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INFLUENCE OF LAND USE/LAND COVER ON LAND SURFACE TEMPERATURE IN LAGOS STATE, NIGERIA

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ABSTRACT

The research was carried out to assess the land use and land cover (LULC) changes in Lagos State for 23 years as well as its impact on the land surface temperature. Landsat 8 images of the years 2000 and 2023 were downloaded and analyzed to determine these changes using supervised classification method after which the land surface temperature was estimated using appropriate formula where necessary. The result showed that barren land and built-up areas increased in 2000 from 0.16% and 47.03% to 5.84% and 50.80% respectively while vegetation and water body decreased from 36.43% and 16.39% to 28.81% and 14.55% respectively. Also, land surface temperature ranged from 17.04°C to 35.38°C in 2000 while in 2023, 17.54°C to 39.85°C. Within the 23yrs of the research, it showed that land use and land cover changes in the state impacted the temperature increase which was majorly caused by the reduction in vegetation and water body. The research conclude that Lagos is becoming warmer and therefore the research recommend that urban forestry should be encouraged by the government.

KEYWORDS: Temperature, LULC, Vegetation, LST

INTRODUCTION

Energy exchange occurs between vegetation and the atmosphere from time to time. Alteration to this interaction leads to imbalance of surface energy which in turn bring great consequences on the environment (Pielke *et al.,* 2002). Activities of urbanization as well as other anthropogenic activities are usual occurrences altering the climate around the cities (Bharath *et al.,* 2013). Alterations in land use, infrastructural development, over-population amongst many other factors play major role in impacting the climate (Adeyeri *et al.,* 2015). These alterations impact on heat storage, solar radiation absorption, land surface temperature etc.

Cities are usually the center of attraction for everyone due to the facilities and economic opportunities accessible to the inhabitants which are some of the major driving forces of urbanization. Lagos is a major city in Nigeria characterized by high rate of industrialization and heavy commercial activities (Ayininuola & Olalusi, 2004). In Lagos, Ojo (1981) confirmed that there was a temperature variation of about 2ºC to 4ºC around Oshodi and Mushin areas which are high traffic zones in the afternoon.

At the local level, land surface temperature was recognized as the standard surface air temperature usually measured with a thermometer placed in a box at about 3m above the grass in an open field (Sun, 2008).

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This measurement represented a point measurement which can only be applied to a small geographical area being considered. Attempts have also been made by researchers to mount a thermometer on a vehicle driven around the town with readings taken intermittently (Huang *et al.,* 2008). These approaches of measuring land surface temperature are laborious, time consuming and subjected to inaccuracy when collecting data. These challenges have hindered the knowledge of the regional and global land-atmosphere exchanges.

The application of remote sensing to solve the limitation in the understanding of environmental processes (locally, regionally and globally) has brought a major shift in science and technology. It is an important tool for estimating land surface models, surface energy balance as well as community modelling (Kim and Liang, 2010). Remotely sensed data or information are taken continuously, repeatedly and usually have a higher resolution in order to allow for measurement of the condition of the earth surface (Owen *et al.,* 1998). The application of remote sensing to further understand the spatial variation of land surface temperature by researchers across the globe are numerous (Weng, Lu & Schubring 2004). Cities by the coast often have different temperatures because of the cooling effect of large bodies of water. However, even though there is a coastline in the vicinity, this cooling impact could be mitigated by widespread land development which could in turn lead to an increase in Land Surface Temperature (LST). The current study aims to identify and quantify how changes in Land Use Land Cover (LULC) shape the dynamics of Land surface Temperature (LST) in Lagos.

Study Area

Lagos State megacity is located in southwestern Nigeria on the West Coast of Africa. The State is bordered to the north and east by Ogun State, to the west by the Republic of Benin and to the south by the Atlantic Ocean/Gulf of Guinea. The longitude and latitude of Lagos State are between 2.6667° E to 4.0833° E and 6.4167° N to 6.6667° N respectively. The total landmass of the state is about 3,345 square kilometers, which is just about 0.4% of the total land area of Nigeria. Lagos consists of two main areas, namely; the Lagos Island and Mainland. Ikoyi, Victoria Island and Lekki corridor areas are referred to as Lagos Island, while Mainland encompasses the other part of the state. The mainland part of the state had developed and still developing rapidly and approaching an eventual merger with the more distant part of the mainland including Ikorodu, Epe and Badagry. A large portion of Lagos Mainland is built on a slightly higher north-south ridge. A considerable part of the state area is made up of Lagoon and creeks. Lagos Mainland Area shares some of the physical and economic characteristics of Lagos State. Lagos State is naturally made up of depositional landform, which include; wetland, barrier island, beaches, low-lying tidal flats and estuaries. The climate is the wet equatorial type influenced by nearness to the equator and the Gulf of Guinea. There are two main seasons, namely; the rainy season and dry season, which usually lasts from April to October and October to March respectively. The rainy season has two peak periods; May to July and September to October, with rainfall being heaviest during the first peaked period. Floods usually results at these periods, which are aggravated by the poor surface drainage systems of the coastal lowlands. The mean annual rainfall varies from one location to another with areas around the Lagos Mainland including Ebute-metta, Yaba, and Bariga recording 1750mm of rainfall. Lagos State has a constant high temperature, with mean monthly maximum temperature of about 30℃. The state experiences the highest temperature around November to December and February to March, while the lowest temperature occurs around June to July which coincides with the middle of the first peak of the rainy season. The humidity level is about 88% almost all through the year.

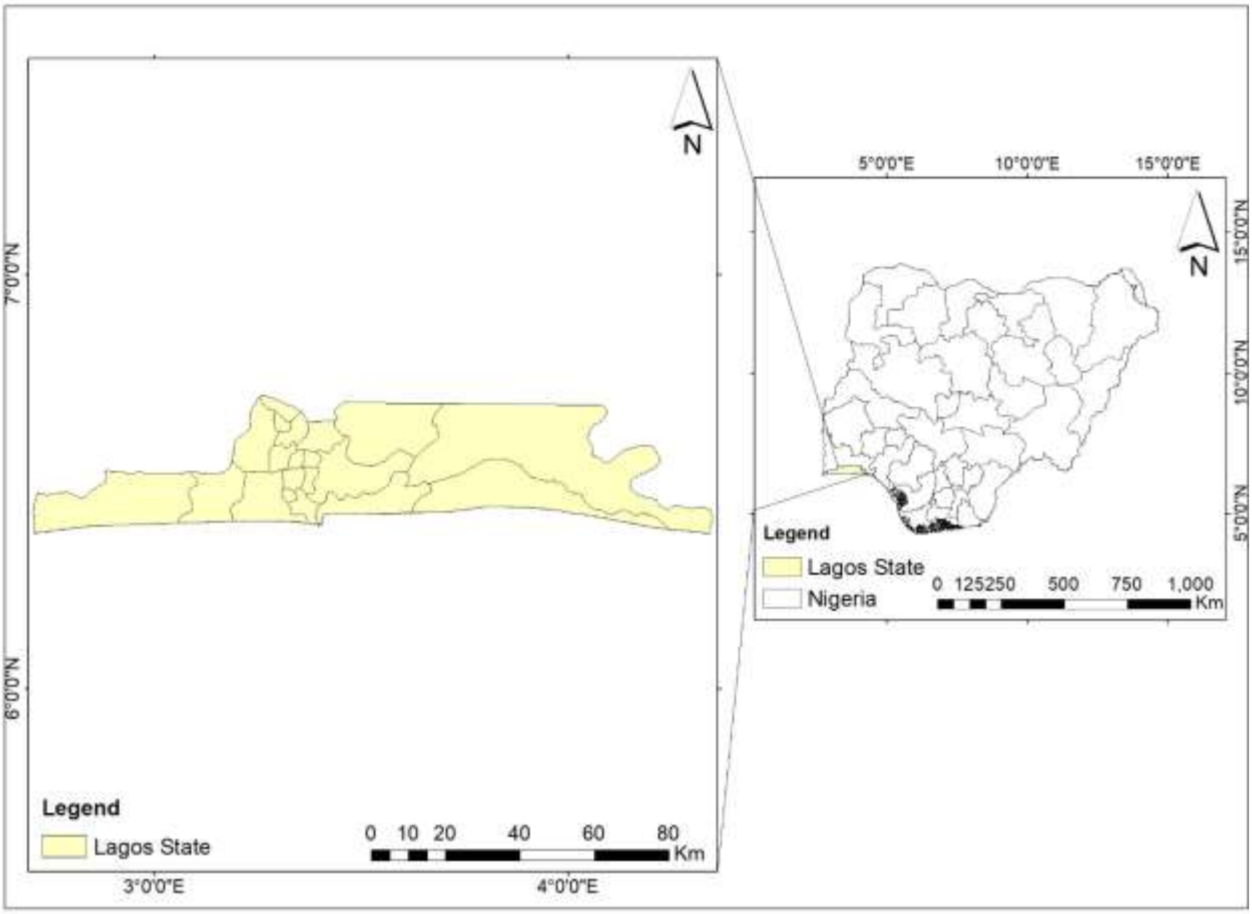

Figure 1: Map of Lagos State

Data Collection and Analysis

Landsat images were obtained from the USGS website (https://earthexplorer.usgs.gov) for Lagos state. The path and row for Lagos was 191 and 055 respectively.

The study specifically examined Landsat satellite images between the year 2000 and 2023. After that, the images were classified into land-use/land-cover (LULC) types using the ArcGIS 10.5 software. Thereafter, the Maximum Likelihood algorithm supervised classification was used to create the Land-use Land cover (LULC) maps.

Land Surface Temperature (LST)

The retrieval of LST follow the single-channel method (Obiefuna et al. 2018). The key stages of the methodology are as follows:

Conversion of digital number (DN) to spectral radiance

The formula for converting DN in Landsat 7 to spectral radiance is given by Zareie et al. (2016):

$$L\lambda = ((Lmax - Lmin)/(QCalMax - QCalMin)) \times (Qcal - Qcalmin) + Lmin \quad \textbf{(1)}$$

where:

Lλ is spectral radiance at the sensor's aperture (W m−2 sr−1 μm−1),

Qcal is a quantized calibrated pixel value in DN,

Lmin is spectral radiance scaled to Qcalmin,

Lmax is spectral radiance scaled to Qcal¬max,

Qcalmin is the minimum quantized calibrated pixel value (corresponding to Lmin) in DN,

Qcalmax is the maximum quantized calibrated pixel value (corresponding to Lmax) in DN.

The formula to derive the spectral radiance for Landsat 8 is given by USGS (2015):

$$L\lambda = ML \times Qcal + AL \quad \textbf{(2)}$$

where:

ML is Radiance multiplicative scaling factor for the band,

AL is Radiance additive scaling factor for the band.

The values for Lmin, Lmax, Qcalmin, Qcalmax, ML and AL will be derived from the Landsat metadata file.

Conversion of spectral radiance to top-of-atmosphere (TOA) brightness temperature

After calculating the spectral radiance (Lλ), the TOA brightness temperature was calculated. The TOA approximation formula is given by Zareie et al. (2016).

$$T = K2 / log(1 + K1 / L\lambda) \quad \textbf{(3)}$$

where:

T is TOA brightness temperature (K),

K1 (W cm−2 sr−1 μm−1) and K2 (K) are pre-launch calibration constants.

Conversion of brightness temperature to LST

The brightness temperature was subsequently converted to LST using the equation below (Hamoodi et al. 2019).

$$S\tau = T/(1 + (\lambda \times T / (\rho) \log \mathcal{E})) \quad \textbf{(4)}$$

where:

Sτ is LST (K)

λ is the Wavelength of emitted radiance (11.5 μm),

ε is Land surface emissivity (typically 0.95),

ρ = h × c / σ = 1.438 × 10−2 m K (σ = Boltz¬mann constant = 1.38 × 10−23 J K−1, h = Planck's constant = 6.626 × 10−34 J s, c = velocity of light = 2.998 × 108 m s−1).

Finally, the LST in Kelvin was converted to degree Celsius by subtracting from 273.15

Result and Discussion

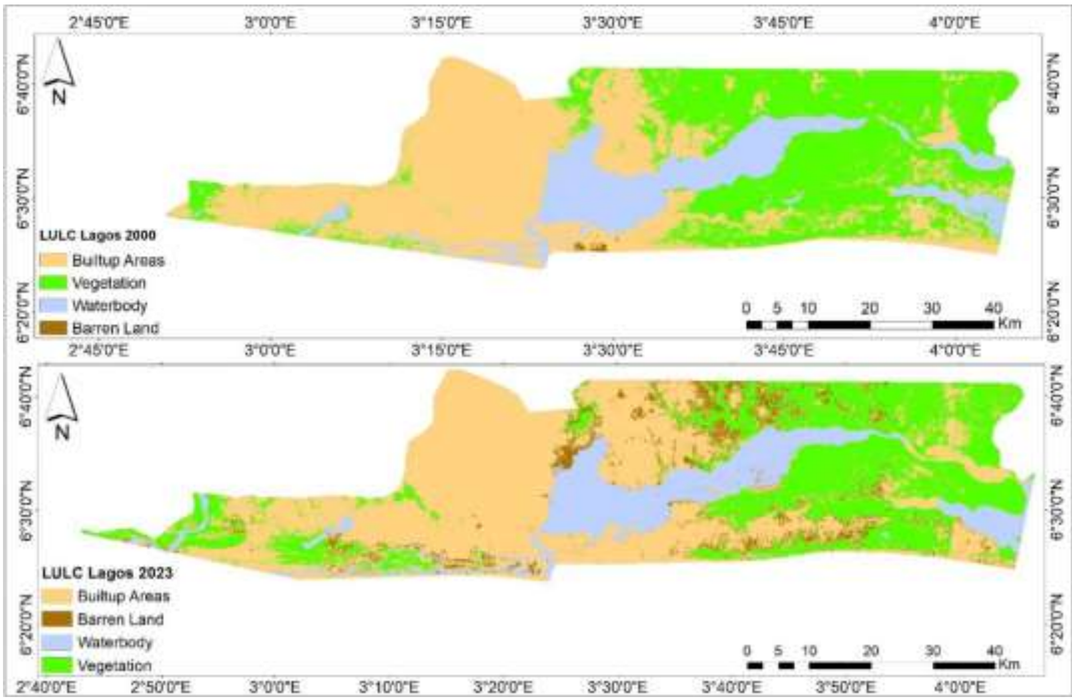

Figure 2: Land Use/Land Cover Change for Lagos in 2000 and 2023

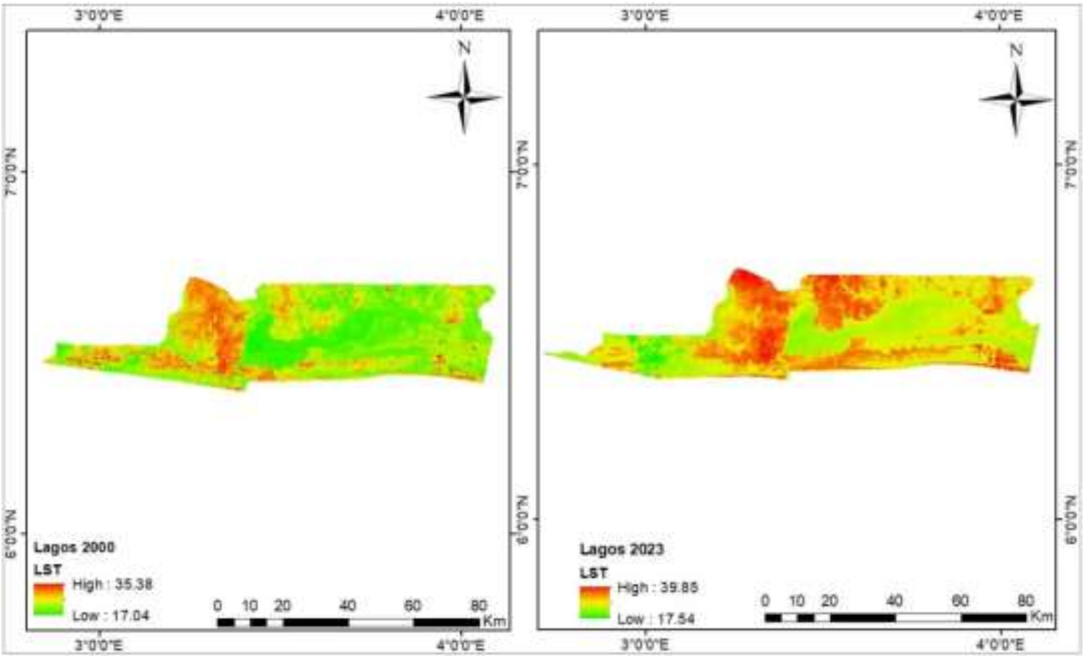

Figure 3: Land Surface Temperature of Lagos in 2000 and 2023

Table 1: Table showing the percentage coverage of Land Use/ Land Cover for Lagos and in 2000 and 2023

Land Use/ Land Cover	2000 Km^2 (%)	2023 Km^2 (%)
Barren Land	4.86 (0.16)	192.94 (5.84)
Built-up Areas	1440.39 (47.03)	1677.23 (50.80)
Vegetation	1115.67 (36.43)	951.18 (28.81)
Water body	501.84 (16.39)	480.33 (14.55)
Total	3062.75 (100)	3301.67 (100)

Figures 2 showed the Land Use/ Land Cover change map of Lagos in the year 2000 and 2023. The variation in the study areas were clearly visible on the map during the period of years studied. From the map, there were four land class types namely Water body, Built-up areas, Barren land and Vegetation. These land class types spread across the study areas in varying proportions.

Table 1 showed the variation of land use/land cover change in Lagos between 2000 and 2023. In Lagos, barren land, built-up areas, vegetation and water body covered 0.16%, 47.03%, 36.43% and 16.39% in the year 2000 while 23 years after, it was 5.84%, 50.80%, 28.81% and 14.55% respectively. Within the 23-year period, barren land and built-up areas increased by 4.68% and 3.77% while vegetation and water bodies decreased by 7.62% and 1.84% respectively. This showed that in Lagos, there was a notable rise in barren land and built-up areas while a marked reduction of vegetation and water body was observed after 23 years. This implied that land was utilized for building construction purposes as well as other uses that led to the significant reduction in vegetation.

Figures 3 showed the results of land surface temperature in Lagos State. It revealed that there was marked variation in temperature between the years 2000 and 2023. This showed how temperature varied in Lagos state for 23 years.

Land surface temperature in Lagos ranged from 17.04°C to 35.38°C and 17.54°C to 39.85°C in 2000 and 2023 respectively. This reflects that there was 0.5°C increase in the minimum temperature while 4.47°C increase was observed in the maximum temperature recorded in 23 years. It also showed that Lagos is increasingly getting hotter as the years go by. This was caused by population increase has placed a continuous pressure for housing and as a result, the demand to convert vegetated areas into built-up areas has been on the rise consistently (Twumasi *et al.,* 2021).

He went further to attribute the major cause of the land use/land cover change as rural-urban migration affecting urban centers in developing countries including Lagos.

Dontree (2010) confirmed that global warming increase is associated with vegetation reduction particularly around city centres as a result of heavy commercial activities contributing to greenhouse effect such as fuel combustion used in transportation, manufacturing, commerce etc.

The combined result of the land use/ land cover type and the land surface temperature deduced that the effect of reduced vegetation impacted on the temperature obtained in the state. This implied that the more the vegetation in a state, the lower the temperature becomes and vice versa which thus showed that an inverse relationship exist between vegetation and temperature (Fashae et al., 2020). As a result of urbanization, more vegetative lands have been cleared to give space for more infrastructures. It is also worthy of note to point out the shrinking water bodies in Lagos due to the sand-filling of seas and rivers to build housing estates (Obiefuna *et al.,* 2018). The results obtained showed that there was a general increase in the temperature confirming the impact of climate change as well as land use impact.

CONCLUSION AND RECOMMENDATION

The study showed that land use/ land cover played a significant role in influencing the temperature of the study area. The primary driver for this as seen from the study was vegetation loss which enhances high temperature. However, replacement of vegetation over the years with built-up areas and barren land has raised the temperature of the surrounding temperature. The study also noted that the cause of vegetation reduction in the study area is as a result of the pressure of increasing population in urban centers which keeps necessitating the need for housing.

The study therefore recommend that urban forestry should be practiced with selected tree species hence, encouraging multiple land use system in urban areas. Also, Government should create a well-structured layout for areas within their state.

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