Landuse and Landcover Change Detection of Jebba Lake Basin Nigeria: Remote Sensing and GIS Approach

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Abstract
This study is focused on change detection on the Jebba Lake Basin between 1978 (five years before the darn 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 geo-referencing, digitizing and map analysis respectively. The two main methods of change detection that were used were area calculations (trends, rates 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, 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.
Keywords: Landuse, GIS, Remote Sensing, Jebba Lake

Introduction
Rivers, lakes, streams and waterbodies have complex ecosystems, ranging from mountain torrents to quiet, still lowland waters, which may be deep or shallow, large or small. (Haslam, 1978). 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 arc 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 Bunimburum/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 stopped 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:

1. mapping landuse/landcover changes of Jebba lake basin using remotelv sensed data and G1S techniques.
2. determining the trend rate nature, location and magnitude of landuse and landcover changes of the study area.
3. 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° 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 woodllands. The soils are mainly riverine. Jebba lake has an average annual rainfall of between 1000 and 1200 mm 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 100 Km. There are six major tributaries that empty into the lake, they are, Oil, Wuruma, Moshi. and Awuru on the western side and Kontangora and Eku on the eastern side (Figure 1). Many settlements are arranged linearly along the lake, but with more along the western bank than the east (Figure l). 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^C55" E. and not the entire area from Kainji to Jebba.

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: ILWIS Academic 3.1; which was used for georeferencing, ARCV1EW GIS 3.2 for digitizing maps, and 1DR1SI 32 Release 2 for map overlay and analysis as well as other complimentary non- GIS packages (COREL DRAW 12) was used.

Description of Data

The data that were used 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 FUMLCU Abuja,

Map Dereferencing/Data Capture

The two maps were scanned, using Corel Draw 12 and then exported to llwis environment through Tagged Image File Format (TIFF) for geo-referencing so that the two maps will have equal reference parameters such as the same rows, column, pixel numbers and other reference parameters, which is a must before maps can overlay. Each of the two maps (1978 and 1995) was geo-referenced. The Latitude and Longitude coordinates of the tour corners of the study area that is Latitude 9^0 02" to 9° 30" and Longitudes 4^0 32" and $4^{\,0}$ 45" were transformed to Universal Transverse Mercado (UTM) through the transform module of IIwis 3.1, to create the geo-reference 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 "V" 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 geo-reference the two map individually. The referenced maps were then re-sampled, using map-to-map registration with 1978 map as the master map and 1995 as the slave map into the earlier created geo-reference corner map. Each of the re-sampled maps was imported into Arcview 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 Landuse/ landcover features are shown in Table I.

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.

1. The first was the calculation of areas of all the themes through the GIS Analysis routine and Area sub-routine of Idrisi software in a tabular form.
2. 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.
3. 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. The digitized Jebba lake areas is shown in Figure 2 and 3.
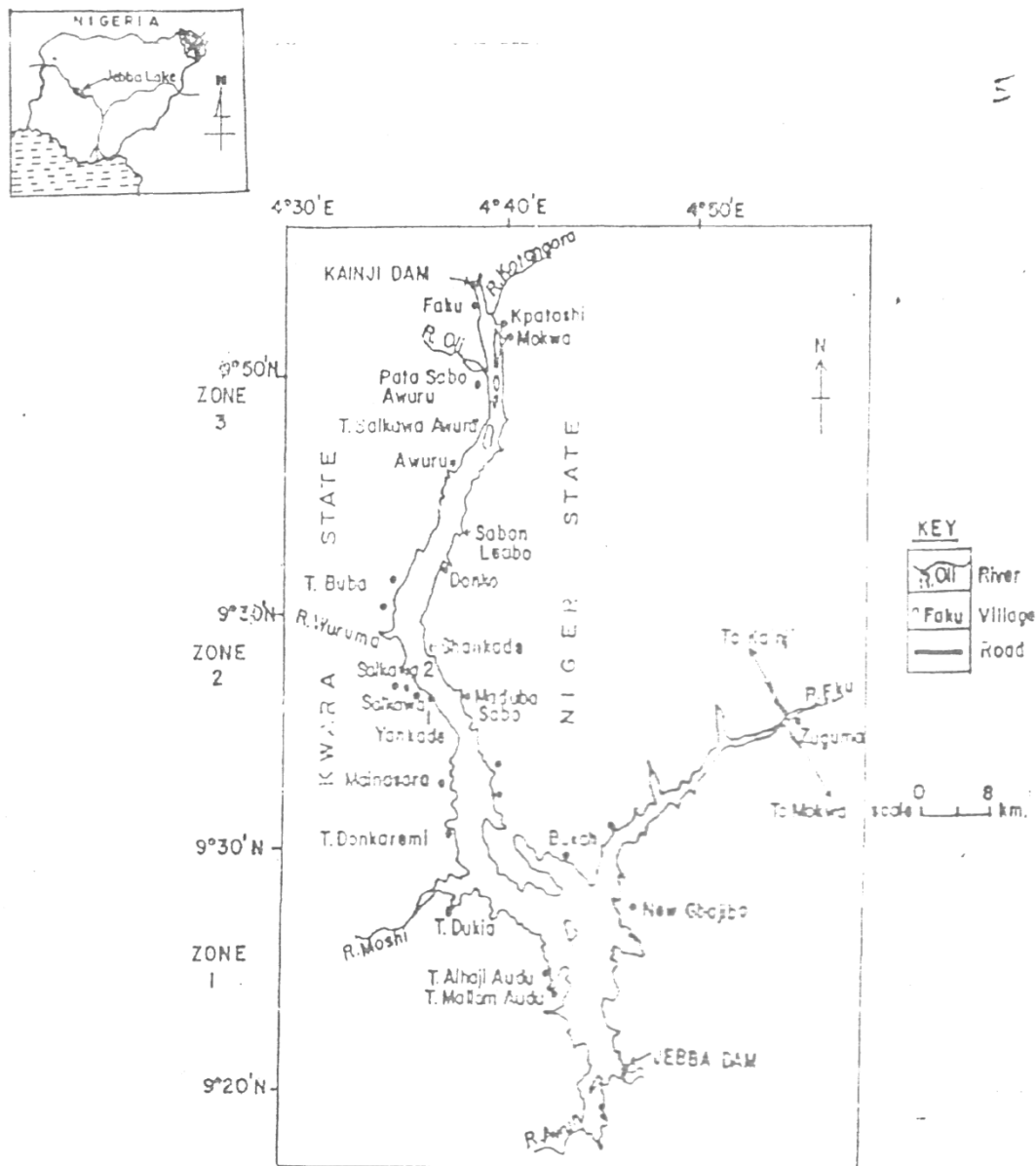
Figure 1: Map of Jebba Lake, Nigeria

Presentation and Analysis of Data

Changes in Landuse and Landcover: Trend and Rate

Extensive agriculture, intensive agriculture and woodlands covered the largest areas with 718.8839 km^2 (35.69%), 653.7817 km^2 (32.46%) and 519.6604 km^2 (25.80%) respectively, from the only seven classes available in 1978 (Table 2). 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, rock 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 km in 1995, that is a difference of 158.92 km within the period of seventeen years. Rail line which is also in kilometers measured 32.68km in both years revealed that there is no increment in the length.

Table 1: Landuse/Landcover in the 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 wamp
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

Landuse and Landcover Changes: Magnitude and Proportion

The magnitude of change is the difference between the areas of each landuse 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 the study years, that is, seventeen (17) years (Table 3).

From Table 3, it was obvious 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; 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 in term of the 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. 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.
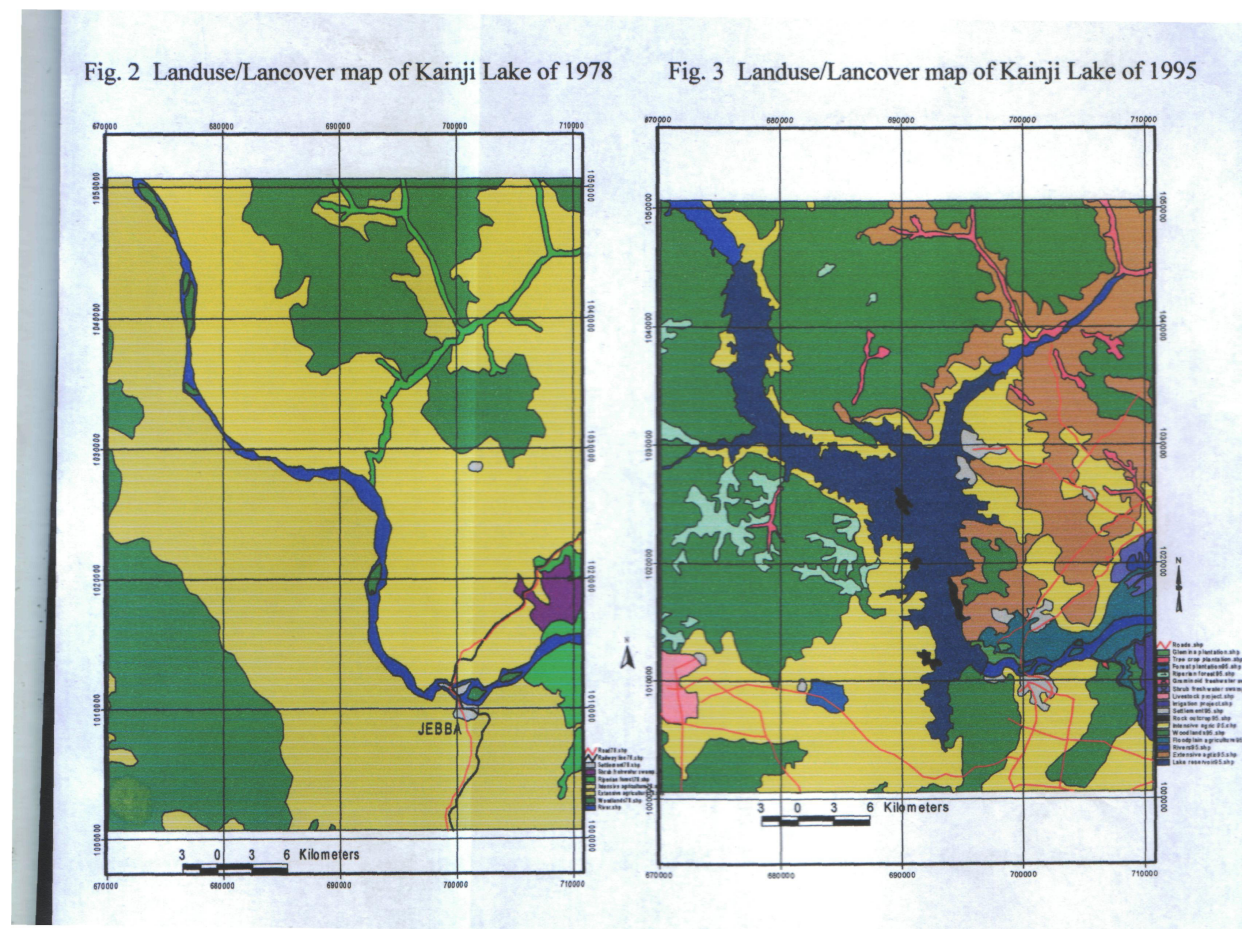
Figures: 2 and 3: Digitized 1978/1995 landuse/landcover of the study Area

Table 2 Land use/Vegetation Cover Distribution for 1978/ 1995 in Jebba Lake Basin

	Landuse/Landcover	1978		1995	
		Area (km^2)	Area (%)	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.S839	35.69	263.2070	13.07
4	Intensive Agriculture	653.1	32.46	473.4644	23.50
5	Riperian Forest	60.5135	3.0	26.2672	1.30
6	Shrub Freshwater swamp	16.3	0.81	7.9771	0.40
7	Settlement	4.2081	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
11	Floodplain Agriculture	-		40.1341	1.99
12	Rock Outcrop	-		5.2368	0.26
13	Forest Plantation	-		7.1472	0.35
14	Graminoid Freshwater Swamp	-		3.7038	0.18
15	Tree Crop Plantation			0.2533	0.01
16	Sedge Freshwater Swamp	-		52.1193	2.59
17	No Data	0.4601		1.4368	
	TOTAL	2014.3496	100	2014.3497	99.98
19	Road	29.80km		188.72 km	
20	Rail	32.68km		32.68 km	

Table 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^2)	Magnitude 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	18.8839	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	I 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		214.4340	214.4340	16.53	] 2.81	Emerged
Livestock Agriculture		15.0054	15.0054	1.16	1 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	5.2;	0.40	0.07	Emerged
Forest , Plantation			7.1472	0.55	0.09	Emerged
Graminoid Freshwater Swamp		3.7038	3.703S	0.29	0.05	Emerged
Crop Plantation		2:33	0.2533	0.02	0.003	Emerged
F/water		52.1193	52.1193	4.02	0.68	Emerged
No data	0.4601	1.4368				
TOTAL	2014.5496	2014.3497	1296.3462	99.99	16.97	

## Table 4: Matrix of Landuse/Landcover for 1978 and 1995

1995 →

1978 →	Rivers 10	Woodlands 20	Extensive Agric 30	Intensive Agric 40	Riparian Agric. 50	Shrub Swamp 60	Settlement 70	Lake 80	Livestock Agric. 90	Irrigation Agric 100	Floodplain Agric 110	Rock Outcrop 120	Forest Plantation 130	Glamhoid Swamp 140	Tree Plantation 150	Sedge swamp 160	Total
Rivers 1	11 / 11.5370	21 / -	31 / -	41 / 0.0465	51 / -	61 / -	71 / 0.1161	81 / 27.0808	91 / -	101 / -	111 / 1.1759	121 / -	131 / -	141 / 0.6960	151 / -	161 / -	40.6523
Woodland 2	12 / 6.0978	22 / 293.6214	32 / 56.3929	42 / 124.4259	52 / 4.6495	62 / -	72 / 1.3544	82 / 5.9124	92 / 13.0163	102 / -	112 / -	122 / -	132 / 6.3332	142 / -	152 / -	162 / 7.8645	519.6684
Ext. Agric 3	13 / 9.0269	23 / 315.6215	33 / 11.0244	43 / 219.1531	53 / 4.0061	63 / .	73 / 3.9337	83 / 102.2382	93 / 1.9861	103 / 1.1369	113 / 1.9004	123 / 4.2860	133 / 0.8140	143 / -	153 / 0.2533	163 / 43.8861	718.9418
Int. Agric. 4	14 / 8.1231	24 / 218.5176	34 / 183.5102	44 / 121.9886	54 / 8.9661	64 / 0.6219	74 / 13.9679	84 / 73.7473	94 / -	104 / -	114 / 19.4926	124 / 0.9508	134 / -	144 / 2.9375	154 / -	164 / 1.1417	653.9653
Riparian Agric. 5	15 / 5.5828	25 / 2.5538	35 / 11.0614	45 / 5.0376	55 / 8.7828	65 / 1.5588	75 / -	85 / 5.4551	95 / -	105 / 8.2145	115 / 12.2901	125 / -	135 / -	145 / -	155 / -	165 / -	63.5369
Shrub Swamp 6	16 / 1.5680	26 / -	36 / 1.1123	46 / 2.6798	56 / -	66 / 5.7963	76 / -	86 / -	96 / -	106 / -	115 / 12.2901	125 / -	135 / -	145 / -	155 / -	165 / -	63.5369
Settlement 7	17 / 1.2455	27 / -	37 / 0.2088	47 / 0.4040	57 / -	67 / -	77 / 2.2249	87 / -	97 / -	107 / -	117 / 0.0708	127 / -	137 / -	147 / 0.0704	157 / -	167 / -	4.2244
Total	43.1811	829.9864	263.31	473.7355	26.4045	7.977	21.597	214.4338	15.0059	9.3514	40.134	5.2368	7.1472	3.7039	0.2533	52.8919	2014.34974

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 number (2014.3497) at the extreme left corner represents the total square kilometer of the study area.

All the bold figures along the diagonals arc the areas with no change throughout the study period. All the figures along the rows, except those I rid 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, floodplain agriculture and glaminoid swamp, but gained from all the available classes in 1978.

The location, which is generated by map overlay is presented in Figure: 4. The reclass module of the Idrisi software was used to classify the study area into static and changed areas, and the area module of the same software was used to calculate the areas of the static and the changed areas.

Figures 4 and 5: The 1978 and 1995 map Overlay of Jebba Lake and Change and Static Area of Jebba
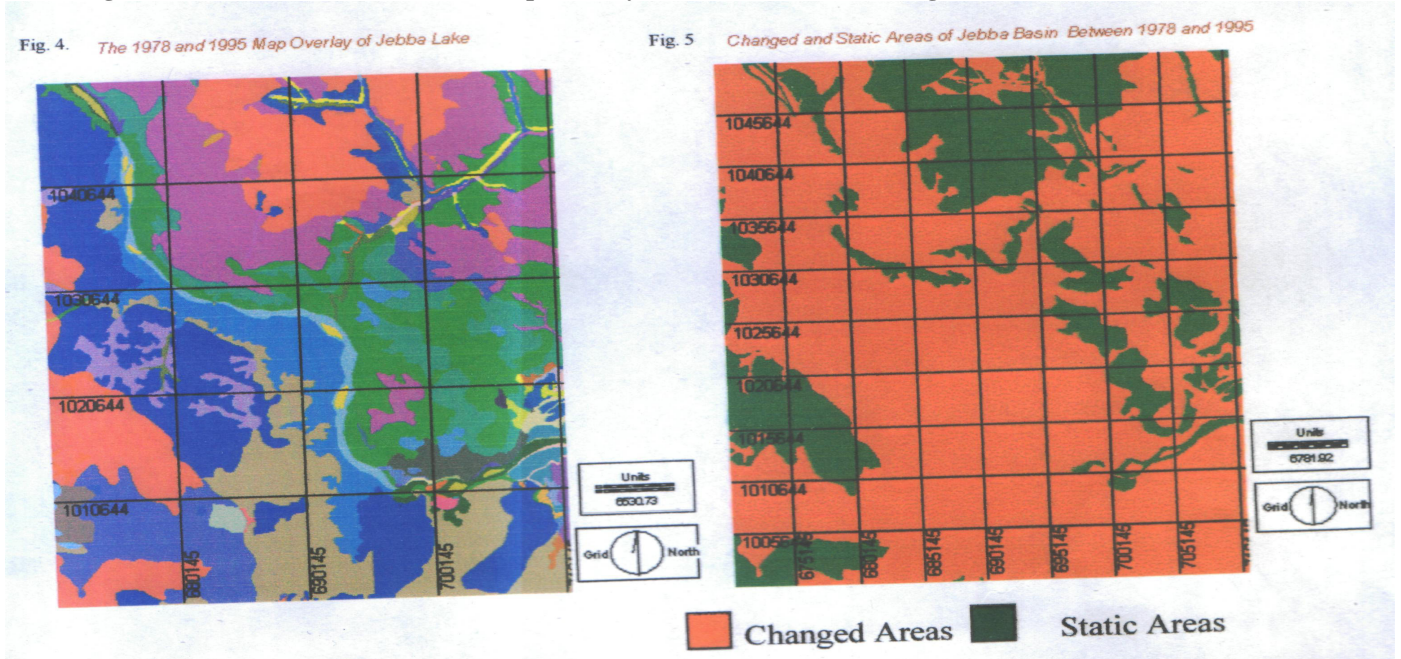
Basin Between 1978 and 1995.

The dark areas (Figure 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 2014.3496km^2 representing 22.59% had not been subjected to changes within the seventeen years, while the remaining 1559.3742km" representing 77.41% had been subjected to changes.

This static and the changed areas can also be confirmed from the matrix table (Table 4) which is the 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) Intrusive 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.

1. 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.

2. 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. (Figures 4 and 5)

3. Development of infrastructures especially roads was also noticed on the image. Before the construction of the dam, the lengths of roads were 29.80 km which increased tremendously to 188.72km. a difference of 158.92 km within a period of twelve years after the lake impoundment.

4. 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.

5. 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 landuse and landcover 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 landuse patterns and changes in landuse through time. The knowledge about landuse such as agricultural, recreational, as well as information on their changing proportions, is needed by legislatures, State and Local Government officers to determine better landuse 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 landuse are essential. "I he uses of reliable landuse data are enormous; landuse and landcover data are needed for water resource inventory, flood control, water supply planning and wastewater treatment. Federal agencies also need landuse 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 landuse patterns and changes for national policy formulation, and to prepare environmental impact statement and assess future impacts on environmental quality.

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