# Savanna

Volume 21 Nos. 1 & 2 June & December, 2008

A JOURNAL OF THE ENVIRONMENTAL AND SOCIAL SCIENCES,
PUBLISHED BY AHMADU BELLO UNIVERSITY PRESS LIMITED, P.M.B. 1094, ZARIA-NIGERIA

Dr A. Illi Jinadu

Volume 21
No. 1&2
June & Dec.
2008

# Savanna



## Subscription Rates

| | | |
|---|---|---|
| Nigeria | Rate - ₦1,000.00 | |
| Other Countries | Rate A (Personal) | - £20 Sterling/$50.00 |
| | Rate B (Institutions) | - £25 Sterling/$60.00 |

All cheques should be made payable to Ahmadu Bello University Press Limited, Zaria. Subscription must be prepaid and must include 10% handling charge.


ISSN 0331-0523

A Journal of the Environmental and Social Sciences, Published by Ahmadu Bello University Press Limited, P.M.B. 1094, Zaria,

**Articles**

Savanna Volume 21, Number 2, December 2008

# The Use of Satellite Image Data in Settlement Growth Forecasting: A Case Study of the Nigerian Federal Capital Territory

A.M Jinadu*

**ABSTRACT**

One of the major challenges of settlement development planning is the dearth of data on the future growth potentials of our towns and cities as well as the pattern of development that is expected. This study attempts to bridge this information gap by estimating the future growth of selected satellite settlements in the Federal capital Territory of Nigeria. It utilizes data from the Landsat TM obtained in 1987, SPOT XS of 1994 and Landsat ETM+ obtained in 2001. The rating method developed by Rao (1995) and regression analysis were used to generate settlement sizes for years 2008 and 2015. Amongst others, the study estimated that, from their original sizes in year 2001, the sizes of Karu-Nyanyan, Kubwa and Lugbe will increase by 16.81, 6.9 and 1.29 square kilometers respectively in year 2008. By the year 2015, the projected size of Karu-Nyanyan is 39188108 square meters (39.19 $km^2$), that of Kubwa is 21900924.4 square meters (21.90$km^2$) while that of Lugbe is 10621302.9 square meters (10.62 $km^2$). It is evident from the study that expected future increases in the sizes of these settlements are quite considerable with huge planning and development control implications. It is therefore necessary to identify the areas where development is likely to take place for further analytical studies in order to generate the required data base for planning the future growth of the settlements concerned.

## Introduction

Human settlements are important landscape elements of interest to geographers and town planners. In the past, researchers have used the conventional map analysis to study settlement location, pattern, physical development and growth. However, some of such studies, especially those that are related to settlement growth monitoring and forecasting, have been limited by lack of adequate temporal data (e. g. real time satellite image maps) to study the physical changes in rural environment.

One major advantage of remote sensing technique is its capacity to provide a synoptic view of the earth's surface and to record the different physical and cultural elements of the human landscape. The synoptic view of the terrestrial environment provided by remote sensing data enables the mapping of spatial distribution of earth surface features. Thus the advent of modern remote sensing has increased human understanding of the dynamics of the physical environment. The technology has shown a great potential for improving the knowledge base, for understanding and anticipating future environmental changes and for informing policies aimed at changing the future of our settlement environment.

Many studies have combined both the conventional reference data and remote sensing data for understanding, monitoring and modelling land use changes (see Rao, 1995; Elnazir *et al.*, 2004; Herold *et al.*, 2002 and Pedro *et al.*, 2006). Results obtained from this approach have shown great improvement over the conventional method as they carry the advantage of real and short - term ability to monitor changes and update existing information. In line with the earlier ones, this study uses satellite image data to estimate future growth of

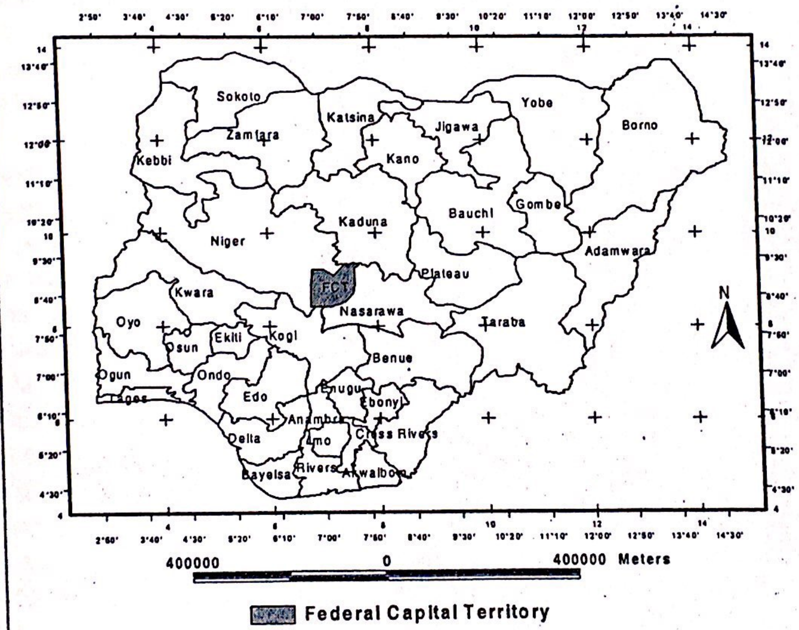
*Department of Urban and Regional Planning, Federal University of Technology, Minna, Nigeria

six settlements within the Federal Capital City (FCC) – Abuja, Nigeria. The aim is to predict settlement sizes for the years 2008 and 2015 with a view to providing information for settlement planning and development in the area.

## Research Setting and Scope

The Federal Capital Territory (FCT) covers an area of 800km$^2$ (FCDA, 1979). It is located at the heart of Nigeria, approximately between latitudes 7$^0$ 25 - 9$^0$ 20 north of the Equator and longitudes 6$^0$ 45 - 7$^0$ 39 east of the Greenwich meridian. The territory is bounded on the northeast by Kaduna State, on the west by Niger, on the east and south-east by Nasarawa State and on the southwest by Kogi State (Figure 1). The study is focused on six satellite settlements around Abuja city, namely, Lugbe, Kubwa, Dutse Alhaji, Gwagwa , Karu and Nyanyan. These settlements have witnessed considerable influx of migrant population in recent years. The population growth and subsequent physical development activities have therefore lead to settlement growth with high potentials for future increases in settlement sizes. This study captures the sizes of the six settlements as at the year 2001 and make projections for the years 2008 and 2015 respectively.

Figure 1: Nigeria Showing the Federal Capital Territory




*Source:* Department of Surveying and Geoinformatics, Federal University of Technology Minna

## Literature Review

The outcomes of many studies have demonstrated the different facets of remote sensing application to urban growth. The work of Dimyati *et al* (1996), amongst others, examined the conversion of other land use types into new settlement areas of Yogyakarta, Indonesia. The authors used Landsat MSS images of May 1972 and October 1984 with thematic maps including the road maps of 1984 and 1990, sub-regency map of 1990 and land use map of 1990. The multi-temporal Landsat images were registered into the UTM map projections and a MLC method was used to analyze land use/land cover from both images. The two images were later superimposed to produce an image of the spatial distribution of land use/land cover change. The authors discovered that settlements grew rapidly in sub-urban areas where more space was available and that the annual growth rate of new settlements to absorb paddy coverage, mixed vegetation and open/barren land were 16 percent, 20 per cent and 64 percent respectively.

Mehta and Sidhu (1991), Salem *et al* (1995) and Yang *et al* (2001) carried out similar works which focused on urban sprawl and the direction of settlement growth. Salem *et al.* (ibid) utilized Landsat TM data to detect the rate of land transformation and the direction of urban sprawl between 1994 and 1990 in Egypt. Analysis of change in the relations between urban growth and agricultural land show an alarming rate (1.47 per cent per annum) of loss of land to non-agricultural uses. They, therefore, concluded that if such a rate of land transformation continues and in the same pattern, all agricultural land in the area would be lost to urbanization and other activities in less than 70 years.

Yang *et al* (2001) applied remote sensing and GIS methods to examine the growth of Wuxi city, China over a 32-year period (1966-1998) using information from topographic map and Landsat TM images. Their study revealed that the built-up area of the city expanded more than ten fold (from 11.6-136.1 km$^2$) during the 32-year period. More expansion was recorded between 1977 and 1984 at a rate of 282.8 per cent.

In addition to the foregoing, other studies that considered the dynamic aspects of urban settlement include Dang *et al* (2002) that used remote sensing, and GIS data to analyze dynamic development of Beijing city and Elnazir *et al.* (2004), which used remote sensing and GIS data to assess urban growth in Shaoxing city, both in China. The studies established that the growth of the two cities has accelerated in the recent years. For instance, the Shaoxing city study showed that physical growth of urban area was upsetting other land cover classes such as farming and water resources and the city was estimated to expand at an average rate of 7 km$^2$ per annum.

In the last few years, models of land use change and urban growth have been expanded and have become innovative tools for city planners in making intelligent decisions for the sustainable settlement development. Herold *et al* (2002) have evaluated and compared thirty-six of such growth models in terms of their data requirements and have applied the Clark's urban growth model (UGM) in the simulation of urban growth in Santa Barbara, U. S. A. According to the authors, the models have shown their potential to support planning and management decisions in understanding the dynamics of urban systems, forecast of future changes or trends of development and in the assessment of the impacts of future developments. Pedro and Alexandria (2006) also used three land change models (two cellular automata based, Markov models and Goemod model) to investigate urban dynamics in Sintra-Cascais municipalities in Portugal. The Landsat TM of 1989 and Landsat ETM+ of 2001 data were classified and used to forecast the type of urban dynamics expected for the year 2025. The result observed a continued tendency for increase of the built-up areas (29.5 percent) between 1989 and 2001. Although there were significantly different results for the three models in a long-term forecast, the authors concluded that the models can provide useful information to detect areas where urban growth is more likely to happen.

The work of Rao (1995) presents excellent examples of the use of urban growth models. The author has demonstrated how remotely sensed data could be used to analyze the past and present as well as future growth of settlements through predictive modeling. Rao (1995), displeased with the use of transportation modeling as a measure of future urban land use, proposed new methods of forecasting settlement growth in Tuni region of Andhra Pradesh, India. His objectives were to identify the growth of built-up land in shape and area, and to develop a relation between the built-up area and socio-economic condition. Digital data for the study were obtained from the Indian Remote Sensing Satellite (IRS-1A-LISSI) on 3 April 1989 and the author developed three techniques to estimate future land use in the area. Two of these techniques are considered below.

The first technique developed by Rao (1995) is the causal modeling technique which identifies several factors that affect situations in a built-up area and develops a formula for forecasting future values. The basic form of the model is given as:

$$Y = a_o + a_1 x_1 + a_2 x_2 + \ldots\ldots a_n x_n \quad \ldots\ldots (1)$$

Where: $Y$ = dependent variable

$x_1, x_2, \ldots\ldots x_n$ = independent variables.

In this case, the built-up area is considered as the dependent variable while causes of land use change such as population and employment growth, growth in non-agricultural land uses, level of education of the people, etc, were selected as independent variables. Each of the independent variables was modeled with a stepwise regression technique and their influence on the built-up area was confirmed. Multiple regressive equations were also developed for the variables and a few of them were statistically chosen for assessing future built-up area activity. The models were used to predict built-up area for all the villages and towns in the Tuni region with the total built-up area estimated for the year 2001 to range between 890,000m$^2$ and 1014000m$^2$.

In a similar study, De Almeida (2005) demonstrated the utility of regression model in her study of urban growth and land use change in Bauru city, Brazil. She applied univariate regression model where the area of certain types of use in 2007 (dependent variable) is explained by demographic or economic indicators (independent variable) such as urban population or local industrial GDP. A forecast of urban growth and land use change between 2000 and 2007 revealed the tendency of urban expansion towards the southwest side of the town where the spring, the source of the city's water supply, was located.

Another model used by Rao (1995) for future land use forecast is the rating method. This method uses geometrical parameters as the main tools for assessing future land activity growth. Here, the base year data extracted from imagery and census data form the basis for future forecast. The following formulas were then adopted to assess growth potential rate for each village.

Influence rate of built-up area of village = $\frac{Circumference\ of\ Village}{Area\ of\ Village}$ ...................... (2)

.Attraction potential rate of town (PR) = $\frac{Circumference\ of\ town}{Area\ of\ town}$ ..........................(3)

Where the village built-up area is under influence of more than one town, the potential rate is calculated with the weighted index of area with distance as a parameter as shown below:

Weighted index potential = $\frac{\sum Area\ of\ potential \times distance\ between\ village\ and\ town}{\sum Distance\ between\ village\ and\ town}$ ........................................ (4)

The growth potential of village/pocket (GPP) = $\frac{Attraction\ potential\ rate}{Influence\ rate}$........... (5)

If the village\pocket is under the influence of more them one town, the G.PP is given as:

GPP = $\frac{Weigted\ index\ potential}{Influence\ rate}$............... (6)

In this case however, Tuni town is the only attraction potential in the region. Attraction potential rate (P.R) value is therefore the same for all villages in Tuni region. Hence the built-up areas were calculated as:

Future built-up land area = (GPP X Area of village in present year + area of village in present year)... (7)

Using equations 2 – 7 above, data for 1971 were processed to estimate the 1981 built-up area. Similar exercises were done to derive the 1991 built-up area and the 1991 data were used to estimate future values for the year 2001, which was estimated at 85125m$^2$. The different estimates derived were found close to the actual data with an error of 0.12. The rating and regression methods were found to provide comparative estimates for present and future built-up areas of settlements with minimum error. Thus, these methods were used in this study as they appear more practical and suitable for settlement growth forecasting.

## Methodology

Data used for the study include Landsat TM obtained in 1987, SPOT XS of 1994 and Landsat ETM+ obtained in 2001 (with 30m, 20m and 30m resolutions respectively). The image data were processed and the settlement features were mapped through the direct tracing approach using the on-screen digitization function of the ERDAS IMAGINE software. The computer cursor was used to map the outlines of the selected settlements. This user-defined lines and polygon method allows for a high degree of control and mapping accuracy even though it is tedious and time consuming. The sizes of the settlement polygons were then queried using the ArcVeiw statistical function.

Assessment of future growth of the settlements was carried out using the rating method developed by Rao (1995) and regression analysis. In the Rao (1995) method (see detail in literature review), the built-up area of land activity (e.g. shapes and area of settlements) was determined from the satellite imageries. The areas (M$^2$) and the circumferences of the Federal Capital City (FCC) as well as the selected settlements were also determined from satellite images and the information derived were used in computing the influence rate (IR), the attraction potential rate (PR) and the growth potential of each settlement (GP). The future built-up area (FBA) of each of the settlements was calculated using the formula:

FBA = (GP x SA in present year + SA in present year).

Where:

FBA = future built-up area.
GP = growth potential rate of settlement
SA = settlement area in $m^2$

The regression method was used to model the future growth of the settlements using the settlement sizes as the criterion variable and the year as the predictor variable. The following formula was used:

$$y = a + bx + e$$

Where:

$y$ = criterion or dependent variable
$x$ = predictor or independent variable
$b$ = regression coefficients
$a$ = y intercept when x = 0
$e$ = error term of the prediction

The rating method was used to forecast settlement sizes up to year the 2008 and the regression method was used to predict settlement sizes from the years 2008 and 2015. The results of the analyses are presented and discussed below.

## Results and Discussion

The estimation of future growth of the settlements was done in two stages. First, settlement sizes for year 2008 were predicted using satellite image data. Second, regression models were used to project settlement sizes to year 2015. With respect to settlement sizes in year 2008, the satellite image map of 2001 was used to determine areas and perimeters of Abuja and the selected settlements (Figure 2). Following the rating method of Rao (1995), the influence rate of built-up area of the settlements (IR), attraction potential rate (APR) of Abuja (assuming the built-up areas of the settlements are under the influence of the FCC as the only attraction potential in the study area) were computed. The IR and the APR values were used to calculate the growth potential (GP) values of the settlements. The growth potential of settlements for 1987 and 1994 were also computed alongside that of 2001 and the average was used in the final computation to account for growth fluctuation over the years. Based on the assumption that the established growth trend (1987-2001) will not change direction suddenly, the average growth potential (AGP) values were used as smoothing constants in a time-series analysis to estimate the future built-up area of the six settlements for the year 2008 (Table 1)

Table 1: **Estimates of built-up areas for the satellite settlements (2001 &-2008)**

| Settlements | Area in 2001 ($M^2$) | Perimeter ($M^2$) | IR | APR | GP | AGP | Calculated values for 2008 ($M^2$) |
|---|---|---|---|---|---|---|---|
| Dutse Alhaji | 1742682.38 | 6260.41 | 0.003 | $1.0 \times 10^{-3}$ | 0.33 | 0.27 | 2213206.62 |
| Gwagwa | 3148687.00 | 9574.92 | 0.003 | $1.0 \times 10^{-3}$ | 0.33 | 0.39 | 4376674.93 |
| Karu/Nyanyan | 27965362.00 | 37624.54 | 0.013 | $1.0 \times 10^{-3}$ | 1.00 | 0.60 | 44744579.2 |
| Kubwa | 13564981.00 | 25629.71 | 0.002 | $1.0 \times 10^{-3}$ | 0.50 | 0.35 | 20483121.31 |
| Lugbe | 4594354.00 | 13236.06 | 0.002 | $1.0 \times 10^{-3}$ | 0.50 | 0.28 | 5880773.12 |

**Notes:**
IR = Influence rate
APR = Attraction potential rate of FCC
GP = Growth potential of the satellite settlements
AGP = Average growth potential of the satellite settlements

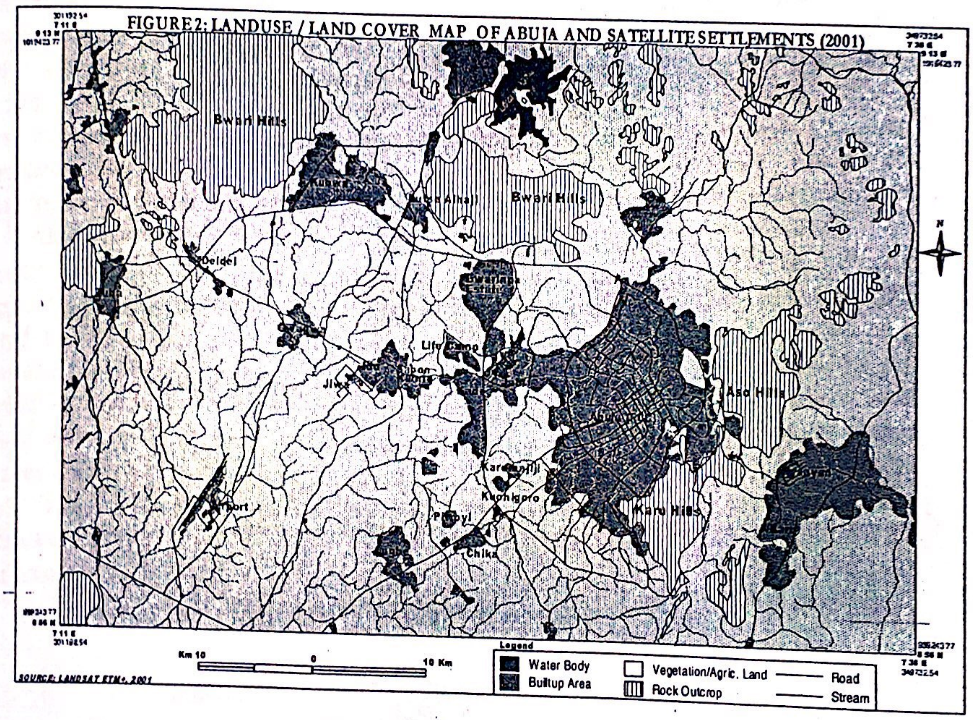


FIGURE2: LANDUSE / LAND COVER MAP OF ABUJA AND SATELLITE SETTLEMENTS (2001)

Table 2 shows the values of the expected future increases in settlement sizes by 2008 which reveals moderate growth anticipated in settlements like Dutse Alhaji (0.470 $Km^2$), Gwagwa (1.227 $Km^2$) and Lugbe (1.286 $Km^2$). However, the expected growths of 6.918 $Km^2$ in Kubwa and 16.779 $Km^2$ in Karu/Nyanyan within a period of seven years are quite considerable.

Table 2: **Expected future increases in settlement sizes**

| Settlements | Area in 2001 ($M^2$) | Estimated values for 2008 ($M^2$) | Future increases ($M^2$) | Equivalent increases ($Km^2$) |
|---|---|---|---|---|
| Dutse Alhaji | 1742682.38 | 2213206.62 | 470524.24 | 0.470 |
| Gwagwa | 3148687.00 | 4376674.93 | 1227987.93 | 1.227 |
| Karu/Nyanyan | 27965362.00 | 44744579.2 | 16779217.2 | 16.779 |
| Kubwa | 13564981.00 | 20483121.31 | 6918140.31 | 6.918 |
| Lugbe | 4594354.00 | 5880773.12 | 1286419.12 | 1.286 |

The merit of the rating approach lies in the use of satellite image-based geometrical parameters of both the FCC and the settlements studied to establish a relationship between growth in the settlements and the attraction potential of the FCC. The reference made to the 1987, 1994 and 2001 image data in the calculation is to establish a consistent development trend which takes care of possible growth fluctuations that may arise from such development constraints as land cost and affordability as well as government's acquisition and protection of land from development.

Although the approach provides estimates for future built-up areas with minimum error (Rao, 1995), its utility is limited by the short-term nature of the allowable range of future projection. The number of years of future projection is limited to the time interval of the earlier data set (1987, 1994 and 2001 image data) used. Thus, the future built-up areas estimated for the selected satellite settlements could not be taken beyond the year 2008. Projecting into a more distant future (i.e 2015) requires data on settlement areas and perimeters for 2008, which were not available as at the time the fieldwork was carried out.

Regression analysis is an alternative approach that could be used to predict future built-up area of the settlements. Bivariate regression analysis was computed for each of the settlements using the settlement sizes as the criterion variables and the years as the predictor variables. Using the formula: $Y = a + bx + e$, the regression (R) values and the coefficients were derived. As shown in Table 3, the regression values for the six settlements range between 0.906 and 0.945 and this shows a high positive relationship between the criterion and the predictor variables. The $R^2$ were calculated to determine the level of prediction and the results show that between 82.1 per cent and 89.4 per cent of settlement size increases is predicted by the year variable.

**Table 3: Regression (R) output values**

| Settlements | Regression values | $R^2$ | Adjusted $R^2$ |
|---|---|---|---|
| Dutse Alhaji | 0.923 | 0.853 | 0.841 |
| Gwagwa | 0.945 | 0.894 | 0.885 |
| Karu/Nyanyan | 0.913 | 0.833 | 0.820 |
| Kubwa | 0.926 | 0.858 | 0.847 |
| Lugbe | 0.906 | 0.821 | 0.807 |

One major requirement of predictive models is a stable or constant relationship between the criterion and the predictor variables so as to be able to make accurate forecast (Okoko, 2001). With the strong positive relationship found between the two variables in the six settlements, the prediction models for each of the settlements were written as shown in Table 4. The forecast for any given future year is determined by substituting for the value of *x* in the linear equation. Based on the model estimates, the built-up areas of the settlements were calculated for the year 2008 and 2015 respectively (Table 5).

Table 4: **Growth prediction models for the satellite settlements**

| Settlements | Growth Prediction Models |
|---|---|
| Gwagwa | $Y = 31923.439 + 158034.2x$ |
| Dutse Alhaji | $Y = -271729 + 102540.1x$ |
| Kubwa | $Y = -2576398 + 844045.6x$ |
| Karu/Nyanyan | $Y = -1663322 + 1408670x$ |
| Lugbe | $Y = -1451741 + 381829.1x$ |

Table 5: **Predicted built-up area of selected settlements for 2008 and 2015**

| Settlements | Predicted Built-up Area | |
|---|---|---|
| | 2008 | 2015 |
| Gwagwa | 3508675.839 | 4614915.239 |
| Dutse Alhaji | 1984153.20 | 2701933.9 |
| Kubwa | 15992605 | 21900924.4 |
| Karu/Nyanyan | 29327418 | 39188108 |
| Lugbe | 7948499.20 | 10621302.9 |

It is noted that the predicted regression values for year 2008 are generally less than the estimates derived from the rating method (Table 1). This is so because the predicted regression values in Table 5 are average values of a range. The lower and the upper bonds of the regression estimates were further established to ascertain the range within which the estimated built-up areas of the settlements lie (Table 6). The range establishes 95 percent confidence limit for the predicted built-up areas. This indicates that we are 95 % sure that the predicted values are correct and the probability that our forecast is wrong is only 5 percent.

Table 6: **Predicted estimates and value range for built-up areas at 95% confidence limit**

| Settlements | Predicted values (2008) | | Regression estimate confidence limit (2σ) | Range at 95% |
|---|---|---|---|---|
| | Rao's Estimates | Regression Estimates | Lower Bound | Upper Bound |
| Gwagwa | 4376674.93 | 3508675.839 | 2492805.6 | 4524545.6 |
| Dutse Alhaji | 2213206.62 | 1984153.20 | 1190454.5 | 2777851.3 |
| Kubwa | 20483121.31 | 15992605.20 | 158299804 | 22402223 |
| Karu/Nyanyan | 44744579.2 | 29327418 | 17583181 | 41071634 |
| Lugbe | 5880773.12 | 7948499.20 | 3623594.8 | 10273403.6 |
| Zuba | 6361184.30 | 1068206414 | - 1308688615 | 918796015.8 |

'he standard error values carry both ositive and negative signs to be able to stablish the lower and upper limits of the egression estimates. In our case, there is ın indication that the standard error values :arry positive signs. It is therefore realised that the estimated built-up area values derived from the use of Rao (1995)'s rating method are generally closer to the upper limit values of the regression models. As seen in the table, all of the values derived from the rating method fall within the range established by the 95 percent confidence limit and this helps establish the reliability of the approach.

The two approaches could complement each other. While the rating method incorporates elements, which relate the growth of the satellite settlements to the influence of Abuja city, the modelling approach is deterministic, mathematically more robust and offers the opportunity to forecast built-up area of the settlements into a more distant future. However, the regression model approach gives average values of a possible range rather than the actual estimates of settlement built-up area.

## Implications of the Findings and Recommendation

The forecast exercise reveals that considerable physical expansion is expected in the satellite settlements in the years ahead and there is the tendency for a consistent trend in the growth of the settlements even in years beyond the forecast period. In his study of rural settlement growth in the Federal Capital Territory, Jinadu (2004) observed a rapid rate of urban expansion in ten satellite settlements between 1994 and year 2001 after Abuja city became fully functional as the administrative capital of Nigeria. The nature of physical development in the settlements was also found to be poor and unplanned with severe implications for the well-being of the residents as well as the existence and functioning of Abuja city.

The implication of the findings of this study is that the considerable expected increases in settlement sizes will generate much physical development activities and the consequent accelerated urban growth will place pressure on infrastructure and the general environment. There is, therefore, the need to prepare for the challenges of the anticipated physical development in the settlements considered. Although the information generated on the expected future growth provides ample data for future planning and development control, one major task is the identification of areas where development is likely to take place so as to be able to plan and guide future development. The direction and pattern of future development in the study area is, therefore, recommended for further studies.

## Conclusion

Forecast models of urban growth and land use change lies in the realm of auxiliary tools to guide and support preventive measures meant to assure safe, comfortable and environmentally sound conditions in the urban areas (De Almeida, 2005). This study has demonstrated how the rating method and regression analysis could be used to estimate future growth of settlements using satellite image data. There is no doubt that Nigeria as a nation needs ample spatial data to plan for both the rural and urban settlements. Urban managers have the responsibility of monitoring urban growth and projection in order to identify problem areas and to proffer planning solutions to deal with anticipated problems. This requirement could be met by making satellite image data available for real time spatial mapping and settlement growth monitoring for the purpose of planning and development control.

## References

Dang, A., Shi, H., and Mao, Q. (2002) "GIS and RS Application Study On Urban Dynamic Development". *Geographic Information Sciences, Vol. 8*, No. 2

De Almeida, C.M. (2005) *Forecast Models for Urban Growth and land Use Change to Assess Human Vulnerability Resulting from Threat to Water Resources.* Brazilian National Institute for Space Research (INPE), Division of Remote Sensing (DSR); Avenida dos Astronauts, 1758 – SERE; Jardin da Granja; Sao Jose de Campos, Sao Paulo, Brazil. pp 1 -17.

Dimyati M., Mizuno, K., Kobayashi, S. and Kitamura, T (1996) "An Analysis of Land use/Cover Change Using the Contribution of Mss Landsat and Land use Map: A Case Study in Togyakarta, Indonesia". *International. Journal of Remote Sensing Vol. 17,* No 5; pp 931 - 944.

Elnazir, R., Xue-Zhi, F and Zheng, C. (2004) "Satellite Remote Sensing for Urban Growth Assessment in Shaoxing City, Zhejiang province". *Journal of Zhejian University SCIENCE, Vol. 5 (9); p1095 – 1101.* http//www.zju.cn/jzus. Accessed on 21st August, 2008

FCDA, (1979) *The Master Plan for Abuja: The New Federal Capital for Nigeria.*International Planning Associates, *pp.* 8, 89 – 90

Jinadu, A.M (2004) *Analysis of Urban Influence on Rural Settlement Growth and Land use/land cover Change in the Federal Capital Territory of Nigeria Using Remote Sensing and GIS Data.* Unpublished Ph.D Thesis, Department Geography, Federal University of Technology, Minna; February 2004.

Herold, M., Menz, G and Clarke, K.C. (2002) *Remote Sensing and Urban Growth Models, Demands and Perspectives.* Department of Geography, University of California, Santa Barbara\Remote Sensing Research Group, Department of Geography, University of Bonn, Germany; http://www.isrg.uni-bonn.de/aufsaetze_pdf/mherold_234_regensb.pdf.

Mehta, H.S. and Sidhu, R.S(1991) "A Systematic Approach for Monitoring Urban Sprawls, Using Space Borne Images – A case study". Proceedings of Asian Conference on Remote Sensing (ACRS); *GIS Development* http://www.gisdevelopment.net/proceedings/index.htm

Okoko, E. (2000) *Quantitative Techniques in Urban Analysis.* KRAF T Books limited.

Pedro, C and Alexandria, Z (2006) "Three Land Change Models for Urban Dynamics Analysis in Sintra – Cascais Area". 1st EARSEel Workshop of the SIG Urban Remote Sensing. Humboldt Universitat zu Berlin; 2 -3, March 2006.

Rao, K. M. L (1995) "Remote Sensing for Land use Planning" *International Journal of Remote Sensing Vol., 16,* No. 1; pp 53 - 60.

Salem, B. B. et al (1995) "Detection of Land Cover Classes in Agro-ecosystems of Northern Egypt by Remote Sensing". *International Journal of Remote Sensing Vol. 16,* No. 14, pp. 2581 – 2593.

Yang, S., Zha, Y and Gao, J. (2001) "Applications of Remote Sensing and GIS to Monitoring of Urban Sprawl: A Case Study in *Wuxi* City, China". *Geographic Information Sciences Vol. 7,* No. 2, December 2001.