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TEMPORAL APPRAISAL OF LAND SURFACE TEMPERATURE DYNAMICS ACROSS THE NINE STATES OF NIGER DELTA REGION OF NIGERIA FROM 2004-2016 USING REMOTE SENSING DATASET OF MODIS

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Abstract

The Niger delta region of Nigeria has undergone severe alterations since the pre oil boom era of 1975 due to several activities of oil exploration and exploitation in the region. Anthropogenic activities such as gas flaring, oil pipeline vandalism and Land cover alteration is believed to cause changes to land surface temperature. This research therefore seeks to accesses the temporal dynamics of Land Surface Temperature(LST) of the Niger Delta Region of Nigeria from historical remote sensing dataset of Moderate Resolution Imaging Spectroradiometer (MODIS) from 2000-2016.

Keywords: Land Surface Temperature; MODIS; Niger Delta Region.

1.0 INTRODUCTION

Since the 1970s, satellite-derived (such as Landsat Thematic Mapper-TM) surface temperature data have been utilized for regional climate analyses on different scale (Carlson et al., 1977; Gallo et al., 1999; Gallo et al., 2002). As climatic data, such as precipitation and air temperature, collected by weather stations have poor spatial resolution, satellite remotely sensed data offer considerable advantages and should be an integral part of monitoring climate change, especially for detecting and retrieving land surface temperature (LST). According to Orhan et al., (2014), LST is a good indicator of the energy balance at the Earth's surface because it is one of the key parameters in the physics of land-surface processes on regional and global scales. LST is also one of the most important environmental parameters used in determining the exchange of energy and matter between the surface of the earth and the lower layer of the atmosphere. Orhan et al., (2014) further opined that continuous monitoring of this parameter is likely to yield information about the suspected climate change. The specific aim of this research was to examine the temporal dynamics of Land Surface

Temperature(LST) across the Niger Delta Region of Nigeria from historical remote sensing dataset of Moderate Resolution Imaging Spectroradiometer (MODIS) from 2000-2016 using GIS techniques.

The Moderate Resolution Imaging Spectroradiometer (MODIS) is a key instrument onboard the Earth Observing System (EOS) Terra satellite, successfully launched in December 1999. It was funded by U.S. National Aeronautics and Space Administration (NASA). The NASA's 36-band Moderate Resolution Imaging Spectroradiometer (MODIS) sensor has superseded AVHRR for many applications, including LST mapping, NDVI calculations for vegetation mapping etc. Table 1 shows the MODIS spectral bands characteristics.

Table 1: The MODIS spectral channels

band	wavelength	band	wavelength	pixel
1	620 - 670	2	841 - 876	250 m
3	450 - 470	4	545 - 565	500 m
5	1230 - 1250	6	1628 - 1652	
7	2105 - 2155			
8	405 - 420	9	438 - 448	1000 m
10	483 - 493	11	526 - 536	
12	546 - 556	13	662 - 672	
14	673 - 683	15	743 - 753	
16	862 - 877	17	890 - 920	
18	931 - 941	19	915 - 965	
20	3660 - 3840	21	3929 - 3989	
22	3929 - 3989	23	4020 - 4080	
24	4433 - 4498	25	4482 - 4549	
26	1360 - 1390	27	6535 - 6895	
28	7175 - 7475	29	8400 - 8700	
30	9580 - 9880	31	10780 - 11280	
32	11770 - 12270	33	13185 - 13485	
34	13485 - 13785	35	13735 - 14085	
36	14085 - 14385			

2.0 MATERIAL AND METHODS

2.1 Study Area

The Niger Delta Region (shown in Figure 1) lies in the southern part of Nigeria where the River Niger divides into numerous tributaries ending at the edge of the Atlantic Ocean. It is bordered to the south by the Atlantic Ocean and to the east by Cameroon. It lies between longitude 4º 30' - 9º 50'E and Latitude 4º 10' - 8º 0'N. The temperature in the region is between 24°C to 32°C throughout the year, rainfall ranges from 3000- 4500mm. The region has two seasons: dry season (starting around

December- February) and the rainy season (starting around July- September) (Nwilo & Badejo, 2006). The region covers nine southern states namely: Cross River, Akwa Ibom, Abia, Imo, River, Bayelsa, Delta, Edo and Ondo state with more than 40 ethnic groups and has about 250 different dialects (NDRDMP, 2004). The region is the sole oil producing basin since the discovery of oil in commercial quantity in 1965. The region is asserted to be the main source of export earnings to Nigeria. Records has it that oil and gas earnings from the region funds 85% of the Nation's yearly budget; and contribute about 95% of Gross Domestic Product (GDP) (Dokubo 2004; NDRDMP, 2004; Ebegbulem et al., 2013; Ringim 2016). A United Nations' report indicates that there are more than 7,000kilometres of pipelines, 5,284 oil wells, 275 flow stations, 10 Gas plants, and 10 Export Terminals operated by more than 13 oil companies (UN Report, 2006).

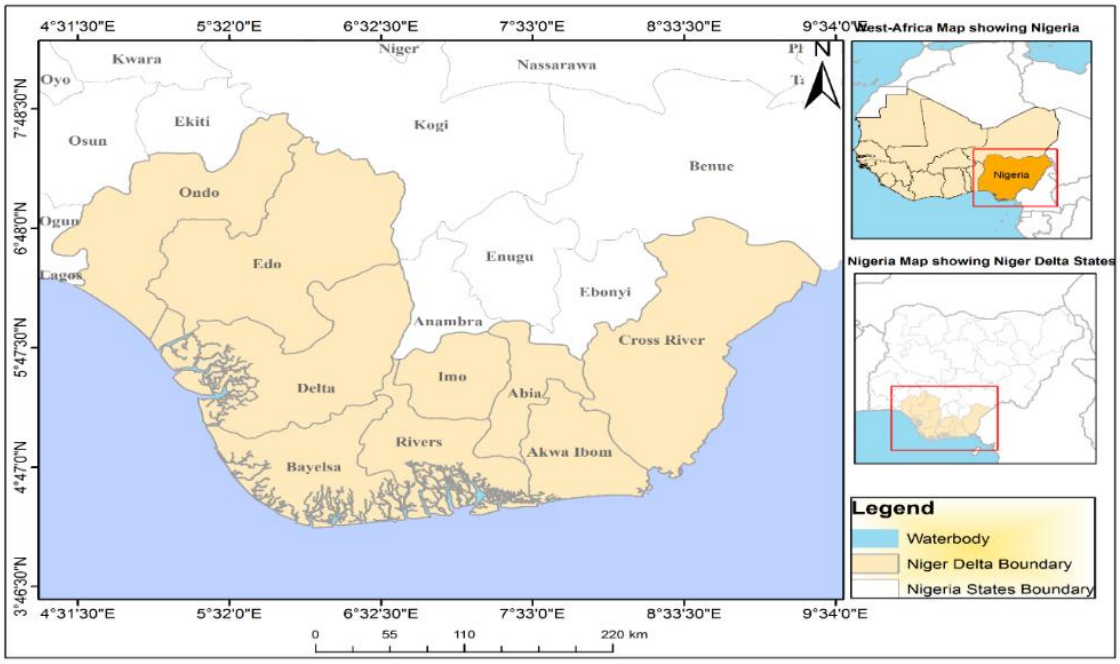

Figure 1: Study Area in relation to West Africa and Nigeria

2.2 Data Preparation and Methodology

The primary data used in this research were Remotely Sensed satellite imagery of MODIS. The MODIS Land Surface Temperature data with spatial resolution of 250 meters was downloaded from NASA Earth Observatory website. The area of interest that covers the study area was used for the temporal trend analysis of monthly and annual LST variation during the day and Night time across the study area using ArcGIS 10.2. The research methodology flow chart is shown in figure 2 below.

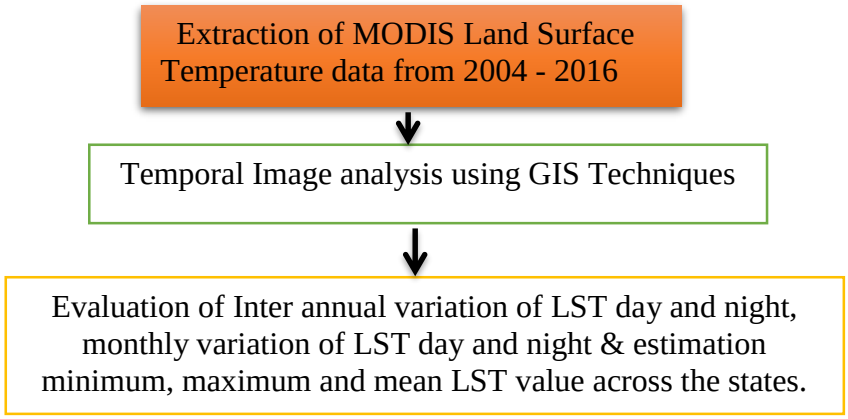

Figure 2: Research methodology flow chart

3.0 RESULT AND DISCUSSION

The results of the assessment of LST from MODIS Data from 2004 to 2016 across the study area were presented in terms of Inter annual variation of Land Surface Temperature (LST) day and night, monthly variation of LST day and night & estimation minimum, maximum and mean LST value across each states the of the study area.

3.1 Inter Annual Variation of LST Day and Night from MODIS Data.

Table 2 and figure 3 below shows the Inter-Annual Variation of day and Night Land Surface Temperature (LST) across the study area.

Table 2: Inter annual values of LST for Both Daytime and Nighttime

Year	LST Day (^{0}C)	LST Night (^{0}C)
2004	24.11	19.45
2005	23.46	19.70
2006	24.03	19.54
2007	23.87	19.72
2008	24.03	19.60
2009	24.59	19.50
2010	25.47	19.71
		Cont....

2011	24.95	19.44
2012	23.09	19.91
2013	24.02	19.72
2014	23.78	20.11
2015	24.26	19.40
2016	23.99	19.50

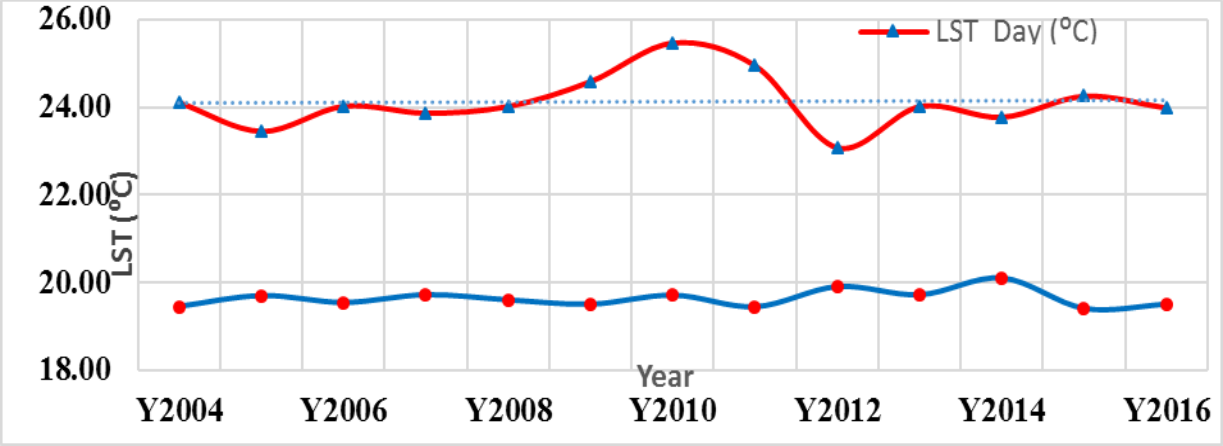

Figure 3: Map showing the Inter-Annual Variation of LST day and Night across the study area

The Result of Inter-annual pattern of LST during the Night and day period indicated a higher value of LST during the day as compared to the Night while the highest value of LST variation was about 25.47 ^{0}C in the year 2010 and the lowest was 23.03 ^{0}C Which occurred in the year 2012. Also there appear to be a steady variation in Night LST value.

3.2 Monthly variation of LST Day and Night from MODIS Data.

From the monthly values of Land Surface Temperature (LST) for both Daytime and Nighttime across the Study Area shown in table 3 below, the month of February had the highest LST values for both day and night while August was the lowest.

Table 3: Monthly values of LST for both Daytime and Nighttime across the Study Area

Months	LST Day(^{0}C)	LST Night(^{0}C)
Jan	25.37	19.59
Feb	25.98	20.61
Mar	24.89	20.31
Apr	25.25	20.21
May	24.17	19.91
Jun	22.72	18.61
Jul	22.28	18.34
Aug	21.82	18.15
Sep	22.47	18.70
Oct	23.32	19.92
Nov	25.18	20.61
Dec	25.73	20.37

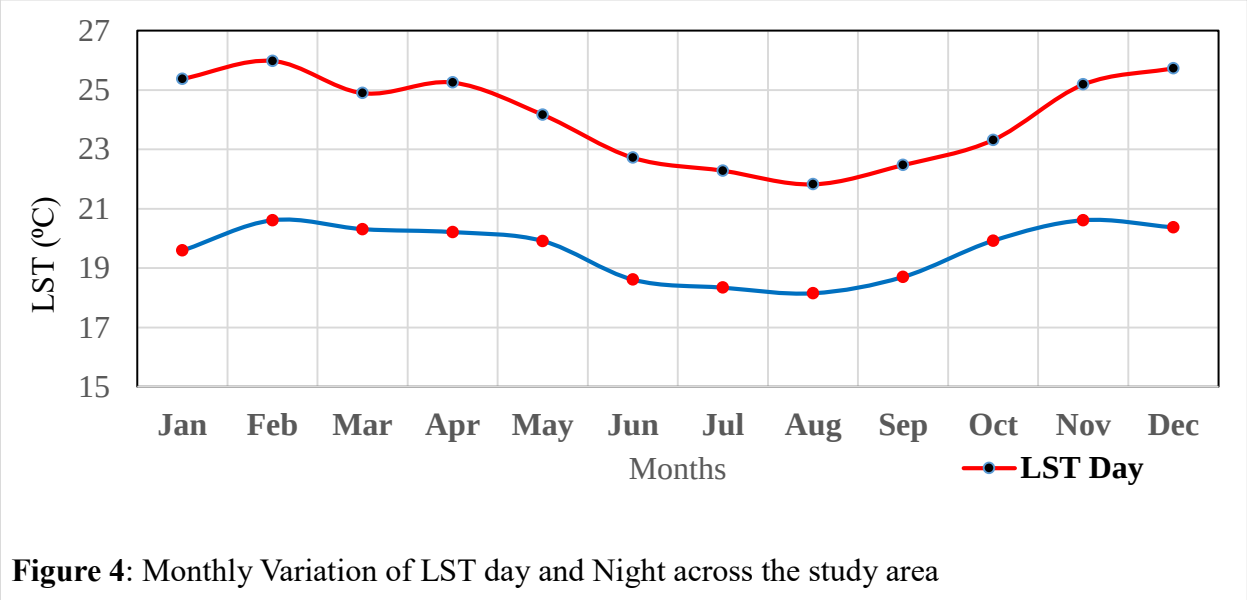

Figure 4: Monthly Variation of LST day and Night across the study area

The Result of monthly variation of LST during the Night and day period indicated that Day and Night LST showed similar pattern of variation with LST value at its peak during the Dec., Jan. and Feb., period while having a low value in the month of August.

3.3 Maximum, Minimum, and Mean LST Values Across Each states of the Study area

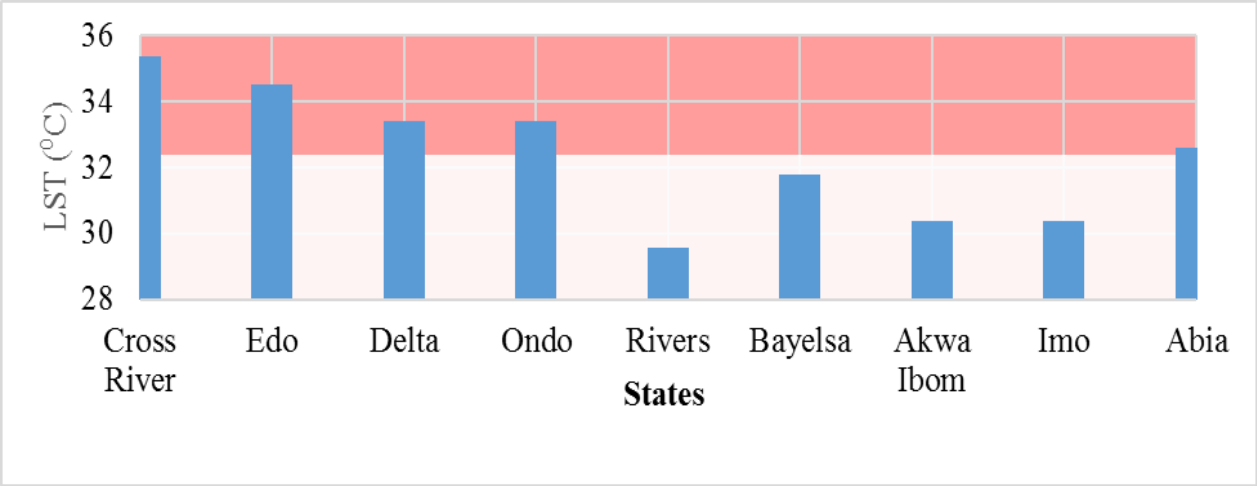

Figure 5: Chart Showing the values of maximum LST value across the states

The Result showed that Cross river states had the highest value of Max. LST of 35.3 ^{0}C while the lowest value of LST is Rivers State with a LST value of 29.5 ^{0}C. Proximity to the coast is considered as the major factor why Rivers state has a low Max LST value while the presence of exposed hills and mountains and large expanse of exposed surfaces in northern part of Cross Rivers State as a major factor for high LST value in Cross Rivers State.

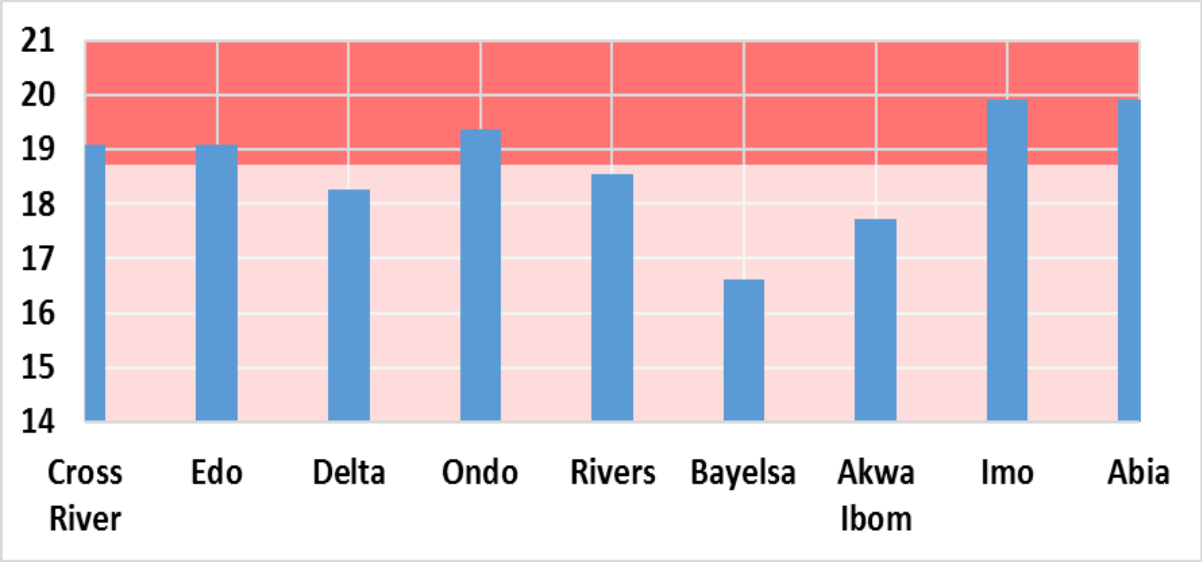

Figure 6: Chart Showing the values of minimum LST value across the states.

Imo and Abia states have the highest LST minimum value while Bayelsa state has the lowest with a value of 16.6 ^{0}C. because of many water bodies and mangrove cover. Akwa Ibom, Delta and Rivers follow suit as a result of near similar conditions.

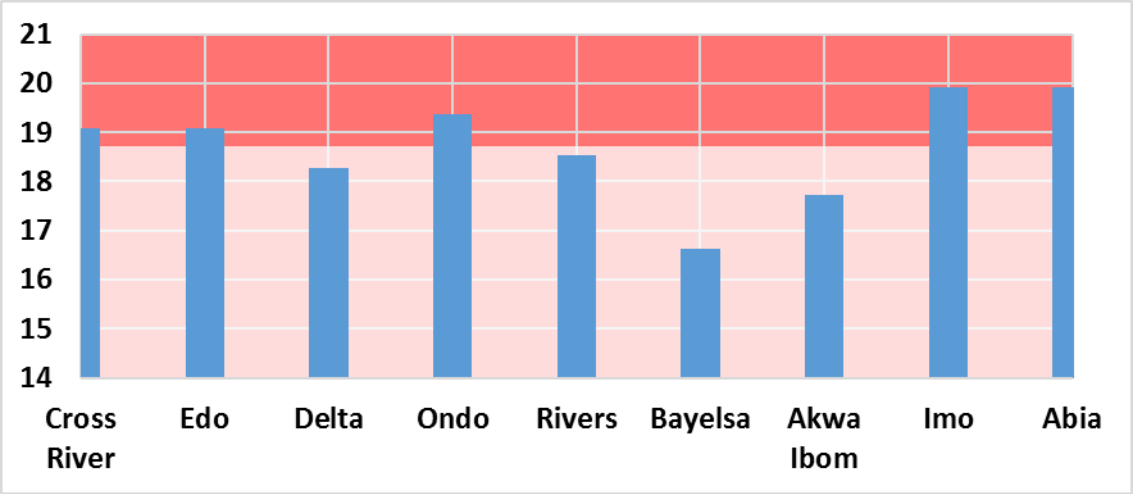

Figure 7: Chart Showing the values of mean LST value across the states.

The Result showed that six states (Cross River, Edo, Ondo, Akwa Ibom, Imo and Abia) have exceeded the mean LST value (24.5^{0}C) with the highest LST value 25.2 ^{0}C while the remaining states have values below the threshold.

Table 4: Mean, Maximum and Minimum, LST value across the states of Niger Delta

States	Mean(^{0}C)	Max(^{0}C)	Min(^{0}C)
Cross River	24.60	35.35	19.09
Edo	25.07	34.53	19.09
Delta	24.13	33.43	18.27
Ondo	24.75	33.43	19.37
Rivers	23.56	29.57	18.54
Bayelsa	23.33	31.77	16.61
Akwa Ibom	25.09	30.39	17.72
Imo	25.22	30.39	19.92
Abia	25.22	32.60	19.92

CONCLUSION

This research has successfully explored the use of satellite remote sensing and GIS techniques in appraising Land surface temperature dynamics of the Niger delta region of Nigeria. The Result of Inter-annual pattern of LST during the Night and day period indicated a higher value of LST during the day as compared to the Night. While the highest value of LST variation was about 25.47 ^{0}C in the year 2010 and the lowest was 23.03 ^{0}C Which occurred in the year 2012. Moreover, there appear to be a steady variation in Night LST values. Also, the result of monthly variation of LST during the Night and day period indicated that Day and Night LST showed similar pattern of variation with LST value at its peak during the December, January and February while having a lower value in the month of August. Furthermore, the result showed that Cross river states had the highest value of LST of 35.3 ^{0}C while the lowest value of Maximum LST was Rivers State with a LST value of 29.5 ^{0}C. Imo and Abia states had the highest minimum LST value while Bayelsa state had the lowest with a value of 16.6 ^{0}C due to the present of many water bodies and large expanse of mangrove cover. Akwa Ibom, Delta and Rivers states followed correspondingly as a result of near similar environmental conditions.

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