Change Detection Analysis of Landuses in Hadejia township of Jigawa State of Nigeria

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Abstract

This study has to do with the determination and analysis of Landuse/Landcover (LULC) dynamics within the period of 31 years viz: 1978 – 2009. Three multidate datasets comprising a basemap of 1978, satellite images of 2005 and 2009 using the combined technologies of Remote Sensing (RS) and Geographic Information System (GIS) to determine the magnitude, rate and dynamics of change in landuse within the study period of the area. The analogue basemap of the area of study was cropped, concatenated, georeferenced, digitized, polygonized and post-classified. The satellite images, submaps created were georeferenced and classified by the method of unsupervised classification based on the following classification scheme: Residential, Commercial Water Bodies, Vegetation, Public Areas and Industrial Areas. Post-Classification approach was adopted which involved the analysis of differences between two or more independent categorization products. The result showed significant rapid growth in Residential Landuse while the vegetation is diminished annually. The annual rate of change in landuse was determined and used as an index in predicting changes for the future using simple regression statistics. Adequate recommendations were made for the town planners, administrators and policy makers for Landuse development in Hadejia Township.

Key words: Landuse, Change Detection, classification. Urban planning and master plan

Introduction

Lunneta (1999) in Lunneta and Elvidge (1999) has observed that a major step forward in the application of Remote Sensing Technologies for environmental monitoring and future change detection studies has been the initiation of consistent Landcover/ Landuse (LCLU) mapping and database development efforts at the global, continental and national scales. Igbokwe (2010) observed that land cover and landuse patterns are basic data used for physical planning and environmental evaluation. Therefore periodic landuse change patterns are needed for many applications including map revision and updating, natural resources inventory and management, urban planning, agricultural land development, forestry and wide life management and demographic studies. Igbokwe (2010) further said that the basic principle in digital evaluation of LCLU changes lies in the fact that there are differences in the spectral reaction of image elements from two or more different periods, if the LCLU have changed within the interval of two or more periods respectively, hence the study for Hadejia Township in Jigawa State of Nigeria.

Area of Study

Hadejia is a town in Hadejia Local Government Area (LGA) of Jigawa State of Nigeria. It is located within latitudes 12^o 23' N to 12^o 28' N and longitudes 10^o 00' E to 10^o 05' E. See figure 1 below for details. It is mainly inhabited by Fulani farmers and herdsmen. The topography is generally of flat terrain and its geology is of Chad formation consisting of consolidated sediments of silt, sand and clay shale and their intercalations (Hadejia, 2012). The area lies in an inland drainage system of the Lake Chad basin with River Hadejia meandering for about 828km across the township. The township lies within the tropical wet and dry season types with rainy season between May – September while the dry season starts from October – April every year. The mean annual temperature is about 25^oC but the monthly temperature ranges between 21^oC in coolest month to 31^o C in the hottest month. The Sudan savannah is the vegetation type of the area of study.

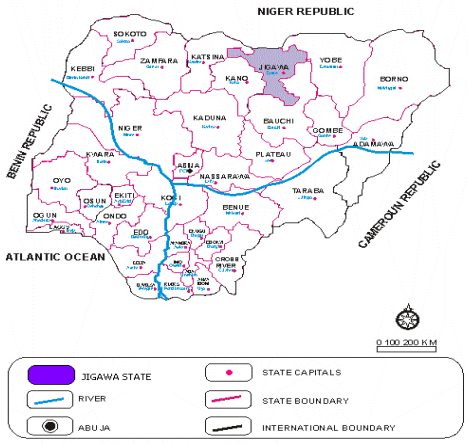

Figure: 1 Map of Nigeria showing Jigawa State

Source: Ministry of Land and Housing Jigawa State

Hadejia Township has since 1960 of Nigeria's independence till date witnessed urban growth. This was as a result of her attainment of metropolitan status of an agro-allied commercial centre as well as intervening centre for other industrial and imported products. These have to a large extent affected its landuse. The Jigawa State Urban Development Board, the agency charged with the responsibility of its town planning was unable to conduct the inventory of its LCLU to monitor these unorganized developments. These seeming delay or oversight has undoubtedly given chance to the local authority and land speculators to embark on uncontrolled land development particularly on plots for residential, industrial and commercial purposes. This inappropriate development coupled with non-availability of renewed master plan for Hadejia Township has made most of the developed areas to assume the appearance of slum or squalor which required urgent attention. Therefore, the study is aimed at determining the changes in Landuses and land cover within the periods of study.

Materials and Methods

The study made use of twelve analogue township maps of Hadejia obtained from the Ministry of Lands and Housing Jigawa State. UTM coordinate data obtained using the Global Positioning System (GPS). Six Quick Bird satellite images of 2005 of Hadejia of 70cm resolution and 7 Geoeye satellite image of 2009 of 1m resolution. The hardware used included personal computer, Hewlett Packard Designjet Scanner, Promark-3 Differential GPS Receiver and Garmin Handheld GPS Receiver. The software included CorelDraw 11 Graphic suite used for maps concatenation, ENVI 4.5 software used to create submap, WGEO-WASY tool was used for georeferencing, GNSS solution software used for processing GPS positional data. Digitization was done in AUTOCAD while ArcView 3.2a and ArcGIS 9.8 were used for image display, scheme classification and chart drawing. Table 1 below shows the township map index of Hadejia at the scale 1:20,000 that were concatenated.

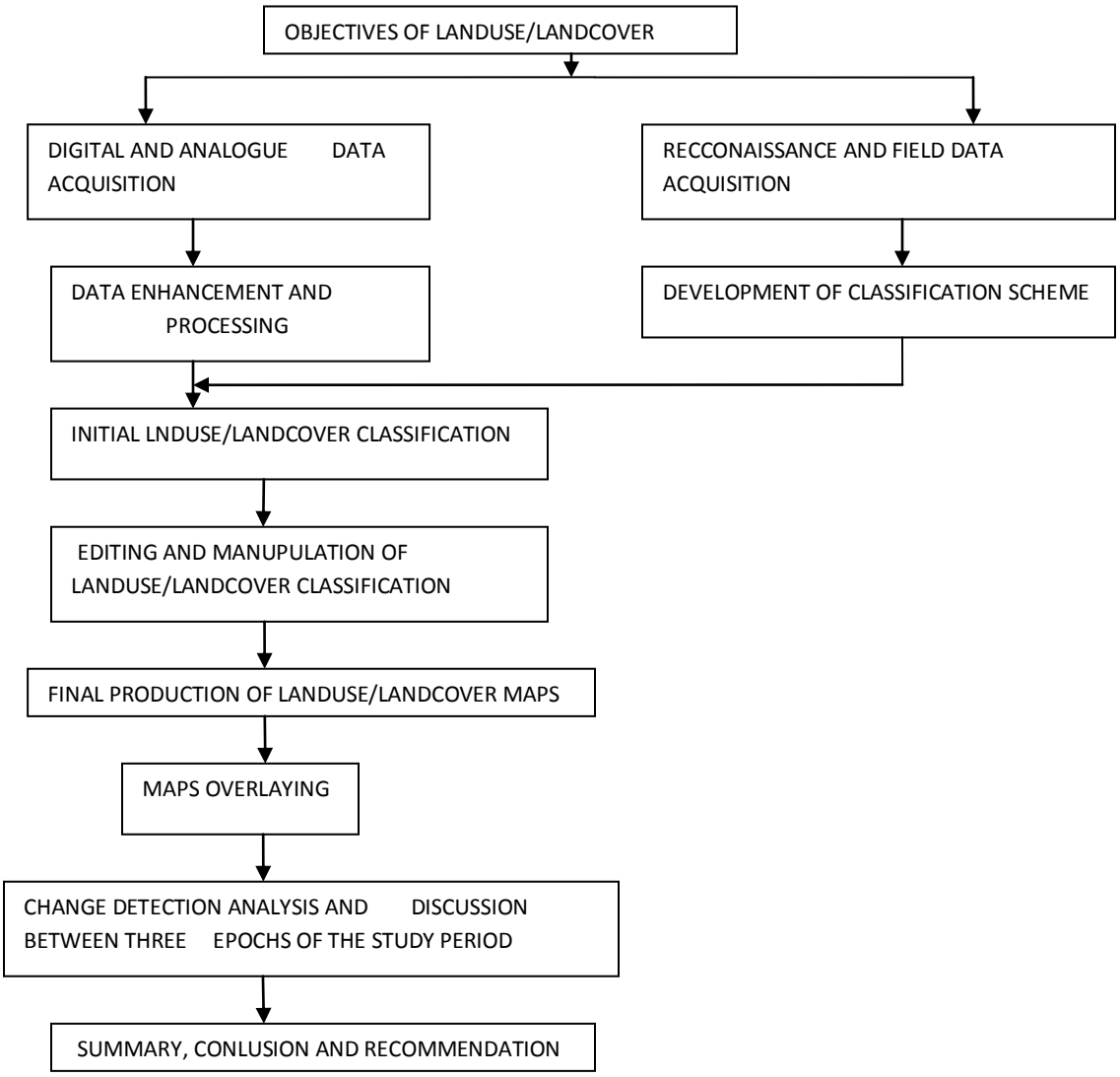

Figure: 2 Methodology Flow-chart
(Modified from Zubair, 2006)

Table 1: Townships index of Hadejia

7	8	9
12	13	14
17	18	19
22	23	24

Source: Ministry of Lands and Housing Jigawa State (1978)

Table 2 below shows the second order classification scheme adopted for this study.

Table 2: Classification Scheme

S/No	Landuse/Landcover classes	Landuse/Landcover class components
1	Residential	High, Medium and Low Density Residential areas
2	Commercial	Hotels, Markets, Shopping mauls, Banks, Cinema Houses etc.
3	Water Bodies	Ponds, Rivers, Reservoirs, Borrow pits, Streams etc.
4	Vegetation	Farmlands, Forests, Plantation, Open Spaces etc.
5	Public Areas	Schools, Hospitals, Churches, Mosques, Government lands, Houses and Offices, Playgrounds, Stadium.
6	Industrial	Industrial houses and sites

Post-Classification method based on un-supervised classification procedure was adopted in this study because in this case, classification was done independent of other images. Inter-image change detection was done rather than intra-image change detection. Faris and Rainis (2002) used parcel-wise classification method, but in this study, pixel-wise classification method adopted in Orisakwe (2008) was used. This is because of its high image classification accuracy and high dependency on digital methods and tools.

Results and Discussion

The study was aimed at the following results:

(1) To detect the landuse changes that occurred within the study period.
(2) To identify the dynamics of the landuse changes.
(3) To identify, quantify and classify the nature, magnitude and direction of landuse changes within the period of study.
(4) To determine the annual rate of change for all landuse classes within the period.
(5) To assess and display the landuse change pattern within the period of study.

The total area in hectares covered by the submap was about 700 hectares (7000000m2) about seven million square metres of Hadejia town.

Table 3 below shows the Landuse/Landcover classification for 1978.

Table 3: Landuse Classification of 1978 dataset

S/No	Landuse Type	Area (Hectares)	Percentages (%)
1	Residential (Low Density)	22.134	3.2
2	Residential (Medium Density)	1.767	0.3
3	Residential (High Density)	52.150	7.5
4	Commercial	2.923	0.4
5	Industrial	0.604	0.1
6	Public Places	82.773	11.8
7	Vegetation	534.402	76.3
8	Water Bodies	3.305	0.5
	Total	**700.00 Hectares**	**100**

Figures 3 and 4 below show the Landuse/Landcover classification distribution of 2005 while Table 3 above shows 1978 dataset as the classification distribution Conventional colours were adopted as Water body is in blue, vegetation in green, public places in yellow, commercial in red and high density residential in brown etc. Also as shown in Table 3 above, vegetation occupies the largest area of about 534.402 hectares out of the 700 hectares which was about 76% of the total area..

Land use Classification of 2005

The landuse classification of 2005 shown as figure 3 and 4 as well as table 4 below indicated that the area covered by residential high density was the dominant landuse having covered an area of 224.811 Hectares. Water bodies, though greater than what was obtained in 1978 was of the lowest value among the Landuses. The histogram of figure 3 and the corresponding pie chart of figure 4 depict the land area of 4.9587 hectares and 0.47% of the landuse distribution of 2005. It may be noted also that the gradual growth of the high density residential area over the between the years 1978 and 2005 can be seen in the population of 2006 census over the 1991 census. The population increased in 1991 from 65,967 to 105,628 in 2006 (NPC, 2009).

Table: 4 Landuse/Landcover Types Classification for 2005

S/No.	Landuse/Landcover Type	Area (Hectares)	Percentage %
1	Residential Low Density	66.599	3.16
2	Residential Medium Density	91.1602	0.25
3	Residential High Density	224.811	7.45
4	Commercial	56.4785	0.42
5	Industrial	13.7987	0.09
6	Public Places	127.7512	11.82
7	Vegetation	114.4427	76.34
8	Water Bodies	4.9587	0.47
Total		**700.0000**	**100.00**

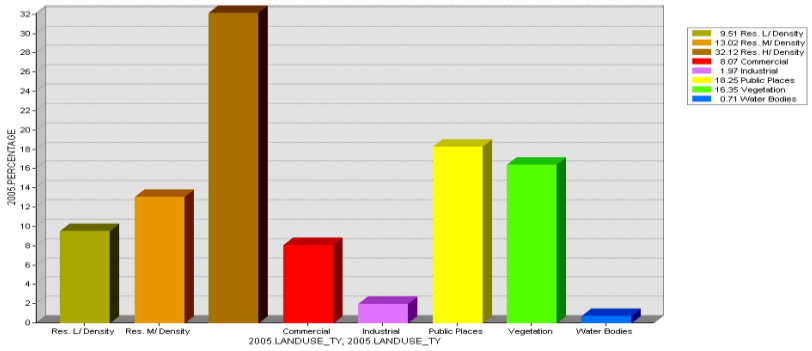

Figure 3: Study area Landuse/Landcover classification bar chart for 2005

Source: Author's Laboratory work

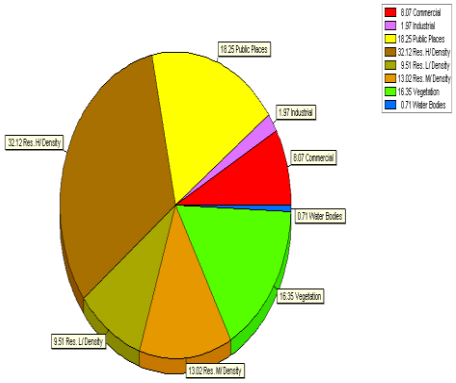

Figure 4: Study area Landuse/Landcover classification pie chart for 2005

Source: Author's Laboratory work

4.5 Landuse/Landcover Classification of 2009

The peculiar characteristics of this epoch lie in the upwards increase of commercial landuse of 11.61% and decrease in industrial landuse (1.44%) as shown in table 5. This increase in commercial landuse buttresses the 2005 trend in urban growth. The more alarming situation is the fall in vegetation Landcover which slipped to 6.03% (42.2 Ha) from 76.34% (114.44 Ha) in 2005.

The table 6 below shows the comparative landuse classification for the epochs 1978, 2005 and 2009.

Table: 5 Landuse/Landcover Types Classification for 2009

S/No.	Landuse Type	Area (Hectares)	Percentage %
1	Residential Low Density	66.599	9.51
2	Residential Medium Density	118.5618	16.94
3	Residential High Density	257.632	36.8
4	Commercial	81.2424	11.61
5	Industrial	10.0704	1.44
6	Public Places	118.7345	16.96
7	Vegetation	42.2012	6.03
8	Water Bodies	4.9587	0.71
Total		**700.0000**	**100.00**

Table: 6 Comparative Landuse/Landcover Classifications for the Epochs 1978, 2005 and 2009

S/No	LANDUSE TYPES	LANDUSE ATTRIBUTES	EPOCHS		
			1978	2005	2009
1	**Res. Low Density**	Area(Hectares)	22.1338	66.599	66.599
		Current Percentage%	3.16	9.51	9.51
		Range Area difference (Ha)		44.4652	0
		Range Percentage %	0	+300.95	0
2	**Res. Medium Density**	Area(Hectares)	1.7667	91.1602	118.5618
		Current Percentage%	0.25	13.02	16.94
		Range Area difference (Ha)		89.3935	27.4016
		Range Percentage %	0	+5208	+130
3	**Res. High Density**	Area(Hectares)	52.15	224.811	257.632
		Current Percentage%	7.45	32.12	36.8
		Range Area difference (Ha)		172.661	32.821
		Range Percentage %	0	+431	+114.6
4	**Commercial**	Area(Hectares)	2.9225	56.4785	81.2424
		Current Percentage%	0.42	8.07	11.61
		Range Area difference (Ha)		53.556	24.7639
		Range Percentage %	0	+1921	+143
5	**Industrial**	Area(Hectares)	0.6035	13.7987	10.0704
		Current Percentage%	0.09	1.97	1.44
		Range Area difference (Ha)		13.1952	3.1246
		Range Percentage %	0	+2188	-26.9
6	**Public Places**	Area(Hectares)	82.7734	127.752	118.735
		Current Percentage%	11.82	18.25	16.96
		Range Area difference (Ha)		44.9778	9.0167
		Range Percentage V%	0	+154	-7.07
7	**Vegetation**	Area(Hectares)	534.404	114.4427	42.2012
		Current Percentage%	76.34	16.35	6.03
		Range Area difference (Ha)		419.9597	72.2415
		Range Percentage %	0	-466.91	-271.14
8	**Water Bodies**	Area(Hectares)	3.3047	4.9587	4.9587
		Current Percentage%	0.47	0.71	0.71
		Range Area difference (Ha)		1.654	0
		Range Percentage %	0	+151.06	0

Source: Author's laboratory work

N.B: Current Percentage- Relative percentage for the year indicated
Range Percentage- Percentage increase/decrease for the range indicated

The table 6 above shows the landuse distribution pattern between the years 1978, 2005 and 2009. The residential low density in the year 1978 was 22.134 Hectares which represents 3.169% of the study area. This landuse rose to 66.6 hectares in 2005 representing 9.51% of the study area. It may be noted that this landuse became stagnated in the period 2005 – 2009.

Conclusively, it is henceforth established that insight into development in Landuse/Landcover behavior would only be brought into limelight through change detection studies. This fact could be seen in the periodic changes in areal extent of the designated Landuses. This finding however, tells the urban growth in commercial activities in Hadejia metropolis. The rapid escalation of Landuse/Landcover of high density residential area buttresses the aforementioned assertion.

Although, the outcome of the Landuse/Landcover changes was presented according to range and annual changes, it is imperative to conclude that the higher Landuse/Landcover development in the study area and impliedly in whole of Hadejia Township was apparent in the range period of 2005 to 2009.

However, within the 31 years used as study period positives changes in Landuse/Landcover development were witnessed in commercial and residential Landuse while in industrial Landuse was fluctuating trend and negative trends in both vegetation and public areas Landuse. The water bodies remained stagnated since 2005.

Finally, this scenario without positive intervention from the concerned authorities such as the Urban Development Board of Jigawa State, Ministry of Environment, Ministry of Health and more importantly Ministry of Lands and Housing in synergic collaboration with Hadejia Local Government Council will eventually lead to chaotic situation and a slum development resulting to poor sanitation, absence of land for government projects in the right locations and inevitably persistent socio-economic problems. Therefore, government intervention is hereby necessary and inevitable for sustainable development in Hadejia Township.

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