Environmental Technology & Science Journal
Vol. 12 Number 2 December 2021

Variation in Land Use Cover and Surface Temperature of Kubwa, Federal Capital Territory, Nigeria

Abbas Y. A, Morenikeji O. O, Dalil M, Ohadugha C. B & Musa H. D
Department of Urban and Regional Planning, Federal University of Technology, Minna
Correspondence: abdullahiabbas64@gmail.com

Received: 26/11/2021 **Revised: 30/12/2021** **Accepted: 15/01/2022**

Increasing human activity within the urban area brings massive changes in Land/Land Cover patterns and has an obvious effect of changes to urban ecosystems that make urban areas fragile. These conversions result in the appearance of numerous micro and mesoscale climates, warmer than the original climate and that of surrounding areas. This paper analyzed urban surface temperature variation on vegetal cover loss in Kubwa, FCT, Abuja. The study employed the used Landsat imageries of (1990, 2000, 2010 and 2020) to analyse land cover changes and land surface temperature. The study revealed that built-up area increase from 1990-2000 with 166% and 80% in 2010 and the year 2020 recorded an average of 23%. Bare surface decreased by -25% between (1990 -2000); further decreased from 3028.5 to 1979.6 hectares and -14% between 2010-2020. The study established that the LST value in 1990 Kubwa was 15℃ and 32.4℃ with a mean value of 23.7℃. The minimum and maximum LST of Kubwa in 2000 was 25℃ and 35℃ with mean of 30℃. The trend further continues, in the year 2010, minimum and maximum LST of 25℃ and 35℃ with a mean of 30℃ and in 2020 with a minimum and maximum LST of 25℃ and 40℃ with mean of 32.5℃. The analysis revealed that temperature variation increases between 1990, 2000, and 2010 were 0.4°C. There was 2°C in LST between the 2010 and 2020 due to urban expansion, infrastructure development, population growth and anthropogenic activities. The study recommends improvements of urban green infrastructure; and the FCT administration should embark into afforestation in order to restore the depleted vegetal land cover of the study area.

Keywords: Urban Growth, Kubwa, Abuja, Surface Temperature, Land Cover, Urbanisation
DOI: https://dx.doi.org/10.4314/etsj.v12i2.7

INTRODUCTION

The increased urbanization has various environmental impacts and it seems to be never-ending with a continuous and rapid increase in population throughout the last decades and still projected to increase even faster (Azeem *et al.,* 2016). Sherbinin *et al.* (2007) listed some of the induced environmental problems associated with urbanization as declining biodiversity; poor water and soil quality; increased runoff and sedimentation rates; transformation of the global carbon cycle and hydrologic cycle; and climate change. Consistent physical development of urban areas by man results in the formation of more and more impervious surfaces which has been considered as a predominant driving force towards the alteration of the natural ecosystem (Zhou *et al.,* 2010). These unreceptive surfaces seal soil cover results in the elimination of rainwater penetration (percolation) and groundwater recharge. This induces surface water runoff which ultimately plays a part in natural catastrophes like flooding. Studies have shown that urban areas differ substantially in their micro-climate (Adebayo & Zemba, 2003; Ifatimehin & Ufuah, 2006). These differences are caused by the alteration of the earth's surface by human activities from the development of built-up areas with concrete, asphalt, and glass to replace natural vegetation.

Land uses usually compete for strategic locations within and around the cities and in the process of accommodating the same; cities experience re-densification which alters the urban environmental quality (Oyugi *et al.,* 2017). Clearing of land for built-up developments reduce vegetation covers acting as carbon sinks consequently raising the concentrations of air pollutants as well as altering airflow, energy, and water balances. With the advent of vegetal cover loss in cities has resulted in higher surface temperature due to built-up of impervious surfaces and high –rise buildings constructed with heavy metal as compared to surrounding rural lands characterized by vegetal land cover and similar pervious surfaces. This phenomenon is known as an Urban Heat Island (UHI), which is a manifestation of land use/ land cover modification (Xiao & Weng, 2007). The alteration of LULC in urban centres is associated with increasing concretization, traffic congestion, and diminishing vegetation covers in cities, thereby producing more elevated temperatures than the greener peripheral areas. LULC is closely tied to Land Surface Temperature (LST), because trees provide shading, increased evaporative cooling, and lower thermal absorption and retention (McPherson and Simpson, 2003; Nowak and Dwyer, 2007; Solecki *et al.,* 2005). The near absence of vegetal land cover in urban areas is known to increase in LST, which is a component of the overall UHI (Voogt & Oke, 2003). Urbanization increase the use of land and loss of vegetation cover which led to temperature rise in an urban environment through anthropogenic activities such as the conversion of vegetal areas to built-up surface leading to energy generated being trapped within the environment. When this heat is released, it increases temperature thus increasing energy consumption within urban areas to modify the environment. In view of the trend of vegetal cover loss because of physical development and its adverse effects on surface temperature rise within and around the city of Kubwa. Therefore, the need to study the urban surface temperature variation on vegetal cover loss is indeed necessary.

LITERATURE REVIEW

Relationship between LULC and LST

Urban development leads to surface modification, land cover changes as well as changes in the structure and content of the atmosphere (Zhou *et al.,* 2011). These conversions result in the appearance of numerous micro and mesoscale climates, warmer than the original climate and that of surrounding areas (Roth *et al.,* 1998). The climatic impact of urbanization on a regional level is mainly described by urban heat island (UHI). UHI displays discrepancy in ambient temperature inside the city and its surrounding areas and displays the result of urban areas producing and storing more heat than the surrounding rural areas (Nonomura *et al.,* 2009; Aniello *et al.,* 1995). Oluseyi *et al.* (2009) opined that there is a direct relationship between the changing pattern among the various LULC types and the variations in the surface temperatures of these LULC types within Lokoja. Variation in LULC of the area were responsible for the rise in the mean surface temperature from 38.39°C in 1987 to 42.61°C in 2001, indicating a 4.22°C increase in 14 years. The study revealed that decline in vegetation covers has influence continuous increase in its radiant surface temperature as the cooling effect of vegetation cover is lost to impervious surfaces that litter the urban landscape. Ukaegbu *et al*. (2016) study on Spatial Assessment of Temperature and Land Cover Change as Climate Change Monitoring Strategies which was carried out in Owerri within three decades to evaluate land cover and temperature variation as the climatic change in the city. The study argued that climate change resulted from development activities contributing to the increasing urban heat in the city. Balew and

Korme (2020) carried out a study on the monitoring of land surface temperature in Bahir Dar city and its surroundings and their study reveals that vegetation cover had a mean LST of 32.22°C in 1987 and increased to 33.91°C in 2002. In their study paved surface had a mean LST of 1.6°C higher than in 1987 and 36.62°C in 2002 as a result of urbanisation. While, Me-ead and McNeil (2019) stated that climate change is the lead cause of LST increase in the Sahara and semi-arid parts of Southern Africa by 1.6°C in 2050s and the equatorial African countries by 1.4°C per year. Study from Adebowale and Kayode (2015) identified various transformations in land use land cover types and their corresponding land surface temperature between a 20year time intervals in Akure. The authors carried out their analysis using available Landsat TM and ETM+ satellite data for two decades. The study also revealed that the built-up area has expanded from 17.88% to 27.02% with a corresponding increase of 9.9°C in LST, indicating an average annual increase of 0.5°C. The vegetation cover has reduced from 47.23% to 37.79% with an increase of 2.79°C in temperature. The results show that uncontrolled expansion in the city exacerbates LST increase.

THE STUDY AREA

The Federal Capital Territory (FCT), covers an area of about 8,000sqkm; with geographic coordinates 9º4°0 'N and 7°29°0"E. The capital shares its boundary with Niger, Kaduna, Nassarawa and Kogi State from which the FCT was carved out. The FCT, therefore, shares some of the attributes of the two zones, thus making it a fascinating area for urban development. The Abuja Master Plan, conceived the Federal Capital City to accommodate an estimated population of 157,750 people upon its inauguration in 1986, then 485,660 persons in 1990, 1,005,800 persons in 1995 and 1,642,100 persons in 2000 and it's expected to reach its maximum estimated population of 3.1 million by 2009 (FCDA, 1979). Between the year 2000 and 2010 made Abuja the fastest growing city in the country, with an annual growth rate of 9.3% (Udeh, 2010). The factors responsible for the choice of Abuja where central location and easy accessibility from all parts of the country, healthy climatic conditions, and low population density, availability of land for future expansion, physical planning convenience and ethnic accord.

MATERIALS AND METHODS

The remote sensing data (satellite imagery) gotten serve as primary sources of data collection for the study, which was used to examine the relationship between Land Use/ Land Cover Changes (LULCC), and Land Surface Temperature (LST). Landsat imageries of four different years were acquired from the USGS portal for the study. The imageries were carefully checked to ensure the same season were selected for the four (4) different periods of 1990, 2000, 2010, and 2020 respectively. The bands 5, 4 and 3 were used for land cover classification. Band 5- have higher reflectivity of urban building which could be strengthen building information and extraction of the built-up land in the urban area; band 4 has high reflectivity of vegetation and band 3 has the capability of reflecting bared surface most. Satellite remote sensing data from Landsat 5 thematic (TM) mapper sensors, Landsat 7 enhanced thematic (TM+) mapper sensors, and Landsat 8 operational land imager sensors (USGS, 2013). The choice of remote sensing data sources was made on a basis of quality, consistency, resolution, duration of the study, time of observation, frequency of observation, and availability. The use of Landsat TM imagery has been used in carrying out studies on LST in terms of heat island effects and provides sufficient spatial resolution at 120m for the analysis at a local (city-wide) and macro (large structure) level. The summary of the imagery metadata used for the study is shown in Table 1.

Table 1: Summary of Metadata used for the study

	1990	2000	2010	2019
Landsat scenc ID	LT418905419 90331XXX03	LT5189054200 0028XXX02	LC8189054201 0107LGN00	LC8189054201 8107LGN00
Acquisition date	1990/11/27	2000/01/28	2010/02/22	2019/04/30
Output format	Geotiff	Geotiff	Geotiff	Geotiff
Spacecraft ID	Landsat 5	Landsat 7	Landsat 8	Landsat 8
Sensor ID	TM	ETM+	ETM+	OLITIRS
Path& Row	189, 54	189, 54	189, 54	189, 54
Resolution	30 metres	30metres	30metres	30metres

The Landsat-TM images of years 1990, 2000, 2010 and 2020 were registered on the ETM+ image with a resultant root mean square Error (RMSE) of 0.22 pixels. The thematic mapper TM/ETM+ imageries are of same spatial resolution and covered same area. All these imageries were adjusted to a common spatial resolution of 30 m, using nearest neighbour resampling technique to merge and obtain a detailed land use/cover classification for the analysis. The Landsat images were further pre-processed using standard procedures including geo-referencing and geometric correction. The projected coordinate system UTM WGS_86 (zone 32N) was used as the coordinate system. Also, Subsets of Landsat imageries were rectified with UTM projection Zone 32, using first order polynomial method and nearest neighbour image re-sampling algorithm. A total of 50 Ground Control Points (GCPs) were used to register the ETM+ image subset with the rectification error less than 1 pixel. IDRISI selva Version 9 was used for image pre-processing. For this research supervised classification techniques was used. The supervised classification method uses the spectral signature obtained from training samples to classify an image. The supervised classification image of each year involves pixel categorizations by taking training area for each class of LU/LC. Using Multispectral Band from band 1 to 5 and 7 for TM 1980,1990 and ETM+ 2000, 2010 and OLI 2019 1 to 7 Bands of the preprocessed images the LULC pattern was mapped. The classification technique used was the supervised classification where signatures that was used as samples were specified for classifying each land feature. The decision rules for the classification were parallel piped for the non-parametric rule, and Maximum Likelihood for the parametric rule. The Maximum likelihood classification (MLC) was considered more accurate than parallelepiped classification. The five land use/land cover classes used for the study for the image classification are; Built-up areas, Open spaces, Water body, Rock outcrop, and Vegetation. Each year of study contain the same number of classes and same colour codes.

Land Surface Temperature Retrieval Method

The land surface temperature analysis requires a spatio-temporal model with a Model Maker tool designed to retrieve land surface temperature (LST) and to describe the changes of urban heat island, as well as urban development. Spectral Radiance, Brightness Temperature, and Emissivity are first calculated from TM and ETM+ imageries, which was used to compute LST by using an author designed algorithm. The LST is classified based on the normalized statistical method, and the normalized heat images are computed between different times. Therefore, the urban heat changes can be shown in the map clearly and directly through an urban heat conversion matrix. This processing is carried out in ArcGIS using the respective formula for each stage of the process. The following stages is used in retrieving land surface temperature from Landsat imagery:

Stage 1: Conversion of Digital Numbers (DN) to Top of Atmosphere (TOA) Radiance

In Operational Landsat Imager (OLI) and TIRS band data can be converted to TOA spatial radiance using the radiance rescaling factor provided in the metadata file of the captured imagery (Zhou *et al.*, 2011).

$L\lambda$ = Lmax-Lmin (DN-QCALmin) + Lmin… . 3.5
QCALmax – QCALmin

Where $L\lambda$ = TOA Spectral Radiance (watts/cm2 *srad*μm)

ML = Band Specific multiplicative rescaling factor from the metadata file (Radiance_Multi_...)

Al - Band Specific additive rescaling factor from the metadata file (Radiance_add_...)

QCAL= Quantized and Calibrated standard product

Note: that the Pixel values are the DNs, At-Satellite Temperature = Temperature of the satellite at the time the image was taken. The At-Satellite Temperature would give result in degree Kelvin were converted to degree Celsius by introducing a divisor 272.15.

Stage 2: Conversion of Radiance to At - Satellite Brightness Temperature

TIRS band can be converted from spectral radiance to brightness temperature using the thermal constants Ki and K2 for each band provided in the metadata file (Zhou *et al.*, 2011):

$$T = \frac{K_2}{1n\left(\frac{K_1}{L_\lambda}+1\right)} \cdots \quad . 3.6$$

Where T = At - Satellite Brightness Temperature (in Kelvin)

$L\lambda$ = TOA Spectral Radiance (watts/cm2 *srad*/μm)

K_1 = Band Specific Thermal Conversion Constant from the metadata file (K_1 constant_Band_x) where x is the band number.

K_2 = Band Specific Thermal Conversion Constant from the metadata file (K_1 constant_Band_x).

Stage 3: Deriving Land Surface Emissivity (LSE)

The Land Surface emissivity is derived using the computed Normalized Difference Vegetative Index Raster already processed for the imageries used for the project. For the different years of study where the surface temperature is determined the NDVT raster for the specific year would be used to compute the LSE (Zhou *et al.*, 2011).

e = 0.004 PV + 0.986 = Constant 3.7

$$PV = (NDVI - NDVI_{min}/NDVI_{max} - NDVI_{min})^2 \ . \quad 3.8$$

Where: PV = Proportion of Vegetation

NDV1: Normalized Difference Vegetative Index

Stage 4: Deriving Land Surface Temperature (LST)

$$T = BT / 1 + \omega \times (BT / P) \times \ln(e) . \quad 3.9$$

BT = At - Satellite Brightness Temperature

ω = wavelength of emitted radiance (11.5μm)

$P = h * c/s\ (1.438 * 10^{-2})$

h = Planck's constant ($6.626 * 10^{-34}$ Js)

s = Boltzmann constant ($1.38 * 10^{-23}$J/K)

c = Velocity of light ($2.998 * 10^{8}$ m/s)

P = 14380 = Constant

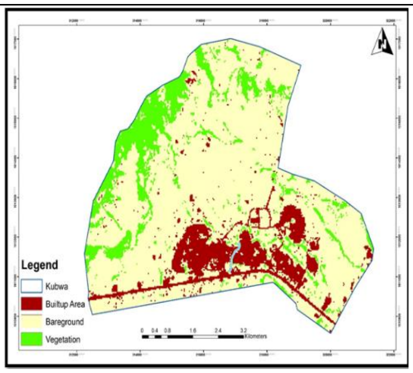
RESULTS AND DISCUSSION

Assessment of Land Cover trend in Land Cover in Kubwa (1990-2020)

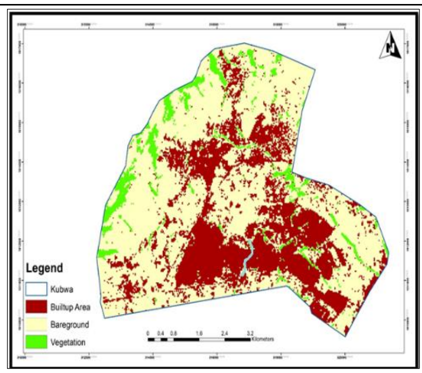
The classified imageries of the study area for three (3) spatio-temporal periods of 1990-2000; 2000-2010; 2010-2020 were assessed to determine the magnitude of LULC using the Erdas imagine 14, based on four (4) key determinant such as; (a) Bare land (b) Built-up area (c) Vegetation (d) Waterbody. Table 2 revealed that in 1990, built up for Kubwa covers 526.5 hectares, bare grounds covers 3028.5 hectares, and vegetation covers 598.41 hectares. The abundance of bare surface was due to increase and modification by anthropogenic activities like construction of roads, bridges, industrial location, deforestation, and increase in population. In the year 2000, built-up area covers 1402.92 hectares by over 200% increase due to general demolition exercise across the FCT led by FCTA, bare ground suffered a reduction in size due to population influx in the area from 3028.5 to 1979.64 hectares and vegetation covers had a gain of (4.2%) increment in size. This is due establishment of the IITA farming scheme (51 hectares) that was onw and another slight demolition exercise at the corridor that is from 246.78 to 770.85 hectares. Similarly, the study revealed that Kubwa in 2010, bare surface decreased to 1630.41 hectares due to the emergence of mining activities, construction of Kubwa express highway and movement of the IITA farming scheme to Abeokuta while the built-up area covers 2523 hectares. This implies that built-up area has increased from 1402.92 hectares in 2000 which accounted for 33.8% to 2523 hectares (60.7%) in 2010, due to massive population influx into the area and high demand for housing. Also, in Kubwa the built-up is increased from 2523 hectares in 2010 to 3102.93 hectares in 2020, bare ground reduced from 1630.41 hectares from the previous year (2010) to 1050.48 hectares in 2020. Figure 1, shows the LULC changes of the study area.

Table 2: Land Cover Changes of the Study Area

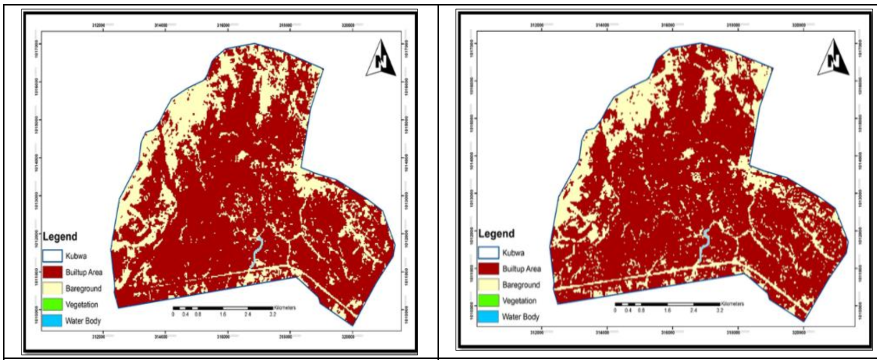
	1990		2000		2010		2020	
Land uses	Area Coverage (ha)	Percentage (%)	Area Coverage (ha)	Percentage (%)	Area Coverage (ha)	Percentage (%)	Area Coverage (ha)	Percentage (%)
Built-up	526.5	12.7	1402.92	33.8	2523	60.7	2494.9	36.0
Bare ground	3028.5	72.9	1979.64	47.7	1630.41	39.3	4193.01	60.5
Vegetation	598.41	14.4	770.85	18.6	-	-	157.58	2.3
Water body	-	-	-	-	-	-	85.32	1.2
Total	4153.41	100.0	4153.41	100.0	4153.41	100.0	6930.81	100.0



1990



2000



2010	2020

Figure 1: Land Use and Land Cover Changes in the study area

Rate of Change of Land Uses in the Study Area

Figure 2 presents the rate of change in the study area between two spatio-temporal periods (1990-2000 and 2010-2020). Kubwa has recorded tremendous development between the 1990-2000 with built up rate of 21.1% and 14% between 2010 and 2020 respectively, it deduced a decrease or reduction in the percentage of the built-up area. This urban growth was caused by the rising price of land within the city centre compared to areas outside the ring road (Toffin, 2010). Kubwa also witnessed an annual reduction of its bare surface by -25% between 1990 and 2000. Also, due to migration, construction and mining activities the town experienced a drastic decrease in its bare surface from 3028.5 to 1979.6 hectares and further decrease by -14% between 2010-2020. Also, in Kubwa there is a decline in the vegetal cover between 1990 to 2000 accounting to -4.2%. And by the year 2010, there was total or no vegetal cover left in the study area. This dramatic declined in vegetal cover could be best linked, to the expansion of settlement, forest fire, population growth, illegal logging, charcoal, and fuelwood extraction. This agrees with the result of Mundia and Aniya (2006) which found out that economic growth and proximity to transportation routes have been the major factors promoting urban expansion within an urban area.

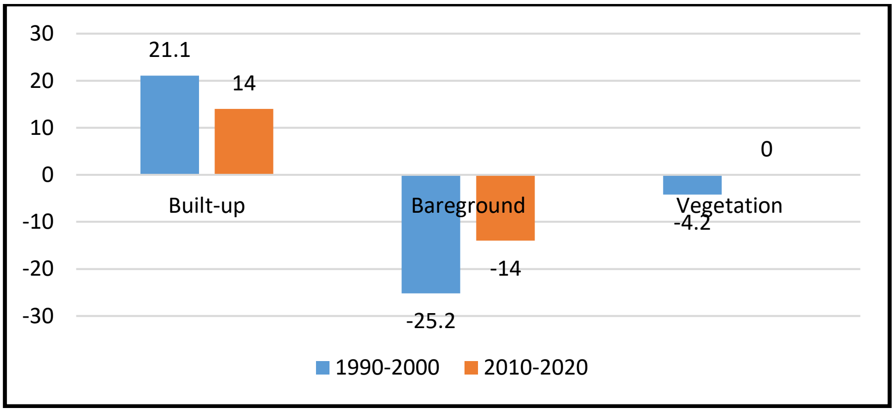


Figure 2: Rate of change of land uses in the study area

Urban Surface Temperature Variation based on Land Cover Changes in Kubwa

The Spatio-temporal pattern of LST of the study area during the four (4) selected periods, (1990, 2000, 2010, and 2020) revealed that the study area exhibited higher LST (see Table 3). In the year, 1990 Kubwa has a minimum and maximum LST of 25℃ and 40℃ with a mean of 32.5℃. A similar, trend was experienced in the study in the year 2000, the minimum and maximum LST of Kubwa was 25℃ and 35℃ with mean of 30℃. The trend further continues, in the year 2010, with minimum and maximum LST of 25℃ and 35℃ with a mean of 30℃. Similarly, the minimum and maximum LST of Kubwa in the year 2020, with minimum and maximum LST of 25℃ and 40℃ with mean of 32.5℃ (see Figure 3).

Table 3: LST of the study area

	1990		**2000**		**2010**		**2020**	
LST (°C)	Area Coverage (Ha)	Percentage (%)	Area Coverage (Ha)	Percentage (%)	Area Coverage (Ha)	Percentage (%)	Area Coverage (Ha)	Percentage (%)
10-15	0	0.0	0	0.0	0	0.0	0	0.0
15.1-20	0	0.0	0	0.0	0	0.0	0	0.0
20.1-25	0	0.0	0	0.0	0	0.0	0	0.0
25.1-30	215.977	5.2	431.955	10.4	153.67617	3.7	99.68184	2.4
30.1-35	2994.61	72.1	3563.63	85.8	3181.51206	76.6	211.82391	5.1
35.1-40	942.824	22.7	157.83	3.8	818.22177	19.7	3841.90425	92.5
Total	**4153.41**	**100.0**	**4153.41**	**100.0**	**4153.41**	**100.0**	**4153.41**	**100.0**

The LST out as shown in Table 3 revealed that in Kubwa, the surface temperature within the range of 25.1-30°C covers a total of 215.977ha (5.2%) of land area; 30.1-35°C of the LST occupies 2994.61ha (72.1%) and 35.1-40°C of LST covers 942.824 ha (22.7%) of the land area. Meanwhile, in 2000, the LST range from 25.1-30°C covering 10.4% (431.99ha) of land area coverage; 30.1-35°C covering 85.8% (3563.63ha) of land cover and 35.1-40°C covering 3.8% (157.83ha) of land area. Similar, trend of LST was recorded in 2010, where LST value ranges from 25.1-30°C covers 3.7% (153.67617ha); 30.1-35°C covers 76.6% (3181.51206ha) and 35.1-40°C covers 19.7% (818.22177ha) of the total land area coverage. In 2020, LST value of 25.130°C covers 2.4% (99.68184ha); 30.1-35°C covers 5.1% (211.82391ha), and 35.1-40°C covers 92.5% (3841.90425ha) of the land area. This implies that population explosion, climatic change, and rapid urban growth are the main drivers of the increase in surface temperature within the study area. The increasing urbanization often engenders the replacement of natural landscape elements (vegetation cover, waterbody, etc.) with artificial elements (built-up area and other non-vegetative features); because the vegetation is usually cleared before the erection of structures, and in response to this, surface energy balance is usually altered resulting in rising temperature (Santamouris *et al.,* 2011; Alavipanah *et al.*, 2015; Adeyeri *et al.,* 2017 and Xiao *et al.*, 2008). This explains the scattered temperature hotspots observed within the study area.

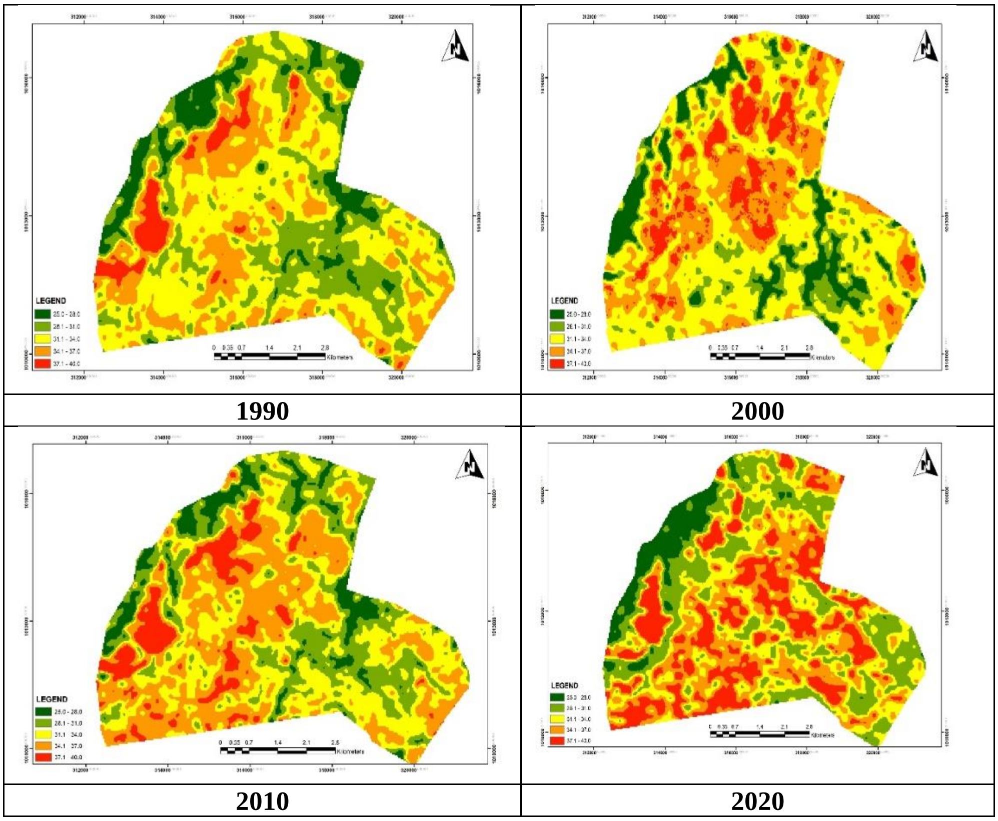


Figure 3: Land Surface Temperature distribution in the study area

CONCLUSION AND RECOMMENDATION

The analysis carried out in the study area revealed that that built-up area increase from 1990-2000 with 166% and 80% in 2010 and the year 2020 recorded an average of 23%. Bare surface decreased by -25% between (1990 -2000); further decreased from 3028.5 to 1979.6 hectares and -14% between 2010-2020. While vegetation decrease from 598.41 to 172.44 hectares from 1990-2000 and there was little or no vegetal cover left in the year 2010. The study revealed that temperature variation increases between 1990, 2000, and 2010 were 0.4°C. While there were 2°C in LST between the 2010 and 2020 due to urban expansion, population growth and anthropogenic activities within and around the study area. The study recommends improvements of urban green infrastructure; and the FCT administration should embark into afforestation in order to restore the depleted vegetal land cover of the study area.

REFERENCES

Adebayo, A. A., & Zemba, A. A. (2003). Analysis of micro climatic variations in Jimeta-Yola, Nigeria. *Global Journal of Social Sciences,* 2(1), 19-88.

Adeyeri, O. E., Akinsanola, A. A., & Ishola, K. A. (2017). Investigating surface urban heat island characteristics over Abuja, Nigeria: Relationship between land surface temperature and multiple vegetation indices.

Remote Sensing Applications: Society and Environment, 7, 57-68.

Adebowale, B. I., & Kayode, S. E. (2015). Geospatial Assessment of Urban Expansion and Land Surface Temperature in Akure, Nigeria. In *Proceedings of the ICUC9—9th International Conference on Urban Climate Jointly with 12th Symposium on the Urban Environment: Toulouse, France* (pp. 20-24).

Alavipanah, S., Wegmann, M., Qureshi, S., Weng, Q., & Koellner, T. (2015). The role of vegetation in mitigating urban land surface temperatures: A case study of Munich, Germany during the warm season. *Sustainability,* 7(4), 4689-4706.

Aniello, C., Morgan, K., Busbey, A., & Newland, L. (1995). Mapping micro-urban heat island using Landsat TM and a GIS. *Computers and Geosciences, 21*(8), 965-969.

Azeem, A., & Muhammad A. Butt (2016). "Assessment of Urban Heat Island (UHI) using Remote Sensing and GIS." *Global Journal of Human-Social Science Research.*

Barlew, A., & Korme, T. (2020). Monitoring land surface temperature in Bashir Dar city and its surrounding using Landsat images. *The Egyptian Journal of Remote Sensing and Space Science, 23* (3), 371-386.

Federal Capital Development Authority (FCDA) (1979). The Master Plan for Abuja: The New Federal Capital of Nigeria. FCDA, Abuja.

Ifatimehin, O. O., & Ufuah, M. E. (2006). An analysis of urban expansion and loss of vegetation cover in Lokoja, using GIS techniques. *Zaria Geographer*, 77(1), 28- 36.

Mundia, C. N., & Aniya, M. (2006). Dynamics of landuse/cover changes and degradation of Nairobi City, Kenya. *Land Degradation & Development,* 77(1), 97-108.

Nonomura, A., Kitahara, M., & Masuda, T. (2009). Impact of land use and land cover changes on the ambient temperature in a middle scale city, Takamatsu, in Southwest Japan. *Journal of environmental management, 90(*11), 3297-3304.

Nowak, D. J., & Dwyer, J. F. (2007). Understanding the benefits and costs of urban forest ecosystems. In *Urban and community forestry in the northeast* (pp. 25- 46). Springer, Dordrecht

Oluseyi, I. O., Fanan, U., & Magaji, J. Y. (2009). An evaluation of the effect of land use/cover change on the surface temperature of Lokoja town, Nigeria. *African Journal of Environmental Science and Technology,* 3(3), 086-090.

Oyugi, M. O., Odenyo, V. A., & Karanja, F. N. (2017). The Implications of Land Use and Land Cover Dynamics on the Environmental Quality of Nairobi City, Kenya. *American Journal of Geographic Information System*, 6(3), 111-127.

Roth, M., Okc, T. R., & Emery, W. J. (1998). Satellite-derived urban heat islands from three coastal cities and the utilization of such data in urban climatology. *International Journal of Remote Sensing*, *I0 (11*), 1699-1720.

Sherbinin, A. D., Carr, D., Cassels, S., & Jiang, L. (2007). Population and Environment. *Annual Review of Environment and Resource, 32,* 345-373.

Solecki, W. D., Rosenzweig, C., Parshall, L., Pope, G., Clark, M., Cox, J., & Wiencke, M. (2005). Mitigation of the heat island effect in urban New Jersey. *Global Environmental Change Part B: Environmental Hazards,* (5(1), 39-49.

Udeh, A. U. (2010). Impact of Development of the Federal Capital City, Abuja on Selected Settlements in Karu Local Government Area, Nasarawa State, Nigeria. Unpublished M. Tech Thesis, Federal University of Technology, Minna.

Ukaegbu, K. O. E., Ivvuji, M. C., Uche, C. C., Osumgborogwu, I. E., & Amangabara, G. T. (2016). Spatial Assessment of Temperature and Land Cover Change as Climate Change Monitoring Strategies in Owerri, Nigeria.

USGS, (2013). United State Geological Survey.US department of the Interior. http://landst.usgs.gov/ retrieved on July 1st, 2014 at 11:39 am.

Voogt, J. A., & Oke, T. R. (2003). Thermal remote sensing of urban climates. *Remote sensing of environment, 86(3),* 370-384.

Xiao, P., I. & Weng, Q. (2007). The impact of land use and land cover changes on land surface temperature in a karst area of China. *Journal of environmental management,* 55(1), 245-257.

Xiao, R., Weng, Q., Ouyang, Z., Li, W., Schienke, E. W., & Zhang, Z. (2008). Land surface temperature variation and major factors in Beijing, China. *Photogrammetric Engineering & Remote Sensing, 74(A),* 451-461.

Zhou, H., Shi, P., Wang, J. A., Yu, D., & Gao, L. (2010). Rapid urbanization and implications for river ecological services restoration: Case study in Shenzhen, China. *Journal of Urban Planning and Development*, 737(2), 121-132.

Zhou, J., Chen, Y., Wang, J., & Zhan, W. (2011). Maximum nighttime urban heat island (UHI) intensity simulation by integrating remotely sensed data and meteorological observations. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 4(*1), 138-146