MULTI-TEMPORAL ASSESSMENT OF VEGETATION, IMPERVIOUS SURFACE AND WATER ANALYSIS OF FEDERAL CAPITAL TERRITORY, NIGERIA.

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Abstract

This study highlights the increasing interest in identifying the parameters adequate to measure vegetation, impervious-surface and water classification (VIW) variations as the determinant of Federal Capital Territory (FCT) Abuja.The Landsat-7 Enhanced Thematic Mapper (ETM+) images of 2001 and 2014 was used to extract vegetation, impervious-surface and water features of the sixArea Council headquarters consisting of Abuja, Bwari, Kwali, Gwagwalada, Abaji and Kuje of the Federal Capital Territory, Nigeria. The results show that the period of 2001 to 2014,the vegetation index of the study areas have decreased tremendously and given rise to impervious-surface.

In addition, impervious-surface also shows increased in spatial distribution by approximately two times during the period of 2001-2014 showing tremendous increase in developmental activities. While, in the same period 2001-2014, the presence of notable water bodies that used to be the only source to the communities, increasedin perimeter-area and density.The result of multivariate regression analysis reveals that 2001 VIW has a positive exponential relationship with 2014 VIW of which the coefficients of determination is 0.954 (95%). Accuracy assessment indicates that the vegetation, impervious-surface and water image of the period 2001 correlates with known 2014 VIW within the ETM+ image. Therefore, 2001 vegetation fraction is 30.98% decreasing to 20.79% in 2014. Moreover, the impervious-surface fraction is also consistent with the distribution in the study area because the 2001 had 67.88% increases to 77.79% in the period of 2014, while, the water fraction one of the important components of urban ecosystem in the period of 2001 is 1.14%, increases in 2014 it was 1.42%. These shows that there has been a reduction of 61.12 (21.55%) of vegetation cover and a growth rate in the development of impervious surface of 59.48 (6.81%) in a lag-year of 13years, while, water in the same vein increases by 1.67 (10.85%) in expansion. The findings from this study would facilitate strategies to ensure proper planning and equitable distribution of the development and natural vegetation, while, minimizing the expansion of urban growth to prevent the disappearances of the natural ecology.

Keywords:Multi-temporal,vegetation, impervious surface and water analysis

1.0 Introduction

The urbanization (Badaru et al. 2014) has brought about progress, but also brought with it the threat of degradation and increased pressure on vegetation, impervious surface and water (VIW). According to Barbour and Billings (1999), vegetation refers to assemblages of plant species and the distribution of ground cover they exhibit. In the words of Henderson et al. (1999)defined impervious surface as any surface such as roads, pavement, buildings and sidewalks that does not allow water to seep through to the soil. In the same vein, Water is a transparent fluid which forms the world's streams, lakes, oceans and rain, and is the major constituent of the fluids of living things (Gleick, 1993).

1.1 Background to the study area

The Federal Capital Territory (FCT), Abuja with an estimated population of 5 million (NPC, 2006), located in the middle of the country and covers a land area of about 8,000 km2 of which the actual city occupies 250sq.km. The Federal Capital Territory lies within latitudes 9^0 20' N and $9^0$25' N of the equator and within longitudes 5^0 45' E and 7^0 39' E (Figure 1). The Federal Capital Territory is bordered to the north by Kaduna state, to the east by Nasarawa State, to the south west by Kogi State and to the west by Niger State.

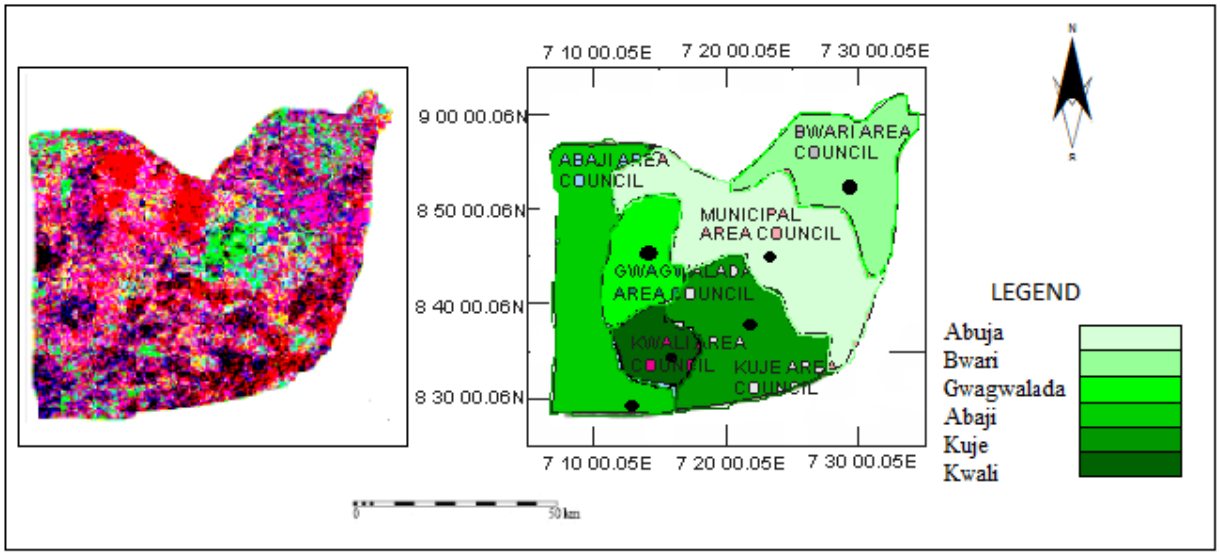

Figure 1: The Study Areas, Federal Capital TerritoryAbuja, Nigeria

1.2 Statement of the Research Problems

VIW classification is needed in all spheres of development. In recent years, VIW studieshas beenincreasingly assuming not only significant, but also threatening proportions, especially in the developmental trend of urban areas, thus contributing substantially to scarcity of vegetation, water bodies and increased in impervious-surface in the study areas. Consequent upon the aforementioned it becomes expedient to assess the VIW and the extent in order to formulate policies and to come up with management techniques geared towards ensuring an equitable balance between development, sustainable vegetation growth and water development.

1.3 The Aim and Objectives

The aim of the study is to examine vegetation, impervious-surface and water (VIW) classification of the Federal Capital Territory, Nigeria. In specific theobjectives of the study are as follow:

a. To identify the variation in 2001 VIW and 2014 VIW using remote sensing techniques

b. To develop the classification scheme to identify VIW of the study areas

c. To make appropriate recommendations based on finding

2.0 Related Literatures

The commonest features in urban area is impervious surfaces such as oversite concrete floor, building roof, paved road, parking spaces and insitu-structure (Wu and Murray, 2003). According to Gluch*et al.*, (2006) the soil and sand have similar spectral response features to impervious surface, and thus often mixed up with the enhanced impervious surface information.Yang *et al*. (2003) mapped the vegetation, impervious surfaces for the entire United States using ETM+ data with the assistance of high-resolution imagery and a decision tree algorithm. Stefanov*et al*. (2001) also mapped the impervious surface analysis of the Metropolitan area from 1986 to 2000 by developing a regression model to relate percent VIW to greenness (Bauer et al. 2004). Yang and Liu (2005) further estimateimpervious surface analysis of the Pensacola area by synergistic use of ETM+ imagery data through multivariate statistical regression models.

3.0 Methods

3.1 Image classification

The methodology of study involves selection of sixtowns of the Federal Capital Territory Abuja, Nigeria. The dominant land-use (LU)was determined from land-cover (LC)variables generated from the 2001 and 2014. Landsat-7 ETM+ of 2001 and 2014 was procured for the study to get an overview of VIW classification major. The Garmin ETREX-GPS instrument and Statistical Package forSocial Science (SPSS)were used to determine the coordinates, waypoints, latitudes, altitude and longitude grids of selected truthing areas.

4.0 Results

4.1 VIW of Gwagwalada

Figure 2 shows the vegetation, impervious surface and water (VIW) of 2001 revealed that the study areas is occupied with farmland accounting for 38.20%, vegetation 30.12%, built-up areas 22.37% and others 9.31%. The Figure 2 also indicates that in the period of 2014the whole area have been fully developed except some pockets of areas where fairly extensive vegetation was allowed to grow. The VIW of 2014 shows that the built-up areas accounting for 36.85%, vegetation 28.08%, farmland 21.00% and others 14.07%.

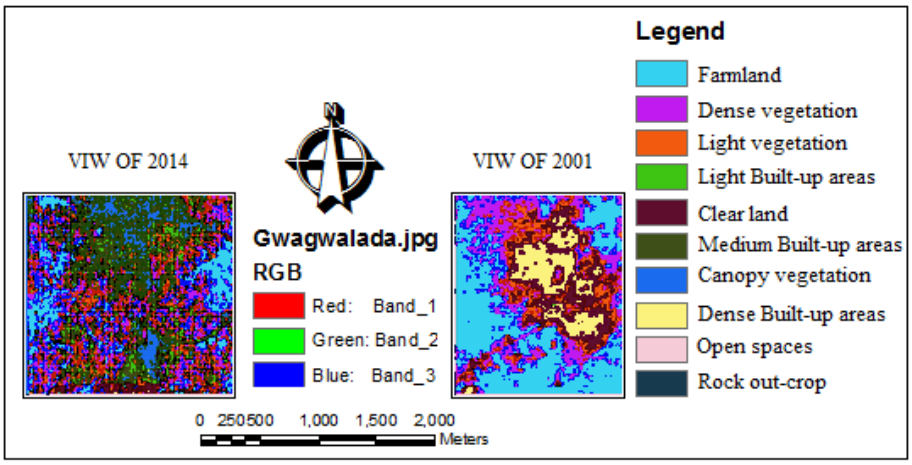

Figure 2: Vegetation-impervious surface and water classifications of 2001-2014, Gwagwalada

4.2 VIW of Federal Capital City Abuja

Figure 3 shows the rock out-crop accounting for 36.30%, built-up areas 32.77%, canopy vegetation 14.48%, open spaces 8.11%, water body 3.42% and others 4.92%. Furthermore, in the period of 2014, the Figure 3 state that thestudy area has achieved tremendous development, particularly the built-up areas accounting for 71.82%, rock out-crop 9.57%, canopy vegetation 7.33%, open spaces 6.24%, water bodies 2.91% and others2.13%.

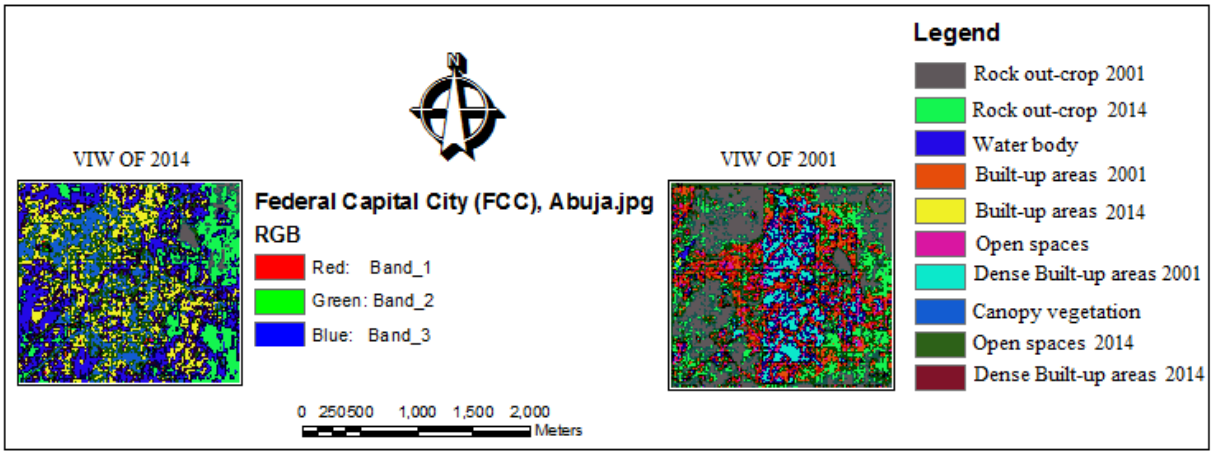

Figure 3: Vegetation-impervious surface and water classification of 2001-2014, FCC-Abuja

4.3 VIW ofAbaji

Figure 4 shows significant variation of the vegetation, impervious surface and water (VIW) analysis of 2001 and 2014. In the period of 2001, dense vegetation accounts for 41.15% of the total, while farmland 32.04%, built-up areas 20.10%, canopy vegetation 4.51% and others 2.20%. The Figure 4 also indicates that in the period of 2014 improvement has set in thebuilt

environment of which the built-up areas accounts for 46.88%, vegetation 20.22%, farmland 19.06%, clear land 6.18%, open spaces 5.66% and others 2.00%.

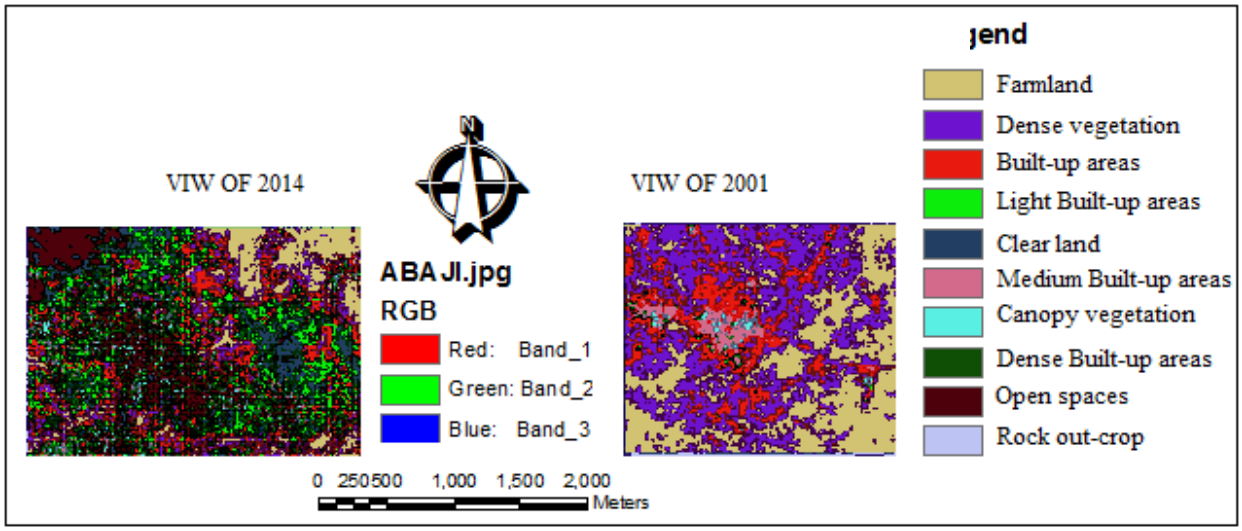

Figure 4: Vegetation-impervious surface and water classification of 2001-2014, Abaji.

4.4 VIW ofBwari

Dominant land use were determined from land cover features generated from the VIW of 2001 shows that the study areas accounts for 38.53% and 35.08% of canopy and dense vegetation respectively, while built-up area 18.92%, water body 3.44% and others 4.03%. The Figure 5 also indicates that in the period of 2014 theland-use (LU) and land-cover (LC) have been fully utilized bythe built-up areas accounting for 38.32%, dense vegetation 30.87%, canopy vegetation 17.64%, water body 5.62% and clear land/farmland 7.55%.

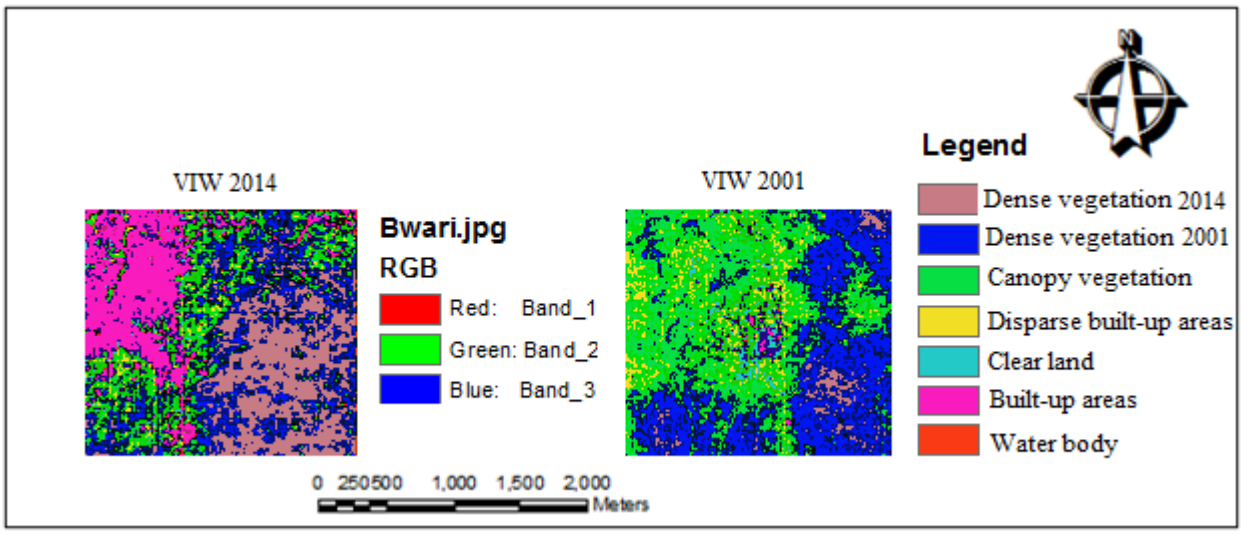

Figure 5: Vegetation-impervious surface and water classification of 2001-2014, Bwari

4.5 VIW ofKuje

Figure 6 shows the vegetation, impervious surface and water (VIW) of 2001 and 2014 respectively. The 2001 period accounts for 42.60% of farmland, dense vegetation 32.61%, built-up areas 21.97% and others 2.89%. However, the period of 2014 witness changes in the LU/LC of which canopy vegetation accounts for 47.59%, built-up areas 36.20%, dense vegetation 12.36% and others 3.85%.

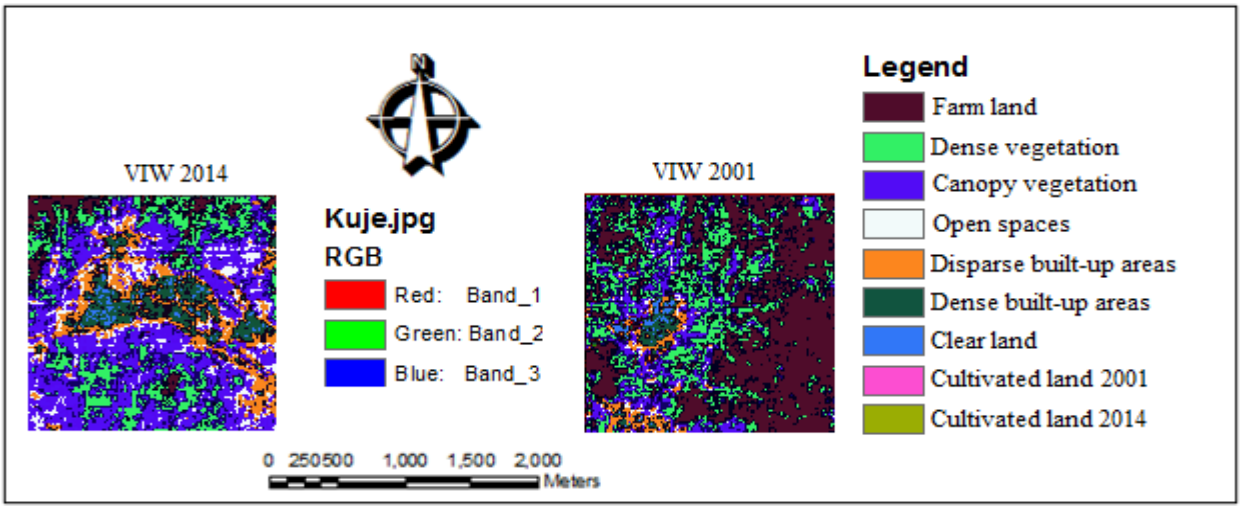

Figure 6: Vegetation-impervious surface and water classification of 2001-2014, Kuje

4.6 VIW ofKwali

Figure 7 shows variation of the vegetation impervious surface and water (VIW) analysis of 2001 and 2014. The Figure 7 shows that canopy vegetation accounts for 32.42%, farmland 27.41%, rock out-crop 18.44%, built-up areas 16.93% and others 4.82% of the period 2001. In the period of 2014, the built-up areas accounts for 36.17% of the total, while dense vegetation 25.88%, farmland 18.74%, rock out-crop 16.82% and others 2.39%.

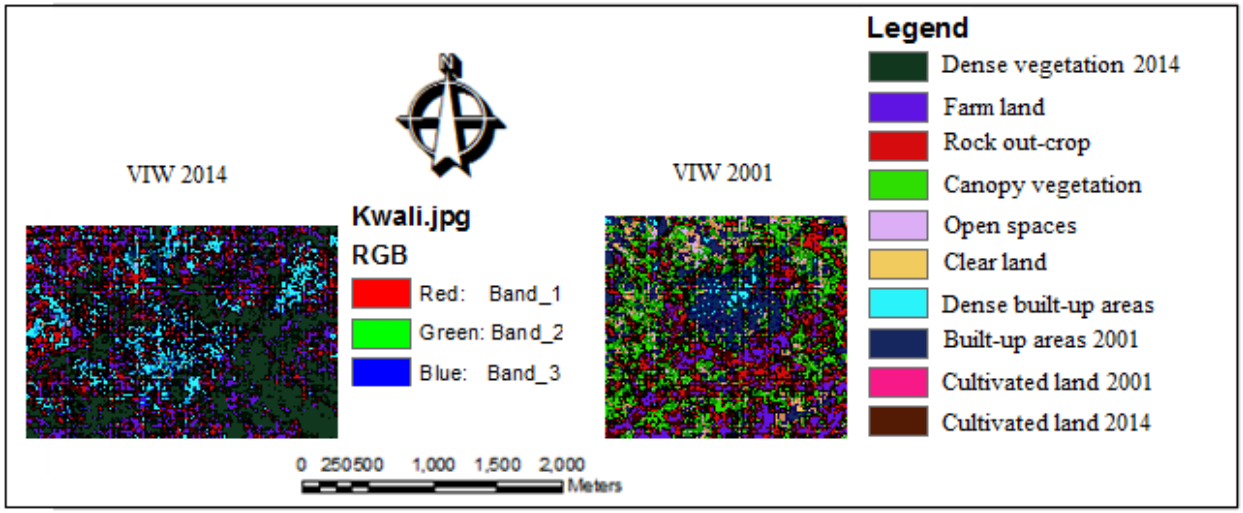

Figure 7: Vegetation-impervious surface and water classification of 2001-2014, Kwali

4.7 Multivariate Regression Analysis

Figure 8 shows positive relationship between 2001 VIW and 2014 VIW, of which the coefficients ofdetermination R^2 of 2001/2014 VIW is 0.954 (95.4%). These results indicate that 2001 VIW correlate with 2014 VIW in the study area and show a high strength in their relationship. Therefore, the study concludes that both values are statistically significant based on their level of confidence.

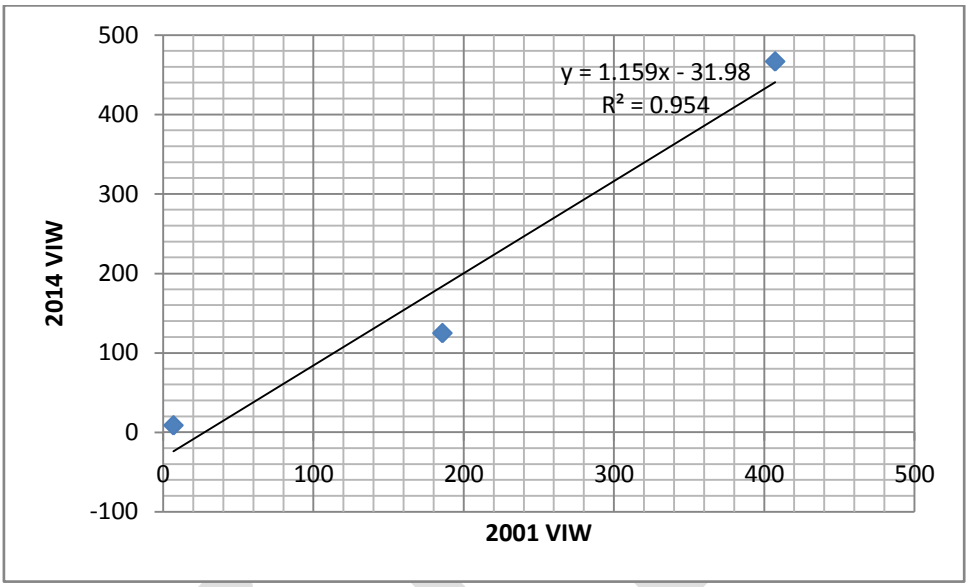

Figure 8: VIW level of determination

4.8 Discussion

The vegetation, impervious-surface and water classification (VIW) were identify, examine and calculated using the Landsat-7 ETM+ data and the final result were shown in Figures 2-8 for the period of 2001 and 2014 respectively. The result shows that the vegetation, impervious-surface and water image of the period 2001 correlates with known 2014 VIW within the ETM+ image.The result of multivariate regression analysis reveals that 2001 VIW has a positive exponential relationship with 2014 VIW of which the coefficients of determination is 0.954 (95%). The 2001 vegetation fraction is 30.98% and 20.79% in 2014. Secondly, the impervious-surface fraction is also consistent with thedistribution in the study area because the 2001 had 67.88% and 77.79% in the period of 2014, While, the water fraction in the period of 2001 is 1.14% expanding to 1.42% in 2014 (Table 1). The summary of the VIW assessment shows that, there is a significant variation in the vegetation areas, there has been at about the same proportion an increment in the impervious surface which has advanced to 10% of development within the lag-year of 13years. It also helps to shows that

very little effort is being made to grow the water coverage which has increased of 1.67 (10.85%) within the same periods.

Table 1: VIW Accuracy Assessment of 2001 and 2014

Study Areas	2001			2014Vegetation	Impervious surface	
	Vegetation	Impervious surface	Water	Water		
Abaji	41.15	58.85	0	20.22	79.78	0
Bwari	35.08	61.48	3.44	30.87	63.51	5.62
FCC-Abuja	14.48	82.10	3.42	7.33	89.79	2.91
Gwagwalada	30.12	69.88	0	28.08	71.92	0
Kuje	32.61	67.39	0	12.36	87.64	0
Kwari	32.42	67.580		25.88	74.120	
Total	185.86	407.28	6.86	124.74	466.76	8.53

Conclusions

In this paper, multitemporal technique is applied to examinevegetation, impervious-surface and water classification under the framework of Landsat-7 ETM+. The final result has shown that the VIW classification model is reasonable to assess and can be used to monitoring urban expansion, especially for VIWarea estimation.

References

Badaru, Y.U.,Abubakar, A.S.,Onuh, S., Akiode, O.A.&Shuaibu O. S. (2014).Assessment of housing conditions for a developing urban slum using geospatial analysis: a case study of durumi, garki-2, gishiri and jabi of the city of abuja, federal capital territory of nigeria. "*Journal of Environment and Earth Science*" Vol. 4, No. 20, 1-15.

Barbour, M. G. & W. D. Billings (1999).*North American Terrestrial Vegetation*.Cambridge: Cambridge University Press.

Barbour, M.G., Burk, J.H. &Pitts, W.D. (1987)."Terrestrial Plant Ecology". Menlo Park: Benjamin Cummings.

Bauer, M.E., Heinert, N.J., Doyle, J.K. & Yuan, F. (2004).Impervious surface mapping and change monitoring using Landsat remote sensing. In *Proceedings of American Society of*

Photogrammetry and RemoteSensing Annual Conference, 24–28 May 2004, Denver, Colorado, USA.

Henderson, C.I., Dindorf, C.J. &Rozumalski, F.J. (1999), Lakescaping for Wildlife and Water Quality. Minnesota Department of Natural Resources

Gleick, P.H. (1993). Water in Crisis: A Guide to the World's Freshwater Resources: Water reserves on the earth"*Oxford University Press*"13, Table 2.1

Gluch, R., Quattrochi, A.D. &Luvall, J.C. (2006).A multi-scale approach to urban thermal analysis. "*Remote Sensing of Environment"* 104(1): 123–132.

Stefanov, W. L., Ramsey, M. S. & Christensen, P. R. (2001). Monitoring urban land cover change: an expert system approach to land cover classification of semiarid to arid urban centers. "*Remote Sensing of Environment*" 77, 173– 185.

Wu, C. & Murray, A.T. (2003).Estimating impervious surface distribution by spectral mixture analysis."*Remote Sensing ofEnvironment"* 84, 493– 505.

Yang, X. & Liu, Z. (2005).Use of satellite-derived landscape imperviousness index to characterize urban spatial growth."*Computers, Environmentand Urban Systems"*29(4): 524–540.

Yang, L., Huang, C., Homer, C.G., Wylie, B.K. &Coan, M.J. (2003). An approach for mapping large-area impervious surfaces: synergistic use of Landsat-7 ETM+ and high spatial resolution imagery. "*CanadianJournal of Remote Sensing"* 29(2): 230–240.

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