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ASSESSMENT OF CHANGES IN LAND USE/LAND COVER AND MORPHOLOGY OF LAKE NJUWA, YOLA ADAMAWA STATE,NIGERIA

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ABSTRACT

This paper is aimed at assessing the temporal trends in land use / land cover changes around Njuwa lake, it will as well assess changes in the physical characteristics of the lake especially changes in its aerial extent over the period of 30 years (1975 – 2005) and the socio-economic consequences of these changes. Data for the study were obtained from analysis of satellite images (LandSat images of 1975 1985 and 2005 to assess land use / land cover changes and aerial extent of lake Njuwa using ArcGIS 9.3. Questionnaires were also administered to randomly selected respondents to provide information on the socioeconomic impact and response to changes in the morphology of lake Njuwa. The result shows a significance change in land use land cover to the effect that built up area expanded from 6% to 45% between 1975 and 2005,and significant reduction in the Lakes aerial extent, with the total percentage change of 33% between 1975 and 2005. There was also expansion in crop lands from 8% in 1975 to 23% in 2005. This implies more sediment and water were delivered to the lake which invariably leads to siltation of the lake, and reduction in its aerial extent. Based on these findings, use of agro forestry and other restoration efforts were recommended.

KEYWORDS: Land Use/ Land cover, Lake Njuwa, Geo-referencing, Over Laying.

INTRODUCTION

Land use and land cover are two separate words that are used inter changeable (Dimyati et al. 2004). Whereas land use is referring to the nature of land occupancy which is based on socio-economic consideration and the physical characteristics of the land. Land cover on the other hand is the physical attributes of the land, it is an expression of what is existing or has existed on the land. These include vegetation cover, built up areas, agricultural as well as other various human and physical landscapes that occupy a parcel of land.

Assessment of land used/land cover, from a spatio temporal perspective provides the basis for sustainable resources management, especially in delicate environment, where any subtle change in the environmental configuration will trigger changes in the system at a micro scale (Anderson,et al. 2004). Various methods of land use/land cover change detection have been developed to track the temporal trajectory of land use/land cover change. These methods include the differencing of Normalized Difference Vegetation Index (NDVI), image overlay, change vector analysis, classification comparisons of land cover statistics, image rationing and principal component analysis. In addition to these change detection methods, there are other methods such as comparison of land cover classification (Todd, 1977, Howarth and Wickware, 1981) Multi date classification (Ester et al. 1982, Schowerngert 1983). Post Classification Comparison (Gordon 1980, Joyce et al 1982, Mas 1999) and Principal Component analysis (Richardson and Milne, 1983, Sigh 1984).

The objectives of the digital change detection as identified by International Geosphere-Biosphere Programme (IGBP) and International Human Dimension Programme (IHDP), (1999) include knowing the pattern of change of land cover over space and time knowing the process of land cover changes and knowing the nature of human response to land use/land cover changes.

However, the main objective of this paper is to assess changes in land use/land cover and the morphology of Lake Njuwa and its impact on the socio-economic disposition of the land users. The specific objective of the paper are to assess the temporal trend in land use/land cover changes around the Lake Njuwa, to also assess changes in the physical and hydrological characteristics of the lake and to examine the socio-economic effects of such changes. The paper is mainly

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justified by the socio-economic and cultural importance of Lake Njuwa, and the response of the local hydrology to the increasing human activities around the lake.

STUDY AREA

Lake Njuwa and its surrounding constitute a micro hydro-geomorphic system, which boarders an expansive residential and other land uses that characterized Yola, the town where the lake is found. The population of Yola is ever increasing as it assumed a political, economic and social status, and this has led to changes in the nature and intensity of land use around the lake.

Lake Njuwa is in Yola South local government, which is located on 9o 04'00"and 9o 14'00N and 12o 17'00 and 12o 33'E with an average altitude of 185m. Yola town is the headquarters of Yola South local government area and the capital of the Adamawa Emirate as such it has an edge over the surrounding settlement in terms of population density; the population of Yola South local government is 194,607 persons (NPC, 2006), A sizeable percentage of this population is in Yola town which is the main town within the local government. The urban status of Yola town is also accompanied by an admixture of land uses such as residential, commercial, institutional land uses etc.

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The study area lies within the tropical savannah climatic region, it is characterized with a distinct rainy season that lasts between April and October and a dry season that lasts between (November and March). The area receives an average monthly rainfall of 600 – 1100mm, with a peak period recorded in August/September, where 60% of the rain is recorded.

The Geology of the area is dominated by the Bima sand stone and alluvial deposit on the shores of lake Njuwa and the river Benue which borders the North and Southern fringes of Yola town. The physiography of the area, is that of a flat terrain with dotted highlands of Bagale hills and the Verre mountains from where a large volume of run off is emptied into river Benue and Lake Njuwa during the peak flow periods.
Soil is another physical characteristics of the area, which mainly affects agricultural production. The soil in the precinct of Lake Njuwa is classified as Gleyic combisol which is mainly made up of mineral hydromorphic and juvenile soils of recent and lacustrine alluvium (Areola, 1983). The soil is dark in colour and rich in nutrients that is required for agricultural production, this is partly responsible for the intensive production of 'Muskuwa' around the lake as the soil has high moisture retention capacity enabling 'Muskuwa' to thrive well on the moisture residue in the soil during the early period of the dry season

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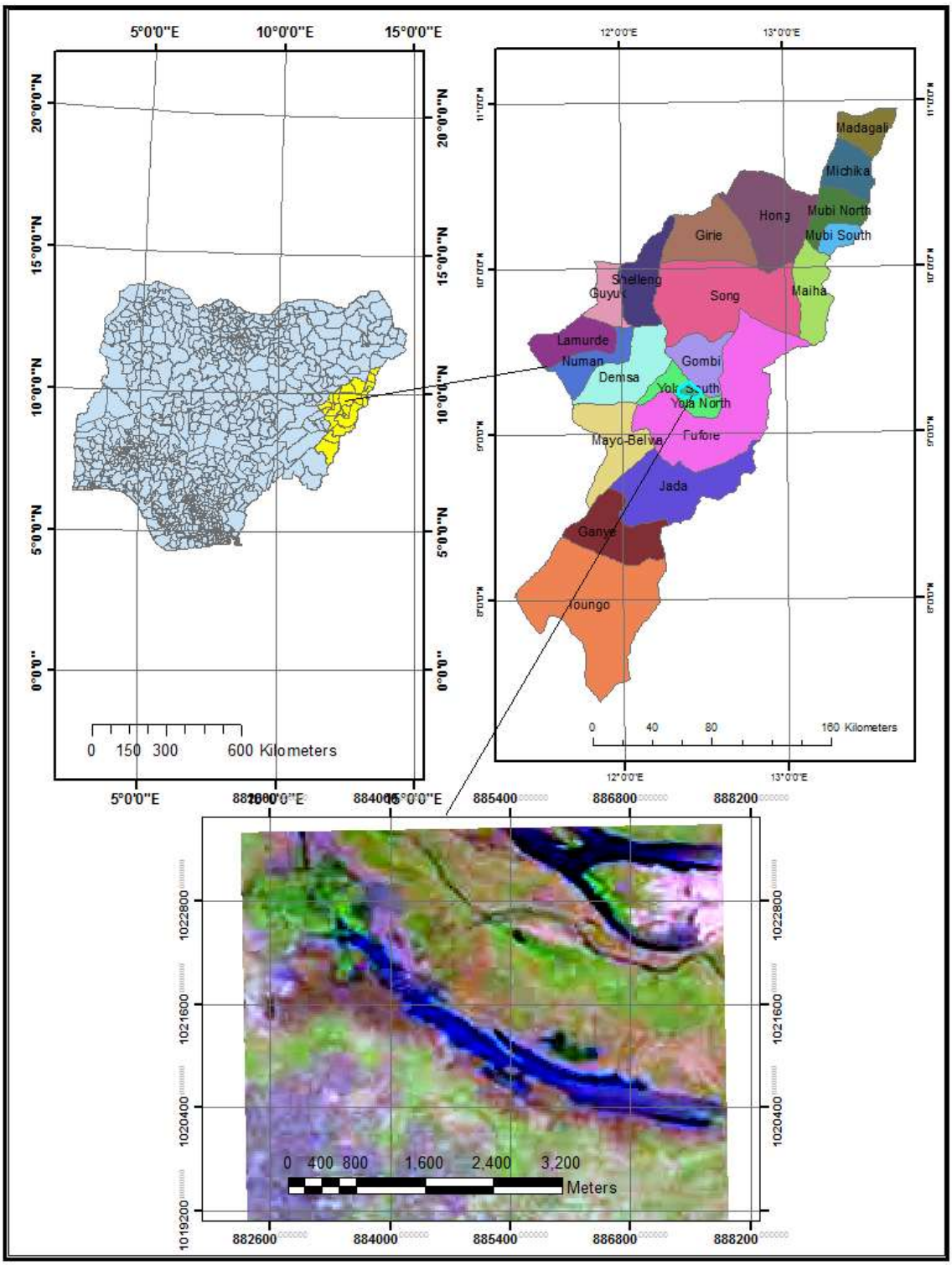

Location Map of the Study Area

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Scientific Journal Impact Factor: 3.449
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METHODS AND MATERIALS

Three LandSat Images of 1975,1985 and 2005 were analysed for Land use/Land cover changes. Lake Njuwa was digitized from the multi date images and overlaid to produce a change map. The analysis of the Satellite images for change detection ,and digitization of lake Njuwa to produce the change map was done using ArcGIS 9.3 .

Image Classification

An unsupervised classification approach was adopted to allow for natural spectral clusters to be defined with a high degree of objectivity. Thus the ISODATA (Iterative Self-Organizing Data Analysis) algorithm in ArcGis 9.3 was used to identify spectral clusters from the Landsat data. It used minimum spectral distance to assign a cluster for each candidate pixel. Firstly, clusters were created using the ArcGIS multivariate toolsets by imputing all the image bands, the name of the output signature files, as well as the number of iterations were registered, minimum class size, and the interval at which to take the sample points from which to calculate the clusters were all specified in the ArcGis multivariate analysis tool box.

The ISO Cluster function returned a signature file containing the multivariate statistics for a subset of the cells for the identified clusters. The resultant calculations identifying which cell location belongs to which cluster, the mean value for the cluster, and the variance–covariance matrix, this information was stored in a text file format. The process was repeated: each cell was assigned to the closest mean in multidimensional attribute space, and new means are calculated for each cluster based on the membership of cells from the iteration.

Satellite images of Njuwa lake and environs in 1975, 1985, and 2005 were processed and classified to identify the different landuse and landcover types in area. However this classification became a medium for understanding, visualizing and identifying spectral changes of each individual pixel of an image giving rise to either increase or decrease in spectral clusters over time. These spectral clusters can be interpreted to mean different land uses/land covers, an increase in one spectral cluster now connotes an increase in a particular land cover and vice versa.

Determining different class means performing an operation with a GIS, first; spectral signature files and iterative self organizing (ISO) cluster files were produced for the georectified images. These are text files produced in the multivariate analysis tool box of ArcGis 9.3 and were used as input files for a maximum likelihood classification model in the spatial analysis extension of ArcGis 9.3. in creating ISO clusters image bands of each LANDSAT were inputted, number of classes were set to 12 (for preliminary pixel analysis),number of iteration, minimum class size and sample intervals were left at default (recommended by the software). In performing the classification, the maximum likelihood classification (unsupervised) method was used. Each raster band was imputed and accompanied by signature files of each LANDSAT, the output classified raster were indicated, a priori probability weighting was set as EQUAL- the operation was then ran. Classified raster of each LANDSAT with 12 classes as specified from the signature files were produced. These clusters were then reclassified into six classes each based on their ordinariness.

Spatial reclassification

The reclassification functions reclassify or change cell values to alternative values using a variety of methods. In this work the “classify using natural breaks” was used to classify the classes into 12, the spatial analyst tool was then used for the final reclassification to identify specific landcover types. The reclassify dialogue box presented old values of each candidate pixel after which new values were assigned to each class. Values of one to 12 were first used for each of the image but there were some spectral confusion which necessitated the use of one to six weighting. The result was the identification of six land use types at Njuwa Lake and environs.

The classified images of each period were vectorized using the spatial analyst extension in Arcmap editing environment. The vectors were saved as shapefiles of polygons after which they were exported to a geo database in order to obtain geometries of the land uses for comparison and statistical analysis. The structured query language (SQL) was used to extract water body landuse and subsequently the pixels that made up the lake; the result was Lake Njuwa in 1975, 1985 and 2005 respectively.

Image differentiation was used in change detection, map algebra was used to determine image differential from an earlier year and the later; this was carried out on both the Land uses classified and the Lake Njuwa extracted.

Change Detection Procedure

A computer-assisted approach was used for land use/cover mapping from Landsat images with spatial resolution 30m, a maximum likelihood classification method was adopted. Signatures files were equally produced as input for the classification. A statistical probability was computed for each class to determine the membership of the cells to the class. The default

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EQUAL a priori option was specified, each cell was classified to the class to which it has the highest probability of being a member.

RESULTS & DISCUSSION

Land use/land cover change around lake njuwa

An analysis of land use/land cover around Lake Njuwa shows a significant change in LU/LC as a response to the increasing population within the area and intensification of agricultural production within the precinct of the lake. These changes as presented on Table I; and figures 1a and 1b is significant in understanding the changes in the lake morphology, especially considering the roles of these changes in influencing the Quantum of sediments and run off delivered to the lake.

Table I: Pattern of Land Use/Landover Around Lake Njuwa

LU/LC classification	Area (Ha) 1975	Percentage (%)	Area (Ha) 1985	Percentage (%)	Area(Ha) 2005	Percentage (%)
Water bodies	339	12	299	11	262	9
Grass lands	460	17	399	14	256	9
Open spaces	285	10	253	9	197	7
Croplands	212	8	448	16	635	23
Green marshy areas	915	33	726	26	557	20
Buildup areas	575	20	661	24	879	32
Total	**2786**	**100**	**2786**	**100**	**2786**	**100**

Source: Satellite Imageries analysis

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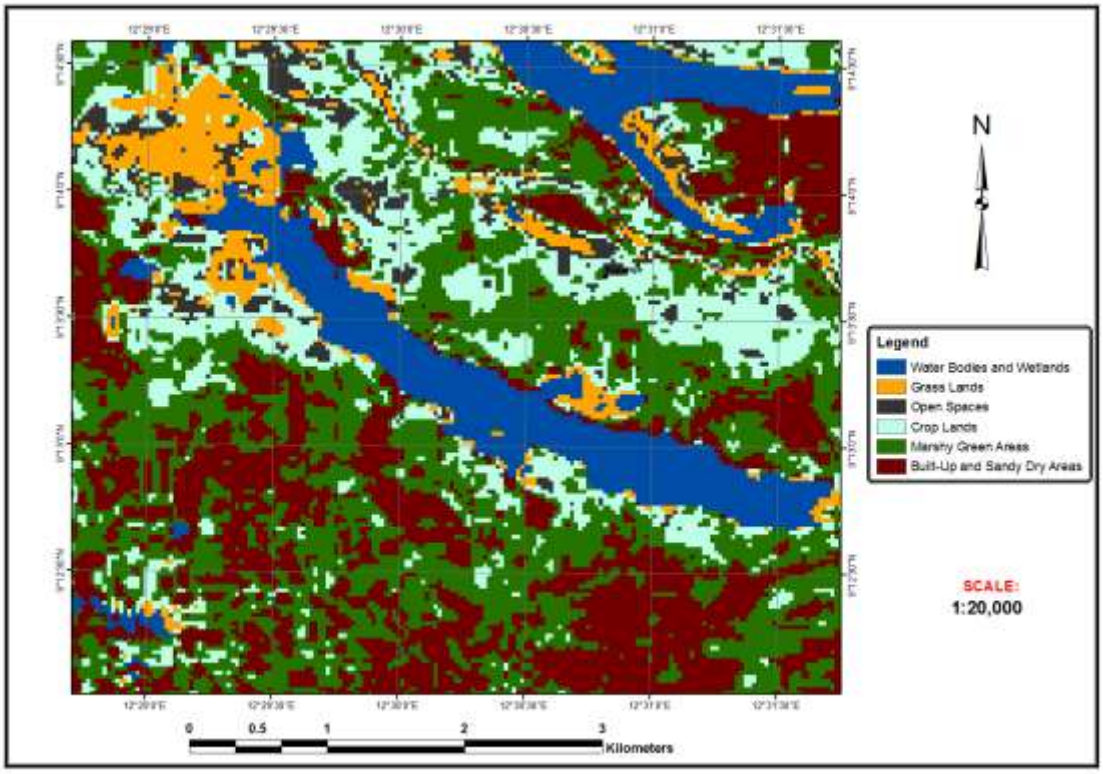
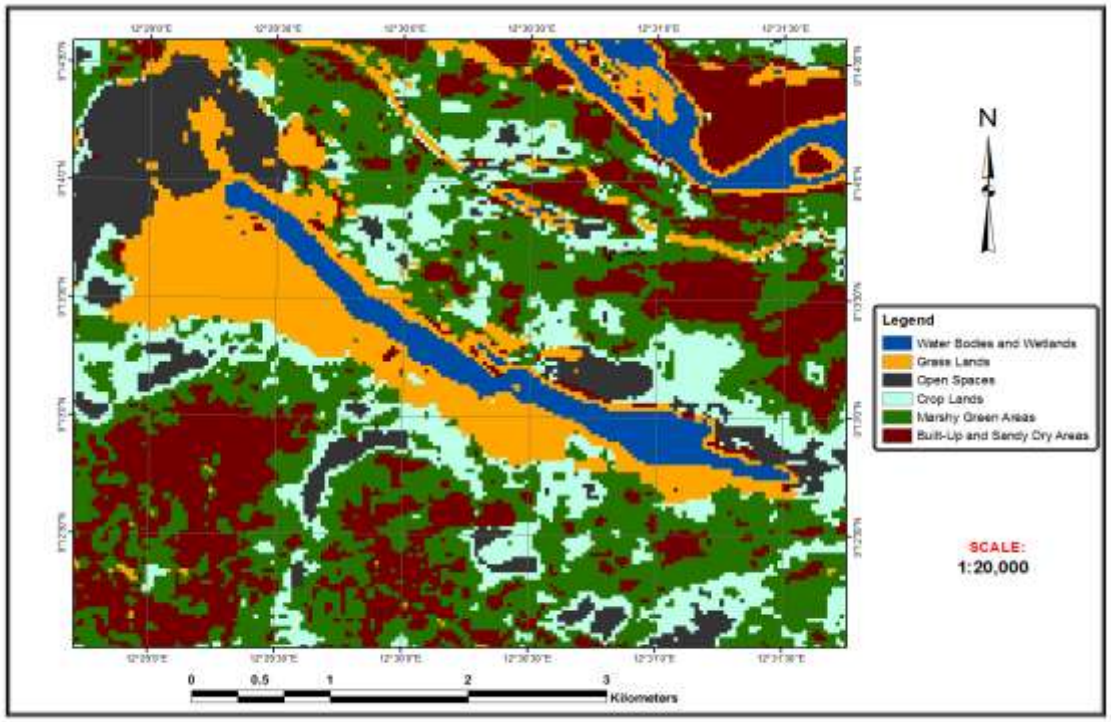


Classified Image (1975)



Classified Image (1985)

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Scientific Journal Impact Factor: 3.449
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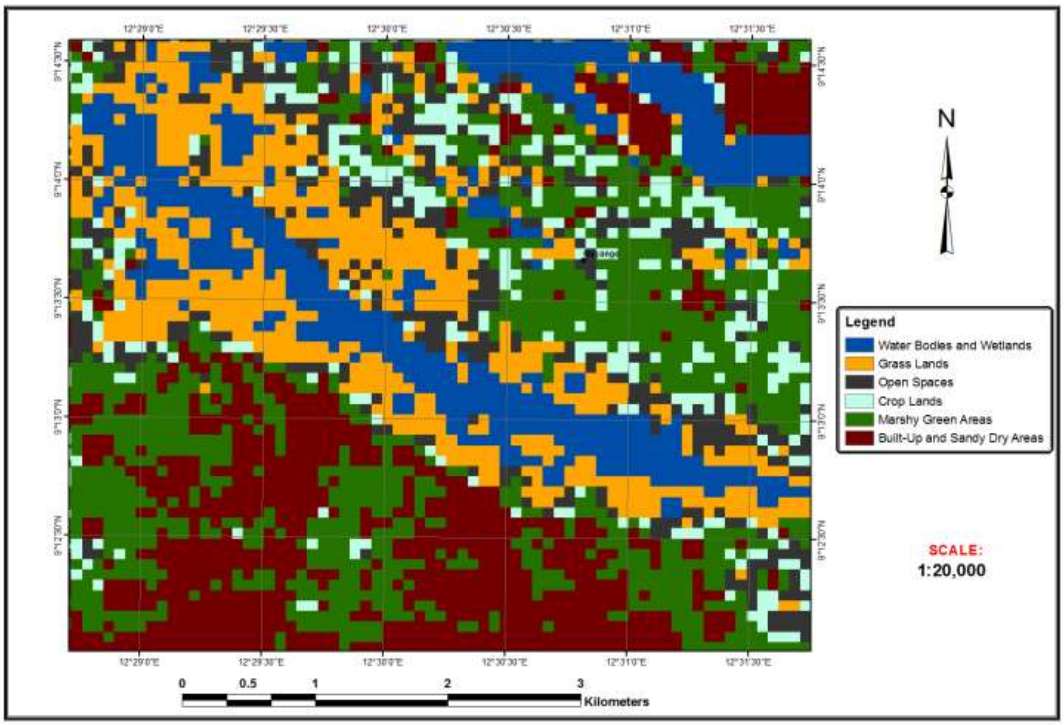

Classified Image (2005)

Figure 1a : Classified Images Of Area Around Lake Njuwa In 1975,1985 And 2005.

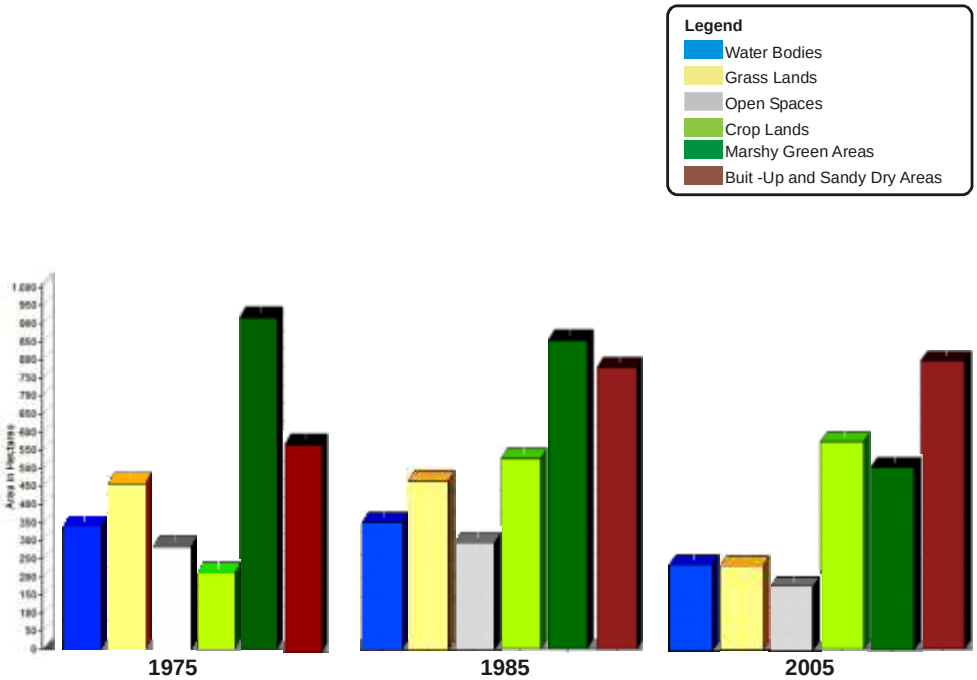

Fig. 1b:
Graphical Presentation Of The LU/LC Changes In 1975,1985 And 2005.

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From the table and Figures 1a and 1b it could be seen that there is an appreciable expansion in build up areas and crop land which could be directly attributed to the increasing population of the study area. These changes have implication on the sediments and water that is delivered to the lake, the lake experiences sedimentation and this resulted to diminishing capacity of the lake to contain more water routed from Yola and environs, thereby significantly altering the local Hydrology and Geomorphology of the lake.

Intensive agricultural expansion and the Quest for grazing fields have combined to reduced the grassland within the precepts of the lake from a total of 17% of the area in 1975 to just 9% in 2005. The areas that were hitherto vegetated are left bare and hardened as a result of the trampling by live stocks and this results to gullying in the area.

CHANGES IN LAKE NJUWA

The extracted Njuwa Lake were overlaid in order to generate two change maps describing changes in the surface area of the lake, which occurred during 1975-1985 and 1985-2005. The extent of the lake in 1975, 1985 and 2005 and the change maps are presented in Figures 2a and 2b.

FIGURE 2A CHANGE MAP OF LAKE NJUWA (1975 – 1985)

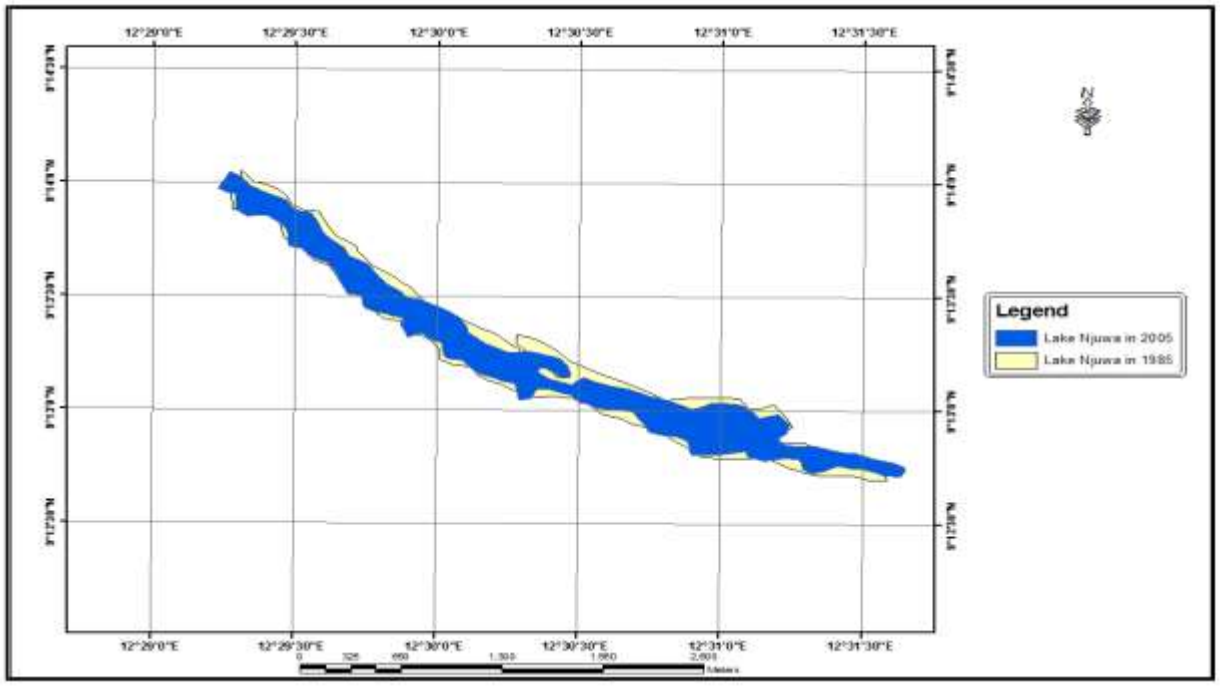

FIGURE 2b CHANGE MAP OF LAKE NJUWA (1985 – 2005)

The changes in the aerial extend of the lake as depicted on figures 2a and 2b is such that the lake has its surface area reduced from 1.7 Km2 in 1975, to 1.3 Km2 and 1.1Km2 in 1985 and 2005 respectively. This represents 33% change in the lake's area between 1975 and 2005. This change could be attributed to the damming of river Benue at Lagdo in the Cameroun Republic and also the truncation of flow of river Chouchi at Yola, as a result of the structures at the proposed site of the Chouchi irrigation project. These interventions are solely responsible for the excessive reduction of inflow into the river and the lake. The intensive cultivation around the lake supplies it with much sediments thereby reducing its capacity to contain much water.

This finding corresponds to similar findings by previous studies, for instance Siddle(2007) noted that changes in the surface area of Lake Inle,Central State has resulted to a loss of 93 % of its surface area due various human activities mainly agricultural development and timber removal. Minale and Rao,(2011) also undertook an assessment of the hydrology and anthropogenic impacts on Lake Tana,North Western Ethiopia, the findings reveals that

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more than 6.2% of the lake's surface area was converted to otsher land cover within a period of 35 yrs as a response to increasing population pressure and climate change experienced in the region.

CONCLUSION

Restoration of lake Njuwa to its pristine values is one of the major way through which microeconomic development and poverty eradication will be achieved. The lake has practically dried up over the thirty years of this study, as evidenced by its shrinkage and diminished yield in fish catch from the lake. In view of the precarious condition of the land users, it is pertinent to make some recommendations that will restore the lake and ensure its efficient and sustainable management and that of other associated resources.

- Adamawa Emirate Council (traditional custodians to the lake) should liaise with Upper Benue River Basin Development Authority to dredge the lake, so as to enhance its capacity to contain more water and avert seasonal flooding within the flood plains.
- Land users around the lake should be encouraged to adapt agro forestry as a system of production, this will check erosion and create a buffer around the lake, which will also reduce sediment influx into the lake.
- The Adamawa Emirate Council should from a management committee to oversee the lake, membership of the committee should be made up of Environmentalist, fisheries and other stake holders.
- The lake should be stocked with fingerlings and the annual Njuwa Fishing Festival should be revived.
- The management committee of the lake should evolve and implement a detailed and long term land use/land management plan around the lake.

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