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DETERMINATION OF CHANGE MATRIX AMONG THE LANDUSE/LANDCOVER TYPES IN JALINGO METROPOLIS, NIGERIA

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ABSTRACT: The study examined the changes in land use/land cover (LULC) in Jalingo between 1988 and 2006. Six LULC types were classified in the study area from Landsat TM image of 1988, Landsat ETM image of 1999 and NigSat image of 2006. The six LULC types were bareland, built-up, cultivation, shrubland, water body and wetland. The data were analyzed using thinning, overlay operations, calculation of the area in km^2 of the resulting LULC type and LULC change matrix. The software used in the analysis are ERDAS and ILWIS 3.2.The areas of bareland, cultivation, water body, shrubland and wetland have decreased by 1.53km^2 (1.6%), 19.22km^2 (71%),0.15km^2 (0.6%) 0.22km^2 (0.81%) and1.64km^2 (6.0%) from 1988 to 2006. Conversely, the area of built-up land has increased by 15.62km^2 (40.2%) during the same period. Built-up land lost 11.64 km^2 and gain 27.26km^2 from 1988 to 2006 with the highest contribution of 19.22km^2 (71%) from cultivated land. The study recommended among others, the need for appropriate legislations to be put in place to check indiscriminate sprawling. The study concludes that increase in the proportion of urban population is the principal driver of land use/land cover change in Jalingo town.

KEYWORDS: land use, land cover, change matrix, built up, jalingo.

1 INTRODUCTION

Recent analyses suggest that 83% of the earth's land surface has been affected by human settlement and activities, leaving only 17% in wilderness (WCS & CIESIN 2002). Urban areas are expanding, particularly in the developing world. UN population division estimates suggest that the world's population will become majority urban by 2030, in contrast the world was only 37% urban in 1970.

Though the extent of urban areas is not that large when compared with other land uses such as agriculture, or forestry, their environmental impact is significant. This is not only to the large concentrations of population that are found in cities, but because they are centres of political, cultural and economic influences, and are often the location of significant industrial activities. In the era of economic globalization, so-called "mega-cities" like New York, London, Sao Paulo and Singapore draw on resources and economic activities around the world to build the wealth and prominence (Schiller et. al. 2001).

According to Turner (2001), urban areas rely on vast hinterland for food, raw materials for industrial, energy, water supplies, construction materials, recreational areas, and myriads of other goods and services.

In terms of urban impacts on the environment and land cover change, there are direct and indirect impacts. The direct impacts include human settlements, industrial and infrastructure land uses, and the expansion of these land uses into areas of natural or agricultural lands (Heilig 1999, Vincent et. al. 2002). Urban built up areas have direct impacts on the hydrological cycle. Because urban paved and built up land surfaces tend to absorb heat and to re-radiate it at night, they can also create heat Islands that affect plant physiology as well as the health and welfare of urban dwellers (Vincent et. al. 2002).

The indirect impact of urban areas on land use and land cover can be even more important. For example, cities expropriate water from large distances; in some cases, such as in the New York city water supply districts, this may have the effect of conserving large areas of land that might otherwise be developed, (Turner, 2001).

A significant indirect impact of urban areas is the need for sinks or dumping sites for the great volumes of waste they produce. Urban wastes can be solid, liquid or gaseous. Problems of solid waste disposal have become increasingly problematic as land fills have reached their maximum capacities. Cities generally have few solutions other than to truck their waste at great cost to distinct landfills, or to incinerate it. (Vincent et al, 2002).

Liquids waste, or sewage, are generally treated and released into water bodies. This can, under certain circumstances, result in completely dead water bodies in which rivers, lakes or bays can no longer sustain life due to an excess of biochemical oxygen demand (Kreimer et.al. 1993). In northern Europe, natural wetlands are often used to filter impurities from water during the latter stages of sewerage treatment. This builds on the natural characteristics of wetlands as nutrients (Folke et. al. 1997).

Atmospheric pollutants can have a significant impact on land use and land cover. Folk et al estimate that the CO_2 emissions of major cities alone would consume 95% of the carbon absorptive capacity of the world's forest. Another major problem is air pollutant impacts on natural vegetation and crops. Acid rain has been a documented problem that dames forest lands in eastern Europe and North America.

Urbanization pathways lead to different impacts on rural landscapes in the developed and developing world. In the developed world, large-scale urban agglomerations and extended peri-urban settlements of such large areas that various ecosystem processes are threatened (Chameides et. al. 1994)

Ecosystem fragmentation, however, in peri-urban areas may be offset by urban-led demands for conservation and recreational land uses. In a different vein, economically and politically powerful urban consumers tend to be disconnected from the realities of resources production and largely in attentive to the impacts of their consumption on distant locales.

STUDY AREA

Jalingo is located in north-eastern Nigeria. It became the capital city of Taraba State in 1991 following the creation of Taraba State from the defunct Gongola State. The city is bordered on the east by Yoro Local Government Area, on the north-west is Lau Local Government Area, and on the south is the Ardo-Kola Local Government Area. It is located at Latitude $8^{o}54''$N and Longitude $11^{o}22''$E (Figure 1.6.1.1 and 1.6.1.2). According to the 2006 population census, Jalingo has estimated population of 118,000 people. Jalingo occupies a total land area of $219.18km^2$

Fig: 1: Map of Nigeria showing Taraba State

Source: Taraba State Ministry of Land and Survey, (2013).

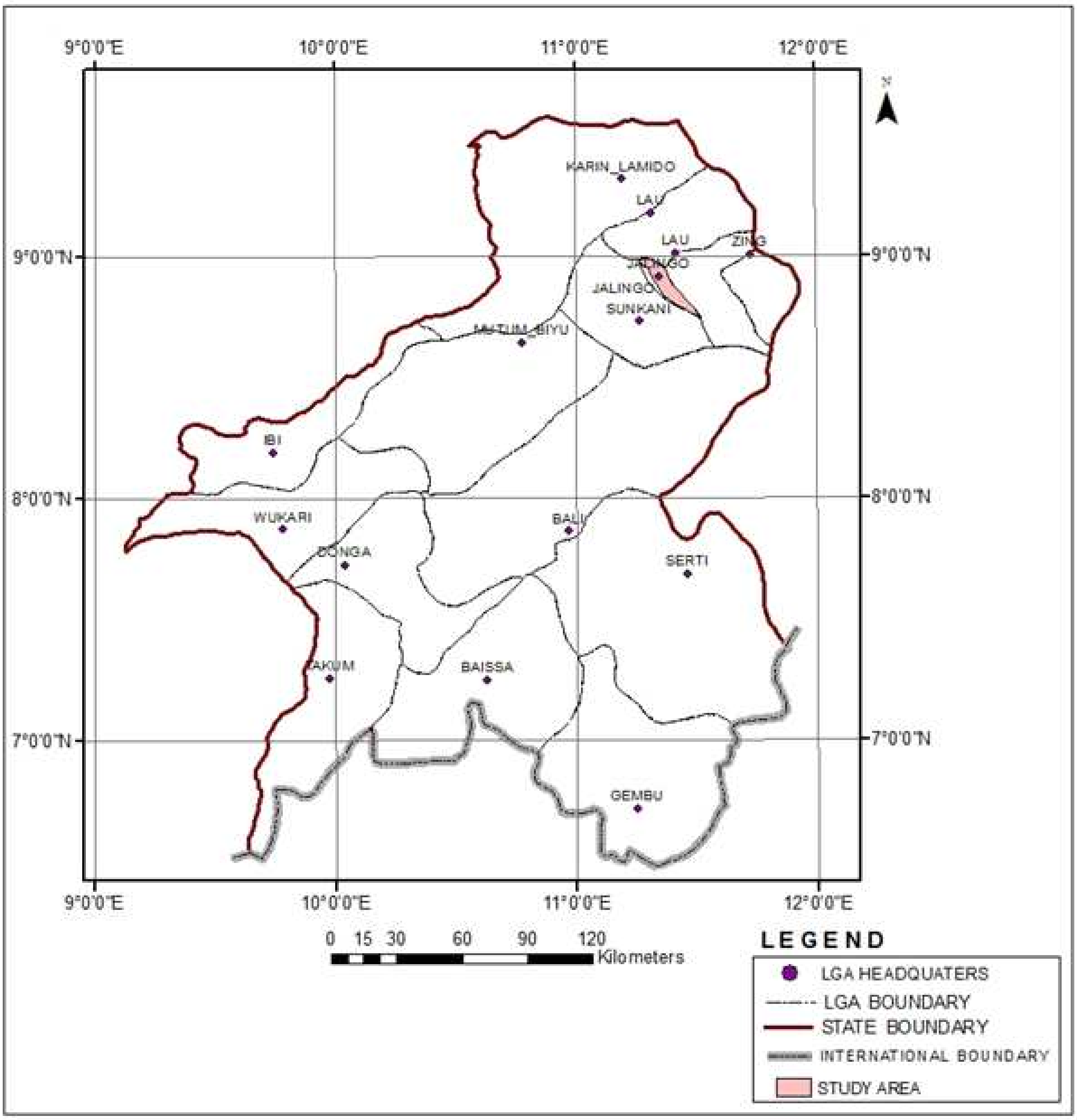

Fig: 2. Map of Taraba State showing study area (Jalingo)

Source: Taraba State Ministry of Land and Survey, (2013).

Jalingo town is blessed with vast plain land surrounded by mountains. It has very fertile soil which supports the various agricultural productions in the area. In the area of solid minerals, Jalingo is endowed with the following: feldspar, clay, quartzite, limestone, granite, marion, musconte, prite, lourmaline and zircon thereby making it a good climate for investment in ceramics, cement, burnt bricks and precious stone processing or production. In addition, due to the vast presence of precious stones, Jalingo is also a good place for the establishment of stone chips and stone crushing industries.

The climate of Jalingo is that of the tropical savanna (wet and dry). This is marked by rainy and dry seasons. Jalingo has temperature range of 18^{o}C (64^{o}F to 36^{o}C (96^{o}F) (1991-2007) and an annual rainfall of about 1,500mm with a single rainfall maxima in September. (Williams & Mary, 2007).The dry season experienced in the study area begins in November and lasts till March. It is characterized by northeasterly or the harmattan wind from Sahara Desert.

With the Northward movement of the Inter-Tropical Convergence Zone (ITCZ) over West Africa, heavy showers coming from convective clouds are experienced. Early onset of rain is experienced along the coastal area in January-February, April-

May in Central state and June-July in Northern parts of the country. (Williams and Mary, 2007).The vegetation of the Jalingo falls within the Guinea Savanna zone, which is characterized by tall grass and scattered tress.

Jalingo is surrounded by hills and mountains though with a vast plain land which supports the population of the area. There is a good drainage system in Jalingo. The town is traversed by two different rivers which banks support the cultivation of rice and sugar cane. (Figure3)

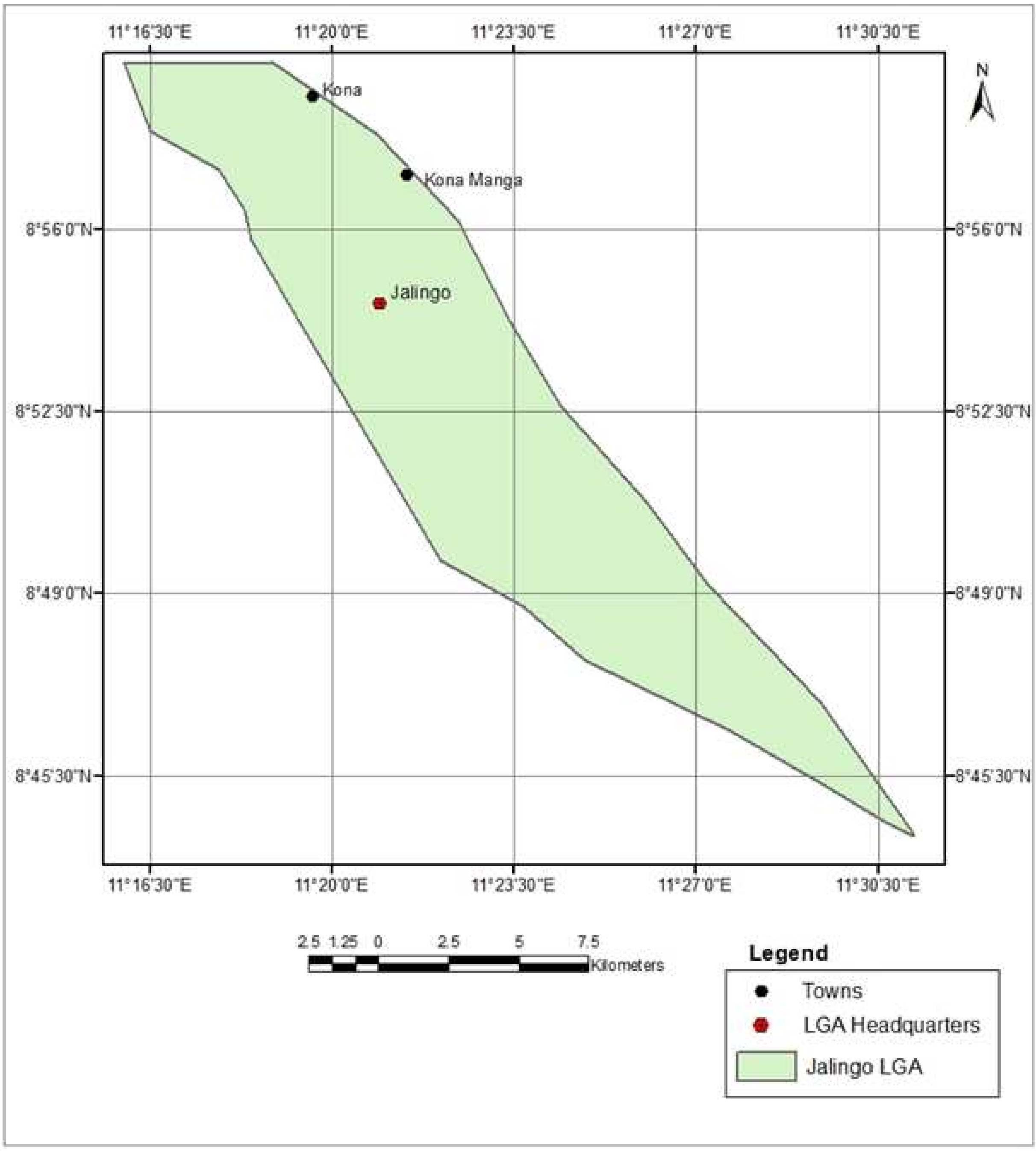

Fig. 3: Map of Jalingo L.G.A.

Source: Taraba State Ministry of Land and Survey, (2013).

The people of Jalingo are primarily engaged in farming which is supported by the vast fertile agricultural land of the area. As a result of its agriculture endowments, the area offers opportunities for cash and food crop production such as cashew, mango, oranges, pineapple, palm oil, plantain, cassava, yam, soya beans, maize, and groundnut among others thus making the place very suitable for the establishment of juice processing industries as well as for cassava chips and starch production, oil mill, flour mill and so on. Other emerging socio-economic activity in the study area includes manufacturing, construction, commerce, transportation and so on.

DATA NEEDS/SOURCE

The data needed for this research work are the different land use/land cover types (in area square km) in Jalingo. NIGSAT 1 image of 5th July, 2006 was acquired from the National Center for Remote Sensing (NCRS) Jos, Nigeria. The satellite image was used for land use/land cover change detection and monitoring in the study area.

PROCESSING OF SATELLITE IMAGES

The raw satellite image NIGSAT1was first processed before usage. The image was rectified to a common Universal Transverse Mercator (UTM) coordinate system based on the topographical map of Jalingo. This converted the imagery format of North-East to South-West orientation to a topographical map format with North-South orientation.

METHOD OF CLASSIFICATION OF LAND USE/LAND COVER TYPES

Supervised classification method was used in this research work for the interpretation of satellite images. Supervised classification using maximum likelihood classifiers is a well established technique for the interpretation of satellite and airborne remotely-sensed images (Weng, 1999). Supervised classification has been developed for satellite image-processing where it has been applied to the classification of spectral layers. However, it can also be applied to other forms of remote sensing and has been used for the classification of interpolated acoustic reflectance data (Zhang et.al, 2004). It can also be used to convert different forms of data, not just 'spectral' values. For example classification can combine reflectance, depth (height), variability e.t.c. Although many of the variables may be correlated, supervised classification is a very versatile and statistically robust tool. However, to work well, the images should be distortion-free. This is often difficult to achieve with different degrees of distortion across an image. Distortion away from the nadir (the point on the sea floor directly under the remote sensing instrument) is a particular problem for many acoustic swath systems and is particularly noticeable where image strips have been mosaic together.

DERIVATION OF LAND USE/LAND COVER TYPES

Six land use/land cover types namely Bareland, Built-up lands, Cultivation, Shrubland, Water body, Wetland, were derived from the satellite image in conjunction with ground truthing using supervised classification method.

DATA ANALYSIS

To detect and analyze the changes in land use/land cover due to urbanization in the study area, satellite image of 2006 was used to investigate the temporal and spatial changes in land use/land cover due to urbanization in Jalingo town.

Five main methods of data analysis were adopted in this study as follow:

i. Image thinning
ii. Overlay operations
iii. Ground truthing
iv. Calculation of Area in sqrkm of the resulting land use/land cover types for each study year and subsequently comparing the results.
v. Intra changes among LULC

i. Image thinning

The first process in the analysis of satellite images is thinning. This is a process where the researcher carefully studies the images and removes the possible noise from them in order to get the correct picture of the area under study.

ii. Overlay operations

Overlay operations is concerned with the identification of the actual location and magnitude of change in a particular land use or land cover type. In this research, overlay operations was however limited to build-up since the major concern in the research is the impact of urbanization on other land use and land cover.

iii. Ground-truthing

Ground-truthing is a term used in remote sensing; it refers to information collected on location. Ground truth allows image data to be related to the real features and materials on the ground. The collection of ground truth data enables calibration of remote sensing data, and aids in the interpretation and analysis of what is being sensed. Examples include cartography, meteorology, analysis of aerial photographs, satellite imagery and other techniques in which data are gathered at a distance.

In this study, ground-truth was carefully done to ascertain the various land use/land cover types physically found in the study area so as to insure that the information reflected on the satellite image are true reflections of what is obtainable on the ground.

iv. Calculation of area in square of the resulting land use/land cover types

To calculate the area in km2 of the resulting land use/land cover types for each study year, a table was developed showing the area in km2 and the percentage for each year (1988, 1999 and 2006) measured against each land use/land cover type. The percentage change was calculated by dividing observed change by the sum of changes multiply by 100.

$$\text{Percentage change} = \frac{\text{observed change} \times 100}{\text{Sum of change (Opeyemi 2006)}} \quad (1)$$

Change matrix

To determine the intra changes among LULC types, changes among the six LULC types were assessed by determining the conversion of one land use/land cover type to another r(i.e, loss and gain in area km^2) among the six LULC types using LULC change matrix.

Result And Discussion

Classification of land use/ land cover types in Jalingo, 1988-2006

A total of six land use / land cover (LULC) types were classified in the study area namely bareland (comprising of bare surfaces), built- up (comprising of roads, highways, buildings, and other paved surfaces), cultivation, (Comprising of cultivated farmlands), shrubland (comprising of grass and shrubs), water body (comprising of rivers, streams, open reservoir), and wetland (comprising of marshes). The LULC types in Jalingo are presented in table1 and figures 2 and 4.

In 1988, cultivation has the largest area of 171.35 km^2, representing 80.8%of the study area. Bareland occupied 7.38 km^2 representing 3.40%, while built-up has 8.95km^2, shrubland has 18.47km^2 representing 3.7%. Water body occupied 3.72km^2 representing 1.7%. Wetlands, on the other hand occupy 9.31km^2 representing 4.3% of the study area.

Table 1: Classification of land use/ land cover in Jlingo 1988, 1999 and 2006

LULC Types	1988 Area(km^2)	%	1999 Area (km^2)	%	2006 Area(km^2)	%
Bareland	7.38	3.40	0.97	0.4	6.3	2.9
Built-up	8.95	3.7	16.77	7.9	27.11	12.7
Cultivation	171.35	80.8	134.13	63.2	132.33	62.7
Shrubland	18.47	8.7	22.03	10.3	40.18	18.9
Water body	3.72	1.7	5.44	2.5	5.72	2.6
Wetland	9.31	4.3	40.24	18.9	7.54	3.5
TOTAL	219.18	100	219.18	100	219.18	100

Source: Author's research work

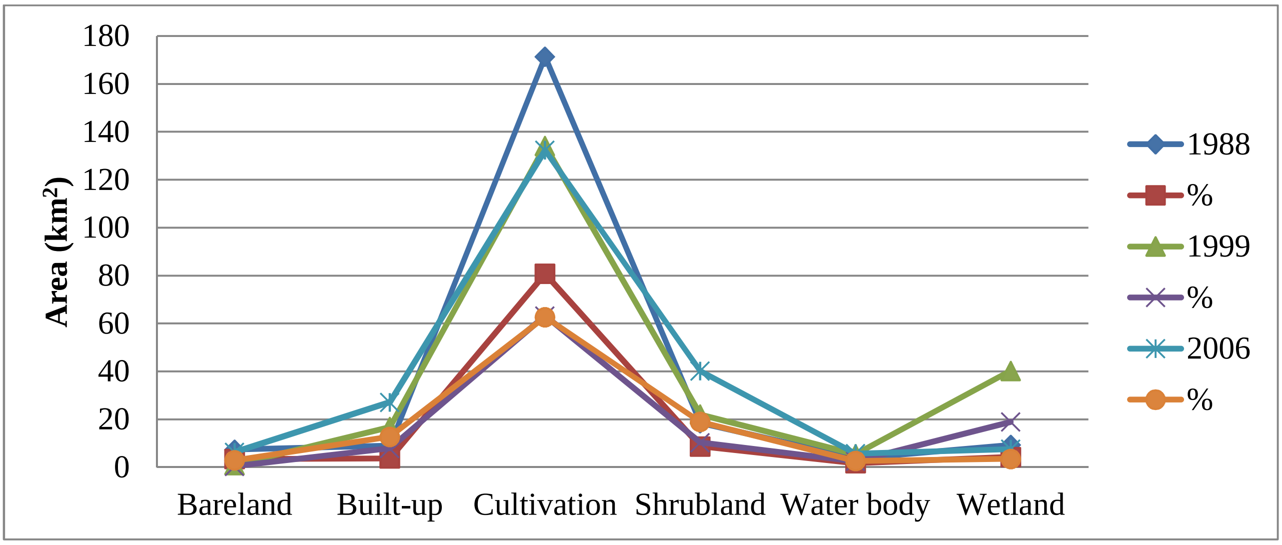

Figure 1: Graphical representation of table 4.2.1 above

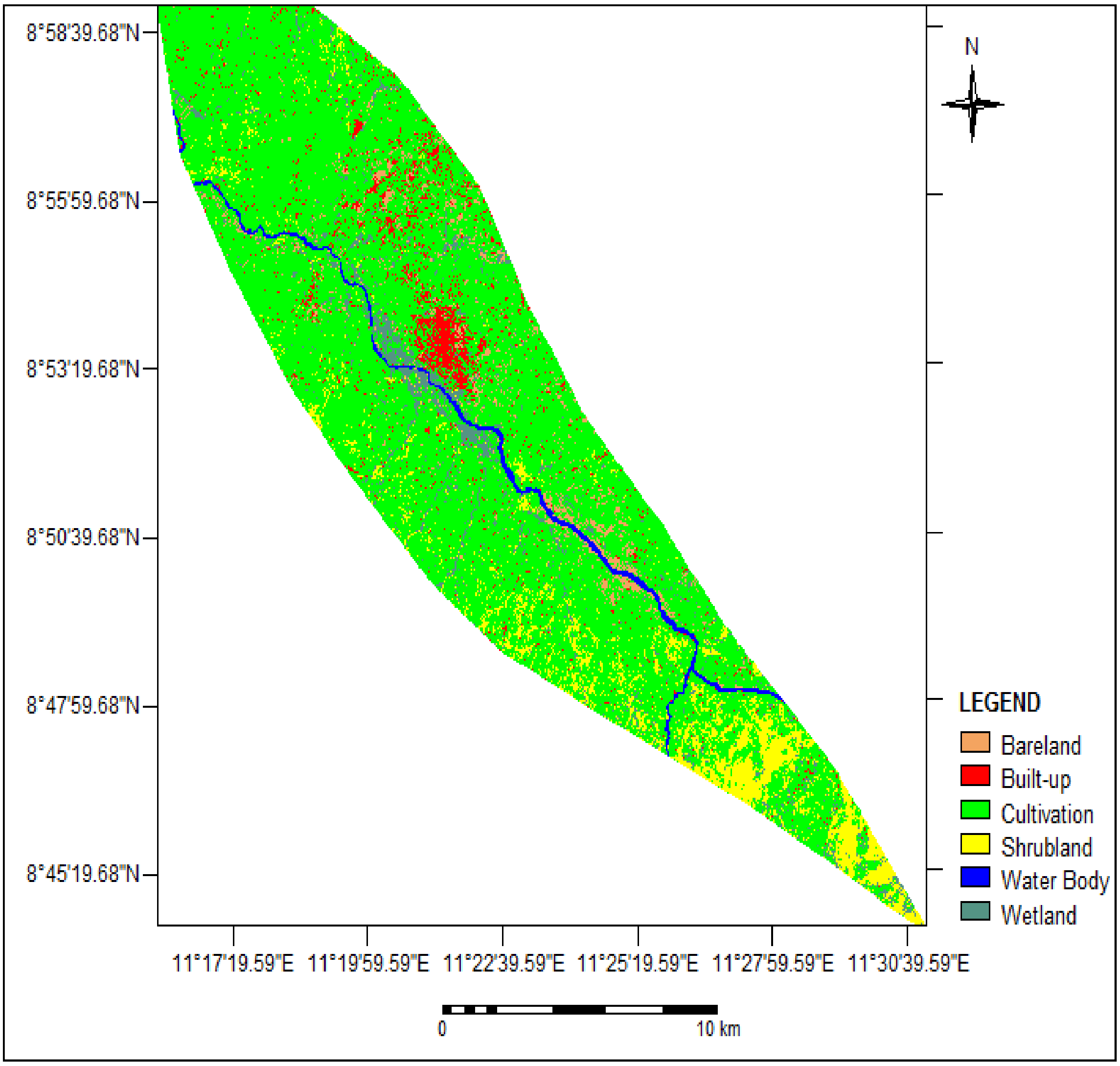

Figure 2: Land use/land cover in Jalingo, 1988.

Cultivation and bareland have the largest and least areas of 134.13km^2 and 0.97km^2 in 1999, representing 63.2% and 0.4% of the study area respectively. Built-up has 16.77 representing 7.9, while shrubland and water body have 22.03km^2 and 5.44km representing 10.3% and 2.5% of the study area respectively. Last but not the least, wetland occupy 40.24km^2, representing 18.9% (table 4.2.1 and figure 4.2.3).

In 2006, cultivation and water body still have the largest and least areas of 132.33km^2 and 5.72km^2, representing 62.3% and 2.6% of the study area respectively. Bareland and built-up occupy 6.3km^2 and 27.11km^2, representing 2.9% and 12.7% respectively. Shrubland and wetland on the other hand, have 40.18km^2 and 7.5km^2, representing 18.8% and 3.5% respectively (table 1 and figure 2).

The high percentage of bareland area in 1988 may be unconnected to the fact that then Jalingo was just a local government headquarter and hence less economic activities. Built- up was less in 1988 with only 3.7% of the study area. This may also be attributed to the same reason stated above. Cultivation in 1988 recorded the highest percentage of land area in Jalingo with 80.8%. This was because at that time Jalingo was more of a rural setting where farming is the main occupation of the populates. The low percentage of shrubland in Jalingo in 1988 could be attributed to the long period of drought witnessed that year. The drought affected the growth of grasses and shrubs in the area. Water body recorded the lowest percentage of land area in 1988 compared to other study years. It could be remembered that 1988 was a drought year in that part of the country. This could be responsible for the low percentage of water body observed that year. Wetland also has the lowest percentage of land area in 1988 compared to other study years. This may still be due to the long period of drought experienced that year.

In 1999, bareland reduced to 0.4% of the total land area in the study area. This was due to the expansion in size of the town. Jalingo was made state capital in 1991 and this of course, has influenced the growth of the town both in terms of population and city size. More bare lands were taken over by buildings and other economic activities as a result of the population growth. The percentage of built-up area in the study area increased to 7.9% in 1999 after the town had been made state capital in 1991. This was due to the boom in population of the town and the increase in economic and industrial activities. The percentage of cultivated land on the other hand decreased to 63.2% in 1999. This may be due to the fact that most of theagricultural land were bought over and converted to other economic uses to accommodate the increasing population. Apart from this, most of the people who got jobs with the state government then abandoned their farming occupation for civil service. Shrubland, in 1999 increased to 10.3%. This may be as a result of disengagement of many people from agriculture to other sector of the economy and the abandoned farmlands gradually turned to shrubland as time went on. In 1999, water body also increased to 2.5% as against 1.7% in 1988. This was due to the restoration of the rainfall being experienced in the area. Wetland also witnessed an increased in percentage of land area compared to 1988. This, the researcher believes was due to the restoration of the usual amount of rainfall of 1,500mm annually.

In 2006, however, bareland increased to 2.9% compared to 0.4% recorded in 1999. This may be as a result of bush burning and cutting down of shrubs for fuel. There was a dramatic increase in percentage of built-up area from 7.9% in 1999 to 12.7% in 2006. This attests to the fact that the government of Reverend Joly Nyame at that time embarked on city decongestion campaign in order to decongest the city centre. This, he did by building several housing estates in the outskirt of the town, relocation of giant projects such as the games village, specialist hospital and the air port to the outskirt of the town. Apart from all these, there was also increase in economic activities by private and corporate bodies in Jalingo town which resulted in the increase in built-up area. Cultivation in 2006 further decreased to 62.3% which shows more and more agricultural lands had been converted to built- up and other purposes. Also at this time, the city had started moving away from the traditional setting where farming seems to form the basis for living. The improvement in the welfare of workers could also attest to this as people are now engaging in other sectors of the economy which are more benefiting than farming. Another increase in shrubland was witnessed in 2006 with 18.9%. The same reason as in year 1999 above could be responsible for this. Water body, in 2006 witnessed an insignificant increase in the percentage of land area covered. The area had 2.6% of water body as against 2.5% obtained in 1999. This shows the annual rainfall of about 1,500mm usually witnessed in the area was maintained within the periods of 1999 and 2006. In 2006 however, the percentage of wetland in Jalingo reduced to 3.5%. This may be due to encroachment into the wetland areas as a result of population growth. Most of the wetlands, especially the ones around Mayo-Goi have been taken over by buildings while some parts of it have been converted to farmland for cultivation of crops such as rice and sugarcane. This may be the root cause of the serious floods that occurred in the area in the recent years.

CHANGE MATRIX AMONG LAND USE/LAND COVER TYPES

Changes among the six LULC types were assessed by determining the conversion of one land use/land cover type to another (i.e, lose and gain in area km^2) among the six LULC types using LULC change matrix. Since the concern in this research work is to determine the impact of built-up on other land use/land cover types, the researchers only focused on the losses of the other LULC types to built-up.

Cultivation, from 1988-2006, recorded the highest loss to built-up. It lost 19.22km^2, representing 71% to built-up. This, as earlier said, was due to the population boom in Jalingo after it was made state capital in 1991. Water body, on the other hand, had the least loss of 0.15km^2, representing 0.6% to built-up.

Table 1: Land use/land cover change matrix

LULC Types	Bareland (km^2)	Built-up (km^2)	Cultivati-on (km^2)	Shrub-land (km^2)	Water body (km^2)	Wetland (km^2)	Total loss (1988)
Bareland	0.65	1.53	4.41	1.47	1.21	0.90	10.17
Built-up	1.62	4.50	3.17	0.91	0.62	0.82	11.64
Cultivation	5.61	19.22	112.13	26.31	2.26	4.49	170.02
Shrubland	0.24	0.22	7.81	10.21	0.42	1.44	20.34
Water Body	0.22	0.15	1.70	0.17	3.35	0.87	6.46
Wetland	0.44	1.64	4.46	2.30	0.26	2.26	11.36
Total gain (2006)	12.58	27.26	133.68	41.37	8.12	10.78	233.79

Source: Author's research work.

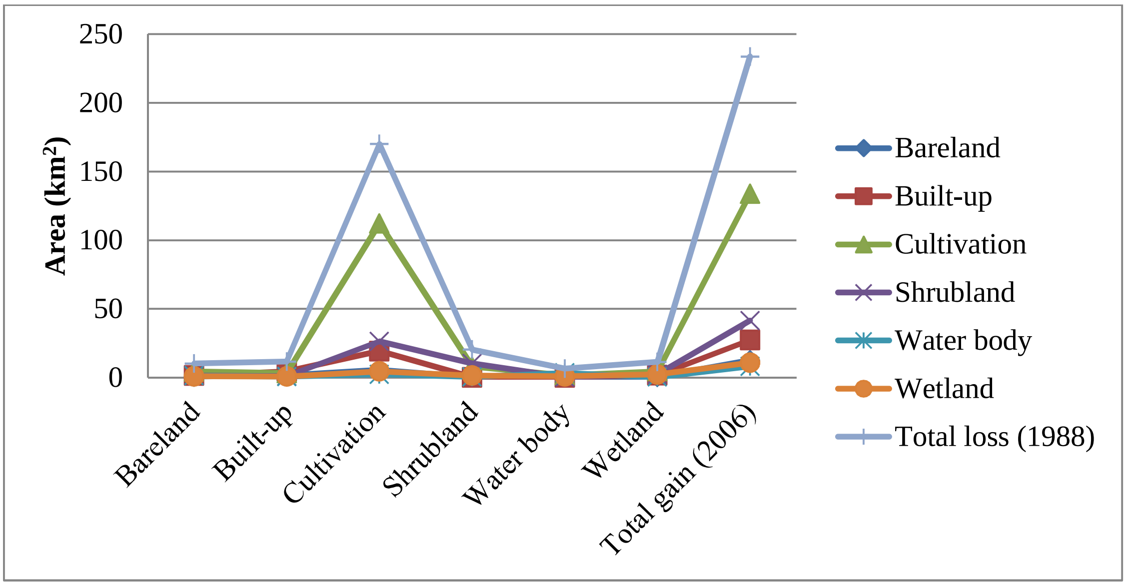

Figure 3: Graphical representation of the table 1 above.

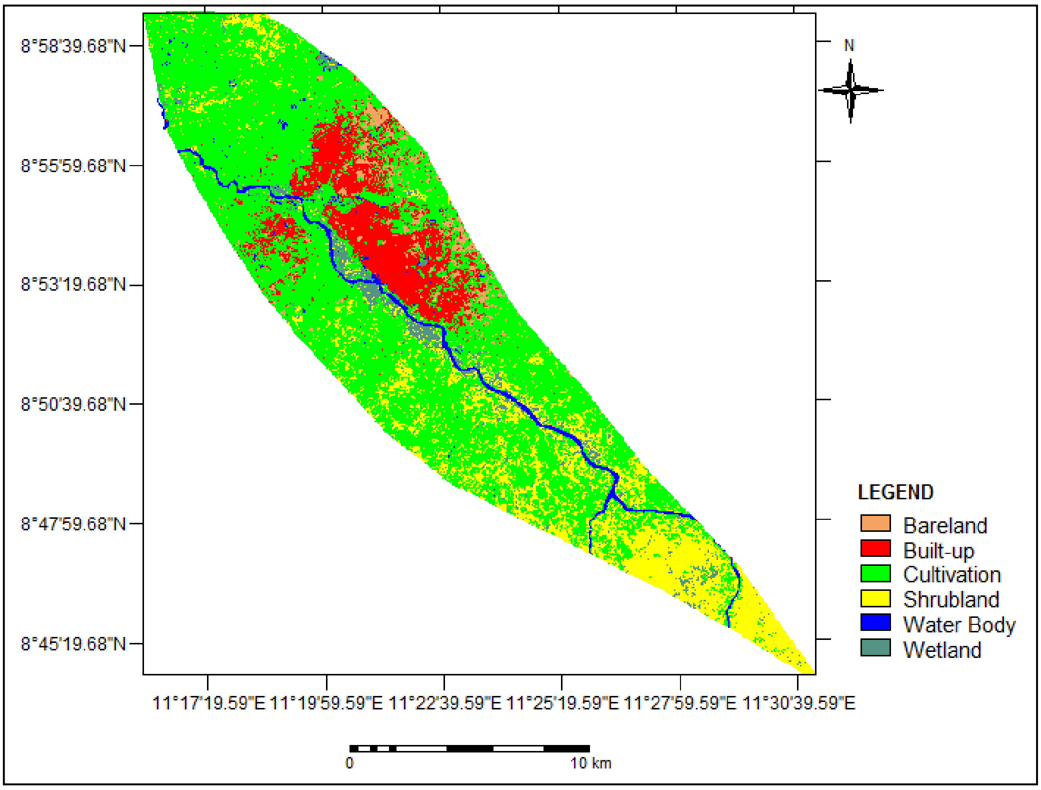

Figure 4. Land use/ land cover in Jalingo, 2006.

Bareland lost 1.53km^2, representing 5.6% to built-up within the study years. While shrubland lost 0.22km^2, representing 0.81%. Next to cultivation in the order of loss is the wetland which lost 1.64km^2, representing 6.0% to built-up. The reason for this, as advanced earlier was as a result of encroachment into the wetland in the study area. Large portion of the wetland was drained, refilled and taken over by buildings to accommodate the teaming population of the town.

CONCLUSION

This research work was carried out to determine the change matrix between land use/land cover(LULC) types in Jalingo town. The research was objectively done and the results proved that expansion in size of the town is the main cause of LULC change in Jalingo town within the period of 1988 and 2006.

The researchers therefore, call for more researches to be carried out in this area so as to come out with more recommendations to proffer better solutions to the problems of urbanization on LULC types in Jalingo town and Nigeria in general.

RECOMMENDATIONS

Having determined the change matrix in LULC types due to urbanization in Jalingo, the researchers hereby recommend the following measures to mitigate the impacts.

Development along flood plain, drainage channels, infrastructure easements and flood prone areas should be avoided. Development Control Authorities (e.g Town Planning and Capital Cities Development Authorities) should enter into partnership with private sectors to ensure that physical development legislations are strictly adhered to by developers.

There is need for appropriate legislations to be put in place to check indiscriminate sprawling. The relevant regulatory institutions and agencies should be empowered to monitor the level of compliance and met out appropriate sanctions.

Researches have shown that the best general way to protect areas of high diversity threatened by urbanization is to purchase those areas specifically for the purpose of conservation (Luck et al, 2004). Combating the threat of urbanization on surrounding land use/land cover is one of the greatest challenges facing conservationists and ecologists. It demands a thorough and often complicated process in which areas of high priority are identified, assessed, and either conserved or restored. These are the first steps in limiting the many ecological disturbances already caused by growing urbanization. Taking a more proactive stance towards conservation right now and in the near future, however, is the only way to assure those future generations in the services of nature we often take for granted.

With the above given recommendations, the researchers believe the impacts of urbanization on LULC will be mitigated if strictly adhered to.

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