An assessment of Land Use and Land Cover Changes in the Kainji Lake Basin, Niger State, Nigeria

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Alternative topic;
AN ASSESSMENT OF LAND DEGRADATION DYNAMICS IN KAIJI LAKE BASIN IN NIGER STATE NIGERIA.

ABTRACT: *This paper assesses the land-use and land-cover changes within the Kainji Lake basin between 1975 and 2018 – a period of 38 years, using remotely sensed data and geographic information systems (GIS). Since 1968 when the River Niger was impounded and Kainji Lake created, various anthropogenic activities such as agriculture, irrigation, deforestation, fishing, and construction have taken place. These human activities together with natural factors had led to environmental degradation and the damage of the ecosystem of the lake basin. Landsat MSS image of 1975, Landsat TM of 1987 and Landsat ETM+ images of 1999 and 2005 and Landsat Operational Land Imager OLI of 2018 were acquired, classified and analysed between 1975 and 2018. Area calculations of the arc GIS 10.2.2 software were used to derive the trends, rates and magnitudes of changes, while map overlay was employed for assessing the nature and location where the changes have taken place. The study reveals that the rate of deforestation and erosion in the study area is linked to population increase that lead to expansion of agricultural lands. Uncontrolled human settlement and demand for fuel wood etc., were some other issues to contend with. If this issue of land degradation in particular is not appropriately dealt with in the future, it could lead to the decrease in the power generating capacity of the ~~proposed~~ hydropower component due to filling up with silt materials and the ultimate shortening of the life span of the dam. Finally, it is hoped that the findings from the study will provide useful insight into the current state of the environment, and the recommendations proposed in this paper would equally be helpful to mitigate, control and to improve the management of the basin xxxxxxby who and who benefits*

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KEYWORDS*: Geographic Information System, Land Use, Kainji Lake Basin, Deforestation*

1. INTRODUCTION

The Kainji Lake basin is one of the most important inland basins in Nigeria, it is the home of the first and the largest hydro-electricity station in the country, the woodland vegetation of the basin is also the home of the first National Parks in Nigeria. Ikusemoran and Adesina 2009,[1] reported that generally whenever a dam is constructed along a river channel, riparian communities around such locations are often affected directly and indirectly. For instance, the places that are inhabited by man are usually flooded, since the surface area of the river channel increases because of the dam construction. Also, the backward effect of the lake water creates some disturbances to the human population around the river channels. Moreover, human activities are also subjected to changes.

The impoundment of Kainji Lake on River Niger has converted the river to a lake ecosystem and has also changed the land cover around the formed lake. The forest formation has changed overtime, which could be due to the change in the orientation of the riparian communities through temporal displacement that took place after the creation of the lake reservoir. In addition, more institutions, government agencies and schools created to take care of the rising population of the inhabitants. The small villages in the Kainji Lake Basin have grown to major towns. This has resulted in the increase in the demand for agricultural land and constructions of houses thereby completely changed the land use and land cover nature of the entire basin.

The knowledge about land-use and land-cover has become increasingly important as every nation plans to overcome the problems of haphazard, uncontrolled development, deteriorating environmental quality, loss of important wetlands, and loss of fish and wildlife habitat. Land-use data analysis are needed in the analysis of environmental processes and problems that must be understood if living conditions and standards are to be improved or maintained at current levels. The knowledge on land-use such as agricultural, recreational as well as information on their changing proportions is needed by legislators, state and local government officers in determining better land-use policies, identification of future development on pressure points and areas, and implementation of effective plans for regional development.

Remote sensing and or Geographic Information System (GIS) have been applied to land-use and land-cover changes of Lake Reservoir within and outside Nigeria. Jesse. et al., (2019) [2] used LANDSAT satellite imagery of 1987 to 2015 in order to assess the class of land use land cover in the area particularly of the change both in extent and volume of water in Dadinkowa reservoir, Gombe state, Nigeria using the Normalized Difference Water Index (NDWI). The result shows that from 1987 to 2000 the water level increased and decreased from 2000 to 2015 due to the climate change condition and the high rate consummation of water due to population growth of the area from 266,844 persons in 1991 to 367,500 persons in 2016. Dadin Kowa reservoir may completely dry up by the year 2029 if the climatic condition remains as it is.

Kamalu and Wokocha,(2019) [3] assessed land use land cover change in Igwuruta in the Niger Delta area of Nigeria using remote sensing, GIS and physical soil resources inventory techniques. Their results shows urban development and industrialization took over most of the suitable lands for agricultural as farm land and bare ground declined steadily within the period. Earlier, Okhimanhe (1993) [4] used the combination of Spot HRV imagery of 1986 and aerial photographs of 1974 to study the environmental impact assessment of Burumburum/Tiga dam in Kano State, Nigeria. The study reveals that the construction of the dam contributed to the depletion of the vegetation that could have minimized desertification.

Therefore, due to the central roles of provision of electricity, conservation of flora and fauna, in addition to the contribution of fisheries production in the Kainji Lake basin, proper monitoring of the Lake Basin and its environs becomes necessary for sustainable utilization and management of water resources. The following were the objectives of the study

i. To create land-use/land-cover maps of the Kainji Lake Basin from 1975- 2018 using GIS technique and remote sensing data to assess the trends, magnitudes, nature and locations of the land use and vegetation cover changes of the lake within the study period.
ii. To assess the actual land areas which have been lost or, gained by the principal features around the lake, i.e., the reservoir, agriculture/settlement within the study period.
iii. To evaluate the environmental implications of the land-use and land-cover changes in the lake basin.

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2. MATERIALS AND METHODS

2.1 The study area

According to National Electric Power Authority (NEPA) Diary (1995) [5], the genesis of Kainji Lake power station dates back to 1951 when the demand for electricity was rising faster than supply due to the growth of industries and rapid urbanization in Nigeria. In order to meet the increasing demand for electricity, and consequent upon the realization that bulk supply of electricity could be cheaper through the utilization of hydro power technology, the former Electricity Corporation of Nigeria (ECN) began the exploitation of water resources of River Niger upstream of Jebba. Nedeco and Balfour (1961) [6] reported that the reason for the choice of Kainji as the best site for the Lake were many among which are; rock foundation which was tested and was found to be capable of holding the enormous height of the dam, it is also the point where the river valley is not too wide, the physical features of upstream of the dam valley also allows for a large reservoir. Agboarumi (1997) [7] observed that the Kainji dam is today a pride of nature, providing cheap and abundant means of electricity for the continuously growing population and industries, sources of revenue, fishing, irrigation, cattle crossing, tourism, employment, international recognition, man-power training and many more.

The lake is located between latitudes 9° 50″ to 10° 42″N and longitudes 4° 20″ to 4° 42″E (Figure 1). Olokor (1995) [8] reported that construction of the Kainji dam which began in March 1964 was completed in December, 1968 and was officially commissioned on 15th February, 1969. The impounding of the lake started exactly on the 2nd August, 1968 and the water level rose to 140.2 m on the 19th of October the same year - a period of seventy eight days. The lake that was formed sunk most parts of Kainji Island on which the dam was constructed. NEPA Diary (1995) [5] stated that the lake covers an area of 1250 km^2 with a maximum depth of 54.9 m. The lake extends to about 136.8 km upstream of Jebba beyond Yelwa in the North. The lake gets its water from two sources: the river Niger with its headwater in Guinea, and local rivers around the lake basin which flow directly into the lake or into River Niger before entering into the lake.

According to Nedeco and Balfour (1961) [6], the soil depth of the area increases with slope and a gentle undulating topography for the area with red to brown well drained soils differing in texture from sandy loam to clay loam. Most of the basin area have dry season of five months starting from early November to middle of March. Rainfall increases from the month of April, reaching the peak in August and starts declining in September. Rainfall decreases with decrease in latitudes within the basin and also increases with increasing altitude (9).

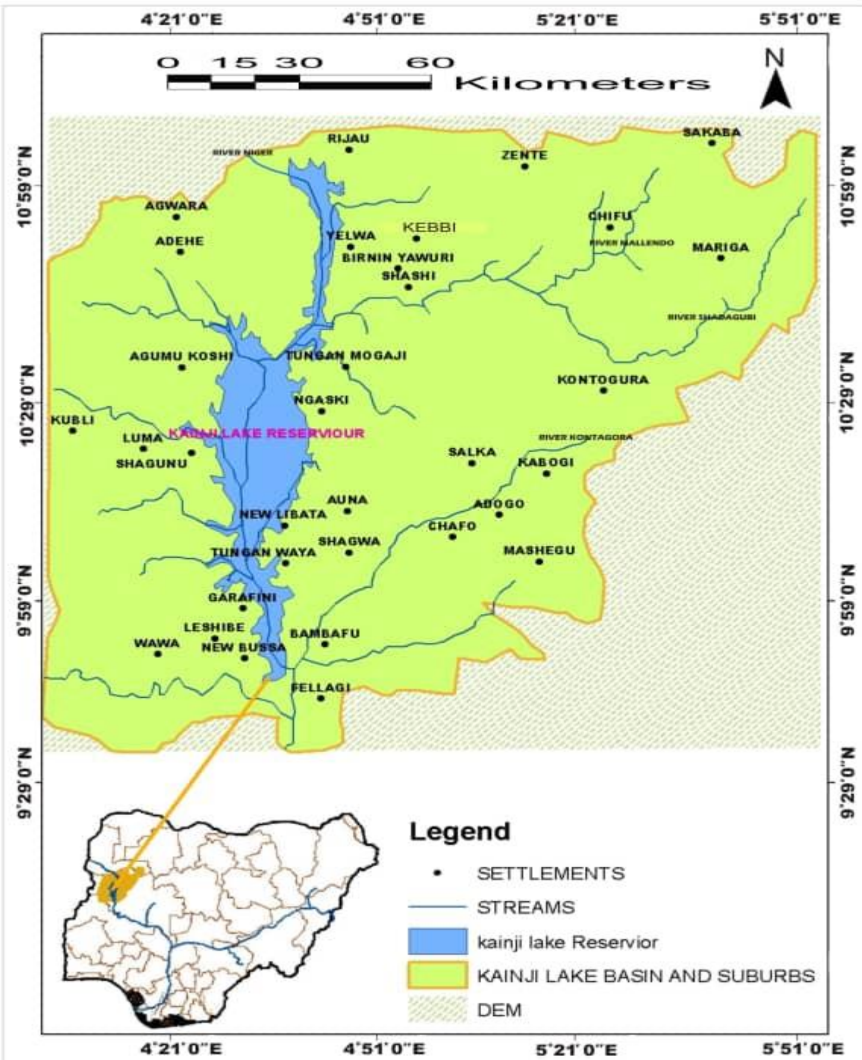

Figure 1: Kainji Lake Basin

2.2 Sources of data

The first four data sets (Table 1) which cover a total period of 38 years (1975-2018) were the main images that were acquired for the assessment of the lake basin.

Table 1 Data type source

S/N	Data Type	Date	Spatial Resolution
1.	Landsat Thematic mapper (TM)	1th July, 1987	30 meters
2	Landsat Enhanced Thematic mapper (ETM)	6th Feb., 1999	30 meters
3.	Landsat Enhanced Thematic mapper (ETM)	5th July, 2005	30 meters
4.	Landsat Operational Land Imager (OLI)	5th Feb., 2018	30 meters

2.3 Image classification

In classifying the images into various themes, the supervised approach to classification was adopted using Arc GIS 10.2.2 software. The images were classified into three major classes: water body; agricultural, built-up and other land-uses and; floodplain and waterweed seen on Table 2. Maximum likelihood classification method was adopted.

Table 2: Land-Use and Land Cover Classification Scheme

Source: Adapted and modified from [10].

Sources: Global Land Cover Facility, 2014

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1. Water body	Lake water
2. Build up areas	Land containing buildings
3. Agricultural	Agriculture lands
4. Dense vegetation	Game reserves
5. Others	Streams, rock out crops

The first two and last two data sets have large gap of at least ten years while the middle two have close gaps of five years. This was designed to reflect the impact of the dam in the past years of low population and the recent years when the population of the country has been increasing tremendously. All four images were acquired between June and September, which is the peaking periods of the wet season, climatic conditions during this period, is the same all over the lake basin [8], hence the vegetation cover and land-use types appear the same on the images regardless of the year they were obtained.

Three features of major concern were selected for this purpose: the lake reservoir, the flood plains and the agriculture/settlement areas. The result was to produce the following:

1. Areas that were not Lake Reservoir in 1975 but have changed to Lake Reservoir in 2018 so as to know whether the lake is expanding or not as has been the fear of Nigerians.

2. Areas that were dense forest in 1975 but have changed to other land-use types in 2018. This was done to determine the land areas of the forest lost that have been lost within the study periods to other land use types.

3. Areas that were not intensive agriculture/settlement in 1975 but have changed to intensive agriculture in 2018 so as to assess the rate of land captured by intensive agriculture/settlement within the study periods

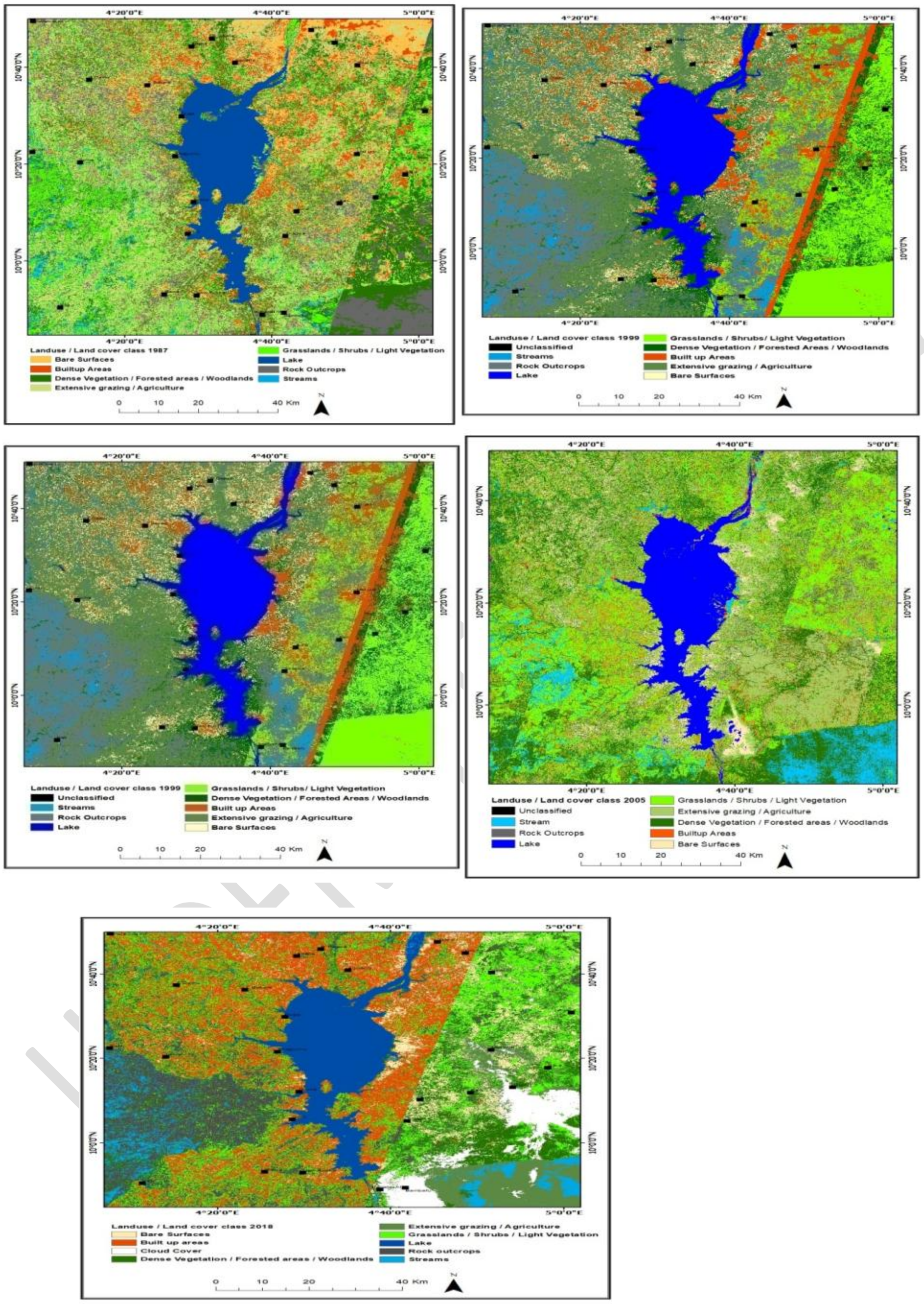

Figure 2: Spatial location of changes in the lake area between 1975 and 2018

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2.4 Change detection techniques

Three main change detection methods which have been previously applied by (Jijingi *et al*, 2016) [11] were employed in this paper, they are:

2.4.1 Change detection by area calculation

1. The first step is the calculation of the magnitude of change, which is derived by subtracting observed change of each period of years from the previous period of years.

2. The second step was the calculation of the trends, that is, the percentage change of each of the land-use, by subtracting the percentage of the previous land-use from the recent land- use divided by the total land-use and multiplied by 100 (BA/ Tx100).

3. The last is the calculation of the annual rate of change by dividing the percentage change by 100 and multiplied by the number of the study years, that is 38 years (1975-2018)

3. Results

The result of the trends of the land-use and land-cover of Kainji Lake Basin is presented in **Table 3,** while the magnitudes, percentage changes and annual rate of change are presented in Tables' 4a-d. The spatial location of changes in the lake area between 1975 and 2015 are presented in Figure 2.

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Table 3: Trends of the land use/ land cover of Kainji Lake basin (1975-2018)

Land use Land cover classification	**1975**		**1987**		**1999**		**2005**		**2018**	
	Area (km_sq)	**%**	**Area (km_sq)**	**%**	**Area (km_sq)**	**%**	**Area (km_sq)**	**%**	**Area (km_sq)**	**%**
Bare Surfaces	585.65	3.58	1,340.95	8.20	1,111.70	6.80	588.97	3.60	1,102.91	6.75
Builtup Areas	715.06	4.38	1,597.28	9.77	2,027.08	12.40	2,823.86	17.28	3,330.50	20.38
Dense Vegetation	4,973.17	30.43	2,976.57	18.21	1,961.30	12.00	2,770.78	16.95	1,976.83	12.10
Extensive grazing / Agriculture	2,144.22	13.12	4,143.12	25.35	4,019.17	24.59	2,783.36	17.03	1,550.67	9.49
Grasslands / Light Vegetation	4,184.22	25.60	2,563.98	15.69	2,936.82	17.97	4,268.93	26.12	3,330.74	20.38
Lake	1,566.49	9.58	1,069.66	6.54	1,215.09	7.43	1,185.94	7.26	1,179.12	7.21
Rock Outcrops	503.28	3.08	2,051.62	12.55	2,565.12	15.69	817.51	5.00	2,273.26	13.91
Streams	1,398.11	8.55	428.81	2.62	507.39	3.10	1,104.21	6.76	714.29	4.37
Unclassified	273.47	1.67	171.67	1.05			0.10	0.00	885.34	5.42
	16,343.66	100.00	16,343.66	100.00	16,343.66	100.00	16,343.66	100.00	16,343.66	100.00

4. Discussion

4.1 Trends, magnitudes, percentage change and annual rate of changes.

Table 3 shows the trends in terms of the area coverage and the percentage of each class of the basin area from 1975 to 2018. It was revealed that the lake reservoir which covered 1566.49 km^2 in 1975 has reduced to 1179.12 km^2 in 2018 which means it lost a total area of 387.3 km^2. Agricultural lands for crop production and grazing of livestock which covered 2144.22 km^2 in 1975 has reduced to 1550.67km^2 in 2018 (a reduction of 593.55 km^2). Scanty settlements found in the basin have dramatically increased from 4 percent, equivalent coverage of 715.06km^2 in 1975 to 20.38 percent (3330.5 km^2) in 2018. This is as result of population increase as also noted by Ikusemoran *et al* (2014)[1].

Table 4a: The magnitude percentage and annual rate of changes of the lake basin (1975 – 1987)

LULC Classification	**1975**	**1987**	**Magnitude of change**	**% change**	**Annual rate of change**	**Remark**
Bare surface	585.65	1340.95	755.3	128.92	+55.46	Increase
Build up area	715.06	1597.28	882.22	123.38	+53.05	Increase
Dense vegetation	4973.17	2976.57	1996.6	-40.15	- 17.26	Decrease
Extensive grazing/ agriculture	2144.22	4143.12	1998.9	93.22	40.08	Increase
Grass lands/light vegetation	4184.22	2563.98	1620.24	- 38.72	- 16.65	Decrease
Lake	1566.49	1069.66	496.8	- 31.72	- 13.64	Decrease
Rock out crops	503.28	2051.62	1548.34	307.64	132.29	Increase
Streams	1398.11	428.81	969.3	- 69.30	- 29.80	Decrease
Un-classification	273.47	171.67	101.8	- 32.22	- 14.28	Decrease

Source: Authors Computation, 2018

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Table 4a Shows that bare surface that was originally 585.65 km^2 in 1975 increased to 1340.95 km2 in 1987 recorded positive change. This could be attributed to the 1983/194 drought which affected the whole country and falls within this period in addition to increase in agricultural activities and other constructions. Build up area or settlements which covers 715.06km2 in 1975 sprang up to 1597.28km^2 in 1987 recorded positive change, this is due to migration of the people to the Lake basin whereby more settlements were formed. Dense vegetation cover that covers 4973.17km2 in 1975 had decreased to 2976.57km^2 in 1987 also recorded negative change and could be attributed to increased deforestation in the area where by forest were cleared to pave way for constructions of settlements, road networks and agricultural lands. Extensive grazing/Agricultural lands that covers only 2144.22km^2 in 1975 expanded to 4143.12km^2 and recorded positive change. This could be attributed to the increase in population of the people who engaged in agriculture as well as the increase in the number of herders that migrated from other part of the North. Table 5a further showed that Grasslands/ light vegetation that covers 4184.22km2 in 1975 and decreased significantly to 2563.98km^2 recording a negetive change. Again, this reduction could be attributed to increase in the human activities such as grazing, farming and increase in the no of settlements in the lake basin. Lake coverage stood at 1566.49 km^2 in 1975 and reduced to 1069.66km^2 in 1987 and recorded negative change. This could also attribute to 1983/1984 drought that ravage the country within this period.

Table 4b: The Magnitude percentage and annual rate of change of the lake basin (1987 – 1999)

LULC Classification	**1987**	**1999**	**Magnitude of Change**	**% Change**	**Annual Rate of Change**	**Remark**
Bare surface	1340.95	1111.70	229.25	- 17.10	- 7.35	Decrease
Build up area	1597.28	2027.08	429.8	26.91	+11.57	Increase
Dense vegetation	2976.57	1961.30	1015	- 34.11	- 14.67	Decrease
Extensive grazing/ agriculture	4143.12	4019.17	123.95	- 2.99	- 1.29	Decrease
Grass lands/light vegetation	2563.98	2936.82	372.84	14.54	+6.25	Increase
Lake	1069.66	1215.09	145.13	13.60	+5.85	Increase
Rock out crops	2051.62	2565.12	513.5	25.03	+10.76	Increase
Streams	428.81	507.39	78.58	18.33	+7.88	Increase
Un-classification	171.67	231.71	59.44	34.97	+15.04	Increase

Source: Authors computation, 2018

Table 4b revealed that bare surface reduced from 1340.95km2 in 1987 to 1111,70 km2 in 1999 and also recorded negative change.. This could be due to continuous usage of land for agriculture may lead to agricultural land been converted to open, non-cultivated type such as open grassland or sandy bare surfaces as noted in the Table. Adeniyi and Omojola (1997) asserted that land exposure and desiccation are noted for increasing the local rainfall run-off and reducing infiltration. This factor affects the total water balance of a drainage basin, reduce soil matter by exposure to agents of erosion and consequently hamper land cultivation. Ogunwusi (2012) also reported that over 90% of the natural vegetation in Nigeria had been cleared and over 350,000 ha of forest and natural vegetation are lost annually.

Table 4b also revealed that build up area or settlement which covered 1597.28km2 in 1997 increased to 2027,08 km2 in1999 with a positive change record. This could be attributed expansion of settlements and the building of more houses in Newbussa and its surrounding villages. Dense vegetation that coverered an area of 2976.57 km2 in 1987 and reduced to 1961.30 km2 with a negetive change record. This could be attributed to increased deforestation in the area where by forest were cleared to pave way for more constructions of settlements, road networks and agricultural lands. Extensive grazing/Agricultural lands that covers 4143.12km2 in 1997 expanded to 4019km2 km^2 in 1999 with a negetive record of change. This could be attribued to the increase in population of the people who engaged in agriculture as well as the increase in the number of herders that migrated to the basin.

Table 4b further showed that Grasslands/ light vegetation that covers 2563.98km2 1997 and increased significantly to 2936.87km^2 recording a positive change. Again, this could be attributed to increase in the human activities such deforestation agricultural and logging which are common in this period in the basin. Lake water covered 1069.66 in 1987 and increased to 1215.09km2 in `1999 recording a positive change, this would not be unconnected to the control measures especially by the National Institute of Freshwater Fisheries Research (formerly Kainji Lake Research Institute). Daddy et al. (1995) reported that the institute evolved mechanical, biological and manual control measures in controlling the water hyacinth on the lake. They reported that 45% of the estimated coverage by the weeds has been effectively removed. It was these efforts that made the lake to regain 49.1 km2 from the weed coverage area within this period.

Table 4c: The Magnitude percentage and annual rate of change of the lake basin (1999 – 2005)

LULC Classification	1999	2005	Magnitude of Change	% Change	Annual Rate of Change	Remark
Bare surface	111.70	588.94	522.73	- 47.02	- 20.22	Decrease
Build up area	2027.08	2823.86	796.78	39.31	+16.90	Increase
Dense vegetation	1961.30	2770.78	809.48	41.27	+17.75	Increase
Extensive grazing/ agriculture	4019.17	2783.36	1235.81	30.74	+13.22	Increase
Grass lands/light vegetation	2936.82	4268.93	1332.11	45.36	+19.50	Increase
Lake	1215.09	1185.94	29.15	- 2.39	-1.03	Decrease
Rock out crops	2565.12	817.5	- 1747.61	- 68.13	+29.30	Increase
Streams	507.39	1104.21	596.82	117.63	+50.58	Increase
Un-classification	231.71	0.10	-	-	-	

Table 4c revealed that bare surface covered 111.70km2 in 1999 and increased to 588.94km2 in 2005 with a positive record of change. This could be traced to increase in population and agricultural activities where forests are cut down for farming and settlement purposes. The table also revealed that Bulit up areas or settlements covered 2027.08km2 in 1999 and increased to 2823.86 km2 in 2005 with also a positive change. This could be attributed continuous expansion of settlements and the building of more houses in New Bussa and its surrounding villages due to increase in population. Similarly densed vegetation, covered 1961.30km2 in 1999 and increased significantly to 2770.78km2 in 2005 with also a positive and could be attributed to increased deforestation in the area where by forest were cleared to pave way for more constructions of settlements, road networks and agricultural lands.

Extensive grazing/Agricultural lands that covers 4019.17km2 in 1999 and increased to 2783.36 km2 km^2 in 2005 with a negative record of change. This could also attribued to the increase in population of the people who engaged in agriculture as well as the increase in the number of herders that migrated to the basin This conforms to the earlier reports of Henry et al.

(2013) that increased human and cattle population is continuously putting more pressure on the Kainji Lake Area and has ultimately cause fragmentation and degradation of wildlife habitats.

Table 4c further showed that Grasslands/ light vegetation that covers 2936..82km2 1999 and increased significantly to 4268.93 km^2 recording a positive change. Again, this could be attributed to increase in the human activities such deforestation agricultural and logging which are common in this period in the basin. Kainji Lake water covered 1215.09km2 in 1999 and reduced 1185.94km2 in 2005 recording a positive record of change. The above mentioned activities help in no small measure in aiding erosions in the basin which in turn, reduce the water body.

Table 4d: The Magnitude percentage and annual rate of change of the lake basin (2005 – 2018)

LULC Classification	**2005**	**2018**	**Magnitude of Change**	**% Change**	**Annual Rate of Change**	**Remark**
Bare surface	588.97	1102.91	513.94	87.26	+37.52	Increase
Build up area	2823.86	3330.50	506.64	17.94	+7071	Increase
Dense vegetation	2770.78	1976.83	793.95	-28.65	-12.32	Decrease
Extensive grazing/ agriculture	2783.36	1550.67	1232.69	-0.44	-0.19	Decrease
Grass lands/light vegetation	4268.93	3330.74	-938.19	-0.22	-0.95	Decrease
Lake	1185.94	1179.12	6.82	-0.58	-0.25	Decrease
Rock out crops	817.51	2273.26	1455.75	178.07	+76.57	Increase
Streams	1104.21	714.29	389.92	-35.31	-15.18	Decrease
Un-classification	0.10	-	0.00	0.00		Increase

Table 4d present the state of land use change in Kainji lake basin. It shows that bare surface covered 588.97km2 in 2005 and increased significantly to 1102.91km2 in 2018 with a positive record of change. This could be attributed to further increase in population and agricultural activities where forests are cut down for farming and settlement purposes.

The table also revealed that Bulit up areas or settlements covered 2823.86 km2 in 2005 and expanded to 3330.50km2 in the year 2018 with also a positive record of change This could also be attributed continuous expansion of settlements and the building of more houses in New Bussa and its surrounding villages due to increase in population. This conform with the report by Eugene (2010) who stated that land use and landscape structure facing serious challenges such as rapid population growth, and pressure on land use, agricultural expansion and climate change. The report also indicated that Nigeria agricultural lands covered only 184,754 km2 in 1975 and expanded to 380,000km2 in 2013, 40 percent of the total land mass and that forest land decreased by 45 percent in 2013.

4.2 Implications of the land-use changes on the lake basin

1. Dam safety concerns: reduction in lake area from 1566.49 km^2 to 1179.12 km^2 since the construction of the dam in 1969 raises a lot of potential concerns, considering the fact that Nigeria economy depends on electricity generated from the dam. On the one hand, the silting up of the dam could lead to inevitable reduction in the capacity of the dam to generate enough electricity. On the other hand, fish production could be affects as spawning ground for fish will be reduced. All this if unchecked could directly affect both electricity generation and fish production.

2. Increase in deforestation: with the alarming rate of settlement and land clearing for agriculture has increase significantly between 1975 and 2018. Forest land meant for National Game Reserves (Kainji Game Reserve) is gradually disappearing (4973.17km^2 to 2976.57km^2). This is an indication of population increase where more land was needed for agriculture and settlement purposes. According to Amusa et al. (2010), reduction of the park land could be attributed to the fact that the primary occupation of the Kainji Lake area is agriculture, which in effects reduced the park land area. This means that sooner or later the woodland vegetation which is the home of the first national park in Nigeria will become a history. Moreover, due to poaching and other

human interference, many animals, plants and other micro organisms in the basin may become extinct.

3. Reduction in fish catch: The degradation of the lake area coupled with other factors such as excessive water (floods) and weed encroachment no doubt have collectively impart negatively on the annual fish catch in the lake area as Omojowo et al. (2010) reported that total fish catch reduced from 38,346 mt in 1996 to 13, 361 mt in 2001.

4. Land exposure/desiccation: Continuous usage of land for agriculture may lead to agricultural land been converted to open, non-cultivated type such as open grassland or sandy bare surfaces as noted in Table 4a-d where bare surface that was not present in the basin in 1975 has been appearing though at a slow rate since 1987. Adeniyi and Omojola (1997) asserted that land exposure and desiccation are noted for increasing the local rainfall run-off and reducing infiltration. This factor affects the total water balance of a drainage basin, reduce soil matter by exposure to agents of erosion and consequently hamper land cultivation. Ogunwusi (2012) also reported that over 90% of the natural vegetation in Nigeria had been cleared and over 350,000 ha of forest and natural vegetation are lost annually

5. Flooding: The expansion of the lake water has resulted into serious flooding especially at the western bank (where much land has been captured by the lake (Table 4a) and the downstream which is the receiving end (Abiodun, 2009) . In the work of Okhimanhe (1993) highest susceptibility of the flood in the Kainji Lake occurs within the first 3 km from the reservoirs including the river channels and surface water body lying between 69 and 162 m above sea level, while the lowest is at 15 km away from the reservoir and greater than 193 m above sea level. The devastative flood at the downstream had caused displacement of settlements and huge destructions of farmlands, fish ponds during the 2012 floods running in millions on Naira.

5. Conclusions and Recommendations

This paper found that the rate of deforestation and erosion in the study area is linked to the methods of farming practices as well as the removal of the catchment vegetation as part of land preparation. Uncontrolled human settlement and demand for fuel wood etc., was another issue to contend with. If this issue of land degradation is not appropriately dealt with in the future, it could lead to the decrease in the power generating capacity and irrigation purposes of the dam due to filling up with silt materials and the ultimate shortening of the life span of the dam. It is very important to emphasize that by working together, it is possible for the responsible authorities, government and the host communities to tackle the major environmental problems facing the fragile environment of the dams.

Finally, it is hoped that the findings from the study area will provide useful insight into the state of the environment, and the recommendations proposed in this paper would equally be helpful to mitigate, control and to improve the management of the dams.

The following recommendation were made

i. The author strongly suggests that the main solution to deforestation has to start from local action. In other words a bottom-up approach between the responsible authorities and local people to work together in partnership to check deforestation is highly recommended.

ii. Tree planting and protection of existing vegetation from fire and land clearing should be also encouraged, as the restoration of degraded lands.

iii. Remote Sensing and GIS techniques are recommended for use in environmental monitoring and management of our already fragile environment.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

6. References

Comment [MOU9]: References could be improved in terms of their number and the currency for an enhanced paper and updated argument. Make sure your references are in accordance with APA or any other approve format.

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