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Analysis of Land Use-Land Cover Changes in Zuru and Its Environment of Kebbi State, Nigeria Using Remote Sensing and Geographic Information System Technology

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Abstract

The environment in recent times has been known to be greatly modified through the activities of man and his technology, this research is therefore concerned with the use of Geographic Information System and Remote Sensing techniques in analyzing land use-land cover changes in Zuru and its environment between 1986 and 2008 as a result of human and natural causes. The land use-land cover changes of Zuru and its environment for a period of twenty two years were analyzed using Land sat (TM) imageries of 1986, 1999 and Landsat (ETM) imagery of 2008. The study employed supervised Classification method using software of ILWIS 3.4 and ArcGIS 9.3. The land use-land covers were classified into built up, vegetation, bare surfaces and water body. The result of the work revealed that the period between 1999 and 2008 witnessed reduction in the rate of physical expansion of the city as against 1986 and 1999. Indeed, this may be due to the lost in the zeal to come back home to build but rather preferred to build in cities like Abuja, Kaduna and Sokoto where there were more social amenities than they were available in the study area.

Keywords: GIS, Imageries, Remote Sensing, Land-cover, Land-use

1. Introduction

Man is the most progressive creature on the earth. For his progress he has made many changes on the earth surface such as industrialization, urbanization, farming and construction activities.

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In this competitive world he has migrated from rural areas to urban centres resulting in increase in urbanization and consequently high demand for dwelling places and hence, rapid expansion of cities (Desai, 2009). Land use-land cover change over time is an inevitable phenomenon occurring globally due to both temporary and or permanent interest of the inhabitants in a particular area. The phenomenon could be revealed either in a small or large scale but the most interesting and fundamental observation is that change occurs over time in a particular place.

Land-cover is the biophysical state of the earth's surface and immediate subsurface is the source and sink for most of the material and energy movements and interactions between the geo-sphere and biosphere. Changes in land-cover include changes in biotic diversity, actual and potential primary productivity, soil quality and sedimentation rates and cannot be well understood without the knowledge of land-use change that drives them. Therefore, land use and land cover changes have environmental implications at local and regional levels, and perhaps are linked to the global environmental process.

According to Meyer (1995), land use and land cover are distinct yet closely linked characteristics of the earth's surface. Land use is defined as any form of activity that the land is put to, such as building construction, forestry and agriculture, while land cover implies the physical or natural state of the Earth's surface including water, vegetation, soil and /or artificial structure (Ellis, 2007). Human need of land resources gives rise to land use which varies with the purposes it serves in terms of processing materials, provision of shelter, food production, and recreation. As human population is increasing so also the activities also increases and the society depends on these activities for its survival. Studies so far have shown that only few landscapes on the Earth are still in their natural state. Land use and land cover is a general term that indicates modification of the earth's terrestrial surface. In the past two centuries the impact of human activities on the land has grown enormously, altering entire landscapes, and ultimately impacting the earth's nutrient and hydrological cycles as well as climate, ((Eludoyin, 2011).

Lambin, *et al.,* (2003) highlighted fundamental high-level causes of land use change as; Resource scarcity leading to an increase in the pressure of production on resources, Changing opportunities created by markets, outside policy intervention, Loss of adaptive capacity and increased vulnerability and Changes in social organization, in resource access, and in attitudes.

The use to which we put land (land-use) could be grazing, agriculture, urban development, logging and mining among many others while land cover categories could be cropland, forest, wetland, pasture, road among others.

The term land cover originally refers to the kind and state of vegetation, such as forest or grass cover but it has broadened in subsequent usage to include other things such as human structures, soil type, biodiversity, surface and ground water (Meyer, 1995). Lambin, *et al.,* (2003); Baulies and Szejwach, (1998) defined Land cover by the attributes of the earth's land surface captured in the distribution of vegetation, water, desert and ice and the immediate subsurface, including biota, soil, topography, surface and groundwater, and it also includes those structures created solely by human activities such as mine exposures and settlement

When land use and land cover are treated jointly, they represent both the physical cover and human imprints on the land. Land use-land cover change represents the changes that are occurring over the cover as a result of human modification of its uses. It can also result from human driven natural processes such as climate change. Land use-land cover change can alter the terrestrial ecosystem and its ability to perform its provisioning and supporting services. The land use-land cover pattern of a region is an outcome of natural and socio – economic factors and utilization by man over time. Land is becoming a scarce resource due to immense agricultural and demographic pressure. Land-use and land-cover change has become a central component in current strategies for managing natural resources and monitoring environmental changes.

According to Baulies and Szejwach (1998), during the next decades, land use-land cover dynamics will play a major role in driving the changes of the global environment. Hence, global mapping of irrigated and dry land agriculture, semi-natural areas and forest cover, reflecting their dynamics, can contribute to the assessment of the biophysical implications of land use and land cover change within the earth's system.

Generally, agriculture is found to be the major driver of land cover change in tropical regions. Lambin *et al.,* (2001) pointed this out that degradation, agriculture and grazing are the major courses of land use-land cover changes.

Agricultural expansion and urbanization are the major and proximate causes of land use- land cover change activities in Nigeria (Abbas and Iguisi 2007) so Zuru and its environment with large scale agriculture will not be an exemption.

Remote sensing is the science and to some extent, art of acquiring information about the Earth's surface without actually being in contact with it. This is done by sensing and recording reflected or emitted energy and processing, analyzing, and applying that information. The collection of remotely sensed data facilitates the synoptic analyses of earth system function, patterning, and change at local, regional and global scales over time; such data also provide an important link between intensive, localized ecological research and regional, national and international conservation and management of biological diversity. Remote sensing becomes useful because it provides synoptic view and multi- temporal land use and land cover data that are often required; serves as a tool for environmental resources assessment and monitoring (Abbas and Iguisi, 2007). Geographic information system (GIS) is a computer assisted system for the acquisition, storage, analysis and display of geographic data. It is a computerized tool for performing operations on geographic data with a view to reveal what is otherwise invisible in geographic information (Longley *et al*., 2005). Remote Sensing and Geographic Information System are now providing new tools for advanced ecosystem management.

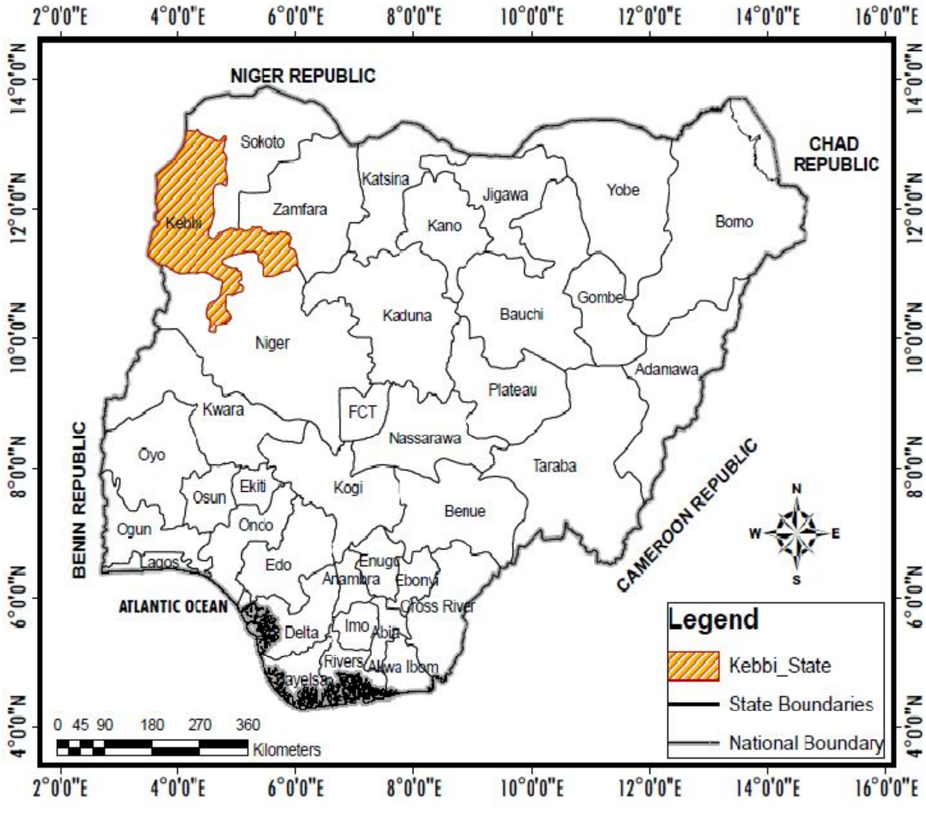
2. The Study Area

Zuru is located in the south eastern region of Kebbi state of Nigeria with a total land mass of 653km². It lies between latitude 10.84^0N to 11.84^0N and longitude 4.45^0E to 6.0^0E. Zuru is bounded in the west by Gwandu and Yauri while in the east it shares boarder with Kuyanbana. Zuru has a population of about 165,547 (National Population Commission, 2006). The major activities in Zuru are farming and rearing of animals. The people of Zuru are often referred to as the “passionately devoted to soil and crop” farmers. Zuru has a favorable climatic condition for growing many crops. The soils are moderately deep, well drained sandy-loam. The average rainfall is about 1825 mm with a mean temperature of 27°C. The wet season is from April to October.

The area experiences a period of harmattan from the months of December to February. Zuru is a savanna kind of vegetation which is transitionally in between northern guinea savanna and Sudan savanna with pockets of woodland vegetation along river basins and is covered by more or less continuous grass cover, but in some parts tree growth suppresses the grass growth.

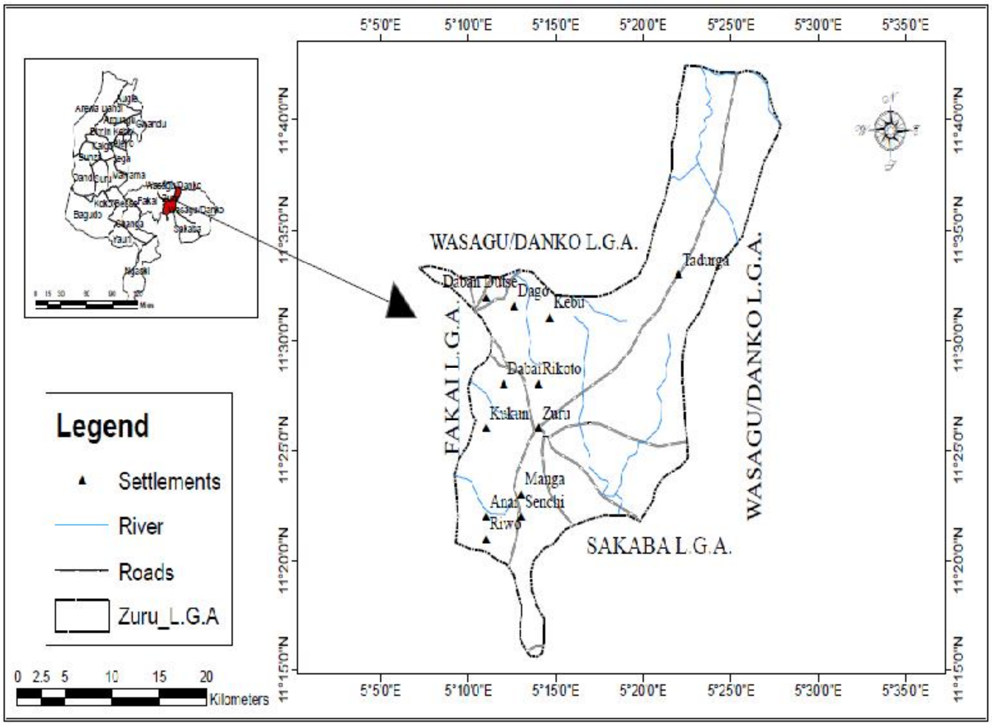
The study are lies on the plains of northern Nigeria, the topography of Zuru is undulating, with a height of about 350 to 1000m above the mean sea level. Zuru is boarded with highlands traversing western side for a substantial distance and in the east is relatively flat with doted isolated granites and inselberg hills. It is naturally well drained area with sedimentary rocks providing cultivatable lands in the lower and eastern regions.

Fig. 1: Map of Nigeria Showing Kebbi State that Harbors the Study Area



Source: GIS Analysis

Fig. 2: The Study Area



Source: GIS Analysis

3. Materials and Methods

The data used for the LULC analysis of the study area were based primarily on LandSat 5 Thematic Mapper (TM) of 1986, 1999 and Enhanced Thematic Mapper (ETM+) of 2008. The 1986 imagery was acquired in the rainy season (August) while 1999 and 2008 imageries were acquired in January and September respectively. Imageries were obtained from Global Land Cover Facility (GLCF) and Earth Science Data Interface.

The images were geometrically corrected to Universal Transverse Mercator (UTM) coordinate system. Ground Control Points (GCPs) were collected to aid different steps of image processing and classification for change detection. Besides this, field observation was made to have better information about the nature of the various land uses and land covers.

ArcGIS 9.3 was used for Geo-referencing, displaying and subsequent processing and enhancement of the image. It was also used for the sub-setting of Zuru from the whole of Kebbi State imagery using both the administrative and local government maps.

The method of classification used was supervised classification. Based on the priori knowledge of the study area for over 20 years and a brief reconnaissance survey with additional information from previous research in the study area, a classification scheme was developed for the study area after Anderson *et al.,* (1976). The classification scheme developed gave a rather broad classification where the land use-land cover was identified by a single digit. ILWIS3.4 software was also used to compliment the display, processing and classification of the data in to different classes.

The interpretation phase was preceded by establishing preliminary legend. The 1986 Landsat imagery depicts a situation that existed 13 years before Landsat imagery of 1999. Hence, the accuracy of the 1999 Landsat imagery could not be checked against the ground truth, but the available historical data for the area was used to validate the interpretation made. However, the 2008 Landsat 7 (ETM+) image was directly checked against the ground truths. Maximum likelihood Classifier was used to identify the land use types.

The magnitude change for each LULC class was calculated by subtracting the area coverage of the second year from that of the initial year as shown in the equation 1:

Magnitude = magnitude of the New Year - magnitude of the previous year…………………………………1

Percentage change (trend) for each LULC type was then calculated by dividing magnitude change by the base year (the initial year) and multiplied by 100 as shown in equation 2:

Trend = Magnitude of change x 100

Base Year ………………………………………………………………………2

In obtaining annual rate of change for each LULC type, the trend (percentage change) was divided by 100 and multiplied by the number of study year 1986 – 1999 (13years), 1999-2008 (9years) as appropriate using following equation 3.

Annual rate of change =Trend x Difference in the study year ……………………………………………..3

4. Results and Discussion

The land use-land cover statistics of Zuru for 1986, 1999 and 2008 is as shown in table 1,

Table 1: Land Use-Land Cover Distribution of Zuru for 1986, 1999 and 2008

	1986		1999		2008	
Land use	Area (km²)	Area %	Area (km²)	Area %	Area (km²)	Area %
Bare Surface	9.25	25.31	14.24	38.95	14.4	48.41
Built-up area	1.54	4.21	5.35	14.63	7.76	10.01
Vegetation	24.36	66.65	15.39	42.10	13.00	38.29
Waterbody	1.40	3.83	1.58	4.32	1.20	3.28
Total	36.55	100	36.56	100	36.56	100

Source: GIS Analysis, 2013

In 1986, bare surface was 9.25km² (25.31%), built-up area had 1.54km² (4.21%), vegetation which was the largest of all the classes occupied 24.36km² (66.65%) and the water body with the lowest proportion occupied 1.4km² (3.83%) of the total area. This can be seen in table 1, figures 3 and 4.

In 1999 as shown in table 1, figures 3 and 5, bare surface increased to 14.24km² (38.95%) this was as a result of bush clearing for farming and construction activities taking place rapidly in the study area, built-up increased rapidly to 5.35km² (14.63%) as a result of the creation of Kebbi state because of the enthusiasm by the inhabitants to go back home to develop their state. Vegetation decreased to 15.39km² (42.10%) this is obvious because of the increase in bare surface and built-up area.

Water body increased to 1.58km²(4.32%) which may be as a result of heavy rainfall experienced in the period the image was captured.

From table 1, figures 3 and 6, it can be observed that in the year 2008, bare surface increased to 14.4km²km (48.41%) though the increase was very insignificant, it could still be as a result of increase in farming and construction activities, built-up increased to 7.76km² (10.01%) a little increase over the previous year which could be due to the reduction in people's zeal to come back home to build as a result of disappointment in the rate at which the infrastructure were been developed in the area. Vegetation decreased to 13.0km² (38.29%) this little decrease was obvious because of the little bush clearance for farming and construction; water body decreased to 1.2km² (3.28%) due to encroachment of farming activities and building around the water body and marshy areas.

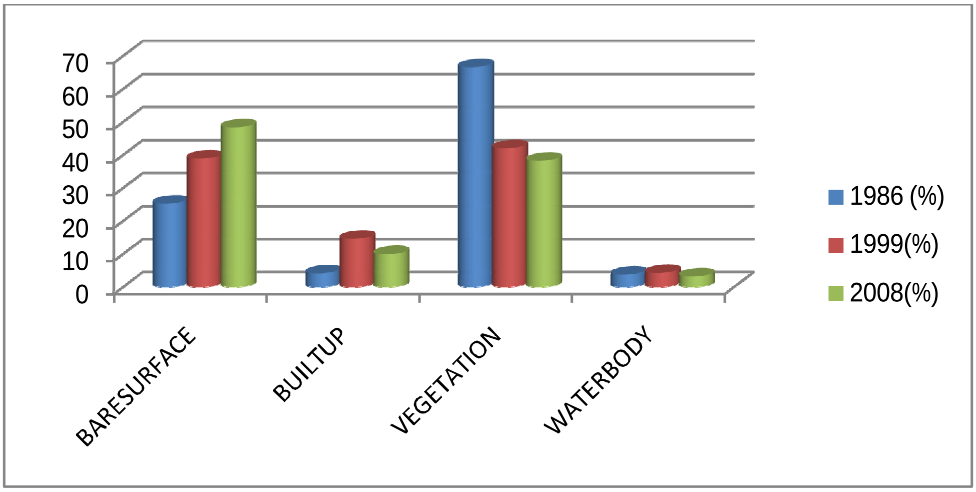
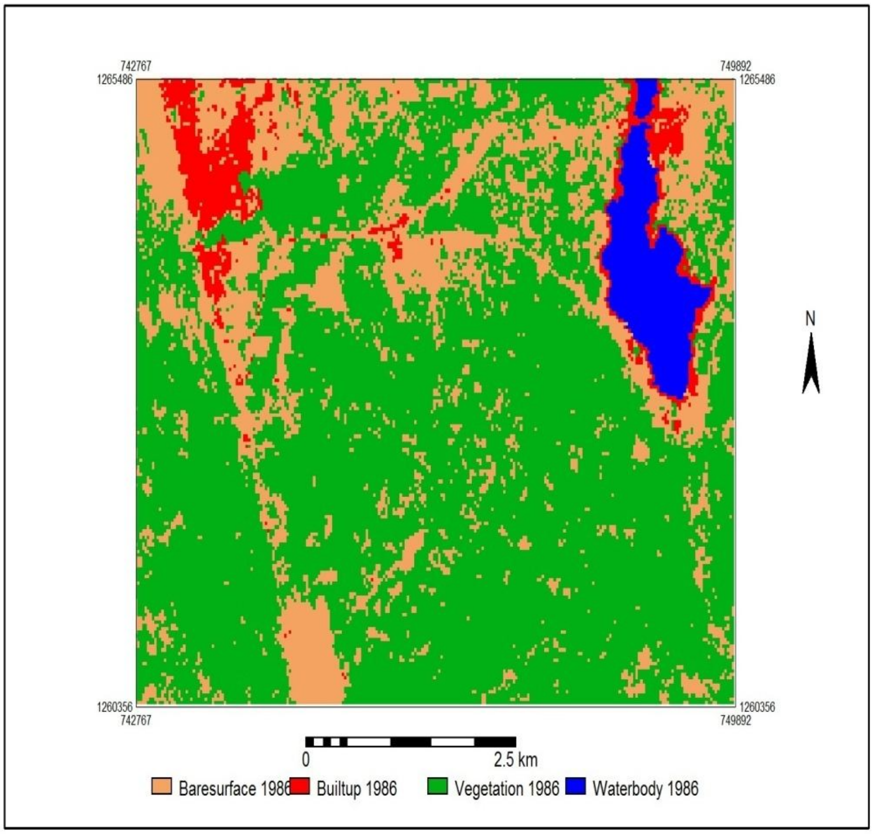


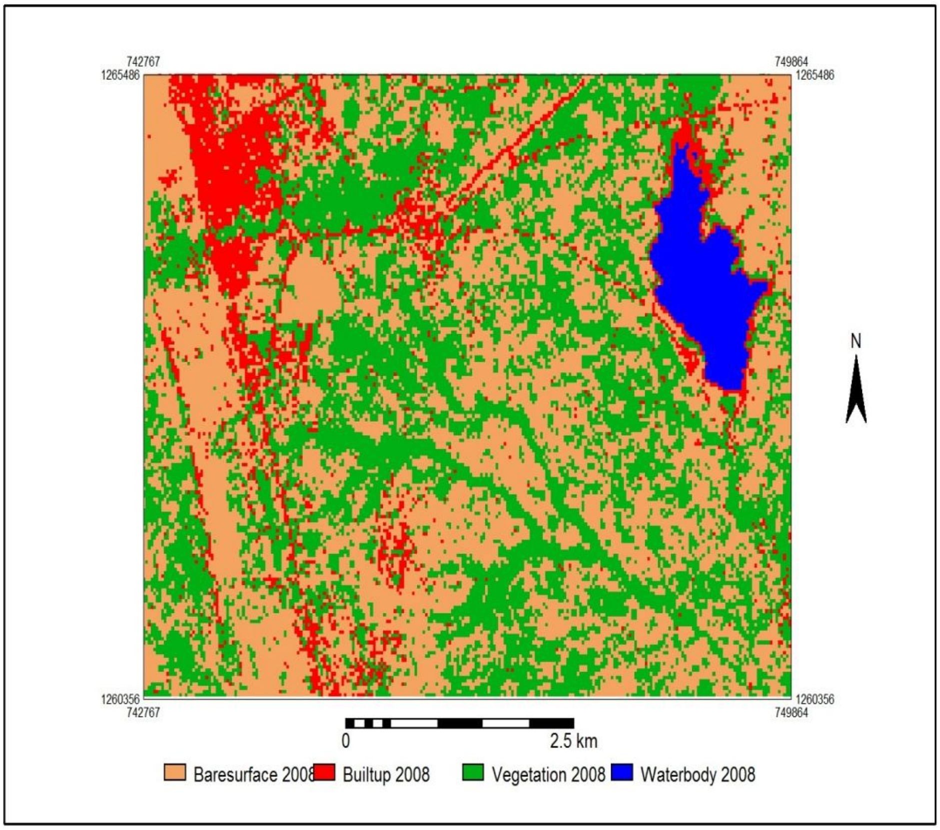
Fig. 3: Graphical Representation of the Land Use-Land Cover Changes in the Study Area (1986, 199 And 2008)

Figure 4: Land use-land Cover of Zuru in 1986



Source: GIS Analysis 2013

Figure 6: Land use-land cover of Zuru in 2008



Source: GIS Analysis 2013

4.1. Land Use-Land Cover Changes

The land use-land cover change is presented in kilometer square and percentage as shown in table 2.

Table 2: Land Use- Land Cover Change (1986-2008)

	1986-1999			1999-2008			1986-2008		
LULC Types	Magnitude (km²)	%	Change rate	Magnitude (km²)	%	Change rate	Magnitude (km²)	%	Change rate
Bare surface	4.99	53.9	.38	0.36	2.5	0.04	5.35	57.8	0.41
Built-up area	3.81	247.4	.29	2.41	45.0	0.26	6.22	403.9	0.48
Vegetation	-8.97	-36.8	0.69	-2.39	-15.5	-0.27	-11.36	-46.6	-0.87
Waterbodies	0.18	12.9	.01	-0.38	-24.1	-0.04	-0.20	-14.3	-0.02

Source: GIS Analysis, 2013

Figure 4 which is the map of the study area, shows the spatial variation in the land use- land cover for the two epochs as represented in table 2. The post 1986 period depicts an analysis up to year 1999 revealing a drastic change in the normal course of urbanization. The year records the built-up areas increased rapidly by 247.4 per cent between 1986 and 1999, while between 1999 and 2008 shows a gradual increased in built up. The study also revealed that the year 2008 has shown a remarkable growth of built up areas in large sized settlements away from the city limits

4.2. Trend, Pattern and rate of Change

The rate at which each class was changing per year is tabulated and is as shown in table 2:

The period between 1999 and 2008 witnessed a drop in the rate at which the physical expansion of the city was going on as against 1986 and 1999.

For instance, the built-up land only increased by 5% per year as against the 19% per year increase between 1986 and 1999. Indeed, the process has led to the elimination of vegetated land mostly towards the eastern and southern outer limits of the city. The growth of built-up areas was mainly towards the east- west route in a linear pattern. The eastern section also recorded growth in the built up area population. The rest of the area depicts dispersed built-up land pattern.

The period 1986 – 1999 resulted in a rapid decline in the water bodies mainly because of the process of acquisition and occupancy of land by the dwellers through land reclamation. Generally, land transformation caused a hike in urban land prices. The study is therefore an important step towards examining land use-land cover change realizing that the land acquisitions were taking place at a fast rate and if sustainable management system is not put in place a major sprawl crisis will happen.

5. Conclusion

This research work demonstrates the ability of GIS and Remote Sensing in capturing spatial-temporal data for land use-land cover change analysis. There is likely going to be crowding in Zuru if the scenario is left unchanged. This situation will have negative implications in the area because of the associated problems of crowdedness like crime and easy spread of diseases. Indeed, between the period of 1986 and 2008, there has been significant increase in Zuru. The changing land use-land cover process has led to the elimination of vegetated land with rapid decline in the water bodies mainly because of the process of acquisition and occupancy of land by the dwellers leading to high financial land value.

After the initial increase in Vegetated land before 1986, the city has witnessed a steady drop in this class and indeed, may continue in this trend if not checked. In other to check this scenario, it is suggested that a deliberate attempt should be made by the government to reverse this trend to avert the danger of serious major food insecurity.

There is a possibility of overcrowding in the near future, It is therefore suggested that encouragement should be given to people to build towards the outskirts, through the provision of incentives and forces of attraction that are available at the city center in these areas to avoid the problem of overcrowdings.

A lot still needs to be done in the area of land use and land cover change mapping particularly for effective land management and sustainable development, and hence, this calls for an urgent need for the use of some modern methods of digital image interpretation for proper management of land in Zuru.

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