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Human Induced Impact on the Land Surface Temperature Dynamics of Obio/Akpor Local Government Area of River State, Nigeria

Chigozi Wali Bethel[a*], Joy Bethel-wali Ugochi[b], Magnus Nwaigwe[c], Charles Oguche[d], Joshua Ezugwu[e], Dr. Kenneth Uchua. A[f]

[a]*University of uyo campus, uyo akwa ibom state, nigeria*

[a,b,c,e,f]*Nasrda-Advanced Space Technology Applications Laboratory Uyo, Akwa Ibom State*

[d]*Nasrda- Centre For Basic Space Science Nsukka, Enugu State*

[a]*Email: Chigoziwali@gmail.com*

Abstract

This research is aimed at evaluating influence of human activities on the land surface temperature of Obio/Akpor L.G.A of River State. land surface temperature (LST) is 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 dynamics, land use land cover dynamics and the relationship between land surface temperature (LST) and land-use land-cover (LULC) were assessed using Landsat satellite data (ETM+ and OLI/TIRS) of Obio/Akpor in River State, Nigeria. The radiometric corrected thermal infrared bands of the Landsat images of 2000 and 2020 were used Calculate NDVI, extract proportion of vegetation, (Emmisivity) for calculating and retrieving the land surface temperature of the study area while the Maximum Likelihood algorithm in Erdas imagine 9.2 was used to generate a classified image for the two periods. Land surface temperature maps, land cover index maps and Normalized Differential Vegetation Index (NDVI)) were generated. Correlation analysis using Pearson's Product Moment Method was carried out between land surface temperature and normalized differential vegetation index (NDVI) data and the land cover index was digitized and overlaid on the LST map of 2020 to determine the association between them. The results revealed noticeable decrease in vegetated areas of Obio/Akpor with an accompanying increase in land surface temperature from 32.6°C in 2000 to 36.2°C in 2020. Built-up increased within the same periods from 75.59 square meters to 157.84 square meters, which could be attributed to anthropogenic activities.

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* Corresponding author.

The land surface temperature distribution maps showed a more pronounced intensity in areas of significant human activities than in areas covered by vegetation and waterbody. correlation coefficient values of –0.85351 and -0.87513 were observed in the land surface temperature and normalized differential vegetation index values for 2000 and 2020 respectively, verify this indicated an inverse relationship between the two variables showing that areas with highest value of LST, recorded low value of NDVI. The study concluded that the nature of land use / land cover patterns in Obio/Akpor have impacted its land surface with a corresponding increase in land surface temperature. It is expected that as the city expands further, the magnitude of the land surface temperature will also increase thereby affecting the living conditions of the urban populace.

Keywords: Human impacts; Land surface temperature; Nigeria; land use/land cover; NDVI; Landsat images.

1. Introduction

Presently, there have been growing concerns on the anthropogenic activities of man on the environment such as gas flaring, combustion of fossil fuel, deforestation, etc, giving rise to the emergence of some factors such as climate change, global warming, greenhouse effect, earth drift and urbanization etc, which impact on the surface temperature coupled with some other natural factors such as elevation, slope and aspect putting into consideration the fact that topography is one of the factors that controls the soil moisture distribution and there by exerting additional influence on the land surface temperature. The land surface temperature (LST) is 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. LST is the surface radiometric temperature emitted by the land surfaces and observed by a sensor at instant viewing angles [32]. This is an accurate measurement tool for indicating the energy exchange balance between the atmosphere and the Earth. The degree of land surface temperature (LST) is affected by the surface attributes, which are significantly influenced by the elevation, slope and aspect, considering the fact that topography plays an important role in soil moisture distribution which will impact on the land surface temperature. Land use is defined as "the arrangements, activities and inputs people undertake in a certain land cover type to produce a change or maintain it". Land use is a change over the time and the most important and primary factor in land use changes is the human need. Human population as settlements and especially large urban and industrial areas could significantly modify their sounding environment. Therefore, it is critical to have a detailed information of temporal and spatial land use changes and their rate. Land use should be matched with land capability and at the same time it should respect to the environment, and global climate systems [41]. Environmental analysts are of the views that these were caused largely by anthropogenic activities: combustion of fossil fuel, sand changes in land-use [3]. All these activities have a direct impact on the near earth surface temperature. It has been stated that the global average combined land and ocean surface temperature data calculated by a linear trend show a warning of 0.85 (0.65 to 1.06) °C between 1880 to 2012 while the global surface temperature has increased by 0.18°C during the last hundred years ending in 2005 and is expected to increase to 1.4°C by 2100 [12]. This is attributable to the onset of the industrial age, which culminated in increased urbanization which is expected to continue Increasing local ambient temperature which implies higher human exposure to heat such that during hot seasons in hot regions of the world, people who are not able to afford either the cost of air conditioning and other cooling methods or the cost of energy required to run them, will be subjected to very severe heat stress and health risks. Both general living environments and working environments will be affected. The latter may impact workers' health, productivity, and socio-economic development [2]. Due to increased population, urban pavement materials of Obio/Akpor has increased and modified the natural spatial features of the city. From colonial time, Obio/Akpor has continued to expand its landscape and swallowing undeveloped plots of land and transforming the land use types. Thus, during the early1980s the study area has drawn much attention to researchers due to increased structural transformation caused by population and economic growth resulting to high thermal activity of the city in the form of Land Surface Temperature(LST). LST of different states of matter whether solid, liquid or gas on the ground surface varies according to location and climatic parameters as well as human activities. Increased in pavement materials is an indication of rise in man's activities to the land surface which results to land surface temperature. From the city centre to the fringes of a city, land surface temperature varies according to different land use types. Over time as human activities in a city begin to increase, land use land cover invariably reduces thereby giving way to LST which alters the regional climate of the area. Many studies have revealed changes in the water cycle and general evapotranspiration processes due to large scale biophysical alteration of the city surface areas. When the LST of a city is compromised, there will be high demand of energy, increased pollutants reaction, rise in greenhouse gas effect, health disaster and low water quality. In the city, there are many parameters that have brought about LST rise such as loss of urban tree cover, emission of greenhouse gas, increased pavement surfaces and low albedo of materials; others are thermal properties of materials, urban morphology, city size and generated anthropogenic heat. With rapid urbanization in the city, there is increased pressure on land thereby altering the vegetal and water bodies particularly in the fringes resulting to serious heat effect. In recent time, geo-spatial technologies such as remote sensing (RS) and geographic information systems (GIS) have become effective instruments for monitoring the trend, pattern and magnitude of LST for long term planning and management of urban heat. Various urban fabrics consume insolation and radiate energy from land surface resulting to atmospheric temperature rise which have a high heat capacity and conductivity due to vegetation and water surfaces. This temperature rise can be monitored using space borne remote sensing process in the form of Top of the Atmosphere (TOA) radiances in the Thermal Infrared (TIR) region. The TOA radiance is the net radiance from the earth's surface as upsurge radiance from the atmosphere and downside radiance from the sky. The brightness temperatures known as the blackbody temperatures are retrieved from the TOA radiance. The brightness temperatures account for various properties of the land surface such as the quantity and nature of vegetation cover and thermal properties as well as moisture content of the soil. It is on this background that this investigation was carried out to evaluate the effects of human activities on the geo-spatial dynamics of land surface temperature of Obio/Akpor in order to further understand the implication of LST in heat disaster management for sustainable living environment. When solar radiations hit the earth's surface, they are either absorbed or reflected back into the atmosphere which is dependent on the land surface material. Vegetation has been proven to absorb more of these radiations for its process of photosynthesis; meanwhile the concreted pavements reflect more of it [46]. In the case of the dark concreted surfaces, they absorb these radiations during the day and released at night as emissions. It is this reflected or emitted solar energy and the latent heat flux that influences the urban temperatures, causing them to be warmer than surrounding areas- a phenomenon known as urban heat island (UHI). The UHI phenomenon is usually evaluated from land surface temperatures (LST). The influence on urban climate from the resulting increase in LST can impact on the development of meteorological events such as increased precipitation, and boosts energy demands, poses threats to environmental quality as well as long-term sustainability of localities, while potentially contributing to global warming [51]. It also has an economic impact on the energy usage by local residents. Hence, it may induce unchecked increases in fossil-fuel consumption for cooling and its consequent increases in the anthropogenic carbon dioxide emission, which could contribute to global warming [10]. There are also devastating human health impacts as has been shown by the excess mortality of 15,000 people in France during the heat wave of the 2003 summer, especially in the largest agglomerations [9]. UHI may be identified by measuring surface or air temperatures. Surface temperatures have an indirect but significant influence on air temperatures. For example, parks and vegetated areas, which typically have cooler surface temperatures, contribute to cooler air temperatures [46]. Dense built-up areas, on the other hand, typically lead to warmer air temperatures. Because air mixes within the atmosphere, though, the relationship between surface and air temperatures is not constant [42,27]. Therefore, the measurement of UHI is done at various levels and by different tools. The LST could be measured at scale point atmospheric temperatures from meteorological stations. However, these measurements are usually not true representation of the LST as they are limited in extent to a scale of area [25]. Some researchers have tried to cover a larger area by mounting thermometers on a car and driving around a city but this is also challenged by the time factor and labour intensive [10]. Some of the measurements also get subjective and unreliable. Monitoring from satellite images has become more attractive because remotely sensed data are almost in real time, and cover a large area [38]. Technological advancements and free availability of these satellite data has translated into a growing base of studies through the LST estimation establishing an existence of the UHI phenomenon within cities across the globe [42,20] with the Asian continent being the most researched and the African continent the least [26]**.**

1.1 Statement of Problem

With rapid urbanization, social and economic development, the influence of human activities on the land surface temperature (LST) has intensified leading to Climate change which impact agriculture and food production around the world due to the effects of elevated CO2 in the atmosphere; higher temperatures; altered precipitation and transpiration regimes; increased frequency of extreme events; and modified weed, pest, and pathogen pressure. Studies have showed that prolong increase in Land Surface Temperature of any geographical location due to rapid growth in population results to heat wave [37,42] which can pose threat to the life of their residents and the local climate of that location [7]. stressed that the most pronounced and locally far reaching effects of man’s activities on microclimate have been in cities. For instance, smog is formed faster in cities because of the hot weather. [51], generally find out that human induced changes in land-use such as urbanization among other factors affect both local and regional climate and even large scale atmospheric circulations. Therefore, studying the dynamics of this land surface temperature variable and decoding its relationship with the change that is taking place in our environment due to human activities become the major focus of this study.

1.2 Aim and Objectives

This study is aimed at evaluating the impacts of human activities on the land surface temperature of the study area

The specific objectives are

1. To identify the various anthropogenic factors impacting on the land surface temperature of the study area

2. To determine the spatiotemporal differences between surface temperature changes and land-use within the period of 2000 through 2020.
3. To reveal the relationship between land-use and land surface temperature from a geographical perspective.

1.3 Significant of the Study

The city of Obio/Akpor has been subjected to several activities resulting to high thermal condition over the years. climate change, global warming, greenhouse effect, earth drift etc, which is of great concern to the society today. This work will therefore serve as guide to relevant stakeholders in taking action in combating climate change. This is in line with goal 13 of the SDGs which takes into account the need to take urgent actions to combat climate change and its impact.

1.4 Study Area

Obio-Akpor is a local government area in the metropolis of Port Harcourt, one of the major centres of economic activities in Nigeria, and one of the major cities of the Niger Delta, located in Rivers State. The local government area covers 260 km^2 and at the 2006 Census held a population of 464,789. Its postal code or ZIP code is 500102. Obio-Akpor has its headquarters at Rumuodomaya. The original indigenous occupants of the area are the Ikwerre people, a subgroup of the Igbo people. Obio-Akpor is bounded by Port Harcourt (local government area) to the south, Oyigbo and Eleme to the east, Ikwerre and Etche to the north, and Emohua to the west. It is located between latitudes 4°45'N and 4°60'N and longitudes 6°50'E and 8°00'E.

1.4.1 Geological setting, Climate, soil and vegetation

Covering around 100 sq mi, Obio-Akpor is generally a lowland area with average elevation below 30 metres above sea level. Its geology comprises basically of alluvial sedimentary basin and basement complex. The thick mangrove forest, raffia palms and light rainforest are the major types of vegetation. Due to high rainfall, the soil in the area is usually sandy or sandy loam. It is always leached, underlain by a layer of impervious pan.

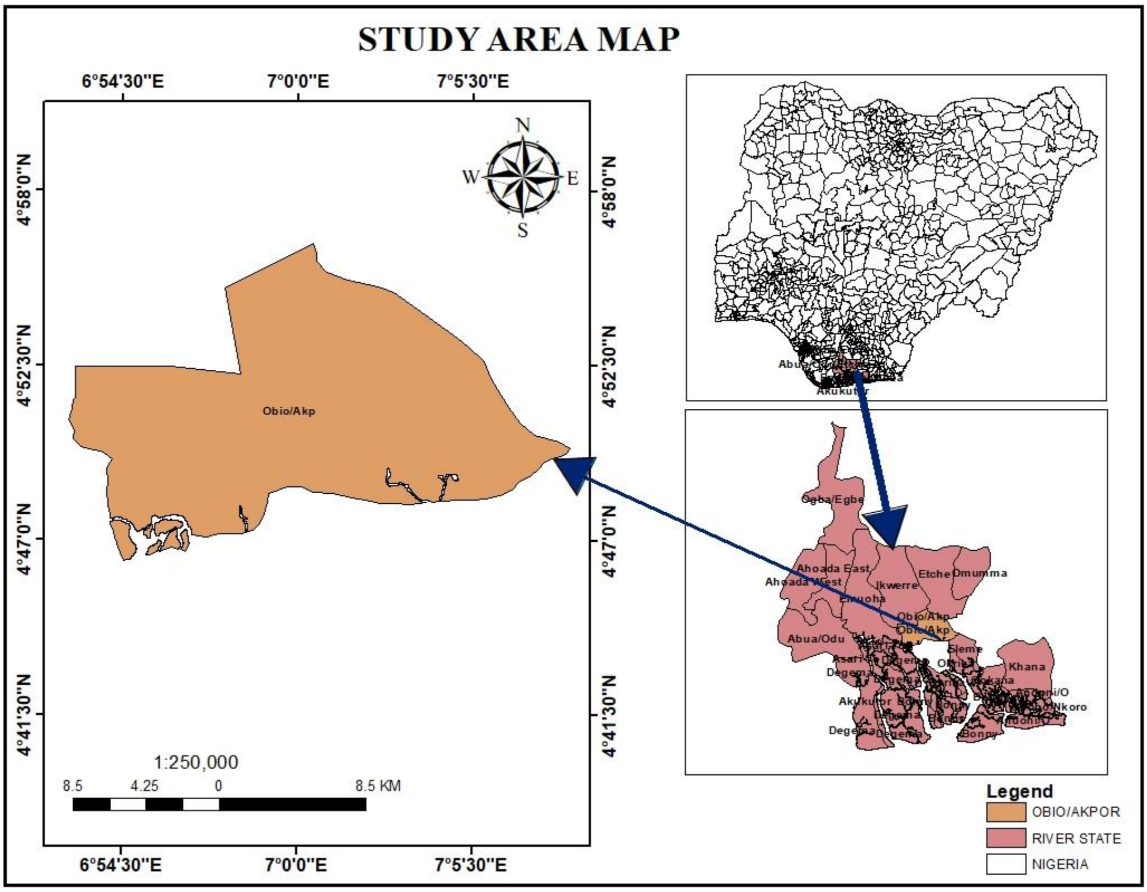


Figure 1.1: Map showing the study area—Obio/Akpor L.G.A of River State.

2. Material and Method

Landsat TM and ETM+ have a single thermal band (band 6) which is the thermal infrared (TIR) channel that records radiation within a 10.4-12.5µm spectral range of the electromagnetic spectrum and Lansat 8 Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS). (OLI and TIRS) records radiation within a 10.6-11.2µm spectral range of the electromagnetic spectrum also. The satellite data used were extracted from two scenes (path/row: 188/57) of Landsat7 ETM and Landsatt8 OLI_TIRS Satellite images of 12th of December 2000 and 31st January 2020 in UTM Projection Zone32, DatumWGS84. The bands selected for classification were 3, 4 and 6 [45], for lansat 7 and band 6 [24] was used to extract the land surface temperature (LST) while band 4, 5 10, were used for the landsat 8 and band 10 was used to extract the LST. The local boundary and Administrative shape files of rivers state on the scale of 1:15,140,906 was obtained from Office of the Surveyor General of the Federation Abuja, Climatic data of Rivers State obtained from NIMET Lagos, Population data of Rivers state was obtained from National Population Commission and information on the physical and socio-economic variables and historical records of River state was mostly obtained from web sources that are affiliated to the city. ERDAS Imagine 9.2, ArcGIS 10.4 and Microsoft office 2016 (word and Excel) were used. Erdas Imagine 9.2 was used for image classification. ArcGIS 10.4 was used for data preparation and map composition. Microsoft office (Word and Excel) was used for reporting and analysis.

2.1 Methods

LST retrieval methods.

Different LST retrieval methods have been developed according to different data sources (thermal bands on a sensor), such as the split-window, temperature/emissivity separation, mono-window, and the single-channel methods [35]. Among these methods three can be applied to Landsat data; these include the radiative transfer equation, mono-window algorithm and single channel algorithm. Although all of these methods can provide good results, some of them such as the radiative transfer equation can only yield results with in situ atmospheric parameters captured simultaneously as the satellite passes over the study area. In addition, the mono-window algorithm can get better results than the single channel algorithm with a root mean square deviation of 0.9°C [35]. It has been recently proven to yield better accuracy for the retrieval of LST from Landsat images as illustrated for Hong Kong with a 0.7°C error [22]. This study therefore makes use of the mono-window algorithm to retrieve the LST from the ETM+ imagery for the city of Obio/Akpor LGA**.** The algorithm is based on thermal radiance transfer equation and requires three parameters: emissivity**,** transmittance and effective mean atmospheric temperature to retrieve LST from Landsat multispectral imagery. The landsat spectral bands were stacked to produce a composite image of the study area for each year, 2000 and 2020. Thermal band 6 for Landsat 7ETM and band 10 for Landsat 8 TIRS were used to extract the surface temperature for all the periods under consideration [23]. The areas of interest were clipped from the composite in Erdas Imagine 9.2. A land cover classification was carried out on the multi-year Landsat images by choosing forested area, farmland, Built-up, bare land and waterbody, as training classes for a supervised classification, using the Maximum Likelihood algorithm. Further classification correction and interpretation were carried out with the Google earth image of the study area. The error matrixes of the two land use and land cover maps were generated to assess the accuracy of the classification result. The mono-window algorithm method was adopted to retrieve the LST from the imageries selected for this study [52]. In the process, the NDVI was calculated first using the red 3 and NIR bands 4 for Landsat 7 and band 5 and 4 for Landsat 8. The data output from this manipulation gave the NDVI image, which was used in calculating the Proportion of Vegetation which in turn was used to generate the emissivity. Consequently, the landsat thermal band 6 and 10 were used to retrieve LST over the study area for the two different years (2000 and 2020) based on the following steps: The DN of the thermal bands of ETM+ were converted into spectral radiance values for each of the investigated years using the following equation

2.2 Calculation of NDVI

NDVI is a simple graphical indicator usually used to analyze remote sensing measurements, and assess if observed target includes green vegetation or not. NDVI is one of the outputs that run into the model to retrieve LST using

$$NDVI = \frac{\text{NIR} - \text{R}}{\text{NIR} + \text{R}}$$

TOA (L) = ML * Qcal + AL

BT = (K2 / (ln (K1 / L) + 1)) − 273.15 =

$$T_i = \frac{K_2}{\ln(\frac{K_1}{L_\lambda} + 1)}$$

NDVI = (Band 5 – Band 4) / (Band 5 + Band 4)

Pv = Square ((NDVI – NDVImin) / (NDVImax – NDVImin))

ε = 0.004 * Pv + 0.986.

LST = (BT / (1 + (0.00115 * BT / 1.4388) * Ln(ε))) = BT/1+w*(BT/p) *In (e)) where

BT= at satellite temperature

W= wavelength of emitted radiance (11.5um)

P= h*c/s(1.438*10~2mk)

H= planks constant(6.626*10~-34js)

S= Boltzmann constant(1.38*10~-23j/k)

C= velocity of light(2.988*10~8m/s)

P=14380.

In e is calculated from the NDVI. Square ((NDVI – NDVImin) / (NDVImax – NDVImin))

ε = 0.004 * Pv + 0.986.

First step

Conversion to TOA Reflectance

TOA (L) = ML * Qcal + AL

Where: ML = Band-specific multiplicative rescaling factor from the metadata (RADIANCE_MULT_BAND_x, where x is the band number).

Al = Band specific additive recalling factor from the metadata (RADIANCE MULT_BAND_x, where x is the band number).

Qcal = Quantized and calibrated standard product pixel values (DN) and also corresponds to band 10. ... K2 = Band-specific thermal conversion constant from the metadata (K2_CONSTANT_BAND_x, where x is the thermal band number).

Second step

Conversion of spectral radiance into at-sensor/ satellite brightness temperature:

The conversion formula is:

BT = (K2 / (ln (K1 / L) + 1)) − 273.15.

Where T = At satellite brightness temperature (k)

Lπ = TOA (L) = ML * Qcal + AL

K2L1=Qcal = Quantized and calibrated standard product pixel values (DN) and also corresponds to band 10. ... K2 = Band-specific thermal conversion constant from the metadata (K1_CONSTANT_BAND_x, where x is the thermal band number).

K2L1= = Band-specific thermal conversion constant from the metadata (K2_CONSTANT_BAND_x, where x is the thermal band number).

The final LST is calculated using this

LST = (BT / (1 + (0.00115 * BT / 1.4388) * Ln(ε))) = BT/1+w*(BT/p) *In (e))

3. Methodology Flow Chart

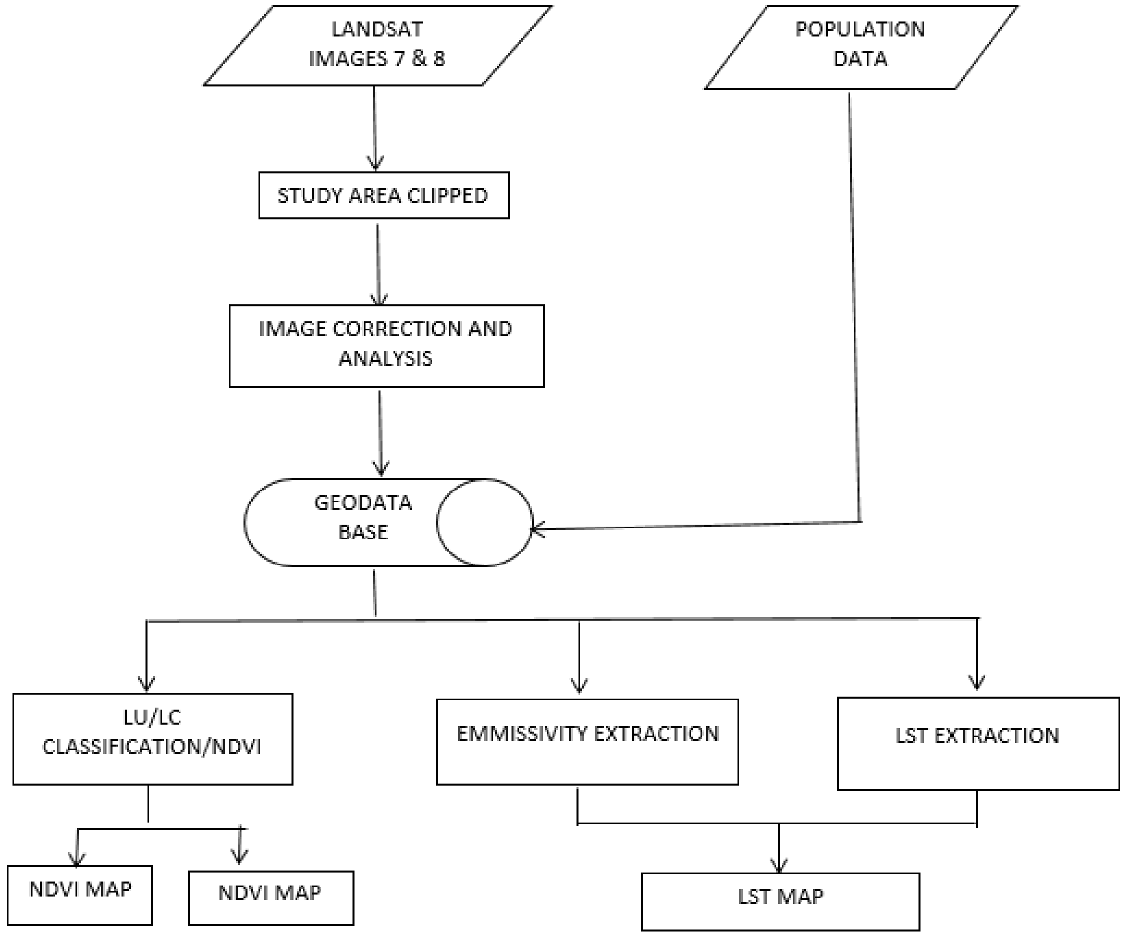


Figure 2

4. Result and Discussion

4.1 This chapter presents the result and discussions as enumerated in the objectives

In achieving objective one, the following were identified as factors emanating from human induced influence on the land surface temperature dynamics of the study area Obio/Apkor based on the reviewed literatures and relevant expert knowledge.

i. Deforestation
ii. Urbanization
iii. Burning of fossil fuel/gas flaring
iv. Climate change/global warning

In order to determine the spatiotemporal differences between surface temperature changes and land-use within the period of 2000 through 2020. The following analysis were carried out.

I. Classification of the LULC of the study area,
II. LST extraction and NDVI estimation of the study area

III. LST/NDVI RELATIONSHIP (CORELLATION MATRIX VALUES OF LST AND NDVI)

IV. An overlay of LST on the LULC.

4.2 Land use Land cover(LULC) Distribution and Change Detection analysis results

This was carried out in order to investigate both the change, nature and magnitude of the land transformation due to human activities. This analysis was carried out using Landsat 7 and 8 for the years 2000 and 2020 respectively. Five classes such as Bare land, Built Up, Farmland, Forested Areas and Water bodies were chosen as (LULC classes) for the supervised classification.

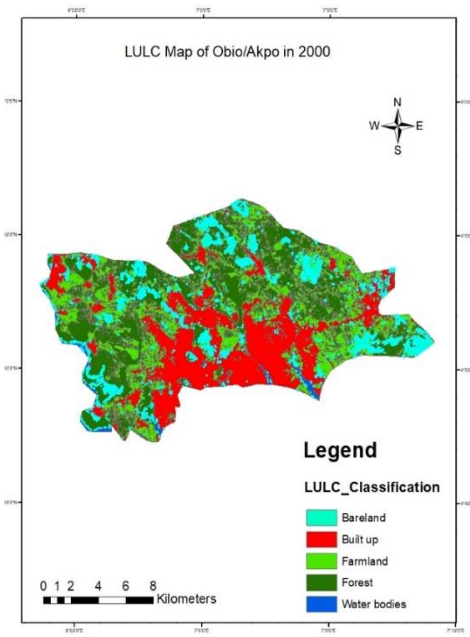


Figure 4.1: LULC Map for the year 2000

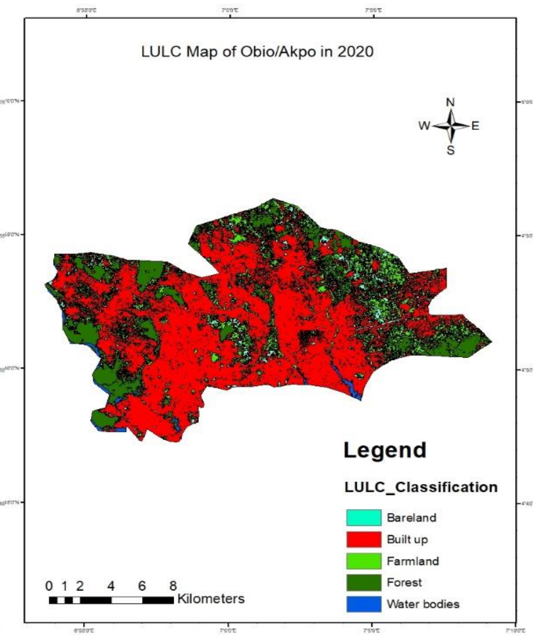


Figure 4.2: LULC Map for the year 2020

Table 4.1: LULC Statistics over the study periods.

LU/LC CLASSES	2000LULC(km^2)	% COVERAGE	2020LU/LC(km^2)	% COVERAGE	Change rate btw the study period(km^2)
Bare land	11.32	4.8	13.03	5.1	1.71
Built up	75.59	29.3	157.84	61.3	82.25
farmland	85.57	33.2	44.13	17.10	-41.44
Forested area	80.99	31.1	39.83	15.47	-41.16
Water body	4.03	1.6	2.66	1.03	-1.37

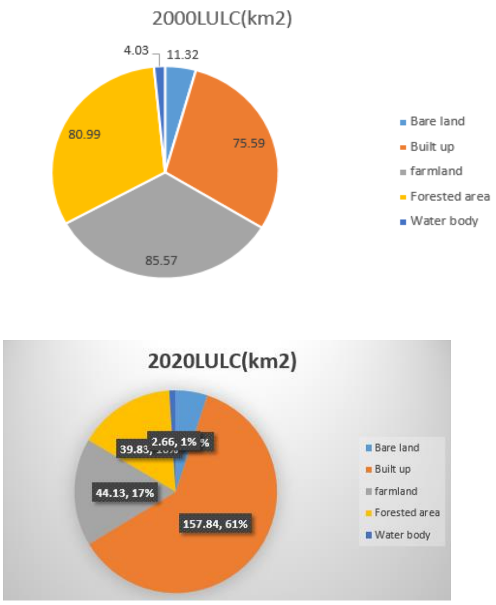
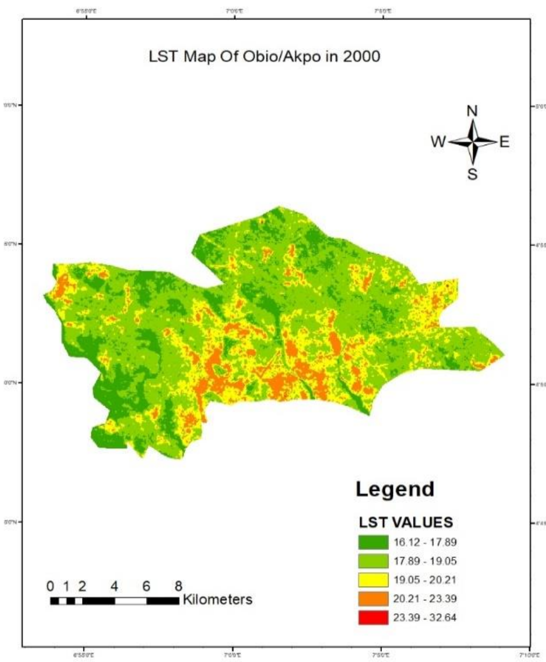


Figure 4.2

In 2000 (Fig ure 4.1), The Land use and land cover analysis showed that Obio/Akpor city has a total area of 257.49square kilometres with bare land occupying 11.32 square kilometre of it, 75.59k for built up, 85.57 for farm land, 80.99 for forested areas, 4.03 for water bodies while in 2020 looking at (Figure 4.2) bare land has an area of 13.03 square kilometres, 157.84 for built up, 44.13 for farm land, 39.83 for forested area and 2.66 for water bodies.

4.3 Spatio-temporal variability and Distribution of the land surface temperature(LST)



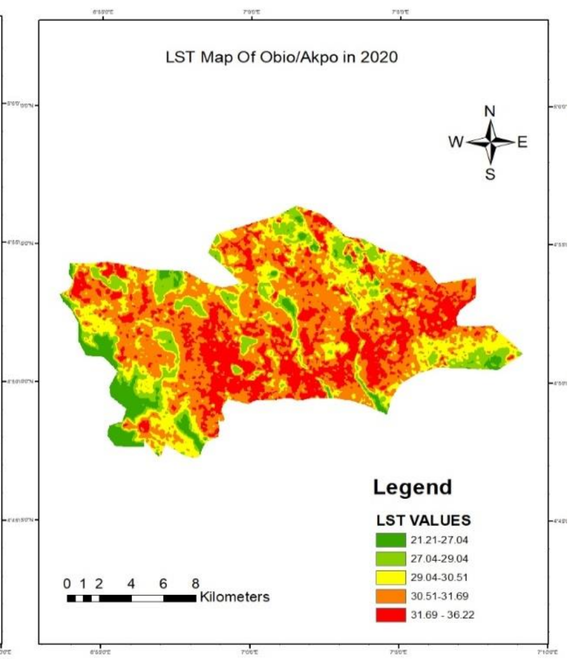


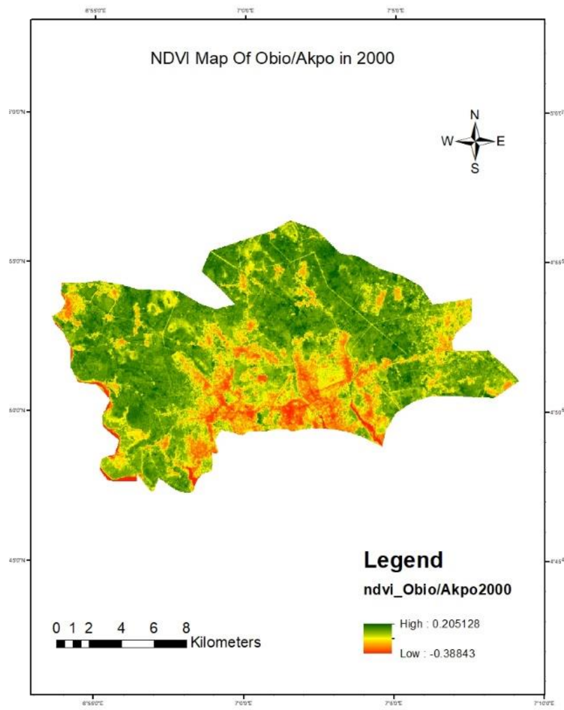
Figure 4.3: LST Map for the year 2000 **Figure 4.4:** LST Map for the year 2020

Table 4.2: land surface temperature value range over the study period.

Temperature range(°c)	Year 2000	Year 2020	Increase between 2000 & 2020
Lowest	16.12	21.21	5.09
Highest	32.64	36.22	3.58
Mean	24.38	28.71	4.33

In (Table 4.2), the result showed that land surface temperature in 2000 had a minimum temperature of 16.12°C and a high temperature of 32.64°C and in 2020 land surface temperature had a low temperature of 21.21°c and a high temperature of 36.2°c. LST had high intensity in the south-eastern segment of Obio/Akpor than every other part. The spatial distribution of LST in Obio/Akpor is a function of variation of urban fabrics and general anthropogenic activities as shown from the analysis and also that in 2000 and 2020, human activities generating LST were more in the south-eastern part of the region. The segments that recorded low concentration of LST were seemingly caused by poor urban infrastructure. Generally, urban growth in Obio/Akpor concentrated on the south-western direction during this period. Thus, LST increasingly spread toward the south-eastern direction indicating area of high urban pavement material concentration and growth. LST was low in some areas from the analysis due to increased vegetal and water body concentration.

4.4 Ndvi of the Study Area



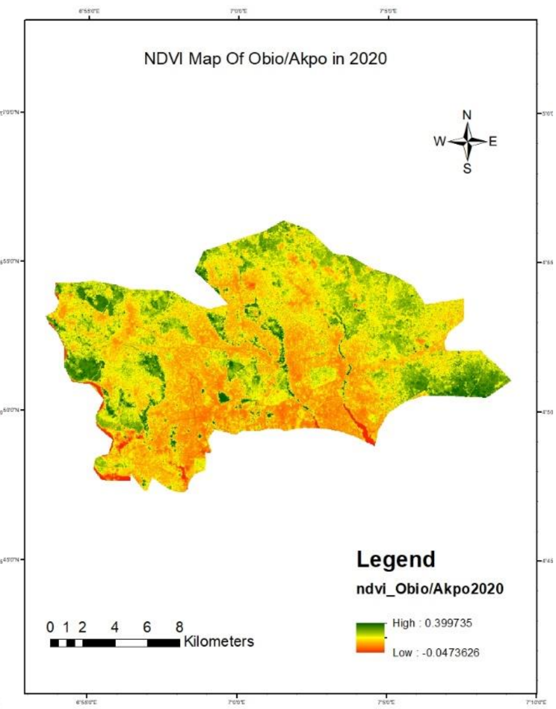


Figure 4.5: NDVI Map for the year 2000 **Figure 4.5:** NDVI Map for the year 2020

From the result, it was observed that the NDVI in the year 2000 recorded -0.38843 as the lowest and 0.205128 as the highest value while in 2020 it recorded -0.0473626 and 0.399735° as lowest and highest values respectively. Areas with the green colour which has positive value shows healthy vegetation while areas in yellow/red colour with negative values shows areas with unhealthy vegetation.

4.5 Lst/Ndvi Relationship (Corellation Matrix Values of Lst And Ndvi) For The Study Period

Table 4.3

LST 2020	NDVI 2020	LST 2000	NDVI 2000
27.0	0.399735	17.85136	0.205128
29.0	0.215636	19.01595	0.039863
30.5	0.163036	20.2862	-0.02298
31.6	0.11745	23.33817	-0.10213
36.2	0.073617	32.6	-0.1929

FOR THE YEAR 2000

Table 4.4

LST 2000	NDVI 2000
17.88678	0.205128
19.05136	0.039863
20.21595	-0.02298
23.3862	-0.10213
32.63817	-0.1929

CORELLATION MATRIX VALUES OF LST AND NDVI FOR 2000

LST	1	
NDVI	-0.85483	1

FOR THE YEAR 2020

Table 4.5

LST 2020	NDVI 2020
27.0	0.399735
29.0	0.215636
30.5	0.163036
31.6	0.11745
36.2	0.073617

CORELLATION MATRIX VALUES OF LST AND NDVI FOR 2020

	LST	*NDVI*
LST	1	
NDVI	-0.87351	1

The table show a strong negative correlation between the LST and NDVI for the entire study period. This entails that LST over the study period varies inversely with the NDVI. The higher the value for the LST, the lesser the value the NDVI. For a better understanding on the kind relationship that exist between the land surface temperature and land NDVI of the study area. The correlation was obtained which showed a strong negative correlation which shows that areas where LST was very high witnessed a low vegetation. By placing LST map and land use land cover map side by side, the association was determined. From the result, it was seen that areas with highest value of LST were areas inhabited by human indicating more of anthropogenic activities whereas areas with low temperature intensity were seen to be region having water bodies and more of vegetation.

5. Conclusion and Recommendation

5.1 Conclusion

It is important to understand the effects of human activities on the land surface temperatures and changes in regional climate of the study area, which has experienced rapid urbanization in last decades, this research provides an ideal test bed. Population rise has become a major challenge in Obio/Akpor looking at the result of the land use land cover map of the study area. In this vein, there is noticeable mass removal of vegetation and other biophysical components of the natural environment that have exposed the land surface of Obio/Akpor and its environs. As a result, land surface temperature has increased thereby leading to concentration of urban heat in some segments of the City. Rise in LST will result to heat waves, loss of urban comfort, increased energy consumption, rise in pollution reaction, loss of water quality etc. Therefore, the use of remotely sensed data became a vital approach in the study. In the last 20 years, land surface temperature in Obio/Akpor metropolis and environs has increased from 32.6°C to 36.2°C with a variation of 3.6°C and population of 263,017 in 1991 census, 462,350 in 2006 census and finally with a projection of 649,600 populations in 2016.Thus, LST and population from 2000 to 2020 has remained dynamic. In recent time, southern segment of the city has recorded the highest LST of 36.2°C indicating area with increased concentration of urban fabrics and is susceptible to heat disaster such as heat cramp and stroke. This was seen from the land use land cover analysis indicating that southern part has more of inhabitants there by constituting more of anthropogenic activities. From the correlation carried out, it was observed that the relationship between LST and NDVI varies inversely with each other. The shared a very strong negative correlation.

5.2 Recommendation

Variation in land surface temperature as discovered from the investigation carried out in the study area over the study periods suggest that urban growth is a major factor responsible for the transformation in the study area. Considering this, development experts should implement tree planting and land management practice that will ameliorate the effect of LST and heat disaster in Obio/Akpor LGA of river state. City planning, location of the city in the region, its layout and orientation, street network, density of built up areas and types of building to be erected should be properly planned. More and higher resolution data should be made available to researchers for more accurate result and more attention should be given in order to ameliorate growing impervious surfaces, water pollution and other harmful human activities.

References

[1]. (Bian, T et al) Ren, G. & Yue, Y. Effect of Urbanization on Land-Surface Temperature at an Urban Climate Station in North China. Boundary-Layer Meteorol 165, 553–567 (2017). https://doi.org/10.1007/s10546-017-0282-x

[2]. Bowen, A., Cochrane, S and Fankhauser, S. (2012). Climate change, adaptation and growth. Climate Change, 113 (2): 95-106

[3]. Costello, A., Abbas, M., Allen, A., Ball, S., Bell, S., Bellamy, R., ...and Lee, M. (2009). Managing the health effects of climate change: lancet and University College London Institute for Global Health Commission. The Lancet, 373 (9676): 1693-1733

[4]. Downing, Thomas E. et al. (2005), "The Social Costs of Carbon: A Closer Look at Uncertainty", SEI, Final Project Report for the UK Department for Environment, Food and Rural Affairs.

[5]. Fankhauser, S. (2006), "The Economics of Adaptation", EBRD Working Paper.

[6]. Fujibe, F. (2009), Detection of urban warming in recent temperature trends in Japan, Int. J. Climatol., **29**(12), 1811– 1822.

[7]. Goudie, A. (1999). The human impact on the natural environment. MIT press, Cambridge, Massachusetts.

[8]. Grimmond, S. (2007), Urbanization and global environmental change: Local effects of urban warming, Geogr. J., **173**(1), 83– 88.

[9]. Hémon D. and E. Jougla, 2003: Estimation de la surmortalité et principales caractéristiques épidémiologiques (Evaluation of comparatively high death rate and epidemiologic main features). Technical report, INSERM. http://www.sante.gouv.fr/htm/actu/surmort_canicule/rapport_complet.pdf Accessed 8 May 2012.

[10]. Huang, L., J. Li, D. Zhao and J. Zhu, 2008: A fieldwork study on the diurnal changes of urban microclimate in four types of ground cover and urban heat island of Nanjing, China. Building and Environment 43: 7-17.

[11]. Huang, L., J. Li, D. Zhao and J. Zhu, 2008: A fieldwork study on the diurnal changes of urban microclimate in four types of ground cover and urban heat island of Nanjing, China. Building and Environment 43: 7-17.

[12]. International Panel on Climate Change. (2014). Climate Change 2014Synthesis Report Summary for Policymakers.

[13]. IPCC (International Panel on Climate Change) (2007), 4 th Assessment (WG1): The Physical Science Basis, UNEP, Geneva.

[14]. IPCC (International Panel on Climate Change) (2007), 4 th Assessment (WG2): Impacts, Adaptation and Vulnerability, UNEP, Geneva.

[15]. IPCC (International Panel on Climate Change) (2007), 4 th Assessment (WG3): Mitigation of Climate

Change UNEP, Geneva

[16]. Jin, M. (2004), Analysis of land skin temperature using AVHRR observations, Bull. Am. Meteorol. Soc., **85**(4), 587.

[17]. Jin, M., and R. E. Dickinson (2002), New observational evidence for global warming from satellite, Geophys. Res. Lett., **29**(10, 1400), doi:10.1029/2001GL013833

[18]. Jin, M., and R. E. Dickinson (2010), Land surface skin temperature climatology: Benefitting from the strengths of satellite observations, Environ. Res. Lett, **5**(4), 044004, doi:10.1088/1748-9326/5/4/044004

[19]. Jones, P. D., D. H. Lister, and Q. Li (2008), Urbanization effects in large- scale temperature records, with an emphasis on China, J. Geophys. Res., **113**, D16122, doi:10.1029/2008JD009916

[20]. Joshi, J. P. and B. Bhatt, 2012: Estimating temporal Land Surface Temperature using remote sensing: A study of VADODARA urban area, Gujarat. International Journal of Geology, Earth and Environmental Sciences ISSN: 2277-2081 (Online) Vol. 2 (1) May-August, 123-130.

[21]. Keller, K., G. Yohe and M. Schlesinger (2007)," Managing the Risks of Climate Thresholds: Uncertainties and Information Needs", An editorial essay, Climatic Change, in the press, published online, http://dx.doi.org/10.1007/s10584-006-9114-6.

[22]. Li, Q., W. Li, P. Si, G. Xiaorong, W. Dong, P. Jones, J. Huang, and L. Cao (2010), Assessment of surface air warming in northeast China, with emphasis on the impacts of urbanization, Theor. Appl. Climatol., **99**(3–4), 469– 478.

[23]. Lunetta, R. S., and Evidge C. D. (1998): Remote Sensing Change Detection. Michigan: An Arbor press, Chapter 7:12,5-16.

[24]. Meng, X., Cheng, J., and Liang, S. (2017). Estimating land surface temperature from feng yun-3c/mersi data using a new land surface emissivity scheme. Remote Sensing, 9 (12): 1247

[25]. Mirzaei, P.A and F. Haghighat, 2010: Approaches to study Urban Heat Island – Abilities and limitations. Building and Environment 45: 2192-2201.

[26]. Ngie, A., K. Abutaleb, F. Ahmed, A. Darwish and M. Ahmed, 2014: Assessment of Urban Heat Island using remotely sensed imagery: A Review. South African Geographical Journal,

[27]. Nichol, J., 2005: Remote sensing of urban heat islands by day and night. Photogrammetric Engineering and Remote Sensing 71(5): 613-621.

[28]. Nordhaus, W.D. (1991), To Slow or Not to Slow: The Economics of the Greenhouse Effect, Economic Journal 101 pp.920–937.

[29]. Parker, D. E. (2010), Urban heat island effects on estimates of observed climate change, Wiley Interdiscip. Rev. Climate Change, **1**(1), 123– 133

[30]. Peng, S., S. Piao, P. Ciais, P. Friedlingstein, C. Ottle, F.- M. Bréon, H. Nan, L. Zhou, and R. B. Myneni (2012), Surface urban heat island across 419 global big cities, Environ. Sci. Technol., **46**(2), 696– 703.

[31]. Peterson, T. C. (2003), Assessment of urban versus rural in situ surface temperatures in the contiguous United States: No difference found, J. Clim., **16**(18), 2941– 2959.

[32]. Prata, A. J., Caselles, V., Coll, C., Sobrino, J. A., & Ottlé, C. (1995). Thermal remote sensing of land surface temperature from satellites: Current status and future prospects. Remote Sensing Reviews, 12(3-4), 175- 224. doi: 10.1080/02757259509532285

[33]. Ren, G. Y., Y. Zhou, Z. Chu, J. Zhou, A. Zhang, J. Guo, and X. Liu (2008), Urbanization effects on observed surface air temperature trends in north China, J. Clim., **21**(6), 1333– 1348.

[34]. Schneider, S. and J. Lane (2004), "Abrupt Non-Linear Climate Change, Irreversibility and Surprise", Global Environmental Change 14 (2004) 245–258.

[35]. Sobrino, J. A., J. C. Jiménez-Muñoz, J. El-Kharraz, M. Gómez, M. Romaguera, and G. Sòria. 2004. "Single-Channel and Two-Channel Methods for Land Surface Temperature Retrieval from DAIS Data and Its Application to the Barrax Site." International Journal of Remote Sensing 25 (1): 215–230. doi:10.1080/0143116031000115210

[36]. Stocker, T. F., et al. (2013), Climate change 2013: The physical science basis, in Intergovernmental Panel on Climate Change, Working Group I Contribution to the IPCC Fifth Assessment Report (AR5), 1535 pp., Cambridge Univ. Press, New York.

[37]. Streutker, D.R., (2002): A remote sensing study of the urban heat island of Houston, Texas. International Journal of Remote Sensing,23,2593-2608.33.

[38]. Streutker, D.R., 2003: Satellite-measured growth of the urban heat island of Houston, Texas. Remote Sensing of Environment 85: 282-289.

[39]. Tol, R.S.J. (2002a), "New Estimates of the Damage Costs of Climate Change, Part I: Benchmark Estimates", Environmental and Resource Economics, 21 (1), 47-73.

[40]. UNEP. (1996). 0ur land our future. FAO/AGLS.Rome. 48.

[41]. Van Leeuwen, T. T., Frank, A. J., Jin, Y., Smyth, P., Goulden, M. L., van der Werf, G. R., & Randerson, J. T. (2011). Optimal use of land surface temperature data to detect changes in tropical forest cover. Journal of Geophysical Research: Bio geosciences, 116(G2), n/an/a. doi: 10.1029/2010JG001488

[42]. Voogt, J. A., and Oke, T. R. (2003). Thermal remote sensing of urban climates. Remote sensing of environment, 86 (3): 370 - 384.35.

[43]. Voogt, J.A. and T.R. Oke, 2003: Thermal remote sensing of urban climates. Remote Sensing of Environment 86: 370-84.

[44]. Weng, Q. (2001). A remote sensing? GIS evaluation of urban expansion and its impact on surface temperature in the Zhujiang Delta, China. International journal of remote sensing, 22 (10), 1999 -2014.

[45]. Weng, Q. 2009. "Thermal Infrared Remote Sensing for Urban Climate and Environmental Studies: Methods, Applications, and Trends." ISPRS Journal of Photogrammetry and Remote Sensing 64 (4): 335–344. doi: 10.1016/j.isprsjprs.2009.03.007.

[46]. Wong, N. H. and C. Yu, 2005. Study of green areas and urban heat island in a tropical city. Habitat International 29: 547-558.

[47]. Wong, N. H. and C. Yu, 2005. Study of green areas and urban heat island in a tropical city. Habitat International 29: 547-558.

[48]. Wu, K., and X. Yang (2013), Urbanization and heterogeneous surface warming in eastern China, Chinese Sci. Bull., **58**(12), 1363– 1373.

[49]. Yan, Z., Z. Li, Q. Li, and P. Jones (2010), Effects of site change and urbanisation in the Beijing temperature series 1977–2006, Int. J. Climatol., **30**(8), 1226– 1234.

[50]. Yang, X., Y. Hou, and B. Chen (2011), Observed surface warming induced by urbanization in east China, J. Geophys. Res., **116**, D14113, doi:10.1029/2010JD015452

[51]. Zhang, Y., 2006: Land surface temperature retrieval from CBERS-02 IRMSS thermal infrared data and its applications in quantitative analysis of urban heat island effect. Journal of Remote Sensing 10:789-797.

[52]. Zhang, Z., Ji, M., Shu, J., Deng, Z., and Wu, Y. (2008). Surface urban heat island in Shanghai, China: Examining the relationship between land surface temperature and impervious surface fractions derived from Landsat ETM+ imagery. International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives, 37: 601 - 606.