Orimoloye IR, Mazinyo SP, Nel W, Kalumba AM. Spatiotemporal monitoring of land surface temperature and estimation radiation using remote sensing: Human health implications for East London, South Africa Environ. Earth Sci. 2018; 77:77. Doi: 10.1007/s12665-018-7252-6
11. Streutker DR. A remote sensing study of the urban heat island of Houston, Texas. International Journal of Remote Sensing. 2002; 23(13):2595-2608.
12. UN-HABITAT. Executive summary plans for Awka, Onitsha and Nnewi, 2009. Accessed at: Https://unhabitat.org/books/executive-summary-of-structure-plans-for-awka-onitsha-and-nnewi-and-environs-2009-2027/executive-summary-of-structure-plans-for-awka-onitsha-and-nnewi-and-environs-2009-2027/
13. Voogt JA, Oke TR. Thermal remote sensing of urban areas. Remote Sensing of Environment. 2003; 86:370384.
14. Weng Q, Lo CP. Spatial analysis of urban growth impacts on vegetative greenness with Landsat TM data. Geocarto International. 2001; 16(4):17-25.
15. Weng Q. A remote sensing-GIS evaluation of urban expansion and its impact on surface temperature in Zhujiang Delta, China. International Journal of Remote Sensing. 2001; 22(10):1999-2014.