LANDUSE AND LANDCOVER CHANGE DETECTION OF JEBBA LAKE BASIN NIGERIA. REMOTE SENSING AND CIS APPROACH

Ikusemoran Mayomi and G.O. Adesina

Abstract

This study is focused on change detection on the Jebba Lake Basin between 1978 (five years before the dam was established) and 1995 (twelve years after the dam impoundment. It is evidently clear that one of the problems associated with dams anywhere in the world, is environmental degradation. Landsat MSS Landuse/landcover map of 1978 and Spot XS landuse/landcover map of 1995 was used to study the landuse/landcover changes of the Lake area between 1978 and 1995 - a period of 17 years. Ilwis for Academic, Arcview 3.0 and Idrisi 32 were used for georeferencing, digitizing and map analysis respectively. The two main methods of change detection that were used were area calculations (trends, rales and proportion), and overlay for the nature and the location of the changes. The study revealed that about 77.41% of the basin~area has been subjected to changes, while, 22.59% had not been subjected to any changes. Five new agricultural practices came into being after the construction of the dam, which include, livestock farming, irrigation agriculture, tloodplain agriculture, forest plantation, and tree crop plantation. All these agricultural activities covered about 808.5529km^2, that is, 40.14% of the basin area.

Introduction

Rivers, lakes, streams and watcrbodies have complex ecosystems, ranging from mountain torrents to quiet, still lowland waters, which may be deep or shallow, large or small. (Haslam,S978). The most important physical variables, which affect the landuse and vegetation of an aquatic ecosystem include: water movement and the quantity of flow; the soil or substance on the bed of the water course, the width and depth of the channel, the general position of the channel in the river .or lake system, the drainage orders, the slope (gradient of the channel and human intervention (Adesina, 2003). Generally, whenever a dam is constructed along a river channel, the riparian communities around such locations are often affected directly or indirectly. For instance, the places that are inhabited by man are usually flooded, since the surface area of the river channel will increase, because of the dam construction. Also, the backward effect creates some disturbances to the human population around the river channel. Moreover, human activities are also subject to changes (Anonymous, 1983). The impoundment of River Niger downstream of the Kainji Lake has converted the river to a lake ecosystem and had also changed the landcover around the newly formed lake. The forest formation has also changed the landcover around the lake. The forest formation had changed overtime, which could be due to the changes in the orientation of the riparian communities through temporal displacement that took place after the creation of the reservoir.

Many researchers have applied Remote Sensing/Geographic Information System (GIS) to study the landuse and landcover change detection around artificial lakes all over the world. Mattikalli (1995), applied Remote Sensing and GIS to the landuse of the River Glen catchments in England by acquiring data from 1931 to 1989. His work revealed that much of the grassland changed to arable land during the study area. Okhimanhe (1993), also used the combination of Spot HRV imagery of 1986 and aerial photographs of 1974 to study the environmental impact assessment of Burumbururn/Tiga dam in Kano state, Nigeria. The work revealed that the construction of Tiga dam contributed to the depletion of the vegetation that could have helped still desert encroachment. Adeniyi and Omojola (1999), used aerial photographs, Landsat MSS, Spot XS/Panchromatic Image Transparency and Topographical maps to study landuse/landcover changes in Sokoto and Guronyo dams, Nigeria, between 1962 and 1986. Their work revealed that settlement covered most part of the area before and after the construction of the dam. Ikusemoran (2003), used Landsat multispectral landuse and vegetation cover maps of 1978 and 1995 in combination with 1965 aerial photographs to study the landuse and landcover changes of Kainji lake basin. The study revealed that the lake reservoir was expanding with increasing agricultural activities around the lake.

Since the reported invasion of Kainji lake by water hyacinth, (Akinyemiju 1995), no detailed vegetation survey of the catchments areas of Jebba lake was carried out since impoundment (Adesina 2003). The aim of this paper is to use remotely sensed data with GIS technique to compare changes that have taken place in the landuse and vegetation cover around the lake basin before the lake impoundment when the lake was only a river system and after the dam impoundment. The specific objectives include:

* mapping landuse/landcover changes of Jebba lake basin using remotely sensed data and GIS techniques.
* determinining the trend, rate, nature, location and magnitude of landuse and landcover changes of the study area.
* evaluating the environmental and social- economic implications of the changes.

The Study Area

Jebba Lake, which was impounded in August 1983, for the generation of electricity among other reasons, lies between latitudes 9°05"N to 9°55"N and longitude 4^{Q}30" to 4° 55" E. The lake is situated on River Niger, just at the northern part of Jebba town from which the name is derived. It is situated in the Guinea savanna belt of Nigeria, covered with edaphic and biotic woodlands. The soils are mainly riverine, Jebba lake has an average annual rainfall of between 1000 and 1200mm, with annual temperature of 26 to 27°C. The lake has a drainage basin extending from Kainji reservoir to Jebba area, a distance of about one hundred kilometers. There are six major tributaries that empty into the lake, they are, Oli, Wuruma, Moshi, and Awuru on the western side and Kontangora and Eku on the eastern side (fig.l). Many settlements are arranged linearly along the lake, but with more along the western bank than the east. (Fig.l)

However, for this paper, the study area is the basin of the reservoir which extends from latitudes 9°02"N to 9°30"N and longitude 4°32" to 4*55" E. and not the entire area from Jebba to Kainji.

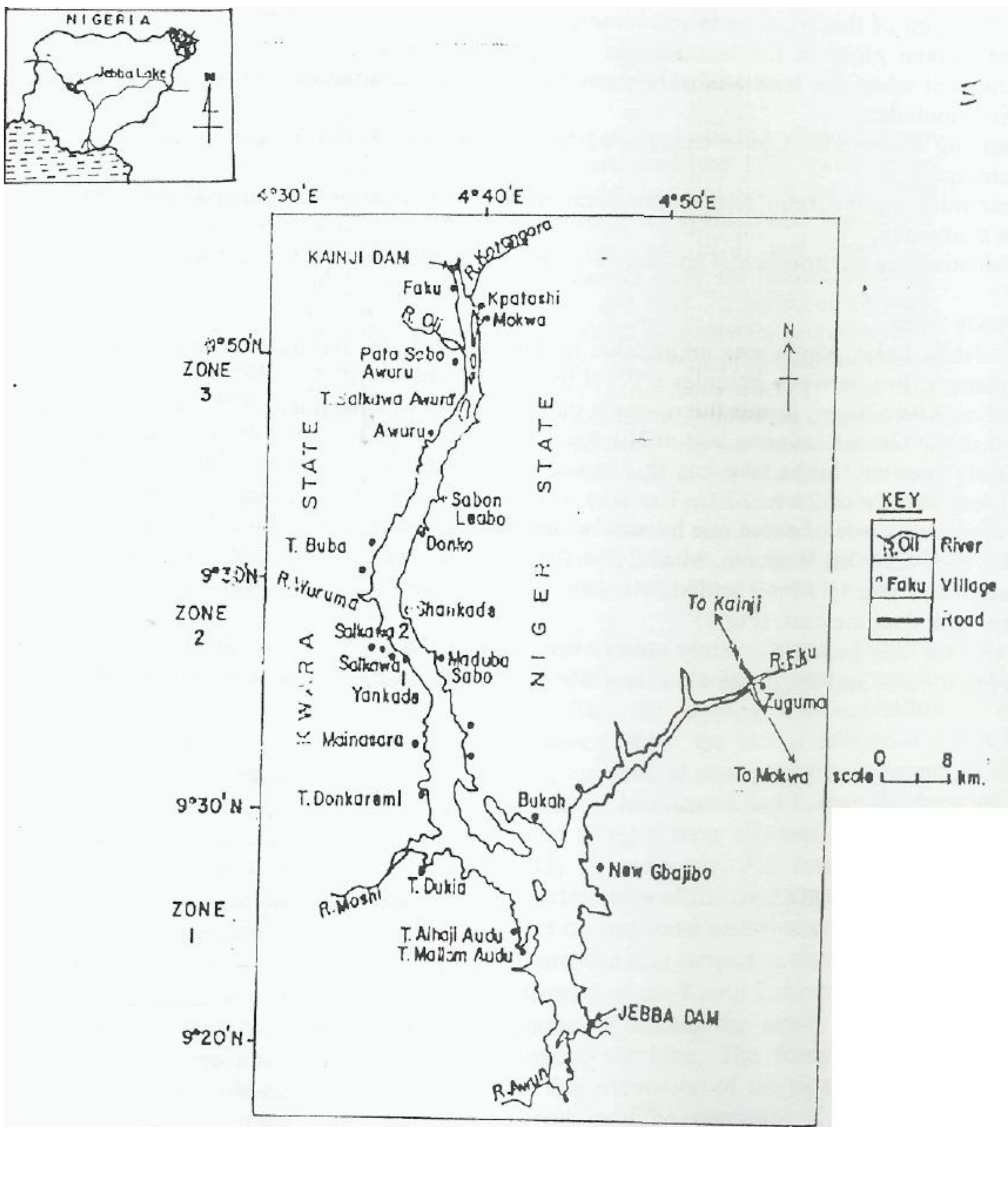


Figure 1: Map showing Jebba lake,Nigeria

Data and Source Description of Materials

An HP Laptop with high RAM, An HP Scanner, and a Colour HP Printer as well as three GIS packages: ILWTS Academic 3.1; which was used for georeferencing, ARCVIEW GIS 3.2 for digitizing maps, and IDRISI 32 Release 2 for map overlay and analysis as well as other complimentary non- GIS packages like COREL DRAW 12 were used.

Description of Data

The data that were used for this paper include; Landuse and Landcover/vegetation cover map interpreted from Landsat MSS image of Jebba region with a scale of 1:250,000, identified by map index 40, acquired from Forestry Evaluation and Coordinating Unit, (FOMECU) Abuja, and Landuse and landcover/vegetation cover map interpreted from Spot XS image of Jebba region with scale 1:250,000, identified by map index 40, also acquired from FOMECU Abuja,

Map Dereferencing/Data Capture

The two maps were scanned, using Corel Draw 11 and then exported to Ilwis environment through Tagged Image File Format (TIFF) for georeferencing so that the two maps will have equal reference parameters such as the same rows, columns, pixel numbers and other reference parameters, which is a must before maps can overlay. Each of the two maps (1978 and 1995) was georeferenced. The Latitude and Longitude coordinates of the four corners of the study area, that is Latitude 9°02" to 9°30" and Longitudes 4°32" and 4"45" were transformed to Universal Transverse Mercado (UTM) through the transform module of Ilwis 3.1, to create the georeference corner. The Transformation gave the minimum "X' and "Y" values as 670145.180 and 1000644.420 respectively, and also 710685.180 and 1050624.420 as the maximum "X" and "Y" respectively. Seven (7) points were selected on the 1978 maps which were used as tie points for the 1995 map. The tie points were then used to georeference the two maps individually. The referenced maps were then resampled, using map-to-map registration with 1978 map as the master map and 1995 as the slave map into the earlier created Georeference corner map. Each of the resampled maps was imported into Arcview, at where the maps were digitized. All the area features such as the landuse classes were digitized as polygon, line features such as roads as line, and locations such as settlement as points. The identified Land uses/1 an dcover features are shown in Table 1.

Table I: Landuse/Landcover in the 1970, 1978 and 1995 Maps

S/N	1978	1995
1	Rivers	Rivers
2	Woodlands	Woodlands
3	Extensive Agriculture	Extensive Agriculture
4	Intensive Agriculture	Intensive Agriculture
5	Riperian Forest	Riperian Forest
6	Shrub Freshwater swamp	Shrub Freshwater swamp
7	Settlement	Settlement
8	Road	Lake Reservoir
9	Rail	Livestock Agriculture
10		Irrigation Agriculture
11		Floodplain Agriculture
12		Rock Outcrop
13		Forest Plantation
14		Glaminiord Freshwater Swamp
15		Tree Crop Plantation
16		Sedge Freshwater Swamp

17		Road
18		Rail

Change Detection by Area Calculation

The maps that were digitized in Arcview were exported to Idrisi for analysis. The themes of the maps were again digitized, but this time with Idrisi digitizing modules. Values were assigned to each of the themes. Three major steps were involved in change detection by calculation of area.

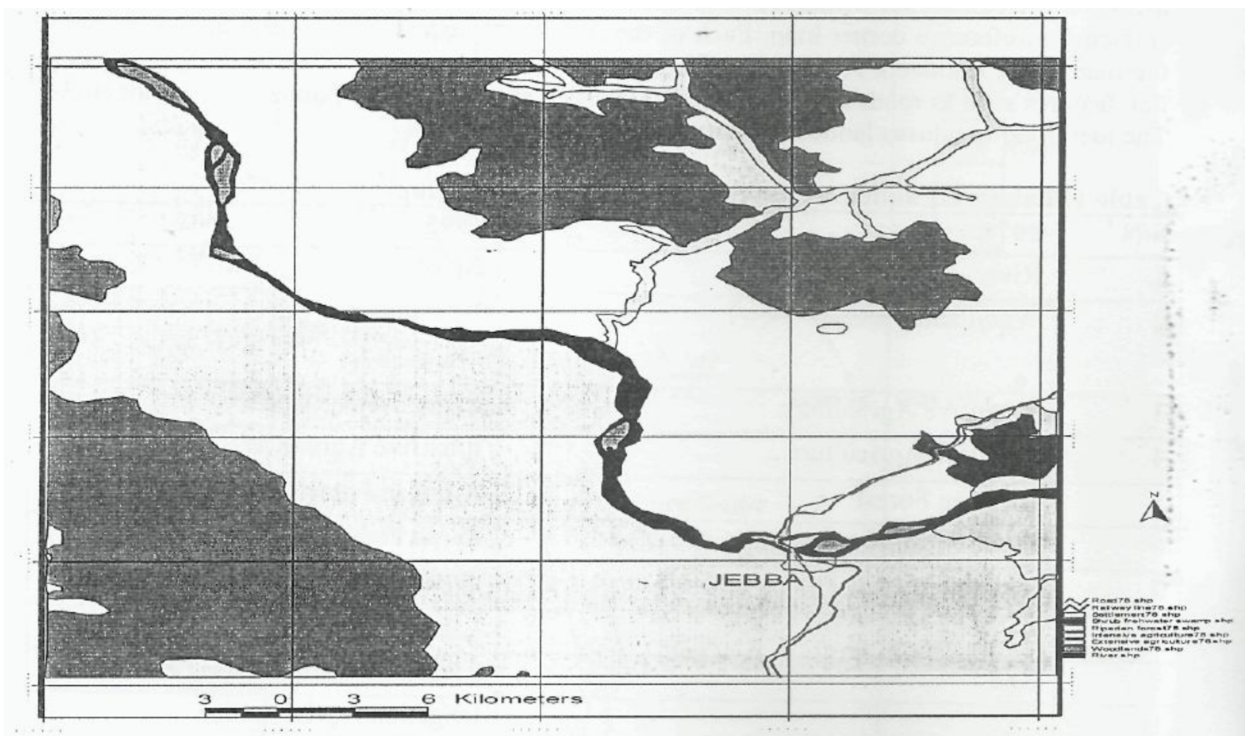
*• The first was the calculation of areas of ail the themes through the CIS Analysis routine and Area sub-routine of Idrisi software in a tabular form.

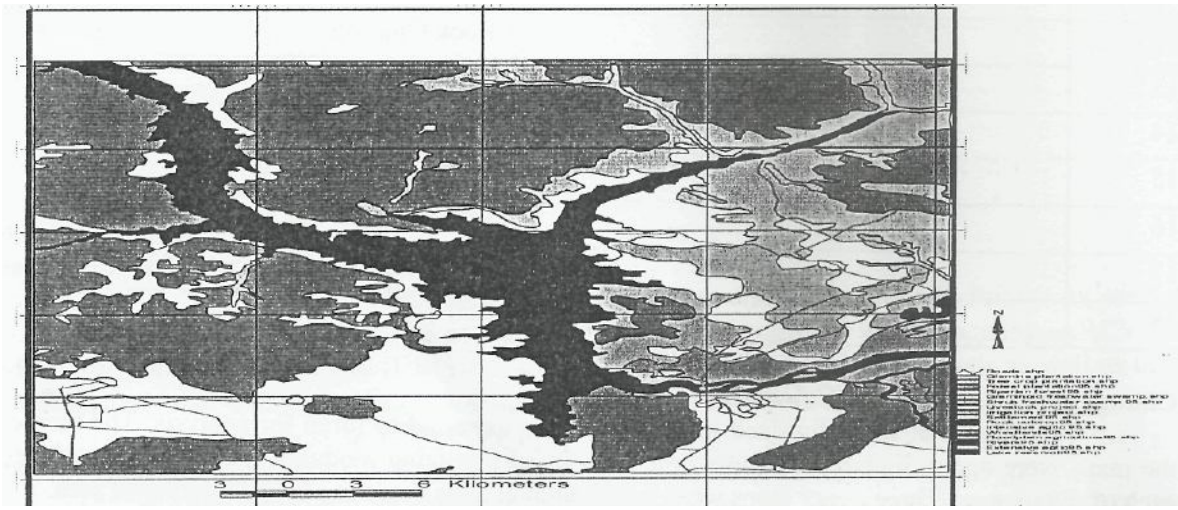
* The second step was the calculation of the trends, that is, the percentage change of each of the landuse, which was derived by dividing observed change by sum of the changes, multiplied by 100.

* The final step was the determination of the annual rate of change which was derived by dividing the percentage change by 100 and multiplied by the numbers of the study years, that is, 1978-1995, which is Seventeen (17) years.

Presentation and Analysis of Data Changes in Landuse and Landcover: Trend **and Rate.** Figs: 2 & 3: **Digitized** 1978/1995 **landuse/landcover of the study Area**

Fig. 2 Landuse/Lancover map of Kainji Lake of 1978





Pig. 3 Landuse/Lancover map of Kainji Lake of 1995

Table 2 Landuse /Vegetation Cover Distribution tor I978/ **1995 in Jebba Lake Basin**

Landuse/Landcover		1978		1995	
		Area (km)	Arc a (%)	Area (km^2)	Area (%)
1	Rivers	40.4713	2.01	43.0283	2.14
2	Woodlands	519.6604	25.80	829.9865	41.20
3	Extensive Agriculture	718.8839	35.69	263.2070	13.07
4	Intensive Agriculture	653.7817	32.46	473.4644	23,50
5	Ripcrian Forest	60.5235	3.0-	26.2672	1.30
6	Shrub Freshwater swamp	16.3606	0.81	7.9771	0.40
7	Settlement	4.208 1	0.02	21.5971	1.07
8	Lake Reservoir	-		214.4340	10.65
9	Livestock Agriculture	-		15.0054	0.74
10	Irrigation Agriculture	-		9.3515	0.46
1l	Ploodplain Agriculture	-		40.1341	1.99
12	Rock Outcrop	-		5.2368	0.26
13	Forest Plantation	-		7.1472	0.35
1 4	Graminoid Freshwater Swamp	-		3.7038	0.18 1
1 5	Tree Crop Plantation	-		0.2533	0.01
t 6	Sedge Freshwater Swamp	-		52.1193	2.59
17	No Data	0.4601		1.4368	
18	TOTAL	2014.3496	100	2014.3497	99.98

1 9	Road	29.80km	188.72km		
2 0	Rail	32.68km	32.68km		

From Table 2, extensive agriculture, intensive agriculture and woodlands covered the largest areas with 718.8839 (35.69%), 653.7817 (32.46%) and 519.6604 (25.80%) respectively, from the only seven classes available in 1978. However, the number of classes increased from seven to sixteen in 1995. Rivers, woodlands and settlement increased, while extensive, intensive, riparian and shrub freshwater swamp all decreased in landmass. The nine new emerged landuse classes that emerged after the 1978 are lake reservoir, livestock agriculture, irrigation agriculture, floodplain agriculture, rocky outcrop, forest plantation, gleminoid freshwater swamp, tree crop plantation and sedge freshwater swamp. Roads which are measured in kilometers covered 29.80km in 1978 and 188.72 kin in 1995, that is a difference of 158.92km within the period of seventeen years. Rail line which is also in kilometers measured 32.68km in both years, that is, no increment in the length.

Landuse and Landcover Changes; Magnitude and Proportion

The magnitude of change is the difference between the areas of each ianduse between the study years, which is derived from the subtraction of the areas covered in one year from the previous year. The percentage change is the changes of each class to the overall change. It is derived by dividing the magnitude of change in each class by the total magnitude of change multiplied by 100. The change proportion is calculated by dividing the percentage change of each class by 100 and multiplied by the number of (he study years, that is, seventeen (17) years. This is presented in table 3.

Table 3.3: The Magnitude (Trend) and Percentage and Annual Rate of Change: 1978/1995

LU/LC	The Magnitudes and the Proportion of Changes					
	1978 (km^2)	1995 (km^3)	Mag of Change	Percentage Change	Annual rate of Change	Remark
Rivers	40.4713	43.0283	2.6117	0.20	0.03	Increase
Woodlands	579.6604	829.9865	250.3261	19.31	3.28	Increase
Extensive Agriculture	718.8839	263.2070	455.6769"	35.15	5.97	Decrease
Intensive Agriculture	653.7817	473.4644	180.3173	13.91	2.36	Decrease
Riperian Forest	60.5235	26.2672	34.2563	2.64	0.45	Decrease
Shrub Freshwater swamp	16.3606	7.9771	8.3835	0.66	0.11	Decrease
Settlement	4.2081	21.5971	17.389	1.34	0.23	Increase
Lake Reservoir		2S4.4340	214.4340	16.53	2.81	Emerged
Livestock Agriculture		15.0054	1 5.0054	1.16	0.20	Emerged
Irrigation Agriculture		9.3515	9.3515	0.72	0.12	Emerged
Fioodplain Agriculture		40.1341	40.1341	3.09	0.52	Emerged
Rock Outcrop		5.2368	5.2368	0.40	0.07	Emerged
Forest Plantation		7.1472	7.1472	0.55	0.09	Emerged
Graminoid Freshwater Swamp		3.7038	3.7038	0.29	0.05	Emerged
Tree Crop Plantation		0.2533	0.2533	0.02	0.003	Emerged

Sedge F/water swamp		52.1193	52.1193	4.02	0.68	Emerged
No data	0.4601	1.4368				
TOTAL	2014.3496	2014.3497	1296.3462	99.99	16.97	

From table 3, it is seen that extensive agriculture had the highest decreased percentage change with 35.15%, while woodlands had the highest decreased percentage of 19.31%. Among the nine newly emerged classes, agricultural activities had five classes, that is, tree crop plantation, forest plantation, floodplain agriculture, irrigation agriculture and livestock agriculture. Extensive agriculture, recorded the highest annual rate of change 5.97%, followed by woodlands with 3.28%. Altogether, the Jebba basin had a total change of 16.97% within the seventeen years of study.

Change **Detection by Overlay**

Change detection by overlay is done in order to find the nature and the actual locations of the changes that have occurred within the study period. Overlay, will also enable accurate calculations of the areas that have or have not changed. The two maps were overlain using Idrisi Reclass module and to classify areas that have changed from those that were static. The Area sub- module was then used to calculate the areas.

Landuse/Landcover Changes: Nature

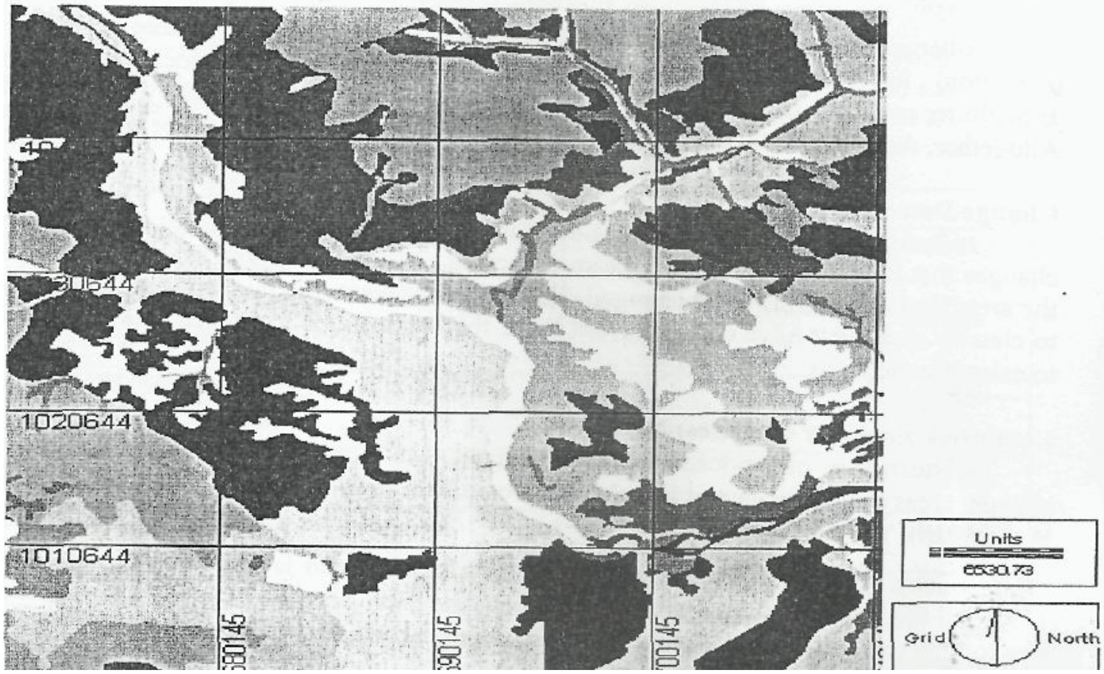
The nature of landuse/landcover changes, that is; areas in the Landuse/landcover with no change, areas that were gained by other classes, and areas that were lost to other classes, is illustrated in the matrix Table in Table 4.

Table 4, shows the matrix tables for the landuse and landcover changes between 1978 and 1995. All the large bold numbers with each landuse names are the pixel values of each of the classes. The top numbers in each cell are the values of each of the classes when the maps were overlain using addition sub routine, while the down figures represent the areas of each of the overlain classes. The figure (2014.3497) at the extreme left corner represents the total square kilometer of the study area.

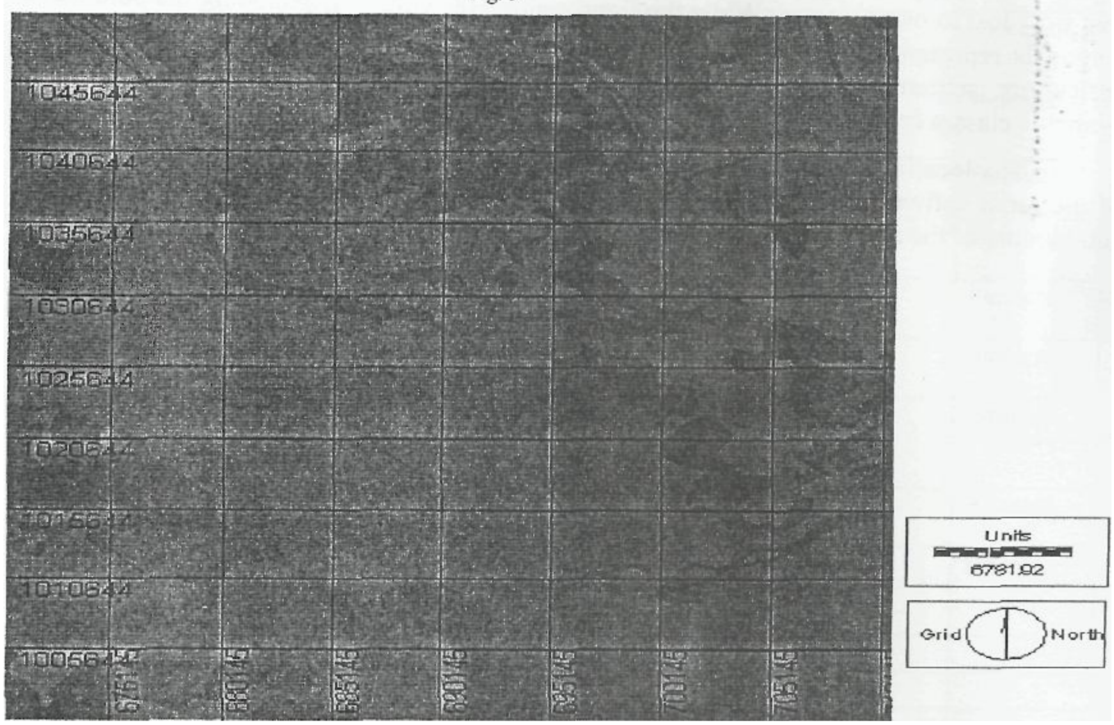
All the bold figures along the diagonals are the areas with no change throughout the study period. All the figures along the rows, except those bold numbers at 'the diagonals represent the areas that were lost to other classes. While the figures along the columns, excluding the bold numbers at the diagonals represent the gained by the landuse and landcover. For instance, rivers lost to intensive agriculture, settlement, lake, fioodplain agriculture and glaminoid swamp, but gained from all the available classes in 1978.

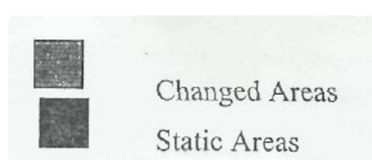
The location, which is generated by map overlay is presented in Fig: 4.1. The reclass module of the Idrisi software was used to classify the study area into static and changed areas, and the area sub module of the same software was used to calculate the areas of the static and the changed areas.

The 1978 and 1995 Map Overlay of Jebba Lake



Changed and Static Areas of Jebba Basin Between 1978 and 1995
Fig. 5





The dark areas (Fig.5) are the areas that have not been subjected to any form of changes within the period of the years of study, while the brighter areas represent the areas that have changed. A total area of 454.9754 km^2 out of the basin area of 20S4.3496km^2, representing 22.59%, had not been subjected to changes within the seventeen years, while the remaining 1559.3742km^2, representing 77.41% had been subjected to changes.

This static and the changed areas can also be confirmed from the matrix tables of 3.4, that is, addition of the bold black figures along the diagonals gives the static figures, while the other figures in the rows and columns give the areas that have changed.

Summary of Findings

The study revealed that a total area of 887.4776 km^2 out of the total area of 2868.5478 km^2, representing 28.08% had not been subjected to changes within the seventeen years of study, while the remaining 20.6323 km^2, representing 71.92% had been subjected to changes. (Figs. 4 & 5) Intensive and extensive agriculture has the highest percentage change with 40.15% and 33.06% respectively. The lake reservoir which covered an area of 887.4776 km^2 in 1978 had increased to 938.2212 km^2 in 1995, which is about 7.59 percentage change.

- The Lake has so much impact on the agricultural activities on the basin. For instance, in addition to the existing extensive and intensive agriculture, five new agricultural practices came to being after the construction of the dam, which include, livestock farming, irrigation agriculture,. floodplain agriculture, forest plantation, and tree crop plantation. All these agricultural activities covered about 808.5529km^2, that is, 40.14% of the basin area.
- The lake formation has also attracted a lot of new settlements which are found in northern Jebba,, the central as well as at the south eastern part of the map. (Figs 4 and 5)
- Development of infrastructures especially roads was also noticed on the image. Before the-
construction of the dam, the lengths of roads were 29.80km which increased tremendously to
188.72km, a difference of!58.92km within a period of twelve years after the lake impoundment, i
- Annual floods on the lake are gradually causing environmental hazards, as the floods might be
resulting into soil erosion. The emergence of rock outcrop at both sides of the dam, noticeable
only after the dam impoundment can be deduced to be a direct result of soil erosion.
- the woodlands, in terms of area covered were more than what was obtained in 1978. This may be attributed to the moisture received even during dry season from the lake water thereby creating a good environment for the development of more flora along the bank of the lake (Adesina, 2003).

Conclusion

Any nation with sustainable utilization of its environment in mind must have adequate information on many complex interrelated aspects of its activities in order to make decisions (Williams 2001), Landuse is only one of such aspects. The knowledge about land use and land cover has become increasingly important as the nation plans to overcome the problems of haphazard, uncontrolled development, deteriorating environmental quality, loss of important wetlands, and loss of fish and wildlife habitat. One of the prime prerequisites for better use of land is information on existing land use patterns and changes in land use through time. The knowledge about land use such as agricultural, recreational, as well as information on their changing proportions, is needed by legislatures. Slate and Local Government officers to determine better land use policy, to identify future development on pressure points and areas, and to implement effective plans for regional development.

In this dynamic situation, accurate and meaningful current data on land use are essential. The uses of reliable land use data are enormous; land use and land cover data are needed for water resource inventory, flood control, water supply planning and wastewater treatment. Federal agencies also need land use data to assess the environmental impact resulting from the development of energy resources, to manage wildlife resources and minimize man-ecosystem conflicts, to make national summaries of land use patterns and changes for national policy formulation, and to prepare environmental impact statements and assess future impacts on environmental quality.

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