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Change Detection Analysis of Land use and Land cover In Kafanchan, Kaduna State

Musa[1], J., Yunusa [2],M.B., Adamu[3], M. ,Mohammed[4], A.
[1,2,3]*Department of Geography, Federal University of Technology, Minna, Nigeria*
[4] *Ibrahim BadamosiBanbangidaUniversity, Lapai, Nigeria.*

Abstract: *This research involves the examination of how changes occurred on land use and land cover of Kafanchan within the period of two decades (1986 – 2014). The satellite imagery used was Landsat TM for the year 1986, 2000 and Landsat ETM+ for the year 2014. These imageries were separately classified in to various land uses. The result shows a rapid growth in built-up areas from 1986 to 2007. During these years , Vegetation cover has decreased seriously from 2641.85ha in 1986 to 1182.51ha in 2014 and bare surfaces also decreased from 1837.08ha in 2000 to 913.68ha in 2014. These changes came as a result of increase in human population and their corresponding diverse activities on land thereby modifying the environment negatively or positively through climate change, deforestation, and other form of development as observed by the researcher. Recommendation were made that Satellite imageries should be taken consistently with defined time interval to aid a closer and up to date monitoring of changes in the environment and Land use mapping should frequently be carried out to meet the rising need of planning*.

I. Introduction

Background of the Study

Rapid growth in population andurbanization has induced numerous environmental problems. It has brought about changes in land use and environmental pattern which may impose either positive or negative effect on the land (Enger and Smith, 2006).

A large proportion of the world's land surface has been changed by the activities of man and his domesticated animals (cultivation, overgrazing, lumbering,mining,construction), but in our modern world, significant amount has been covered with buildings, streets,highways and other products of the society (Abaje, 2007). Over a period of time, changing population and commercial activities often necessitate demand for land and change in land use plan. As human population increase so also does the activity of man in the environment for survival.

With the shift of man's activities from hunting to farming of food crops and husbandry, the face of the earth has changed, with destruction of delicate balances and interplays of nature.Farming led to the creation of settlements and consequently, urbanization. With the advent of new technologies over the years, man has tried to make life more conducive for himself; these pursuits for a better life came at a great cost with forest being cleared, grasslands ploughed, dams built and cities constructed.

World over, population growth has brought about changes in the status of settlements. Villages are becoming towns, towns are becoming cities and cities are fast changing into mega cities. This change is known as the concept of urbanization. Urbanization is a complex process of change of lifestyle from rural to urban ones.It can be defined as the changes that occur in the territorial and socio-economic progress of an area including the general transformation of land use categories from being non-developed to being developed (Weber, 2011).

Environment planning date back to when man began domesticating animals and propagating crops with the advent of industrial revolution in the 18th century came an increase in world population due to improved health facilities which reduced death rate, thus giving way for increasing birth rate and advancement in science and technology which enabled man to make machines which explore and exploit his immediate natural environment for the production of commodity which improves his livelihood. These factors lead to an increase in pressure of the environment leading to environmental deterioration. This has necessitated the concept of environmental awareness which brought about a new field of study known as environmental science, focusing on proper environmental management. Remote sensing and Geographic Information System (GIS) falls under this field of study and these aids quantitative and literature analysis of spatial data. Remote sensing is a technique or an act of capturing the pictures of an object without the sensor coming in contact with the object.

The land use and land cover pattern of a region is an outcome of natural and socio – economic factors and their utilization by man in time and space. Land is becoming a scarce resource due to immense agricultural and demographic pressure. Hence, information on land use and land cover and possibilities for their optimal use is essential for the selection, planning and implementation of land use schemes to meet the increasing demands for basic human needs and welfare. This information also assists in monitoring the dynamics of land use resulting out of changing demands of increasing population (Zubair, 2006).

Land use and land cover change has become a central component in current strategies for managing natural resources and monitoring environmental changes. The advancement in the concept of vegetation mapping has greatly increased research on land use and land cover change thus providing an accurate evaluation of the spread and health of the world’s forest, grassland, and agricultural resources has become an important priority (Zubair, 2006).

Viewing the Earth from space is now crucial to the understanding of the influence of man’s activities on his natural resource base over time. In situations of rapid and often unrecorded land use change, observations of the earth from space provide objective information of human utilization of the landscape. Over the past years, data from Earth sensing satellites has become vital in mapping the Earth’s features and infrastructures, managing natural resources and studying environmental change (Zubair, 2006).

Remotely sensed data are capable of only measuring energy reflected off, emitted from physical substances from a distance (Ridd,1995) while Geographic Information System (GIS) refers to a system of software and procedures designed to support the capture, management, manipulation, analysis, modeling and display of spatially referenced data for solving complex planning and management problems (Rhind,1989). Hence geographical Information refers to any data which relates to specific location on the earth surface. It includes data on natural resources, land use, utility distribution, urban structure, pollutants and waste disposal etc. merging these two technologies has resulted in a great increase in information about man and his environment for any kind of user (Jeffrey *et al.*, 1984).

The combination of remote sensing and GIS technique can provide spatially consistent and detailed information about urban service structure, permitting more accurate representation and understanding of urban growth process (Deng *et al.*, 2009). They have been recognized as powerful and effective tools for detecting the spatio-temporal dynamics of landscape changes of various scales (Geri, Amici and Rocchini, 2010; Serra, Pons and Sauri, 2008).

Remote sensing and GIS tools will therefore be used to analyze the urban expansion of kafanchan area of Kaduna state and its effect on landuse and landcover.

Objectives

i. Identify various landuse and landcover types existing within the period of 1986 to 2014.
ii. Examine the trend, nature and magnitude of landuse and landcover change that has occurred in the study area within the period of 1986 to 2014.

II. Study Area

Location

Kafanchan is located in Jama’a Local Government Area of Kaduna State; it is a town in southern Kaduna in North-Central Nigeria and also the headquarters of Jama’a Local Government. It has a geographical coordinate between latitude $9^{o}33\,'30''$to $9^{o}36\,'30''$North and longitude $8^{o}\,16\,'0''$ to $8^{o}\,20\,'0''$East with an elevation of 739km (2,425 feet) and a time zone of WAT (UTC+1). It is the junction station of the Nigerian railway cooperation and it sits on the line connecting port-Harcourt, Enugu, Kuru, Bauchi and Maiduguri. It is bounded by Sabo to the northeast, UngwanMadaki to the north, Kwarabe to the southeast and Gigira to the southeast. Kafanchan is dominated by the kanikon people known as the nikyop and the minor fantsuam. (en.wikipedia.org\wiki.kafanchan).

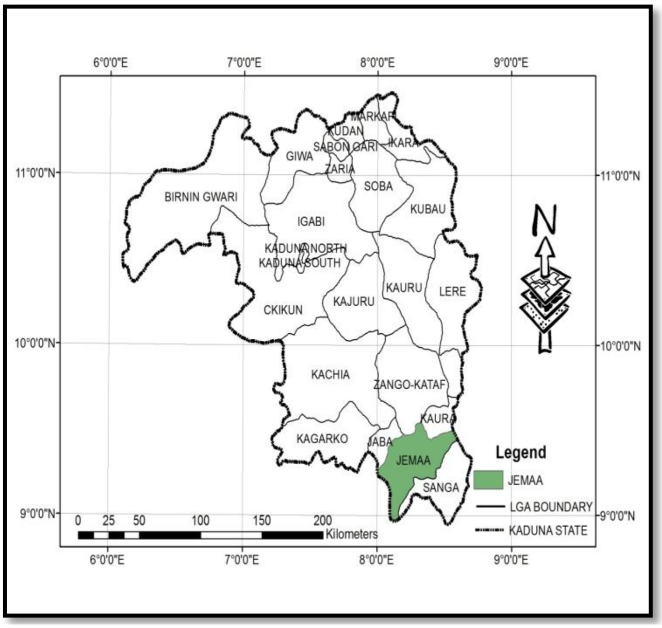

Figure 1: Location of Jama'a in Kaduna State

Source: Kaduna State Ministry of Lands and Survey, Kaduna State

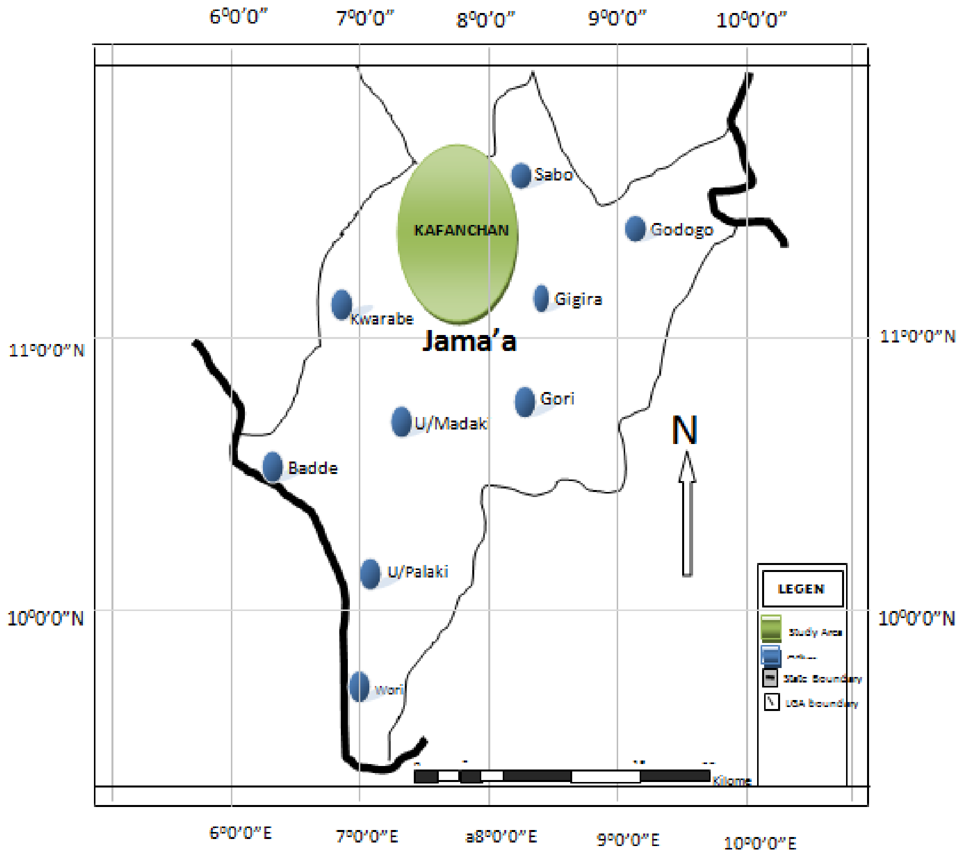

Figure2: Location of Kafanchan in Jema'aLGA, Kaduna State

Source: Kaduna State Ministry of Lands and Survey, Kaduna State

III. Research Methodology

Field Work

The field work includes the following:Reconnaissance survey to get a general idea of the area features and accessibility, Checking sample points and checking unresolved cases; after checking the polygons they were designed in appropriate classification code.

Secondary data

The secondary sources of data used in this research were satellite imagery of the study area, relevant texts and material of remote sensing in journals andtextbooks. Land use and land cover classification were done. This includes designing land use and land cover classification scheme based on the available data source, defining the different land use and land cover classes. Satellite imageries of 1986, 2000 and 2014 were acquired and were used to set the minimum delineation unit for classifying the different land use and land cover.

Method of Data Analysis

Three main methods of data analysis adopted to identify changes in land use types in this study are:

- Calculation of the area in hectares and percentage of the resulting land use and land cover types for each study year and subsequent comparing of the results.
- Marcov chain analysis and cellular Automate for predicting change.
- Maximum likelihood classification.

The comparism of the land use and land cover statistics assists in identifying the percentage change, trend and rate of changes between 1986, 2000 and 2014.

In achieving this, the first task was to develop a table showing the area in hectares and percentage change for each year (1986, 2000 and 2014) measuring against each land use and land cover types, percentage change to determine the trend of change can then be calculated by dividing the observed change by the sum of the change and multiply by 100.

(Trend) Percentage Change= $\frac{observedc\ hange}{sumofc\ hange} x\ 100$

In obtaining annual rate of change, the percentage change is divided by 100 and multiplied by the number of the study year (1986, 2000 and 2014) which is ten (14) years interval.

Going by the Markov Chain Analysis and Cellular Automata, Markov Chain Analysis is a convenient tool for modeling land use change when change and processes in the landscape are difficult to be described. A Markovian process is one in which the future state of a system can be modeled purely on the basis of immediately preceding state. Markov Chain Analysis will describe land use changes form one period to another and use this as a basis to project future change. This is achieve by developing a transition probability matrix of land use change from time one to time two, which show the nature of change while still serving as the basis for projecting to a later time. The transition probability may be accurate on per category basis but there is no knowledge of the spatial distribution of occurrence within each land use category. Hence, Cellular Automata, Markov use the output from the Markov chain analysis particularly transition area file to apply a contiguity filter to grow out land use from time two to a later time. In essence the cellular automata will develop, especially explicit weighting more heaving area that proximate to existing land use classes and not wholly random.

Overlay operation will help to identify the actual location and magnitude of change, although it will be limited to built-up land been constructed as a result of this development. Considerable area of bare surface in 1986 has been taken over by building. These changes are show on the map.The last method of analysis which is the maximum likelihood classification is the most advance classifier but it requires a considerable amount of computation time. As computer has become faster and powerful, maximum likelihood is now the most widely use. It takes into account the average digital number valves of the training areas. The variance used to estimate the probability of membership for a certain land cover class. Maximum likelihood classifier is very powerful and it is sensitive to the quality of an area. The likelihood probability is compared based on the assumption that the training data have a multivariate, normal or Gaussian frequency distribution.

IV. Results And Discussion

Results from Satellite Imagery

Land use and land cover changes of Kafanchan in 1986

Figure 3 shows the land use and land cover map of Kafanchan in 1986 and is classified into four (4) land use and land cover types. These are built-up area, vegetation, bared surface and water body.

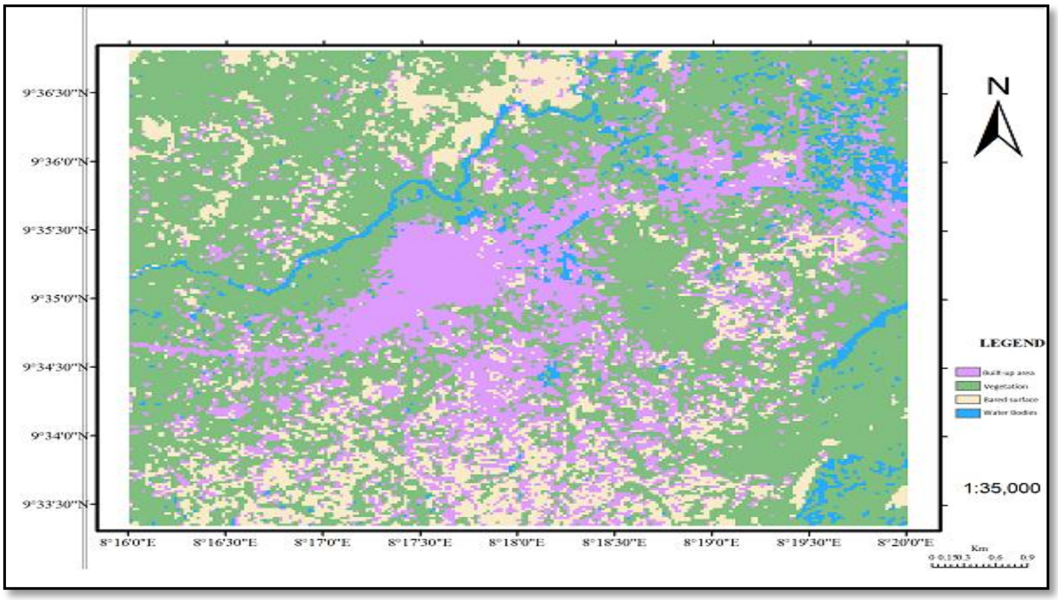

Fig. 3: Classified Landsat (TM) Satellite imagery of Kafanchan in 1986

Source: National Centre for Remote Sensing, Jos (2014)

Table 1: Land use distribution of Kafanchan for 1986

Land Use Type	**Area (Ha)**	**Percentage (%)**
Buit-up Area	1094.85	23.4
Vegetation	2641.23	56.5
Bared Surface	748.8	16.0
Water Body	192.6	4.1
Total	**4677.48**	**100**

Source: Field Work, 2014

Table 1 shows that built-up area occupied 23.4% (1094.85 ha) of the total land area for the study year. Vegetation had the highest percentage occupying 56.5% (2641.23 ha) of the total land area. This could largely be attributed that the major activities that took place in Kafanchan as of then was farming and forestry. It would also be observed that bare surface occupied 16.0% (748.8, ha) and lastly water body occupied 4.1% (192.6, ha).

Landuse and landcover changes of Kafanchan in 2000

Figure 4 shows the landuse and landcover map of Kafanchan in 1998 and is classified into four (4) landuse and landcover types. These are built-up area, vegetation, bared surface and water body.

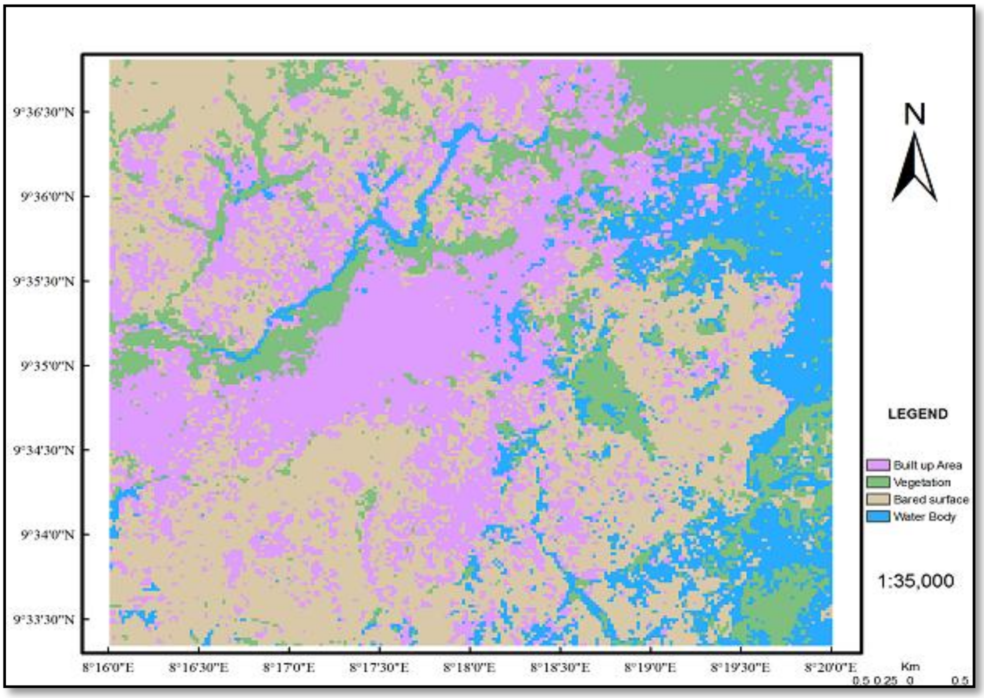

Fig 4: Classified Landsat (TM) Satellite Imagery of Kafanchan in 2000
Source: National Centre for Remote Sensing, Jos. 2014

Table 2: Land Use Distribution of Kafanchan for 2000

Land Use Type	Area (Ha)	Percentage (%)
Built-up Area	1467.63	31.4
Vegetation	730.89	15.6
Bared Surface	1837.08	39.3
Water Body	641.88	13.7
Total	**4677.48**	**100**

Source: Field Work 2014

Table 2 showed that built-up area rose substantially from 23.4% - 31.4%, occupying 1467.63 hectares of the total land area. This could be attributed to more migrants trooping into the town to engage in differentactivities (primary and secondary). A practical example of this activities include the aquamarine (Koranda) mining in Nisama and other neighboring villages of Jama'a local government and the location of Kafanchan as a Junction station of the Nigerian Railway Corporation. Vegetation drastically reduced from 56.5%-15.6%. This could be said to be due to higher demand of fuel wood by inhabitant and/or clearance for other uses.

Bare surface for the study year increased significantly from 16.0%-39.3%. This could be said that the Landsat imagery of 2000 for the study area was taken in the dry (harvest) season, when the land surface is stripped of vegetation. The percentage for water body rose from 4.1%-13.7%.

Landuse and Landcover Changes of Kafanchan in 2014

Figure 5 shows the landuse and landcover map of Kafanchan in 2014 and is classified into four (4) landuse and landcover types. These are built-up area, vegetation, baresurface and water body.

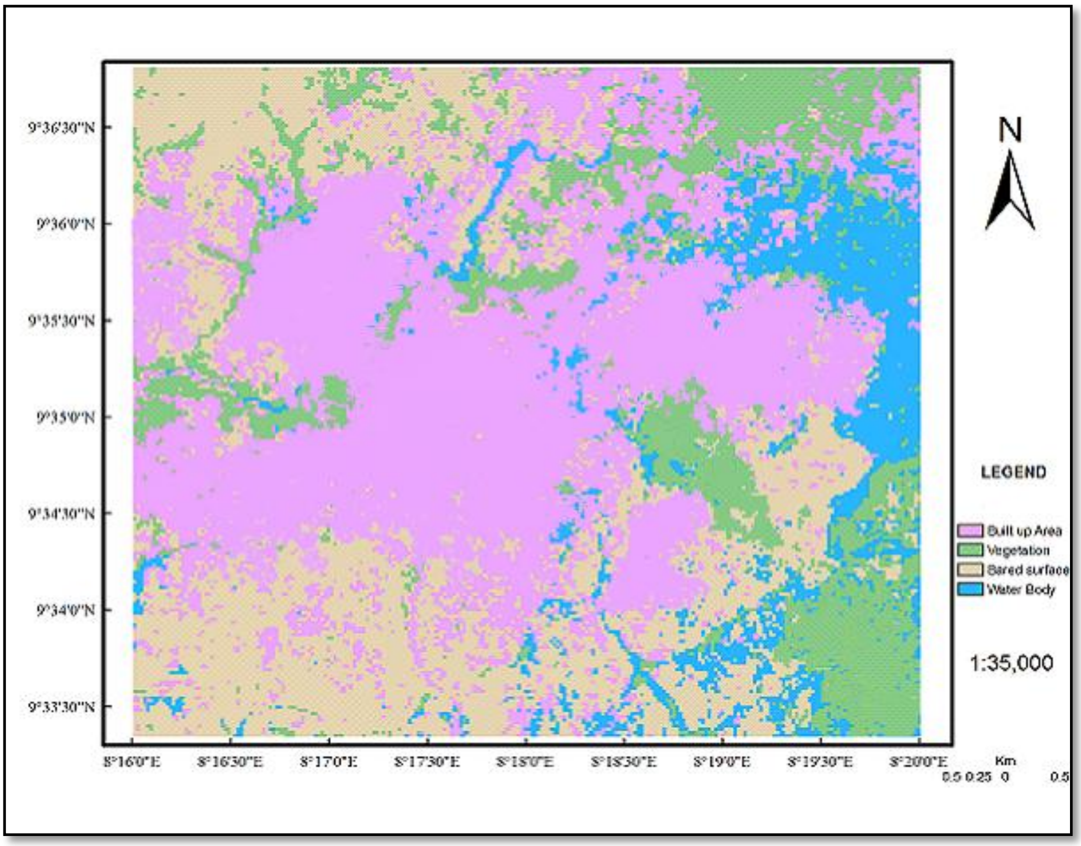

Figure 5: Classified Landsat (ETM+) Satellite Imagery of Kafanchan in 2014
Source: National Centre for Remote Sensing, Jos(2014)

Table 3: Land Use Distribution of Kafanchan for 2014

Land Use Type	Area (Ha)	Percentage (%)
Built-up Area	2067.75	44.2
Vegetation	1182.51	25.3
Bared Surface	913.68	19.5
Water Body	513.54	11.0
Total	**4677.48**	**100**

Source: Field Work, 2014

Table 3 showed that built-up area occupied the highest proportion of the total land area for the study area. It occupied 44.28% (2062.75 ha). This is an evident of urban expansion and other product of society (High-ways, road construction). Vegetation drastically increased from 15.6%-25.3%. This could be due to afforestation of the forest/reserve areas.

It should be noted that both natural and artificial (forest and cultivated land) vegetation are grouped under one class. This is strictly because of lower resolution of the imageries which could not be properly viewed for the classification. Bare surface reduced from 39.3% - 19.5%. This could be attributed to competition for space for other uses; and as a result of mass buildings erupting in the town to support the ever increasing population. Water body which was 13.7% dropped to 11.0%.

Changes between the Periods of 1986-2014

Change in this study refers to the expansion and contraction of the various land use types. The changes focused more on Built-up area; change detection map was produce to detect the changes that occur between 1986 to 1998 and 2000 to 2014. Figure 6 shows change detection map of 1986 to 2000 and figure 4.3 shows change detection map of 2000 to 2014.

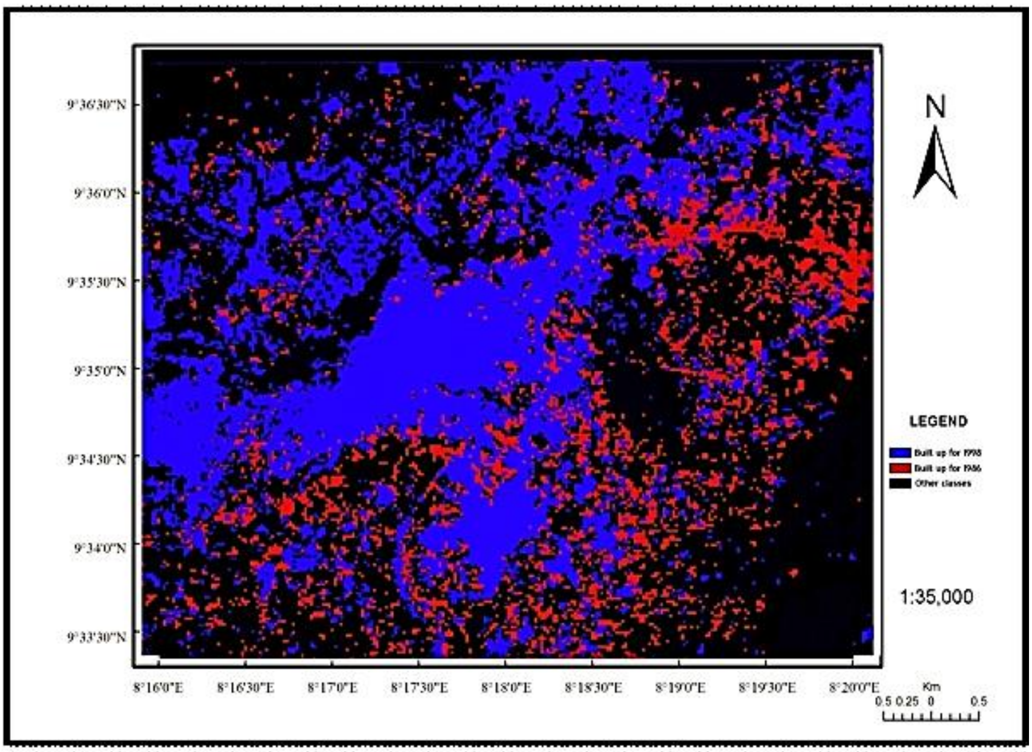

Figure 6: Change detection map between 1986-2000

Source:Field Work, 2014

Thus the changes become easy and direct. The amount of change was calculated and represented with a chart in figure 6, Built-up area recorded the highest amount of change from 2000 to 2014. Other classes reduced.

This indicates that urban development in terms of increase in the built up areas has seriously affected natural resource, vegetation decreases as a result of human activities. A lot of new buildings had been constructed as a result of this development. Considerable area of vegetation was cleared. These changes are shown on the map.

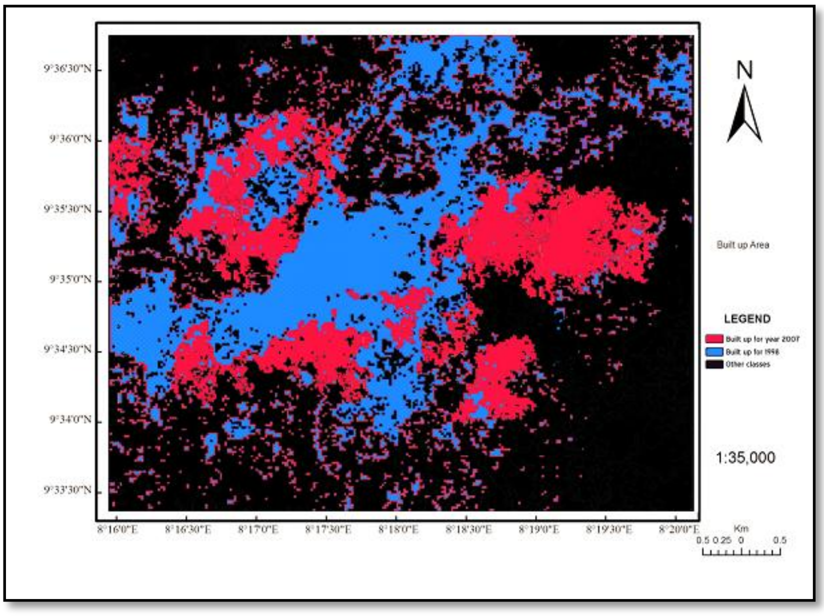

Figure 7: Change detection map between 2000-2014

Source: Field Work, 2014

Table 4: Landuse Change Detection

Land Use Type	1986		2000		2014	
	Area (Ha)	**Percentage**	**Area (Ha)**	**Percentage**	**Area (Ha)**	**Percentage**
Built-up Area	1094.85	23.4	1467.63	31.4	2067.75	44.2
Vegetation	2641.23	56.5	730.89	15.6	1182.51	25.3
Bare Surface	748.8	16.0	1837.08	39.3	913.68	19.5
Water Body	192.6	4.1	641.88	13.7	513.54	11.0
Total	**4677.48**	**100**	**4677.48**	**100**	**4677.48**	**100**

Source: Field Work, 2014

Figure 4.6: Land Use Changes of Kafanchan (1986-2014)

Source: Field Work, 2014

Thus the analysis of change becomes easy and direct. The amount change was calculated and represented with a chart. From the tables Vegetation and Built-up recorded the highest amount of change, Vegetation decrease seriously from 56.5% in 1986 to 25.3% in 2014, Bared surface drastically decrease from 39.3 in 2000 to 19.5 in 2014.

This indicates that landuse and landcover changes in urban development in terms of increase in the settlement and individual buildings. A lot of new buildings had been constructed as a result of this development. Considerable area of bare surface in 1998 has been taken over by buildings. These changes are shown on the map.

Clustered area land which depicts unplanned residential land with structures erected haphazardly recorded a percentage increase. This area is characterized by numerous footpath and minor routes all over the place, with poor social amenities and poor waste disposal.

V. Discussion Of Results

Due to the fact that the satellite imageries used were of different years slight problems were encountered. The scale of the 1986 and 1998 Landsat Imagery were of a better resolution than the 2007. The landuse categories that were mapped out were more generalized than that of 2007. Road were too small to be mapped out or were not identified on the Image. So it is difficult to say exactly how much of such changes occurred within the study area. In other words due to the difference in scale, errors are likely to arise on the landuse change map. Errors may have also come from the technique used in calculating the area coverage for each landuse category. However, the landuse map produced provides adequate information of the general landuse of the area as well as gives an idea of the rate of development.

Kafanchan which was once very sparsely populated and considered as rural has changed significantly. As mentioned earlier, this is basically due to the general increase in population. There is likely going to be crowdedness brought by compactness in Kafanchan come the near future. This situation will have negative implications in the area because of the associated problems of crowdedness like crime and easy spread of diseases. 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. Indeed, between the period of 1986 and 1998, there has been a reduction in the spatial expansion of Kafanchan compared to the period of 2007. There is a possibility of continual reduction in this state over the next few years. This may therefore suggest that the city has reduced in producing functions that attracted migration into the area. Indeed, there have been many defunct industries within this period. Vegetation has been steady in reduction between 1998 and 2007 and in deed; this may likely be the trend in the future. It will be in the good of the State and indeed, the Nation as a whole if the moderate reduction in bare surface land observed in-between 1986 and 2007 which is also projected in the future is upheld. Also, land absorption coefficient being a measure of consumption of new possible changes by each unit increase in urban population which was high between 1986 and 1998, reduced between 1998 and 2007. This therefore observes that the rate at which new lands are acquired for development is low. This may also be the trend in future as there seems to be concentration of development at the city center rather than expanding towards the outskirts. This may be as a result of people's reluctance to move away from the center of activities to the outskirts of the city.

VI. Conclusion And Recommendations

Conclusion

The use of satellite imagery has made the mapping of land cover much more practical. Currently, it is possible to look at land cover from global to local scale.In the analysis of this study, it shows that significant changes have occurred in Kafanchan over the past 21 years (1986-2007).

Recommendations

Based on the findings in this study, the following recommendations are made:

1. Satellite imageries should be taken consistently with defined time interval to aid a closer and up to date monitoring of changes in the environment.
2. Land use mapping should frequently be carried out to meet the rising need of planning.

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