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Mapping Land Use-land Cover and Change Detection in Kafur Local Government, Katsina, Nigeria (1995-2008) Using Remote Sensing and Gis

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Abstract: This paper assessed the Changes in land use/land cover in Kafur local government area of Katsina state, Nigeria over 13 year period. The study made use of Land use/land cover map of the study area for1995 and Google earth imagery of 2008. The image and the map were digitized into GIS environment using Arc view 3.2 GIS software for analysis. A paired t-test analysis was also used to see if there was significant change in the land use/land cover between 1995 and 2008.The results show that open space covered 13.56 square kilometers of the land area and constituted 34.00% in 1995 which constituted the most extensive type of land use/land cover in the study area. The increasing population and economic activities were noted to be putting pressure on the available land resources. This paper highlights the land use/land cover types, the change over the years and the causes of the change. The importance of remote sensing and GIS techniques in mapping and change detection was also highlighted.

Key words: Change detection, conversion, GIS, land use, land cover, mapping and remote sensing

INTRODUCTION

Land use/land cover (LULC) mapping and detection of change using remote sensing and GIS techniques is of paramount importance to planners, geographers, environmentalists, and policy makers, infact to everybody who cares about human sustainable development. Land use is the human modification of the natural environment or wilderness into built environment such as field, pasture, industrialization, settlement and agricultural practice etc. The major effect of land use on land cover has been deforestation especially of temperate regions.

More recent significant effects of land use include Urban sprawl, soil erosion, soil and land degradation, salinization and desertification. Land use changes, together with the use of fossil fuel are the major anthropogenic source of carbon dioxide, a dominant green house gas into the atmosphere (World Bank Environment Development, 1993). In recent years, local government areas in Nigeria have experienced rapid population growth especially their headquarters, thus changing population size and commercial needs often necessitate demand for land and change in land use plan (Abdullah, 2006).

The extent and the type of land use directly affect wild life habitat and there by impact local and global biodiversity. Human alteration of landscape from natural vegetation (e.g. wilderness) to any other use typically result in habitat loss, degradation and fragmentation, all which can have devastating effect on biodiversity.

Land conversion is the greatest cause of extinction of terrestrial species, of particular concern is deforestation, where logging or burning is followed by the conversion of the land to agriculture or other land uses. Even if forest is left standing, the resulting fragmented landscape typically fails to support many species that previously existed there (Bierregaard, *et al*., 2000).

The terms “land use” and “land cover” are often confused. Land use is “the total of all arrangements, activities and inputs that people undertake in a certain land cover type”. In contrast, Land cover “is the observed physical and biological cover of the earth’s land as vegetation, rocks, water body or man-made features” (U.N.F.A.O., 1997).

However, Land use is obviously determined by environmental factors such as soil characteristics, climate, topography, vegetation and water body etc. but also reflect the land’s importance as fundamental factor of production. So, understanding past changes in Land use and projecting future land use trajectories require understanding the interaction of the basic human forces that motivate production and consumption.

High population growth or increasing consumer demand, combine with varied Land-tenure arrangements, and degree of access to financial capital, local inheritance, customs and laws produce unique land uses. Research like this, on how such human factors interact in driving land use will improve projection of land use and land cover and our comprehension of human responses to environmental changes (Turner, *et al*., 2006).

Land use and Land cover changes leading to degradation have impact on the global carbon cycle and as such this can add or remove carbon dioxide [or more generally carbon] from the atmosphere, contributing to climate change which can lead to global warming. The Intergovernmental Panel on Climate Change (I.P.C.C,

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1998) estimated that land use changes e.g. the conversion of forest into agricultural land, contribute a net 1.6+0.6Gt carbon per year to the atmosphere.

For comparism, the major sources of carbon dioxide CO2 are; emission from fossil fuel combustion, cement production, urbanization, food production e.t.c. I.P.C.C also states that; from 1850 to 1998, about 136(+55)Gt carbon gas been emitted as carbon dioxide into the atmosphere as a result of land use changes, pre-dominantly from forest ecosystem (I.P.C.C., 1998).

Land use and Land management practices have major impact on natural resources including water, soil nutrients, plants and animals. Land use information can be used to develop solutions for natural resource management issues such as salinity and water quality. For instance, water bodies in regions that have been forested or having erosion will have different water quality than those in areas that are forested.

With the advent of earth mapping technology and computerization, it is possible to monitor and manage both rural and urban land use changes. Geographic Information System (GIS) is a computer base system that deals with spatial data; collection, storage, management, retrieval, conversion/changing, analysis, modeling, and display information about the features that make up the Earth's surface. A GIS can generate a two – or three dimensional images of an area, showing such natural features as hills and rivers with artificial features such as roads and power lines. Scientist use GIS images as models, making precise measurements, gathering data, and testing ideas with the help of the computer (Michael, 2005).

GIS can also be described as a complex – based system designed to support the capture, management, manipulation, analysis, modeling and display of spatially referenced data at different points in time. While Remote Sensing, is the process of obtaining information about land, water or an object, without any physical contact between the sensor and the subject of analysis. The term remote sensing refers to the collection of data by instruments carried aboard aircraft or satellites. Remote sensing systems are commonly used to survey map, and monitor the resources, environment of the Earth and to explore other planets.

There are several different types of remote sensing devices. Examples are; camera – which record reflected energy in the visible spectrum, multi-spectral scanners – which produce images across both the visible and the infra-red system (James, 2008).

However, Remote Sensing and GIS are complementary technologies, the objective of including remote sensing to GIS is to make user more aware of the wide range of information that can be produced using this technology as in the other field of specialization.

The purpose of this study was to assess and map the land use –land cover situation for 1995 and 2008 and the changes (rate and pattern) that have taken place over the years in Kafur Local Government Area, Katsina State using remote sensing and GIS techniques.

Study Area: Kafur Local Government Area is located in southern Katsina State between latitude 7º 29[1] and 7º 55[1] east of the equator and longitude 12º 22[1] and 12º 52[1] North of the equator (Fig. 1). It shares boundary with Danja LGA in the North-west, to the North-east is Karaye LGA of Kano state to the south-west is Malumfashi and Bakori Local Government Areas. (Fig 1) Kafur Local Government has area coverage of 220km^2 with a distance of 150km from Katsina the capital of Katsina State.

There are two (2) seasons, the first one is the rainy season which last from April – October, and the wettest month is August when the average rainfall is over 254mm. The second is the dry season, which last from November – March with the coming up of harmattan which is dry, cool, and dusty.

Relative humidity falls considerably during the hamattan. Maximum day temperature is about 33.1ºC while the minimum day temperature is about 19.2ºC. Overall, the climate is hot and dry for many month s of the year due to the latitudinal location of the town and its location away from the sea (Mortimore, 1970).

The vegetation over the region is a Sudan savanna type. It is made up of stunted trees which are scattered within the area and concentrated where aforestation was carried out.

The tallest trees in the area are normally the silk cotton trees and the Baobab trees of up to 30m height. Other trees include; Tamirindus indica, Adamsonia digitata, DanioliaOliveri, and Mangifera indica

The study area lies within the highest plain of Hausa – land, which slopes gently towards the desert and the streams drain north – east toward Lake Chad. The plains reach altitude of about 71m in the southern part and gradually decline in altitude north ward (Mortimore, 1970).

The soils are slightly acidic and the alkalinity is not a serious problem. They are derived from a fine sandy drift and belong to the Zaria group. On the upper slope the soils are red – brown to orange in color and form a sandy clay loam within a PH value of about 5.6, overlying vesicular iron stone and partly indurated, strongly motted, grittily clay(Mortimore, 1970).

Kafur L.G.A of Katsina State has a population of about 202,884 consisting of 98,132 male and 104,752 female according to the 1991 population census and about 448,000 by 2006 (NPC 2006).

The pre-dominant people are Hausas and Fulani by tribe and about ninety two percent (92%) of the populaces are Muslim, Five percent Christians and three percent traditional worshipers (maguzawa) by religion.

MATERIALS AND METHODS

Data Sources: Land use-land cover map of the study area of 1995 was acquired from the local government council and digitized into the GIS environment using on-screen digitization as base map. Google earth image of 2008 was accessed from the internet.

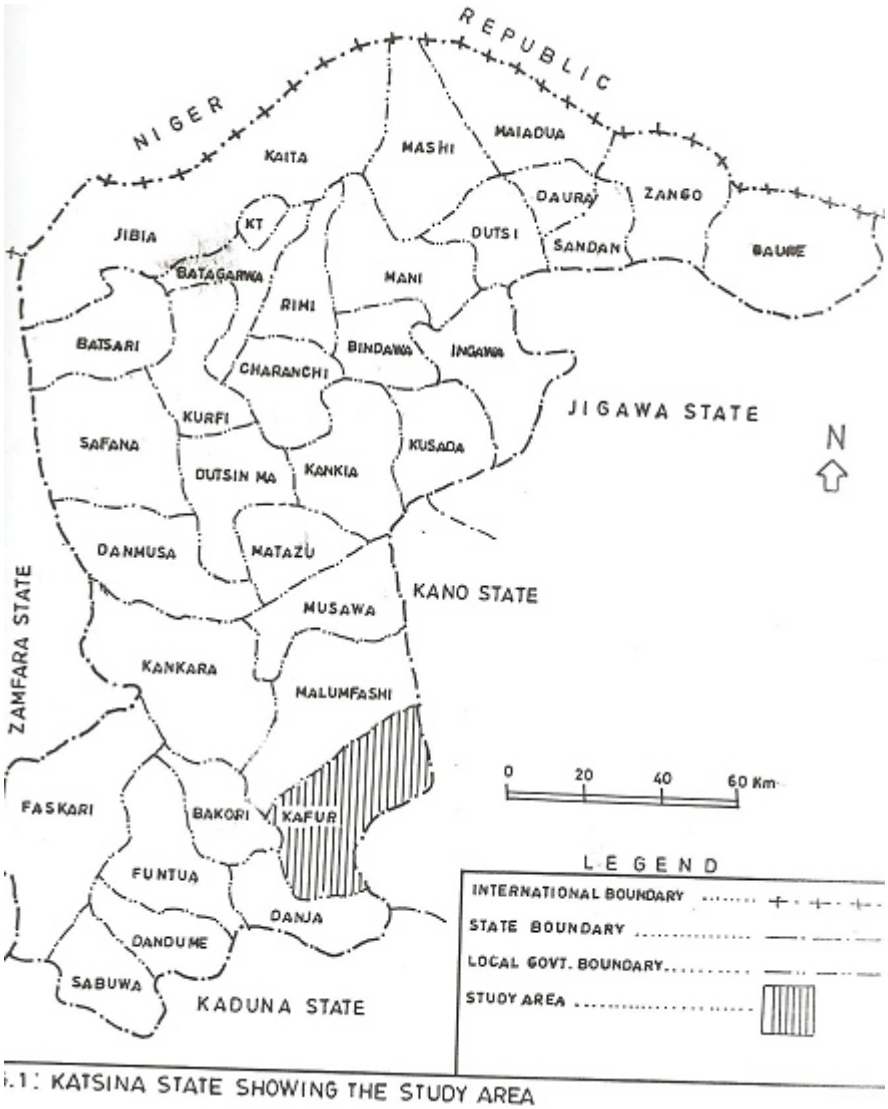

Fig 1: Katsina State Showing the Study Area

GIS Analysis: The study depended on the use of computer-assisted interpretation of the map and the imagery. Field survey was performed throughout the study area using Global Positioning System (GPS). This survey was performed in order to obtain accurate location point data for each LULC class included in the classification scheme as well as for the creation of training sites and for signature generation. The 1995 land use/land cover base map depicts a situation that existed 13 years before the Google earth image of 2008. Hence, the 1995 base map could not be checked against the ground truth but, the available historical data for the area were used to validate the interpretation made. However, the 2008 Google earth image was directly checked against ground truths.

Statistical Analysis and Test: A suitable statistical test was chosen to carry out a test for relationship between the Land use/Land cover situation between 1995 and 2008. A paired t-test was therefore used as the statistical test for this research.. A t-test is a parametric test and it is used to find the difference between two sets of data.

Using these formulae; $-T = \frac{D}{S.P}$

Where S.P = $\frac{\sum D^2 - (\sum D)^{2/n}}{n-1}$

Where t = critical point

D = Difference between the two sets of data
S.P = Variance of the sum of the difference
n = Number of observations

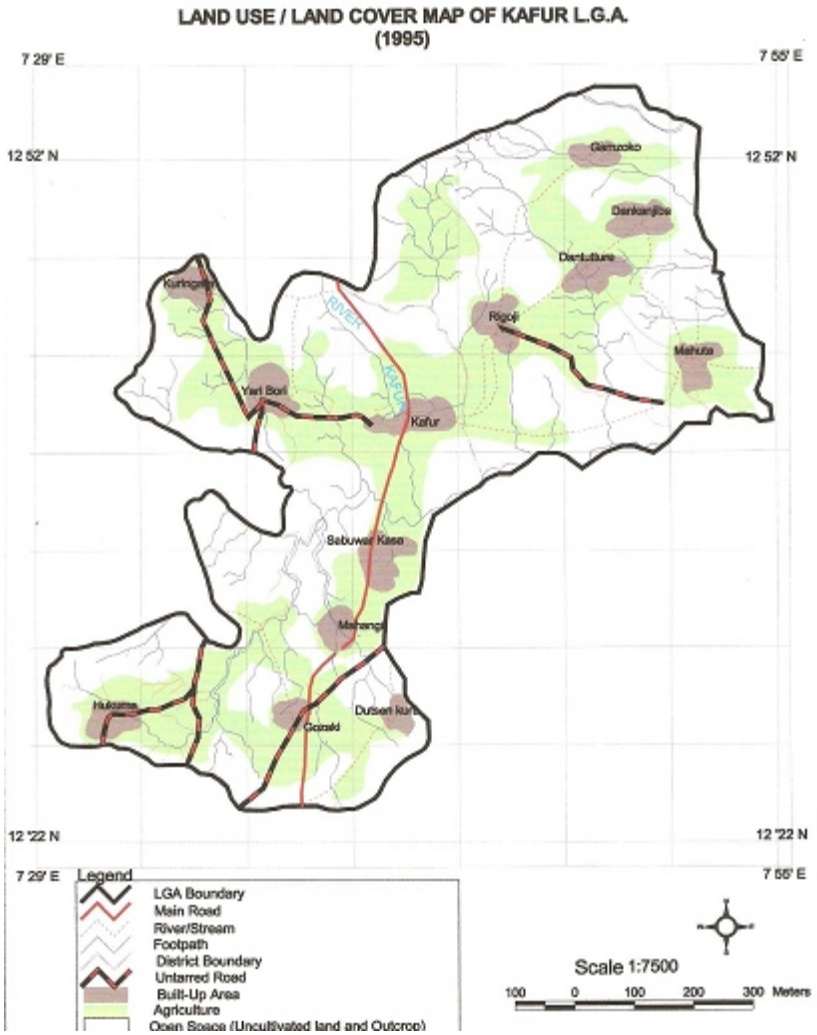

Fig 2: Land use/ Land cover map of Kafur L.G.A (1995)

RESULTS AND DISCUSSION

The relative distribution of land use/land cover classes in the study area in 1995(Fig. 2) and 2008 (Fig 3) is represented in Tables 1 and 2 respectively. The land uses/land covers identified by this study were of five categories and they were assessed and found to be as follows;

Built-up areas: include educational, health, and socio-economic facilities like; games/sport viewing centers and shops e.t.c. Built-up areas are represented by an ash color and constituted 3.87square kilometers, with percentage of about 9.70% of the total land area in 1995. In 2008, the area found to be covered by built-up areas became 5.56 square kilometers and about 13.94% of the total land area of Kafur L.G.A.

Agricultural: This encompasses both cultivated and irrigated lands. As shown in the map is represented by a green color. It covered 8.77square kilometers of the land area and constituting 21.99% in 1995, while in 2008 the land used by agricultural land uses increased to 10.95 square kilometers, about 27.46%of the total area.

Water Body: Include Rivers and Streams. It is represented by a Blue color on the map, and it covered 7.53 square kilometers in 1995 with an area percentage of 18.88% of the total area. In 2008, it decreases to about 5.62square kilometers, likewise the percentage decreases to about 14.09% of the total area.

Transportation: this include; the main road (conspicuously represented by a Red color), foot paths (represented by dotted red lines), and un-tarred roads (represented by red and black colored lines) on the map. It covered 6.15 square kilometers in 1995 with 15.42% of the total land and in 2008 the transport land use did not change (it maintained the same area i.e. 6.15 square kilometers) rather, some un-tarred roads were upgraded to tarred roads e.g. Kafur to Rigoji

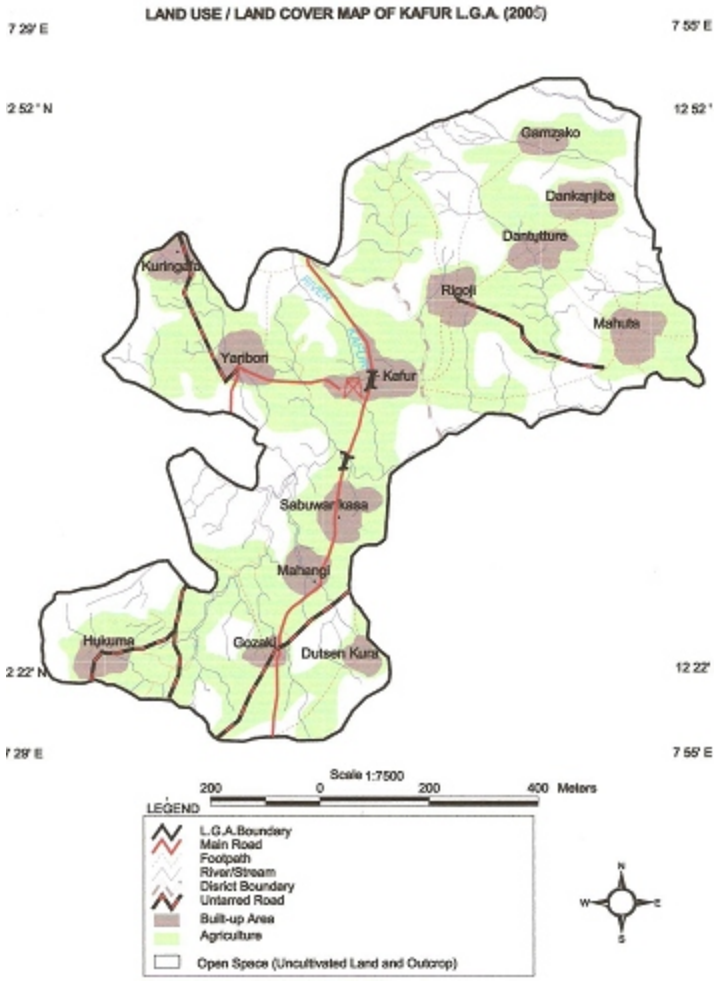

Fig. 3: Land use/Land cover map of Kafur L.G.A (2008)

Table 1: Land use/Land covers size for 1995

Land use/land cover type	Area covered (km^2)	Percentage (%)
Built-up areas	3.87	9.70%
Agriculture	8.77	21.99%
Water Body	7.53	18.88%
Transportation	6.15	1242%
Open Space	13.56	34.00%
Total	39.88	100%

Source: GIS analysis

Table 2: Land use/Land cover size for 2008

Land use/land cover type	Area covered (km^2)	Percentage (%)
Built-up areas	5.56	13.94%
Agriculture	10.95	27.46%
Water Body	5.62	14.09%
Transportation	6.15	15.42%
Open Space	11.60	29.09%
Total	39.88	100%

Source: GIS analysis

Open Space: This include uncultivated land and rock outcrop in the study area, it is represented by a white color. It covered 13.56 square kilometers of the land area and constituted 34.00% in 1995. While in 2008, land covered by open space decreased to about 11.60 square kilometers, which is 29.09% of the total land area.

Analysis of Land Use/Land Cover Change (Rate and Pattern): This analysis was carried out to find the rate and pattern of change that had occurred. This can be achieved by subtracting the total area in 2008 which is donated as (B), from the total area in 1995 which is donated as (A) multiply by 100 to obtain the rate of change that occurred, which could be positive (increase) or negative (decrease).

Statistical Result: The above Table 3 was computed to obtain ($\sum D$); the summation of the differences between

Table 3: Computed Statistical Table

D (km^2)	(B –A = X) D^2 (km^2)
1.69	2.8561
2.18	4.7524
1.91	3.6481
0.00	0.0000
1.96	3.8416
$\sum D = 7.74$	15.0982

Table 4: Land use/Land cover changes 1995 and 2008

Land use/land cover type	(A)1995 Area covered(km^2)	(B)2008 Area covered(km^2)	Difference; A-B in (km^2)	Percentage changed (%)
Built-up areas	3.87	5.56	1.69	1.83 %
Agriculture	8.77	10.95	2.18	28.17 %
Water Body	7.53	5.62	-1.91	24.68%
Transportation	6.15	6.15	0.00	0.00%
Open Space	13.56	11.60	-1.96	25.32 %
Total	39.88	39.88	7.74	100 %

Source: GIS Analysis
N.B + is increase
- is decrease

the two sets of data and ($\sum D^2$); square the summation of the differences between the two sets of data which will be used in calculating to determine the calculated t.

Calculations :- (substituting into the formulae)
n= 2 (1995 and 2008)

$\sum D = 7.74$
$\sum D^2 = 15.0982$

$$S.P = \frac{\sum D^2 - (\sum D)^{2/n}}{n - 1}$$

$$S.P = \frac{15.0982 - (7.74)^{2/2}}{2 - 1}$$

$$S.P = \frac{15.0982 - 7.74}{2 - 1}$$

$$S.P = \frac{7.3582}{1}$$

$= 7.36$

Therefore, the calculated t = 7.36
Using table,
The degree of freedom = n-k
Where n = Number of observations
K= Number of variables
Hence, n = 2
And k = 1
The degree of freedom =2-1= 1
Using 5% significant level
Therefore,5/100÷ 2 = 0.05/2
= 0.025

Using the table with degree of freedom which is = 1 and checking at 0.025 significant level.
The tabulated = 12.71

Therefore calculated t (7.36) is < tabulated t (12.71), hence we accept the null hypothesis, since calculated value (of t) is less than the tabulated or critical value of t. Therefore, in the result interpretation we conclude that there is no significant change in land use/land cover pattern between 1995 and 2008.

Causes of land use-land cover Change: Table 4 shows between 1995 and 2008, Built-up areas increased by 1.69 km^2 (1.83%). This was as a result of increase in housing (i.e. settlements) and infrastructural development such as health, educational and other socio-economic reasons.

The area covered by Agriculture increased by 2.18 km^2 with percentage change of about 28.17%. The increase in Agricultural land can be attributed to the adoption of new agricultural practices which made some un-usable lands before 2008 usable due to technological advancement e.g. fertilizers supplies, irrigation e.t.c. It is also as a result of the local government effort to support the farmers with farm inputs and the need to feed the growing population.

The area covered by Water Body decreased by 1.91 km^2 because most of the distributaries have dried up, with percentage change of about 24.68%.

Transportation land use witnessed no significant change between the years of study (i.e.6.15 km^2).thus, has 0.00 km^2 percentage change. This could be because no new road was constructed within the period of study but there were road upgrading from one category to another.

Open Space land cover decreased by 1.96 km^2, with percentage change of about 25.32%.This decrease in area can be attributed to increase in the agricultural land uses, built-up areas, infrastructures and the high population growth of the area.

CONCLUSION

The study has shown the major land use/land cover types in the study area as built-up areas, agricultural land, water body, transport land use and open spaces and that there was no significant change in the various land uses and land covers in the study area over the period of 13 years studied. It therefore follows that land management in the study area was actually good.

This study has also demonstrated that the recent advancements in remote sensing and GIS technologies provide powerful tool for mapping and detecting changes in land use/land cover. This research further demonstrated that these modern technologies in conjunction with field observation can be very good tool in showing both land cover conversion and modification.

Land use/land cover mapping and detection of changes shown here may not provide the ultimate explanation for all problems related to land use/land cover changes but it serves as a base to understand the patterns and possible causes and consequences of land use/land cover changes in the area.

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