International Journal of Agriculture and Environmental Research

ISSN: 2455-6939

Volume:03, Issue:03 "May-June 2017"

SPATIO-TEMPORAL TREND OF VEGETATION COVER OVER ABUJA USING LANDSAT DATASETS

[1]Adeyeri O. E., [2]Okogbue Emmanuel C., [3]Akinluyi F. O., and [2]Ishola K. A.

[1]Universite D'Abomey-Calavi, Cotonou, Republique du Benin

[2]Department of Meteorology and Climate Science, Federal University of Technology, PMB 704, Akure, Nigeria.

[3]Department of Remote sensing and Geoinformatics, Federal University of Technology, PMB 704, Akure, Nigeria.

ABSTRACT

Vegetation cover has acted as a source of carbon sinks and air purifier for a long period of time especially in developed cities thereby affecting the global climate change. The study was conducted to spatially estimate the Normalized Difference Vegetative Index (NDVI) which is a vegetation indicator for a period of 28 epoch years for Abuja from 1987 to 2014. The positive signatures of NDVI decrease from 2009 to 2014. Statistical analysis of the observed data samples at 95% confidence interval revealed that the changes observed in Year 2009 contributed most to the changes that was occurred in Year 2014.The modeled NDVI values for the year 2014 based on the regression analysis of the previous three years shows a significant agreement between the simulated values for year 2014 and the observed values. In general, there has been fast transformation of the vegetation cover to other land uses. The study reveals vegetation cover had reduced more significantly. It is also worthy to know that the model generated in this research can be used to predict future changes and trends in the vegetation cover. This will provide policy makers with useful information for the proper planning and design of the city and other capital cities over West Africa.

Keywords: NDVI; Regression Model; Landsat; Vegetation; GIS, Landsat

1. INTRODUCTION

The impacts of climate change and anthropogenic activities such as transformation of vegetation to other built up area and overgrazing have led to the degradation of vast vegetal covers (Gang et al 2014). Studies such as Vitousek 1992 and Clevers et al., 2004 showed that land use and land cover (LULC) is a key driver to global climate change. Vegetation degradation from overgrazing and rapid transformations among landuse classes are common in developing countries, in which resident inhabitants suffer from the repercussions of vegetation degradation like socioeconomic

ISSN: 2455-6939

Volume:03, Issue:03 "May-June 2017"

adversity and increased natural catastrophes (Liu and Diamond 2005). Most capital cities of the world had witnessed a major modification in their land covers due to various developmental activities which had led to the growth and expansion of such cities. In Nigeria, numerous studies have shown that there has been tremendous changes in LULC (Fagbeja, 2000; Fashona and Omojona, 2005), particularly in urban areas (Adeniyi and Omojola 1999; Omojola 2004; Ojiji 2006). Several urban areas have expanded mostly on agricultural land in recent decades. Increasing population pressure and land use acts are threats to the present day environment (Vernon, 2002). Abuja, the Federal Capital Territory of Nigeria, is not exempted from this observed LULC changes especially in terms of vegetation degradation. It has witnessed various transformations since its inception in 1979 and this has led to significant alteration and adjustment in the condition and position of the land cover over time particularly in the area of the transformation of green surfaces to other land use categories. There are various attempts to measuring the extent of vegetation degradation in developing countries. For example, in China, about 90% of vegetal covers are being degraded as a result of overgrazing and some other factors (Liu and Diamond 2005). Adeyeri et al. (2017), Akiyama and Kawamura (2007) proposed monitoring vegetal cover using remote sensing (RS) is a capable tool for monitoring, restoring and managing degraded vegetal covers. RS has also been proven to monitor arid and semiarid grassland cover which is essential in determining livestock capacity in order to prevent desertification (Purevdorj et al 1998). The observation of vegetation cover at both high temporal and spatial makes RS approaches beneficial for monitoring purposes.

The Normalized Difference Vegetative Index (NDVI) is a RS-based equation aiming at finding the difference between Near Infrared and visible band of the satellite image. It quantitates the amount of live green vegetation in a particular area. The principle holds that healthy vegetation absorbs the visible light targeted at it and reflects at the Near Infrared region of the electromagnetic spectrum while bare surfaces moderately reflects both at the visible and infrared region of the electromagnetic spectrum. The unhealthy vegetation reflects less of the near infrared radiation.

Therefore, attempt will be made in this paper to map out the status of the vegetation of Abuja between 1987 and 2014 using both Geographic Information System and Remote Sensing data.

2. STUDY AREA

Abuja is located in the center of the country in the Guinea savanna of the middle belt between latitude 8° 25" and 9° 25" North of the Equator and longitude 6° 45" and 7° 45" East of the Greenwich and occupies an area of about 8,000 square kilometers. The annual rainfall is about 1,631.7 mm (Adekaye 2000). The annual mean temperature ranges between 25.8^{o}c and 30.2°C (Balogun 2001). Abuja officially became the capital city of Nigeria in 1991 after its

ISSN: 2455-6939

Volume:03, Issue:03 "May-June 2017"

construction in 1980. In 2006 census, the population of Abuja was 776,298 people (PLAC, 2006), making it one of the heavily populated cities in Nigeria. Between 2000 and 2010, its growth rate was estimated to be 139.7%, making it one of the fastest emerging cities in the world (Euromonitor, 2010). In 2015, the annual growth was at least 35%, making it the fastest-growing city in Africa (Abuja Facts, 2015). In 2016, the cosmopolitan area of Abuja was estimated as having a population of 6 million people (Jaiyeola and Andrews, 2016). The Köppen climate classification for Abuja features a tropical wet and dry climate (Adeyeri, 2017). The city of Abuja was chosen as the target area for this study so as to fully understand and document the trend of various transformations that had taken place in the city since it became the capital city of Nigeria particularly in the area of vegetation cover.

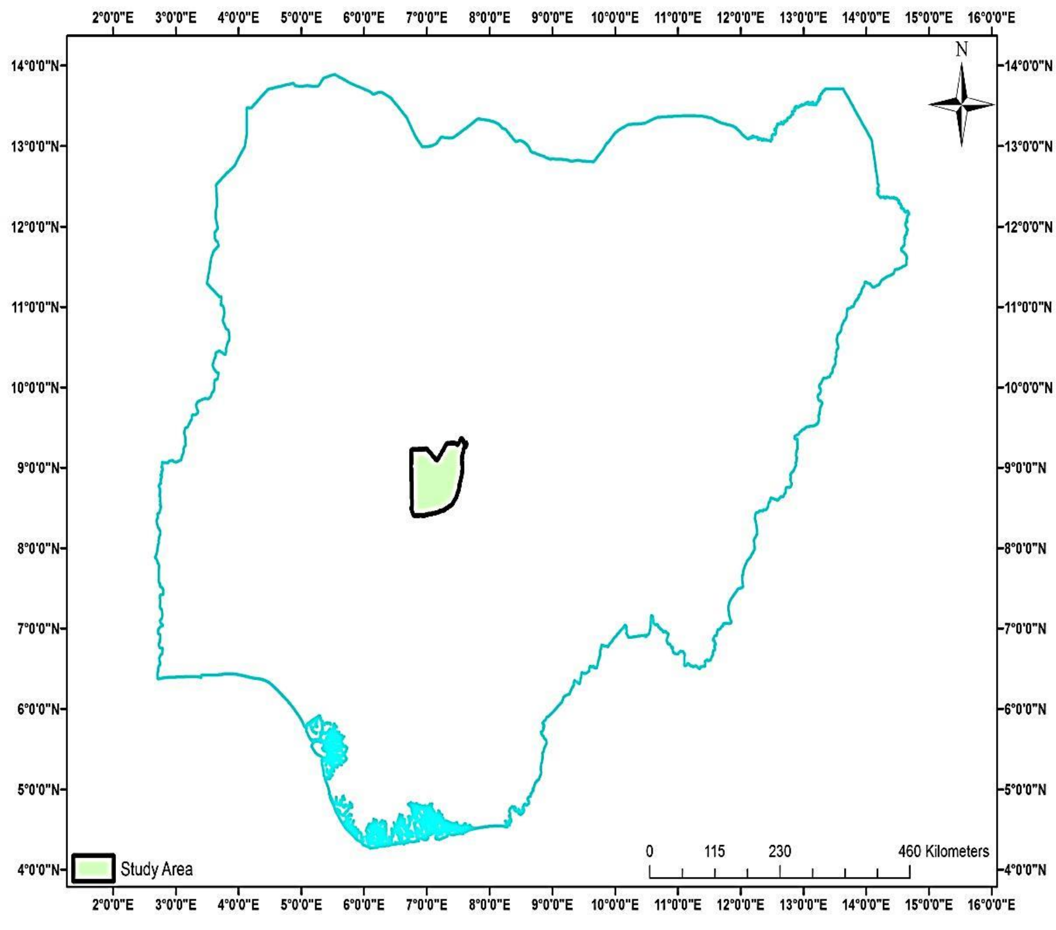

Figure 1: Map of Nigeria showing Abuja the study area

ISSN: 2455-6939

Volume:03, Issue:03 "May-June 2017"

3. DATA AND METHODOLOGY

A. Data

The bands required for the calculation of the NDVI are the red and the near infra-red (NIR) bands. These were gotten from the Landsat 5 TM, Landsat 7 ETM$^+$ and Landsat 8 OLI/TIRS sensors. The Landsat satellites follow a repetitive, circular and sun-synchronous, near earth orbit (Adeyeri, 2016).

TABLE 1. LANDSAT 7 TM/ETM$^+$ AND LANDSAT 8 OLI/TIRS BAND SPECIFICATIONS

SENSOR	**TM/ETM$^+$**		**OLI/TIRS**	
BAND	**Red**	**NIR**	**Red**	**NIR**
Spectral Resolution (µm)	0.63-0.69	0.78-0.90	0.64-0.67	0.85-0.88
Spatial Resolution (m*m)	30*30	30*30	30*30	30*30
Temporal Resolution (days)	16	16	16	16

Four years satellite images spanning through twenty seven epoch years were gotten from the United States Geological Survey (USGS). The study spans 1987 through 2014.

The specification details of the 4 images are described in Table 2.

TABLE 2. LANDSAT IMAGE PRE-PROCESSING

NO.	**YEAR**	**SENSOR**	**PRE-PROCESSING**
1	21-12-1987	Landsat 4 TM	Geo-rectification
2	28-01-1999	Landsat 5 TM	Geo-rectification
3	1-12-2009	Landsat 7 ETM+	Geo-rectification
4	5-1-2014	Landsat 8 OLI/TIRS	Geo-rectification

B. Image Pre-processing

1) Normalized Difference Vegetation Index (NDVI) Pre-processing

NDVI is the normalized difference vegetation index (Jensen 2000), which was calculated as follows:

ISSN: 2455-6939

Volume:03, Issue:03 "May-June 2017"

$$NDVI = \frac{\rho_{NIR} - \rho_{red}}{\rho_{NIR} + \rho_{red}} \qquad (1)$$

Where ρ_{NIR} is near-infrared reflectance and

ρ_{red} is the reflectance in the red region of the visible spectrum.

The NDVI indicates of the amount and condition of green vegetation. Values for NDVI range between -1 and +1.

2) Statistical Analysis

In an attempt to understand the trend of the vegetation cover and also derive the prediction for future trend, a detailed statistical analysis was carried out. The analysis of multiple regression is to observe the relationship between independent (y) or predictor variable and a dependent (x) or criterion variable (Lehmann 1998). The Pearson's product moment of correlation coefficient (r) was used in determining the relationship between different sample sites and this is given as

$$r = \frac{\frac{1}{n}\sum xy - \bar{x}\bar{y}}{s_x s_y} \qquad (2)$$

Where

$$s_x = \sqrt{\frac{1}{n}\sum x^2 - \bar{x}^2} \quad \text{and} \quad s_y = \sqrt{\frac{1}{n}\sum y^2 - \bar{y}^2}$$

The Mean Square Error (MSE), was also calculated by dividing the error sum of squares by its associated degrees of freedom *n*-2. Similarly, the **regression mean square (*MSR*) was gotten** by dividing the regression sum of squares by its degrees of freedom 1 [5]. This follows that the regression sum of squares (*SSR*) and the regression mean square (*MSR*) are identical for the regression model because their expected values suggest how to test the null hypothesis H_0: $\beta_1 = 0$ which says the changes in the vegetation cover in 2014 was directly affected by the changes which occurred in the years before against the alternative hypothesis H_A: $\beta_1 \neq 0$ which says the changes in the vegetation cover in 2014 was not directly affected by the changes which occurred in the years before, hence, the mean squares (MS) and sum of squares (SS) has to be computed. The degrees of freedom associated with *SSR* will always be 1 for the simple linear regression model and the degrees of freedom associated with the sum square error (*SSE*) is *n*-2 [5].

$$MSE = \frac{\sum(y_i - \hat{y}_i)(y_i - \hat{y}_i)}{n-2} = \frac{SSE}{n-2} \qquad (3)$$

$$MSR = \frac{\sum(\hat{y}_i - \bar{y})(\hat{y}_i - \bar{y})}{n-2} = \frac{SSR}{1} \qquad (4)$$

ISSN: 2455-6939

Volume:03, Issue:03 "May-June 2017"

The null hypothesis is H_0: $\beta_1 = 0$ and the alternative hypothesis is H_A: $\beta_1 \neq 0$.

The test statistic is

$$F^* = \frac{MSR}{MSE} \quad (5)$$

The P-value is determined by comparing F* to a F distribution with 1 numerator degree of freedom and n-2 denominator degrees of freedom [4]. The 95% confidence interval was used in this paper.

4. RESULTS AND DISCUSSION

1) Variations in Normalized Difference Vegetation Index (NDVI) data

To fully understand the spatio-temporal distribution of the amount of live green vegetation over Abuja, there is a need to map out the variation in the status of the vegetation cover observed.

Figures 2 to 4 show the spatial distribution of the NDVI in the city of Abuja, derived from Landsat TM, ETM+ and OLI/TIRS sensors for December 1987, 2009 and January 1999 and 2014.

ISSN: 2455-6939

Volume:03, Issue:03 "May-June 2017"

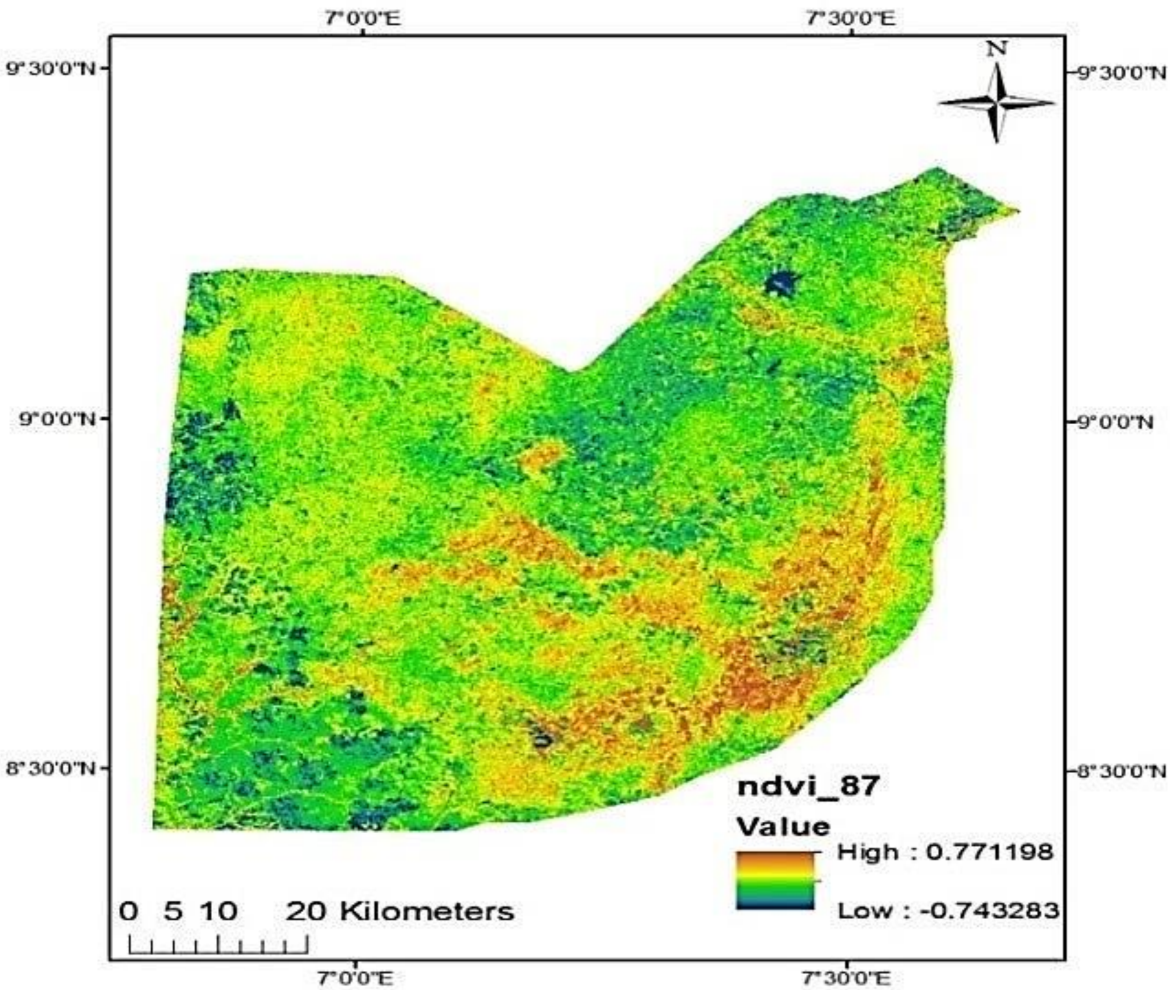

Figure 2: NDVI of 1987

ISSN: 2455-6939

Volume:03, Issue:03 "May-June 2017"

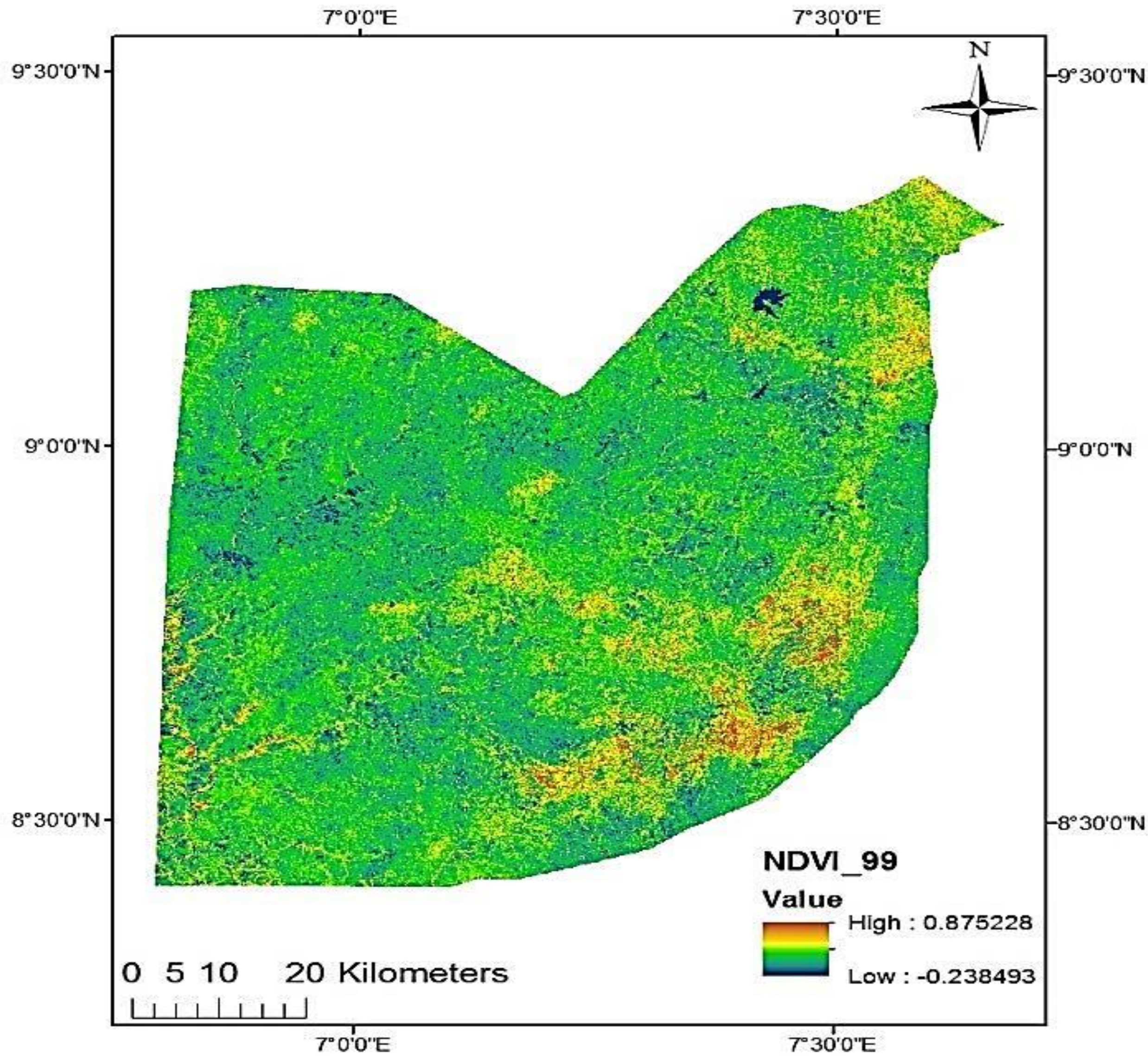

Figure 3: NDVI of 1999

Comparing figures 2 and 3, it was observed that the vegetation cover was more in 1987 than in 1999 but considering the ranges of the NDVI values for both years, it was observed that 1999 has a higher NDVI value which signifies that the vegetation was healthier in 1999 than 1987.

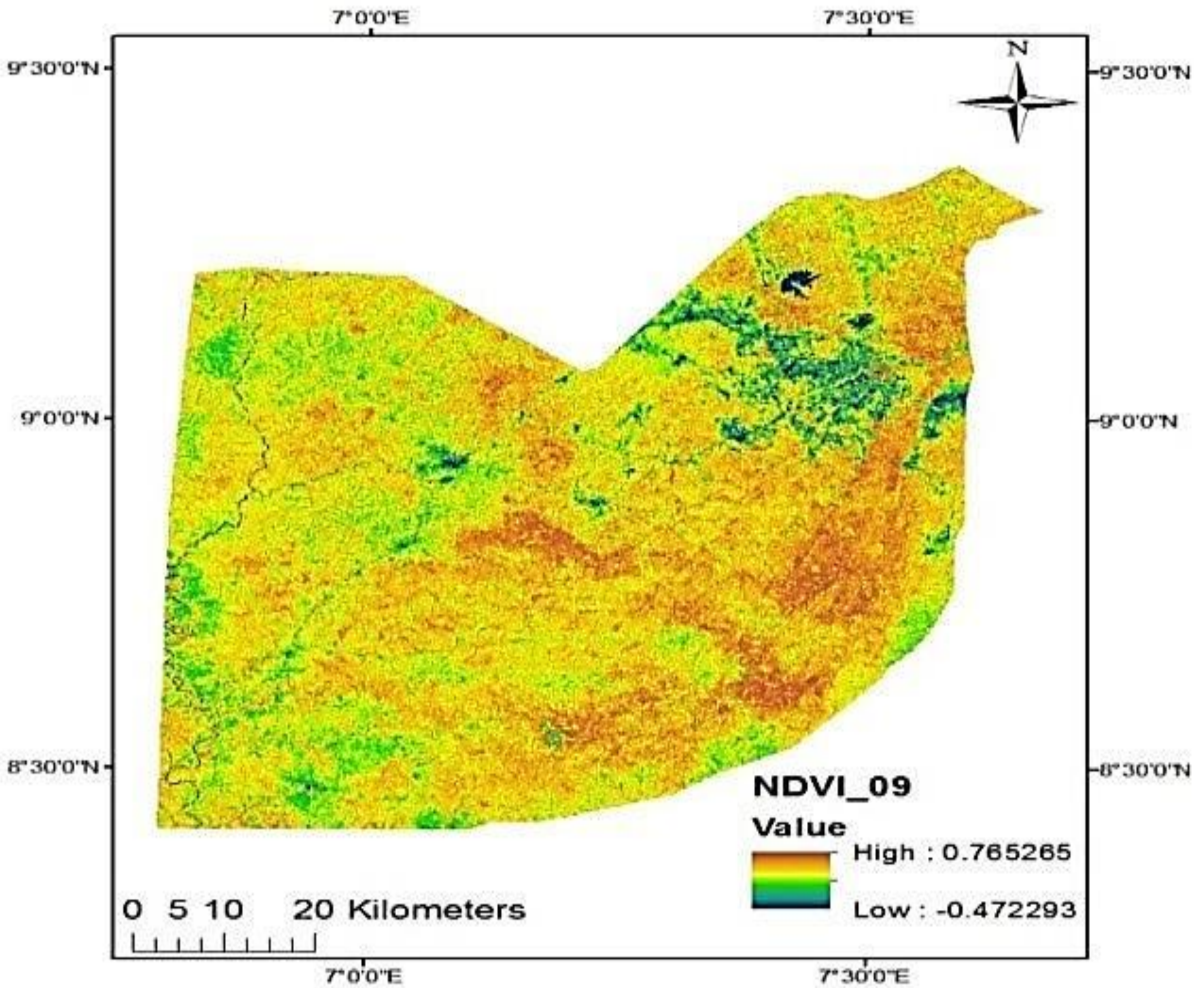

Figure 4: NDVI of 2009

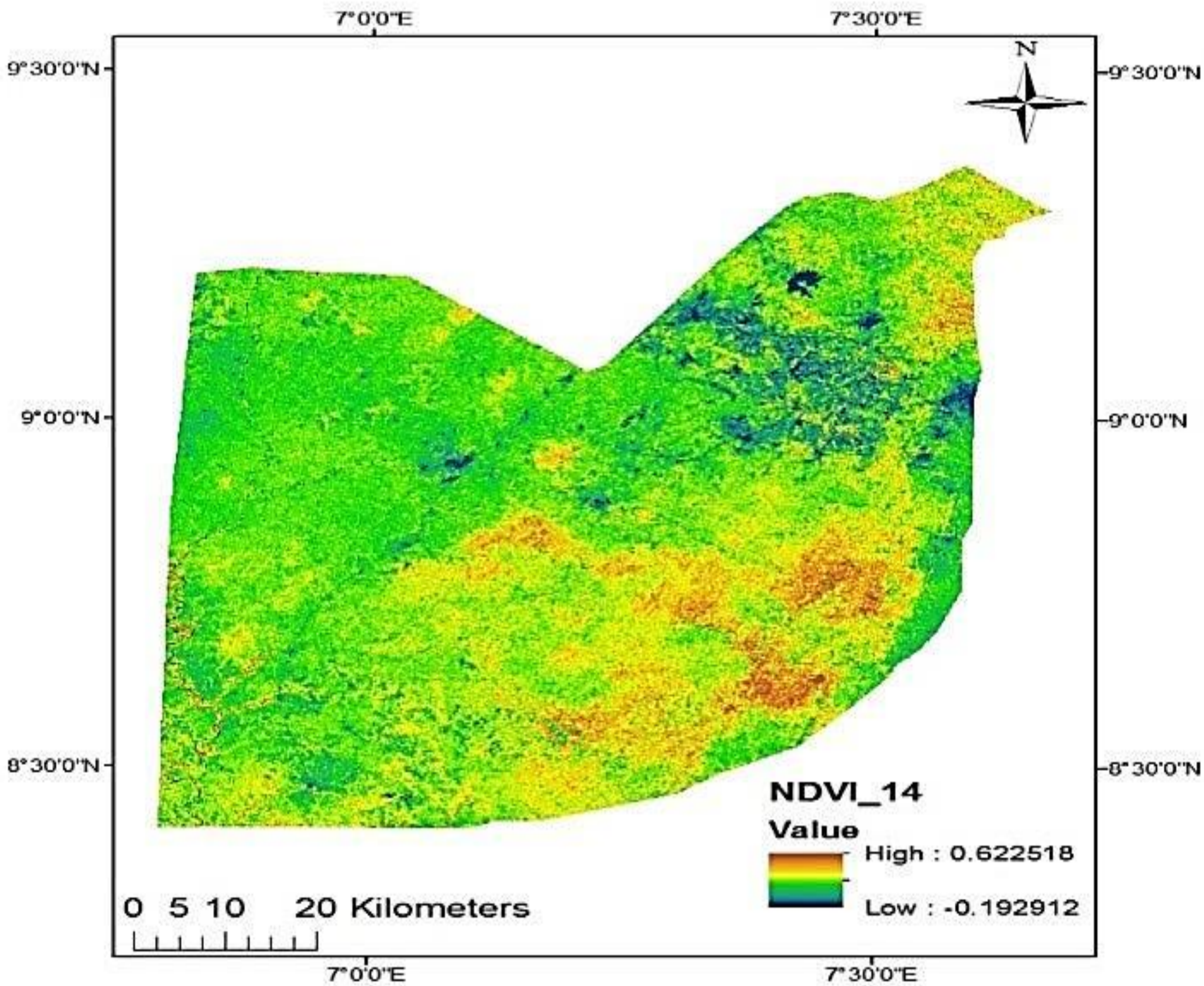

Figure 5: NDVI of 2014

NDVI image of 2014 (Figure 5) shows a reduction in vegetation cover from the NDVI image of 2009 (Figure 4). For the period of study, 2009 (Figure 3) has the highest vegetation cover while 1999 has the lowest vegetation cover.

Table 3 shows an increment of the mean NDVI values from 0.101 in 1987 to 0.254 in 2009 for the selected pixels except for the negative signatures which represent the water bodies. The selected pixels were in Universal Transverse Macerator (UTM) coordinate system. A comparison between year 2009 and 2014 shows that the positive signatures of NDVI decreased. It is worthy to note that 1999 has the lowest NDVI negative signature (- 0.042) and 2009 having the highest positive signature (0.6). The higher the values of positive NDVI signatures, the healthier the vegetation covers while the far negative NDVI signatures depict the water body. The negative skewness indicates that the distribution has an asymmetric tail extending towards more negative values while the negative kurtosis indicates a relatively flat distribution.

Table 3: Changes in NDVI values for selected pixels

		1987	**1999**	**2009**	**2014**
X (UTM)	**Y (UTM)**	**NDVI**	**NDVI**	**NDVI**	**NDVI**
283862.2403	972210.7391	0.349	0.408	0.532	0.351
300759.436	975282.9565	0.442	0.494	0.600	0.372
328189.9484	1017196.78	-0.198	-0.041	-0.324	-0.130
280131.6906	951144.1056	0.185	0.270	0.419	0.294
266087.2683	997007.9224	0.098	0.271	0.416	0.253
281228.9111	973966.2919	0.272	0.261	0.437	0.261
327531.6161	1017196.78	-0.086	0.214	0.261	0.187
327312.172	1017855.112	-0.257	-0.042	-0.312	-0.141
	Min	-0.257	-0.042	-0.324	-0.141
	Max	0.442	0.494	0.600	0.372
	Mean	0.101	0.229	0.254	0.181
	Standard Deviation	0.258	0.19	0.366	0.204
	Skewness	-0.201	-0.425	-1.147	-1.109
	Kurtosis	-1.519	-0.528	-0.386	-0.415
	Std.Err.Mean	0.091	0.067	0.129	0.072

2) Statistical Results

Statistical analysis done on the sample data helps in scrutinizing every data sample considered and the contributory order of the dependent variable. Table 4 presents the comparison between the satellite derived NDVI values in 2014 and the modeled values. It is clear that the observed values were very close to the modeled values, having small residuals. After carrying out the statistical analysis, the regression equation for the prediction of the modeled data for the Year 2014 is given as;

$$\textbf{Year 2014} = \mathbf{0.0290 - 0.0083\ Year\ 1987 + 0.105\ Year\ 1999 + 0.5075\ Year\ 2009} \quad (6)$$

ISSN: 2455-6939

Volume:03, Issue:03 "May-June 2017"

Table 4: Comparison of Satellite Derived NDVI and Predicted NDVI

	Year 2014 Satellite Derived NDVI	Year 2014 Model Predictions	Year 2014 Model Residuals
First sample	0.351	0.338748586	0.012251414
Second sample	0.372	0.381474938	-0.009474938
Third sample	-0.13	-0.13803136	0.00803136
Fourth sample	0.294	0.268340133	0.025659867
Fifth sample	0.253	0.267648421	-0.014648421
Sixth sample	0.261	0.275806807	-0.014806807
Seventh sample	0.187	0.184566645	0.002433355
Eight sample	-0.141	-0.131554169	-0.009445831

Table 5 shows the results of the statistical analysis of the observed data samples and at 95% confidence interval, it was seen that Year 2009 contributed most to the changes that observed in Year 2014, having the lowest P value of 0.003 while Year 1987 had the least significance on the changes observed with a P value of 0.926. The root mean square error (Root MSE) also shows that the lag between the sampled dataset and the modelled dataset is very insignificant. This shows that the model can be used to predict future changes and trends in the vegetation cover.

ISSN: 2455-6939

Volume:03, Issue:03 "May-June 2017"

Table 5: Model Summary

Number of observations	S	R squared	R squared adjusted	Probability > F	R squared predicted	Root MSE
8	0.0193117	99.49%	99.10%	0.0000	98.01%	0.01931
COEFFICIENTS						
Term	Coefficients	SE Coefficient	P value	Adjusted SS	Adjusted MS	
Year 1987	-0.0083	0.085	0.926	0.000004	0.000004	
Year 1999	0.105	0.176	0.584	0.000132	0.000132	
Year 2009	0.5075	0.0756	0.003	0.016795	0.016795	

Figure 6 shows a similar trend observed in the satellite derived (actual) and the modeled (predicted) NDVI values for Year 2014 for the eight sample sites. To justify the results of the P values for the different years, the correlation matrix between Year 2014 and Year 2009 (Table 6) also revealed the highest value of 0.997.

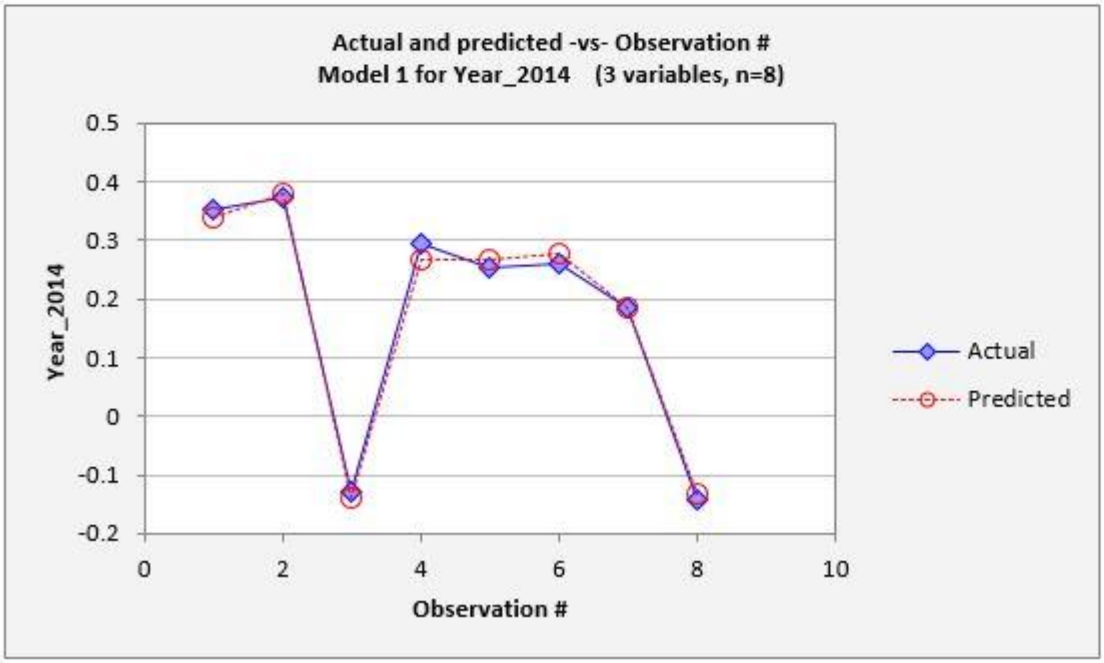

Figure 6: Graph of Actual and Predicted values

Correlation Matrix (n=8)

Variable	Year_1987	Year_1999	Year_2009	Year_2014
Year_1987	1.000			
Year_1999	**0.943**	1.000		
Year_2009	**0.915**	**0.964**	1.000	
Year_2014	**0.917**	**0.968**	**0.997**	1.000

Table 6: Correlation Matrix

In general, there has been fast alteration in the healthy vegetal cover. It is also worthy to know that the model generated in this research can be used to predict future changes and trends in the vegetation cover. This will provide policy makers with useful information for the proper planning and design of the city and other capital cities over West Africa. This will serve as a medium of check and balancing for the indiscriminate alterations to the vegetation ecosystem as a result of urbanization.

ISSN: 2455-6939

Volume:03, Issue:03 "May-June 2017"

5. CONCLUSION

This study uses the techniques of Remote Sensing and Geographical Information Systems (GIS) in driving towards sustainable environmental development with particular respect to landcover transformations, vegetation lost and also on the exploitation of other environmental natural resources. Although the loss of vegetal cover to urban expansion cannot be totally halted, there is a need for sustainable planning and management which will go a long way towards reliable and sustainable way of protecting the vegetal cover which has acted as a Carbon sink and home to different biomes for a long time. The study proposes a statistical model to complement the Remote Sensing and Geographical Information Systems (GIS) techniques in projecting future vegetal cover and this will aid the policy makers in putting in place environmental- friendly policies such as incorporating afforestation and establishments of green belts and parks into the city planning schemes so as to restore the loss vegetal cover.

CONFLICT OF INTEREST

The Authors have read and understood policy on declaration of interests and declare that we have no competing interests. The research received no direct funding from any quarters. This article does not contain any studies with human or animal subjects.

ACKNOWLEDGEMENT

The authors of this paper wish to acknowledge the United States Geological Survey (USGS) for the provision of free Landsat images.

REFERENCES

Abuja Facts .2015. "Top 5 Cities To Do Business In Nigeria. ABUJA Is 2nd". Retrieved 26 October 2015.

Adakayi P.E. (2000). Climate. In: Dawam, P.D.(ed) Geography of Abuja, Federal Capital Territory. Famous/Asanlu Publishers, Abuja.

Adeniyi, P. O. and Omojola, A. .1999. Landuse/Landcover Change Evaluation in Sokoto-Rima Basin of N W Nigeria Based on Archival Remote Sensing and GIS Techniques'. In Geoinformation Technology Applications of Remote Sensing Applications for Resource and Environmental Management in Africa. Ed. by Adeniyi, P. O.: African Association of Remote Sensing of the Environment

Adeyeri O.E., Akinsanola A.A. and Ishola K.A. 2017. Investigating Urban Heat Island Characteristics over Abuja, Nigeria: relationship between land surface temperature and multiple vegetation indices**.** Remote Sensing Applications: Society and Environment (In press)

Adeyeri O.E., Okogbue E.C., Akinluyi F.O., 2016. Mapping Evapotranspiration for different landcover of the Lake Chad area of Nigeria. Journal of Remote sensing Technology,DOI: 10.18005/JRST0401005

Akiyama T, Kawamura K. 2007. Grassland degradation in China: Methods of monitoring, management and restoration. Grassland Science 53:1–17.

Balogun O., (2001). The Federal Capital Territory of Nigeria: Geography of Its Development. University Press,Ibadan.

Clevers J, Bartholomeus H, Müchers S, De-Witt A .2004. Land Cover Classification with the Medium Resolution Imaging Spectrometer .MERIS. EARSeL eProceedings 3.

Euromonitor .2010. "World's Fastest Growing Cities are in Asia and Africa". Archived from the original on October 2015. Retrieved 26 October 2015.

Fagbeja MA 2000. Mapping the Incidences of Chronic Bronchitis and Bronchopneumonia and Verification of High Risk Areas Using GIS. Unpublished M.Sc. Dissertation, Department of Geography,University of Ibadan, Ibadan, Nigeria.

Fashona MJ, Omojola AS. 2005. Climate Change, Human Security and Communal Clashes in Nigeria.International Workshop on Human Security and Climate Change, Oslo, Norway. June 21-23. Available On-line at http://www.gechs.org/downloads/holmen/fasona_omojola.pdf

Jaiyeola .I, Andrews O. .2016. "FCT Minister Harps on Development of Satellite Towns".Archived from this day live. Accessed 5th January 2017.

Jensen, J.R., (2000). Remote sensing of the environment: An earth resource perspective Prentice-Hall, Inc., New Jersey.

Lehmann, E. L.; Casella, George (1998). Theory of Point Estimation (2nd ed.). New York: Springer. ISBN 0-387-98502-6. MR 1639875.

Liu J, Diamond J. 2005. China's environment in a globalizing world. Nature 435:1179–1186

Ojiji, L. M. .2006 'Analysis of Spatial Variations of Abuja Land Use and Land Cover from Image Classification Algorithms' SPRS Commission VII Mid-Term Symposium-Remote Sensing: From Pixel to Processes. Held 8-11 May at Enschede, The Netherlands Omojola, A. .2004. 'Urban and Rural Landuse Mapping of Parts of Ekiti

Omojola, A. and Fasona, M. J. .2004 'GIS and Remote Sensing for Urban Planning: A Case of FESTAC Town, Lagos, Nigeria' 12th International Conference on Geoinformatics Geospatial Information.

Policy and Legal Advocacy Centre .PLAC .2006. "Legal Notice on Publication of 2006 Census Final Results". Retrieved 10 June 2012.

Purevdorj T, Tateishi R, Ishiyama T, Honda Y. 1998. Relationships between percent vegetation cover and vegetation indices. International Journal of Remote Sensing 19:3519–3535.

Vernon, H., 2002:Urbanization in Developing Countries; the World Bank Research Observer, 17(1): 89-112.

Vitousek, P.M., 1992. Global Environmental Change: An introduction. Ann. Rev. Ecol. Syst. 23: 1-14.

