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Regression Analysis and the Use of Spot Remotely Sensed Data in Monitoring Environmental Changes

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Abstract: This research paper studied the relationship between urban land use and the impacts of socio-economic activities on the land-use pattern in Warri area of Delta State, Nigeria. it also predicts the changes in land use by December in the year 2006. the area measurements of the various land uses were made by the use of square grids, with a graph sheet with grid squares made up of 25 cells from a Black and White aerial photographs at a scale of 1:10,000 obtained from the Federal Ministry of Land and Surveys and SPOT Multispectral (RGB) of 1994 on a scale of 1:50,000. The data were analysed by the use of regression analysis and the analysis showed an increasing trend of $Yc = -209 + 1.27 X$ with a prediction of 193.76km^2 increment in urban residential, commercial, transportation, industrial, institutional land use by December 2006.

Key words: Regression analysis, land use, changes, prediction, grids, socio-economic, urban

INTRODUCTION

The use of land can be traced to the origin of man. The impact of man right from the time he settled on earth to the present moment has been established in various ways and many changes in the pattern of land use have been remarkably witnessed. These changes according to Adeniyi (1980) in land use are to a large extent reflective of how society respond to socio-economic, institutional and management practices and thus provide essential impute for an objective evaluation of these practices.

According to Kelvin (1972), in order for man to satisfy his diverse needs for food, shelter, recreation and development he must utilize the space around him, in order words man must fill that space with his field, highways, home's parks and wood-lands. From the foregoing, land use refers to the use to which the land is put.

In an attempt to identify the various uses into which land is put, there has been a basic conceptual confusion in differentiating land use and land cover. According to F.A.O (1991), land use has been defined as "man's activities on land which are directly related to the land". Land cover on the other hand, describes "the vegetations and artificial constructions covering the land surface.

Land use comprises mainly of two types categorically, the rural land use and the urban land use. The rural land use is that which is concerned mainly of agro- based activities and other uses into which rural land can be put into such as cultivation purposes, small scale industries meant for pre- processing purposes. Urban land use has varied function into which it is put and these include, residential, commercial, transportation, industrial, institutional recreation, non-urban land, vacant land water (Adeniyi 1980).

Several literatures have been devoted to urban land use analysis. These include those of Avery (1965), Oyelesse (1968) anderson (1976), Ikhuoria (1981, 1989), Onosemuode (2000). The quantitative methods adopted by the above researchers were the determination of the area occupied by the various land use without subjection of the derived data to statistical analysis.

Objectives of this study: The objectives of this study are to:

- Determine if there is a relationship between urban land use and the activities into which it is put.
- Predict the change in land use by the year 2006
- Examine the impact of socio-economic activities on the land-use pattern.

The study area: The location chosen for the analysis of land use changes is Warri which is bounded by latitudes 5°.40' and 5°.50'N and longitude 5° 3' and 5°.34'E. The study area is a make up of three local government areas namely Uvwie, Udu and Warri South Local Government Area. The major settlements are Ekpan, Effurun and

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Table 1: Climatic element

Warri	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Max Wind (M/S)	2.77	2.10	2.10	2.77	2.10	2.77	2.77	2.10	2.10	2.10	2.10	2.10
Max Hum (%)	85	85	85	90	90	89	90	90	90	90	90	90
Max Temp (°C)	34	34	35	36	35	32	30.2	32	31	33.5	34	34
Max Rainfall (mm)	12	12	40	76	76	21	86	86	86	72	30	26

Source SPDC Warri (1999)

Enerhen in Uvwie local government area, Ubeji. Warri and Ode Itsekivi in Warri south local government area and the cornubated part of Udu with Uvwie Local Government Area.

Climatically, Warri is situated in the equatorial region between 5° and 10° North and South of the equator and has the equatorial hot, wet climate with a mean monthly temperature of about 33°C (92°F), the hottest month being 36°C (96°F) new view of this situation therefore, the relative humidity is consistently high, the annual rainfall ranges from 1524 mm to about 2699 mm and is evenly distributed through out the year (Table 1).

The vegetation found in the study area include mangrove and fresh water swamp forest. The mangrove forest appears essentially alike in the physiognomy and its ecological relationship throughout its entire world range.

The inhabitants of the study area are mainly the Urhobos, Itsekiri and Ijaws who are mainly involved in commercial activities. Being a major town in the oil producing area of Delta state has led to the springing up of industrial area which attract the influx of people of different walks of life. This has had a tremendous effect on the land use pattern of the study area which calls for timely data that could be used to predict the change pattern which may occur over a time period.

MATERIALS AND METHODS

Data, data sources and characteristics: The data selected for the study consist of Black and White aerial photographs at a scale of 1:10,000 obtained from the Federal Ministry of Land and surveys and SPOT multispectral (RGB) 231 imagery at a scale of 1:50,000 of 5th January 1994. Collateral information were also obtained from the following sources: Topographical maps: Nigeria 1:50,000 Warri S.W 2 sheet 309 S.W prepared in 1964, street guide of Warri and its environ of 1996 at a scale of 1:25,000.

Development of a classification scheme: Classification of features with regards to their spatial occurrence and distribution is a major theme among the papers prosecuted by the founding fathers of modern geography such as Alexander Von Humboldt and Carl Rilter. Classification enables us to facilitate typification by giving names to things.

Adeniyi (1980) devised an urban land use classification scheme for Lagos which appear to have potential for wider application. There are no universally accepted criteria for mapping land use as any procedure could be adopted to suit the researcher, this depends on the degree of detail requires.

A modification of the Adeniyi classification scheme is adopted in the classification of the land use types as follows

Residential, Commercial, transportation, Industria, institution, Recreation, Non-urban l and, Vacant land and Water. Each of the above classified land uses can further be subdivided into classes but are not of interest in this study.

Analysis of data: The quantification of the 1977 and 1994 land use maps of Warri and its environs are necessary because of its aid in detecting the changes of the various land uses.

The area measurement of the various land uses were made by the use of square grids, with a graph sheet with grid squares made up of 25cells.

In calculating the land use for each period the land use map was land over a graph sheet and the number of cells covered by the land was counted and converted to kilometers. The half or partial cells were counted, divided by 2 and then added to the result of the complete cells.

The total obtained was then related to the scale of the map in order to determine the scale of the map and the size of each classified land use km^2. The results of the land use for 1977 and 1994 are shown on Table 2.

THE USE OF REGRESSION ANALYSIS IN URBAN LAND USE STUDIES

The multiple regression model: Multiple regression analysis operates on the assumption that the relationship between one variable, the dependent variable Y and a host of P other variables xi (I = 1,2,- - -P) called the independent variables may be expressed by an equation of the form

$$Y = b_o + b_1X_1 + b_2X_2 + .. + b_nX_n + E$$

Table 2: Land use categories for 1977 and 1994 and their areas covered in km^2.

No.	Land use category	Area covered (KM^2) 1977	Area covered (KM^2) 1994
1.	Residential	192.25	599.25
2.	Commercial	120.05	464.25
3.	Transportation	6.09	369.2
4.	Industrial	104.83	275
5.	Institutional	147.33	305.36
6.	Recreation	33.40	7.59
7.	Non-urban land	5686.25	4586.05
8.	Vacant land	191.85	62.7
9.	Water	564.62	297.25
	Total	6966.67	6966.67

In this formulation, bo is called the constant term. While b_1, b_2 --, bn are the regression coefficients and E is called the errors term representing the errors that enter the model as a result of some other variables which could not be specified or are inappropriately measured as well as other random effect errors (King, 1969). The regression coefficients are called partial regression coefficient because they describe the values by which y could change as a result of a unit change in the values of the independent variables.

COMPUTING THE COEFFICIENTS

The data used in computing the coefficients are the data derived quantitatively from the land use map of 1977 and 1994, which are shown on Table 2.

The data for 1977 and 1994 land use and their computed regression coefficients are shown on Table 3.

To arrive at the coefficients at column (4) the mean of the data in column (2) were calculated thus:-

$\tilde{Y} = \sum f / N$ = where Σf is the summation of the data in column 2

N = Number of data in column 2

:. $Y = {}^{6966.67}/_{9} = 774$

Similar procedure was carried out on data in column (3) to arrive at the data in column (5). Columns (6) is the product of columns (4) and (5) while columns (7) and (8) are the squares of columns (5) and (4), respectively.

Next is the computation of the regression equation, which is represented thus:

YC = a + bx where a = Y intercept (The value of Yc when x = o)

b. = slope of the regression line (The increase or decrease in Yc for each change of one unit of x)

x = a given value of the independent value

Yc = a computed value of the dependent variable

Using the data on Table 3,

$$b = {}^{?xy}/_{?(x^2)} = {}^{21093844.6}/_{16611318} = 1.27$$

a = Y-bx = 774 – (1.27 (774)

a = 774 – 982.98

a = -208.99

a = -209

From the above, the regression equation which describes the relationship between urban and use and the activities into which its put is-:

Yc = -209 + 1.27 (x)

VERIFICATION OF THE PREDICTIVE POWER OF THE REGRESSION MODEL

In predicting using the regression analytical technique, the THEILIS inequality coefficient is used to test the predictive power of the regressive model.

THEILIS inequality coefficient is represented with the formula below:-

$$U \; \frac{(P_1 - Aj)^{2/n}}{A_1^{\;2/n}}$$

where P_1 is the predicted value of the dependent variable (x) it is the

$A_1{}^2/_n$ actual value of the independent variable (Y) while n is the sample size

The inequality coefficient in this regard assumes a value of between zero and infinity. The smaller the value of the coefficient, the better is the predictive performance of the mode P_1 is equal to A_1. However, where the coefficient is 1, it is indeterminate as no change in the value of the variable is predicted. But if the value of the coefficient assume a value of more than 1, the predictive power of the mode is worse than no change prediction.

The Table 4 shows the expression of the various components of the THEIL'S inequality coefficient.

To obtain the predicted value in column (4) the value of X is substituted in the regression equation-:

Y = a + bx

Y = 209 – 1.27x

= 209 – 1.27 (599.25)

= 209 – 761.05

= -552.50 and so on for the next value of x

Table 3: Land use data of 1977 and 1994 and their computed regression coefficients

(1) Land use category	(2) 1977 Y	(3) 1994 X	(4) y (Y-Y)	(5) x (X-X)	(6) xy	(7) x^2	(8) y^2
Residential	192.25	599.25	-581.75	-174.75	101660.8	30537.	338433.1
Commercial	120.05	464.25	-653.95	-309.75	202561.0	95945.1	427650.6
Transportation	6.09	369.2	767.91	-404.8	310840.1	163863.0	589685.8
Industrial	104.83	275	-669.17	-499	333915.8	249001	447788.5
Institutional	147.33	305.36	-626.67	-468.64	293682.6	218623.5	392715.3
Recreation	13.40	7.59	-760.6	-766.41	582931.5	587384.3	578512.4
Non-urban land	5686.25	4586.05	4912.25	3812.05	1872572.6	14531725.2	24130200.1
Vacant land	191.85	62.7	-582.15	-711.3	414083.3	505947.7	338898.6
Water	504.62	297.25	-269.38	-476.75	128426.9	227290.6	72565.6
Total	6966.67	6966.67			21093844.6	16611318	2731645.0

Table 4:Computed coefficient to test the predictive power of the regression model

(1) Land use	(2) 1977 A_1	(3) 1994 (X)	(4) Predicted Value (P_1)	(5)$(P_1 - A)^2$	(6)A_1^2
Residential	192.25	599.25	-552.05	5539.49	36960.06
Commercial	120.05	464.25	-380.60	250650.42	14412.00
Transportation	6.09	369.2	-259.88	70740.04	37.09
Industrial	104.83	275	-140.25	60064.21	10989.33
Institutional	147.33	305.36	-178.81	106367.30	21706.13
Recreation	13.40	7.59	199.36	34581.12	179.56
Non-urban land	5686.25	4586.05	-5615.28	127724580.3	323334339.06
Vacant land	191.85	62.7	129.37	3903.75	36806.42
Water	504.62	297.25	-168.51	453130.92	254661.53
				129258000.6	32709191.18

$$U = \sqrt{\frac{(P_1 - A_1)^{2/n}}{A_1^{2/n}}}$$

$$U = \frac{129258000.6}{9} = 14362000.06, \text{ app } = 144$$

$$\therefore \frac{32709191.18}{9} = 3634354.58, \text{ app } = 363$$

$$U = \sqrt{\frac{144}{363}}$$

$$= 0.3967$$

$$= 0.4$$

With a Theil's coefficient of 0.4, the predictive power of the model is of a better performance.

With the reliability power of the regression equation, forecast in the relationship between urban land use and the activities into which it is put can be highly dependent upon

PREDICTING THE CHANGE IN LAND USE BY THE YEAR 2006

The change in urban land use by the year 2006 from when it was last estimated in 1994 can be predicted using the regression equation which describes the relationship between urban land use and the activities into which it is put.

The regression equation is

$$YC = 209 - 1.27x$$

The period under prediction that is from 1994 to 2006 is about 12 years. The change then can be calculated thus:-

$$YC = 209 - 1.27\,(12)$$
$$YC = 209 - 15.24$$
$$YC = 193.76$$

From the above predictive figure, by the year 2006 there will be an increase by 193.76 km^2 in urban residential, commercial, transportation, industrial, institutional land use respectively while there will be a decrease by 193.76 km^2 in urban recreational non-urban land, vacant land and water land uses.

It should be noted that the above prediction could not account for which of the land use is taken over by the other. In this regard the trend of economic activities or development of the area under study has a major role to play in explaining which of the land use is taking over the other.

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