Analysis of Land Use/Land Cover of Girei, Yola North and South Local Government Areas of Adamawa State, Nigeria Using Satellite Imagery

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Abstract
This research demonstrated the use of satellite imagery in detecting changes in land use/ land cover on the fringes of urban areas. Satellite data of the same geographical area, recorded over a decade, were used to identify changes in the pattern of land use/land cover. The study used multi date satellite imageries namely, Landsat MSS 1978 and SPOT5 2007. The images were separately classified and then compared using ILWIS 3.3 and Erdas Imagine 9.3 Versions. The land use/land cover statistics results obtained from the two classifications process showed that built-up areas, sand, water bodies, and open/barren land were found to have been increasing at alarming rate while agricultural land and scrubs were encroached upon by other land use/land cover types. The study showed that land use/land cover change was better captured and monitored through the use of satellite imagery that served as a means of efficiently updating digital databases as shown in the research.

Key Words: Remote sensing, GIS, Urban-rural interaction, Planning, Land use, Satellite imagery, Change detection.

Introduction

The history and development of land is as old as man himself.Land is defined based on the number of natural characteristics, which includes climate, soil topography, hydrology and geology. Land may also be define as any portion of the earth's surface which is capable of ownership as property, including anything natural or human made which is annexed to it. Land is immobile, finite and essential to human exercise (Amer *et al.*1999).Man always wants to develop this land to make it habitable, conducive, and comfortable for living and man wants this development to be quick, easy and accurate. In order to achieve this, man has adopted and employed different methods surveying inclusive, which provides basis for sustainable development.

Land use/cover is driven by human activities and they also create changes that have impact on humans (Agarwal *et al.* 2002). In this regards, there is need to update land database continuously, to meet the rapid changes in the environment caused by urbanization and industrialization. To achieve this, Geographic Information System (GIS) as a computerized technique provides the capability for land use/cover mapping with improved accuracy, which can be done repeatedly, that is, continuously at regular time intervals. Toju and Okoduwa (2000) reported how they use GIS to map flood risk zones in Benin city, Nigeria. The resultant map was a raster map showing variation in soil strength across the study area. While Carmelo *et al* (2014) used a combination of remote sensing data and mapping information from different sources to create the land cover map. USGS (2012) carried out analysis of potential future land cover change in the United States, where they used an approach of scenario construction and spatially explicit land cover modeling.

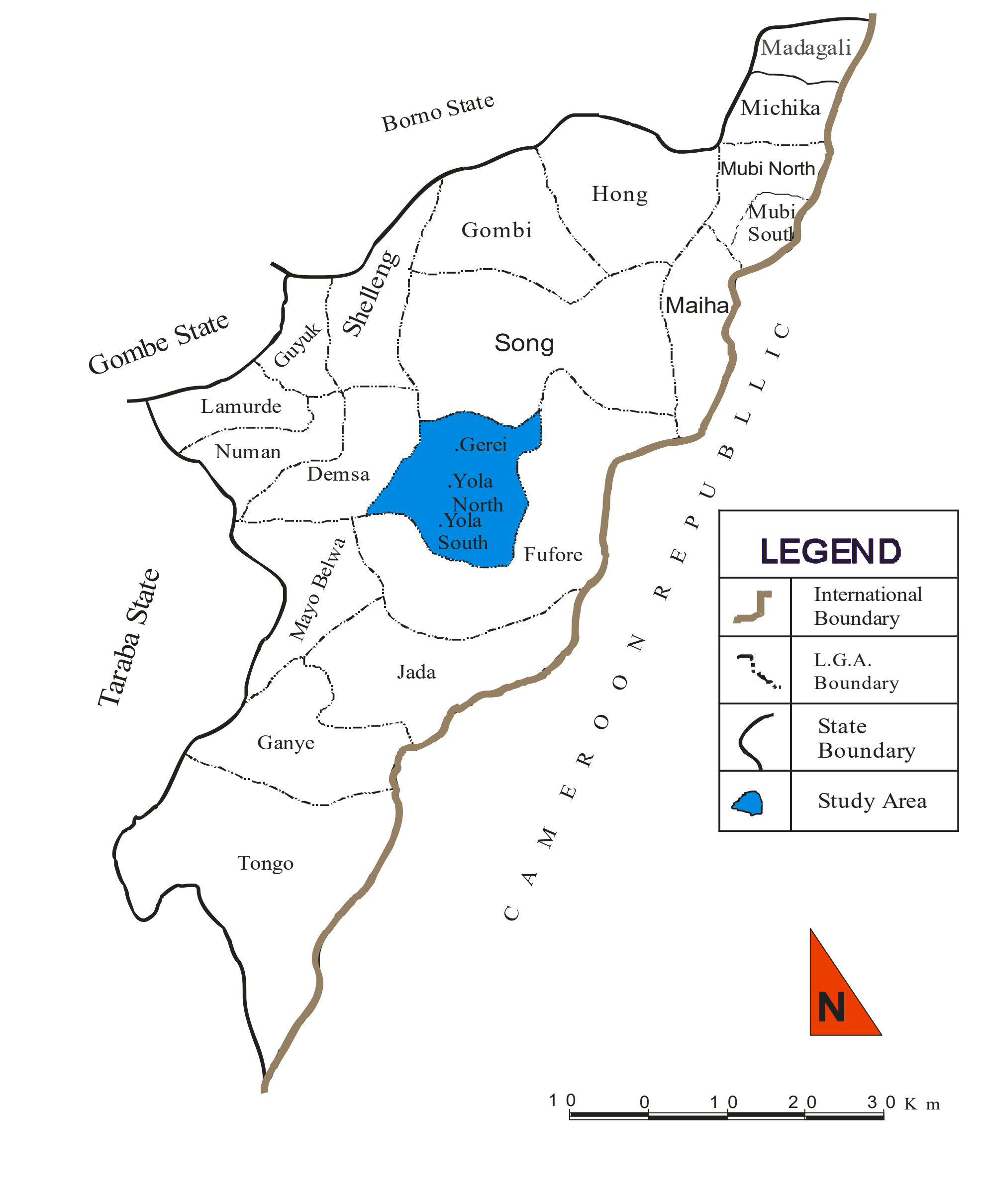
Nowadays, most of the world populations live in city and metropolis. However, it is often the case that settlements grow irregularly under the pressure of masses coming to cities and these do not develop according to well-defined plans. Hence, it's necessary to monitor urban areas with frequent update. Land use in urban areas continuously change over time and geographic location. This poses a serious challenge to the urban planners who need to monitor the change and update the land use/land cover databases to reflect current use. An urban environment can be characterized by two main classes namely, built-up areas (developed) which comprise of industrial, residential, commercial, parking areas, roads etc and non-built up areas (reserved) e.g. gardens, spots field, green areas, urban agriculture, etc. therefore, town planning departments attempt to incorporates these design plans (building and land use etc) depicting the type and extent of the permitted use of land and the corresponding constraints, where by any change is expected to conform to these plans. However, it is not uncommon to unveil that these plans particularly in developing countries like Nigeria are not adhered to due to problems associated with poverty, immigration, overpopulation, ignorance, lack of government participation in active planning/monitoring of any environmental changes, either positive or negative which also implies that the necessary infrastructure is not implemented.

Spatial distribution of land use/land cover information and its changes is desirable for any planning, management and monitoring Programmes at local, regional and national levels (Adeniyi and Omojola 1999).This information not only provides a better understanding of land utilization aspects but also play a vital role in the formulation of policies and programs required for development of future and making provisions for it, and also for ensuring sustainable development. It is necessary to monitor the ongoing changes in land use/ land cover pattern over a period, this requires the present and past land use information of the area and pattern of changes with respect to urban settlements and other local resources (Musa, 2000).Again, for these to be possible, Geospatial data are required, which are acquired from many sources such as existing databases and records, digitized and scanned maps. Global Positioning System (GPS), field sampling of attributes, remote sensing and aerial photography. Remote sensing (RS) makes use of satellite images to extract useful information. A unique attribute of satellite images is sure advantage of large coverage and consistent revisit, since the satellite is in the orbit and at high altitude, enough to cover large ground tracks. For instance, Nigerian Sat. 1, an earth-observation micro-satellite fully owned by Nigeria has an important role in geo-spatial data acquisition because it will focus on Nigeria to provide abundant and up-to-date satellite images.

Study Area

The study covers two local governments namely Yola North and South in Adamawa state, Nigeria. The area comprises of important towns like Jimeta, Yola and Girei. Yola metropolis is the heart and capital city of Adamawa state; other towns continuously growing in size and population also surround it. The cities have high density of buildings and have not earlier been developed according to periodic urban plans; thus, resulting in clusters of buildings with different sizes and shapes. The agricultural fields surround the cities and it is relatively flat in eastern and some northern part. This metropolis, with increasing institutional development (2 universities, colleges and various government departments); this together with good road network provided by the Jimeta Bridge connects peoples from the northern part of the state with southern part. This created additional urban expansion pressure with Santuraki province (Song, Gombi, Hong, Mubi, Maiha, Michika, and Madagali L.G.A). Industrial and residential areas with high population density are located in the northern part called Jimeta and spreading in the Lamido's city called Yola. (I.e. residential areas, both densely and sparsely built-up are located at the southern edge of the city). The general urban areas were built on a relatively flat surface, even though some hills with reasonable slopes are present in the city center. The local government areas are located within: Girei: Lat.$9^0 15^/$N, Long.$12^0 25^/$, Jimeta: Lat.$9^0 6^/$N, Long.$12^0 27^/$ and Yola Lat.$9^0 14^/$, Long.$12^0 27^/$.

MAP OF ADAMAWA STATE SHOWING STUDY AREA



Source: Adamawa State in maps

Materials and Methods

Data: The study utilized Landsat MSS1978and SPOT5 2007.The details of the satellite imageries used are shown in Table 1 below:

S/N	Data Type	Source	Spatial Resolution	Acquisition Date
1	Landsat MSS	http: glcf.umiacs.umd.edu accessed on June 18, 2009	60m x 72m	1978
2	SPOT5	Department of Geography, O.AU. Ile-Ife.	5m x 5m	2007

Equipment: Handheld GPS (Garmin 76) was used to generate the coordinates of some selected ground control points in the study area which were used to georeferenced the acquired images.

Hardware: The hardware employed for the research was Laptop ProBook 4530s

Software:The study used GIS technologies such as ILWIS 3.3and Erdas Imagine 9.3 version. ILWIS 3.3 was used to import the satellite imageries to the Erdas Imagine for further processing. Erdas Imagine 9.3 was utilized for the development of land use/land cover classes and subsequently for change detection analysis of the study area. Microsoft word was used basically for the presentation of the research.

Data Presentation and Pre-Processing

Both the images were loaded, imported and displayed in the ERDAS Imagine environment. The images were processed using digital image processing techniques such as image enhancement and filtering to improve the pictorial quality of the images. Subset operation was performed on the images to create the Area of Interest (AOI). Image to image registration was carried out since SPOT5 had been georeferenced and subsequently, Landsat MSS 1978 and SPOT5 2007 were resampled to cater for differences in their spatial resolutions using polynomial transformation and bicubic resampling method.Principal component analysis (PCA) was carried out on LANDSAT MSS for effective image classification. This is because LANDSAT MSS has four bands and the human eye is only limited to three bands. There was therefore the need to reduce the 4 bands to 3 components so that the colour composite that will follow will make use of all the information in the four bands. PCA was however not carried out for SPOT5, since the image has basically only 3 bands.

Image Classification

The process of sorting pixels into a finite number of individual classes, or categories of data, based on their data file values may be described as multispectral classification. This involves the training of computer to recognize patterns in the remotely sensed image. A supervised method was utilized simply because it permits selection of pixels that represent patterns or land use features that is recognizable or identifiable with the use of other sources such as ground truth data and topographical maps. Knowledge of the data, and of the classes desired, is required before classification. For this study, more than twelve training areas were selected. This training area represents the classes for each of the six land use/land cover types used for the classification of the entire images. The six classes of land use/land cover types selected for the classification are Built-up areas (BUA), Agricultural lands (AL), Sand (SD), Water Bodies (WB), Scrubs (SS) and Open/barren land (OBL). Having trained the computer, the system thereafter used a special program to determine the numerical signatures for each training class. Each pixel in the image was therefore compared to these signatures and labeled as the class it most closely resembled digitally. Signatures in ERDAS IMAGINE can be parametric or non-parametric. A non-parametric signature is not based on statistics, but on discrete objects (polygons or rectangles) in a feature space image. These feature space objects are used to define the boundaries for the classes. A non-parametric classifier uses a set of non-parametric signatures to assign pixels to a class based on their location either inside or outside the area in the feature space image. Supervised training was used to generate non-parametric signatures. ERDAS IMAGINE enables you to generate statistics for a non-parametric signature. This function allows a feature space object to be used to create a parametric signature from the image being classified. However, since a parametric classifier requires a normal distribution of data, the only feature space object for which this would be mathematically valid would be an ellipse. When both parametric and nonparametric signatures are used to classify an image, one is more able to analyze and visualize the class definitions than either type of signature provides independently. Thus, both parametric and non-parametric signatures were used for the classification of the images in this study. The classification algorithm used was Maximum Likelihood. Here, the probability of a given pixel belonging to a given cluster is computed, this forms the basis for accepting it as belonging to that cluster or rejecting it. So, the technique is based on probability theory in performing its task.

Ground truthing is necessary to confirm spatial information from remotely sensed imageries and to facilitate accurate interpretation of the satellite imageries and update data available on spots of perceived significance to the general interpretation and understanding of the imageries. To this end, confusion matrix operation was performed to identify the nature of the classification errors (errors of omission or exclusion; errors of commission or inclusion), as well as their quantities.Finallythe Output stage displays the view as training set error matrix. Selecting the error matrix option launches a classification error with sample areas of known class to evaluate the accuracy of the current class raster. The class of each sample area cell is compared to the class assigned to the corresponding cell in the class. Having obtained the land use/land cover auto-classification result and the error matrix which is also one of the statistical operations to determine the acceptability of result, the classification Dendrogram was selected and the process of estimating or computing the areal extent was done.

Change Detection

From the review of the literature, it is obvious that there are six types of change detection techniques namely image differencing, vegetation index differencing, selective principal component analysis, direct multi-date classification, post-classification analysis and combination image enhancement/post-classification analysis. The most obvious method of change detection is a comparative analysis of spectral classifications for times t_1 and t_2 produced independently (Singh, 1989). Inthis context it should be noticed that the change map of two images will only begenerally as accurate as the product of the accuracies of each individual classification(Stow *et al.* 1980). Accuracy of relevant class changes depends on spectral separabilityof classes involved. In the present study, Landsat MSS 1978and SPOT5 2007 data wereindependently classified using the maximum likelihood classifier. The classified images were cross-tabulated using cross tabulation technique of Erdas Imagine to generate the required data for change detection analysis of the study area between 1978 and 2007.

Results and Discussion

Error (Confusion) Matrix

Each row in the matrix represents an output class and each column represents ground truth data. The value in each matrix cell is the number of pixels (raster cells) with the corresponding combination of output class and ground truth class. For each cell on the leading diagonal of the matrix, the output class equals the input class, so that the values in these cells give the number of correctly classified pixels for each class. The values in the off-diagonal matrix cells represent incorrectly classified pixels. The overall accuracy values are calculated by dividing the total number of correctly classified raster cells [the sum of the leading diagonal values] by the total number of cells in the ground truth raster, and expressing the result as a percentage. For instance, Table 1 shows the producer's accuracy for the image classification of Landsat MSS 1978 into six classes of land use/land cover types:

Built-up Areas (BUA) = 99.7%
Agriculture (AL) = 94.9%
Sand (SD) = 88.9%
Water Bodies (WB) = 74.1%
Scrubs (SS) = 96.2%
Open/Barren land (OBL) = 97.6%

Also the user's accuracy as shown in the same table indicates the probability that a pixel classified into a given category are the true representation of that category on the ground: -

Built-up Areas (BUA) = 90.8%
Agriculture (AL) = 99.0%
Sand (SD) = 90.6%
Water Bodies (WB) = 90.1%
Scrubs (SS) = 95.1%
Open/Barren land (OBL) = 96.8%

Overall Accuracy = TD (Sum of Major Diagonal) divided by TR (Row Totals) = 45919/47574 = 96.5%. This indicates that error is considered to be consistent with limits of the available technology.

Table 1: Error Matrix for Landsat MSS 1978

Classification	**Ground Truth**							
	Built-up Areas	Agriculture	Sand	Water Bodies	Scrubs	Open/Barren land	**TR**	**Accuracy**
Built-up Areas	6934	0	19	0	0	0	6953	99.7%
Agriculture	110	5725	98	09	68	24	6034	94.9%
Sand	273	0	3314	19	96	24	3726	88.9%
Water Bodies	09	16	76	729	83	71	984	74.1%
Scrubs	73	43	70	28	10686	205	11105	96.2%
Open/Barren land	240	0	82	24	104	18322	18772	97.6%
TC	7639	5784	3659	809	11237	18931	47574	
Reliability	90.8%	99.0%	90.6%	90.1%	95.1%	96.8%		

Where TC = Column; TD = Sum of Major Diagonal; TR = Row Totals; Average Accuracy= 91.9% ; Average Reliability = 93.7% ; Overall Accuracy = TD/TR (45919/47574 x100)= 96.5%. Error was considered to be consistent with limits of the available technology.

Table 2: Error Matrix for SPOT5 2007

Classification	**Ground Truth**							
	Built-up Areas	Agriculture	Sand	Water Bodies	Scrubs	Open/Barren land	**TR**	**Accuracy**
Built-up Areas	9182	73	79	0	853	0	10187	90.1%
Agriculture	51	8482	96	60	44	358	9091	93.3%
Sand	956	0	5683	42	939	82	7702	73.8%
Water Bodies	0	399	21	7261	367	20	8068	90.0%
Scrubs	285	1753	105	117	11810	52	14122	83.6%
Open/Barren land	09	0	22	73	522	21954	22580	97.2%
TC	10483	10707	6006	7553	14535	22466	71750	
Reliability	87.6%	79.2%	94.6%	96.1%	81.3%	97.7%		

Where TC = Column; TD = Sum of Major Diagonal; TR = Row Totals; Average Accuracy= 88.0% ; Average Reliability = 89.4% ; Overall Accuracy = TD/TR (64372/71750 x100)= 89.7% . Error was considered to be consistent with limits of the available technology.

Similarly, Table 2 shows the producer's accuracy of the training set data for the six classes of land use/land cover types used for the image classification of the study area in 2007:

Built up Areas (BUA) =90.1 %
Agricultural land (AL) = 93.3 %
Sand (SD) = 73.8 %
Water Bodies (WB)= 90.0 %
Scrubs (SS) = 83.6 %
Open/Barren Lands (OBL) = 97.2 %

The user's accuracy for the training set which indicates the probability that a pixel classified into a given category are the true representation of that category on the ground as shown from the table above are: -

Built up Areas BUA) = 87.6 %
Agricultural land (AL) = 79.2 %
Sand (SD) = 94.6 %
Water Bodies (WB) = 96.1 %
Scrubs (SS) = 81.3 %
Open/Barren Lands (OBL) = 97.7 %

Overall Accuracy = TD (Sum of Major Diagonal) divided by TR (Row Totals) = 64372/71750 X 100 = 89.7%. This indicates that error is considered to be consistent with limits of the available technology.

Table 3: Land Use/Cover Classification Statistics over the Study Area, Year 1978.

Vegetation Class	Area Extent (Km^2)	Proportion of Total Area (%)
Built-up area	6.06	3.4
Agriculture	41.04	22.9
Sand	3.23	1.8
Water Bodies	21.45	12.0
Scrubs	43.37	24.2
Open/Barren Land	63.85	35.7
Total	**179**	**100**

Source: Author's Image Analysis, 2011

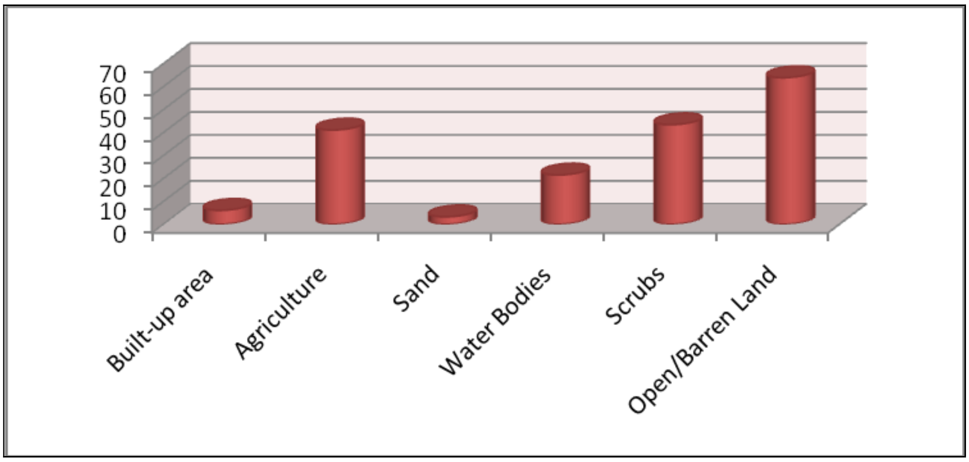


Figure 2: Land use/Land covers Areal Extent in 1978

Table 4: Land Use/Cover Classification Statistics over the Study Area, Year 2007.

Classifications	Area Extent (Km^2)	Proportion of Total Area (%)
Built-up area	19.5	10.9
Agriculture	14.5	8.1
Sand	10.6	5.9
Water Bodies	30.6	17.1
Scrubs	21.6	12.1
Open/Barren Land	82.2	45.9
Total	**179**	**100**

Source: Author's Image Analysis, 2011

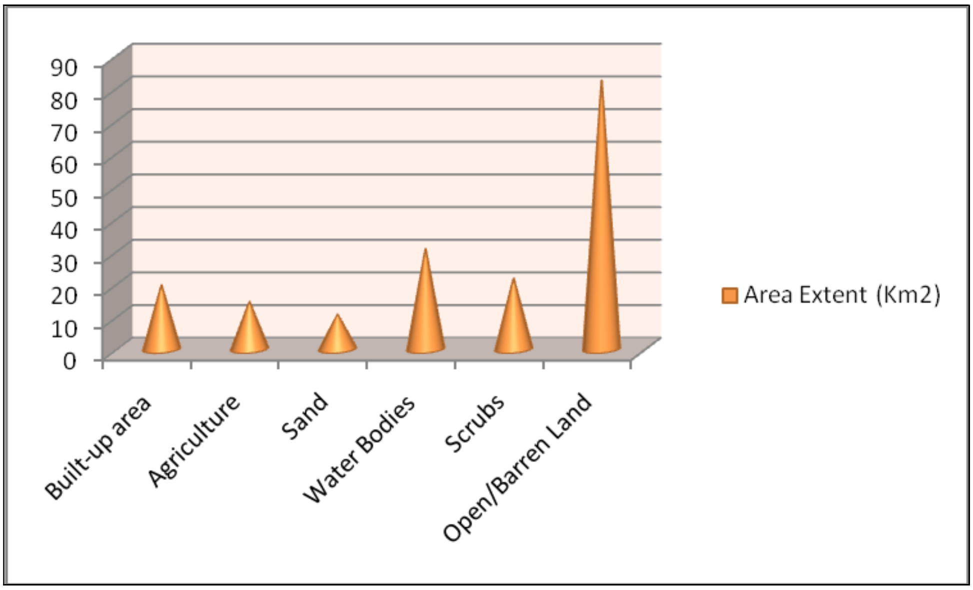


Figure 3: Land use/Land covers Areal Extent in 2007

Remote sensing methods have been widely applied in mapping land surface features in urban areas with the availability of multispectral images in digital form and the advances in digital processing and analysis; remote sensing has become a new perspective for the land use change detection. This project indicates that land use change detection from satellite imagery is a useful planning tool in provision of services, utilities and infrastructure. Urbanization has an important influence on the spatial distribution of land use. The result is that land is becoming a scarce and valuable commodity, especially in cities, effective land use is therefore necessary for the optimal functioning of administrative economic and social activities of communities. Again, it is worth knowing that urban structures are dynamic and spatial morphology, population structure and activity patterns are in a constant process of change and growth. As cities grow its land use pattern also changes. This change is more dynamic in urban/ rural fringe. Thus, the result of the land use/land cover change detection as was analyzed in this chapter using statistical means shows that there was a both positive and negative change:

Built-Up Areas: From Tables 3 and 4, the built-up areas that formerly occupied a proportion of 3.4% (6.06Km^2) in 1978 and increased to 10.9% (19.5Km^2) in 2007. This indicates that within 29 years urban expansion has encroached on other land use/land cover types by 221.78% (13.44Km^2). This further suggests that urban expansion in the study area has been taken place at an average rate of 0.46Km^2 per annum (see Table 5). This is a clear indication of increase in population and infrastructure development in the metropolis, regardless of use or pattern. This was clearly illustrated in Figures 2, 3, 4&5)

Agricultural Lands: Agricultural lands receded from 22.9% (41.04Km^2) as at 1978 to 8.1%(14.5Km^2) in 2007. This is an indication of decline in agricultural land use by 64.67% (26.54Km^2) at 2.23% per annum. This may be attributed to rapid urbanization process comprising physical expansions of residential, commercial and services, industrial complexes, transportation and communications/utilities taken place within the period of the study.

Sand (sandy areas): The sand land cover type increased from 1.8% (3.23Km^2) in 1978 to 5.9% (10.6Km^2) by 2007. This land cover type has been increasing at 7.87% (0.25Km^2) per annum. Within the period of the study, it increased by 228.17% (7.37Km^2). This is may be attributed to the prevailing effect of desertification and climate change that promotes downward shift in the boundary of Sahel savanna.

Water Bodies: These include rivers, streams and lakes. The proportion of the study area under water bodies recorded an upward increase from 12.0% (21.45Km^2) in 1978 to 17.1% (30.6Km^2) by 2007. The total area covered by water bodies increased by 42.66% (9.15Km^2) within the period of 29 years at 1.47% (0.32Km^2) per annum. This may be explained on account of increasing precipitation that occurs in the area characterized by scanty vegetal cover and also the area is drained by R. Benue that occasionally overflows its banks.

Scrubs: This includes savannah, grassland, mixed forestland and plantations. The result shows that scrubs occupy a good proportion of 24.2% (43.37Km^2) of the total area and hence the second largest after open/barren land in the year 1978 but was reduced to 12.1% (21.6Km^2) in the year 2007. This implies that area covered by scrubs recede by 50.2% (21.77Km^2) at the rate of 1.73% (0.75Km^2) per annum.

Open/Barren Land: This class includes rocky out crops, hilly lands, barren lands and open surface mining area. This class recorded apositive change over the year under study. Bare surface proportion was 35.7% (63.85Km^2) in 1978 but increased to 45.9% (82.2Km^2) in 2007 (Figures4&5). The area occupied by open/barren land remained the most extensive land use/land cover type that increased in areal extent to the tune of 28.74% (18.35Km^2) within the period of the study at 0.99% (0.63Km^2) per annum. This can be attributed to human activities, which includes, over –grazing indiscriminate bush burning, fire wood (fuel) extraction which are some of the characteristics of savannah regions of Nigeria where study areas is located. Another factor that is responsible is the short rainy seasons that are normally experience in these areas. Hence, from the overall results the areas liable to expansion are enormous particularly in the southwest and south-south of the metropolis. These areas will expand at expenses of the agricultural, scrubs, and open space that are remaining.

Table 5: Land Use/Land Cover Change between 1978 and 2007.

Land Use Class	Change between 1978 and 2007		Average rate of Change	
	Km^2	%	Km^2/yr	%
Built-up area	+13.44	+221.78	+0.46	+7.65
Agriculture	-26.54	-64.67	-0.92	-2.23
Sand	+7.37	+228.17	+0.25	+7.87
Water Bodies	+9.15	+42.66	+0.32	+1.47
Scrubs	-21.77	-50.20	-0.75	-1.73
Open/Barren Land	+18.35	+28.74	+0.63	+0.99

Source: Author's Image Analysis, 2011

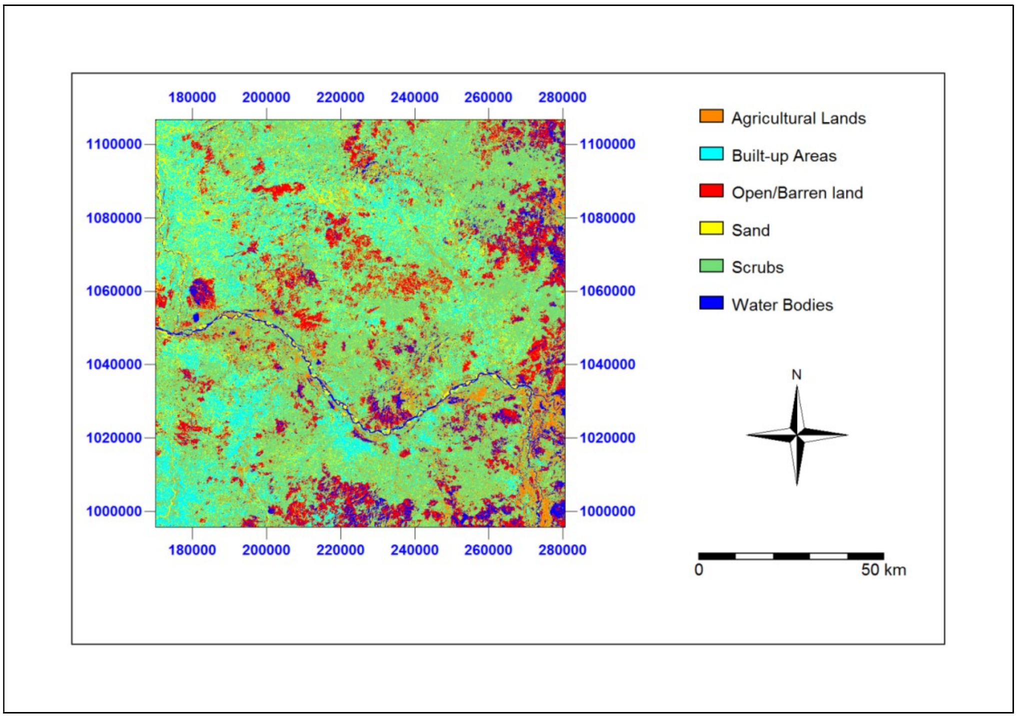


Figure 4:Land Use/Land Cover Map of the Study Area in 1978

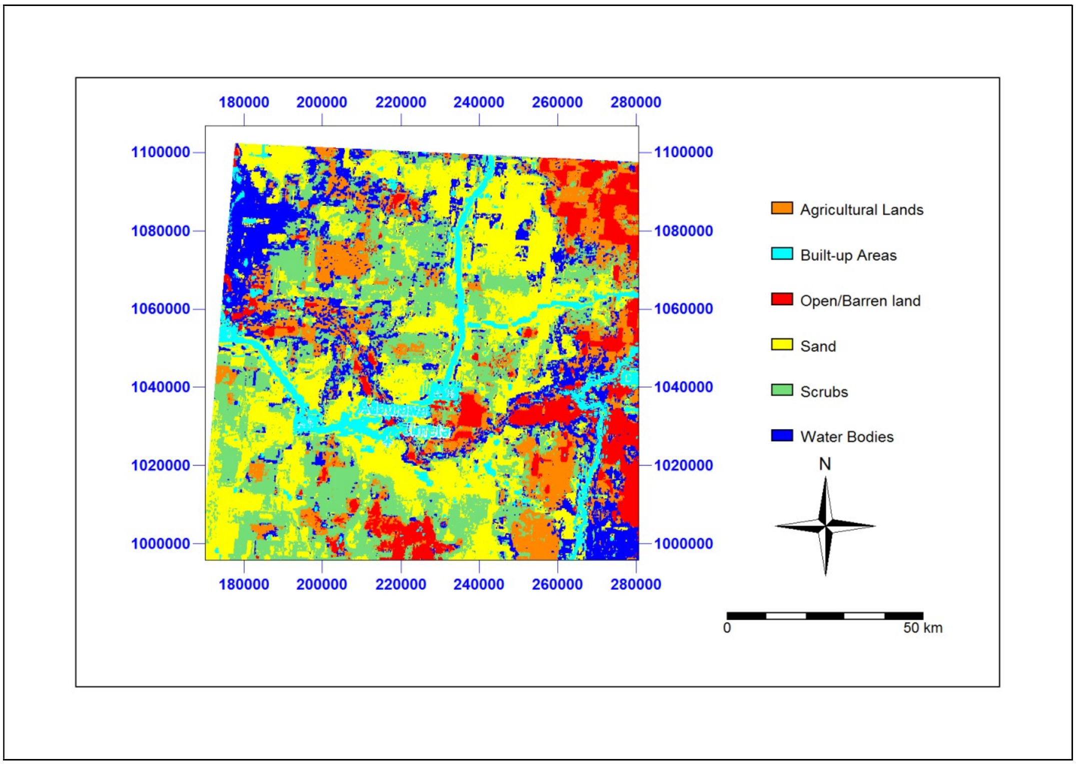


Figure 5: Land Use/Land Cover Map of the Study Area in 2007

Table 6: Proportions of land use/land cover units gained and/or lost between 1978 and 2007

Land use/Land cover units	**Proportion of LULC in 1978 and unchanged in 2007**		**Proportion of LULC in 1978 lost to other LULC types by 2007**		**Proportion of LULC in 1978 gained from other LULC types by 2007**		**LULC in 2007 (unchanged + gained)**		**Difference of LULC gained-lost (1978-2007)**	
	Km^2	**%**	**Km^2**	**%**	**Km^2**	**%**	**Km^2**	**%**	**Km^2**	**%**
Built-up Areas	5.66	5.8	0.4	0.5	13.84	17.1	19.5	10.9	+13.44	+16.6
Agriculture	13.05	13.3	27.99	34.5	1.45	1.8	14.5	8.1	-26.54	-32.7
Sand	1.97	2.0	1.26	1.6	8.63	10.6	10.6	5.9	+7.37	+9.0
Water Bodies	12.72	13.0	8.73	10.8	17.88	22.0	30.6	17.1	+9.15	+11.2
Scrubs	18.74	19.2	24.63	30.4	2.86	3.5	21.6	12.1	-21.77	-26.9
Open/Barren Land	45.74	46.7	18.11	22.3	36.46	45.0	82.2	45.9	+18.35	22.7
Total	**97.88**	**100**	**81.12**	**100**	**81.12**	**100**	**179**	100	…….	…..

Changes in Land use/Land cover between 1978 and 2007

Tables 6 and 7 revealed the pattern of changes in the land use/land cover of the study area between 1978 and 2007. Open/barren land, water bodies and built-up areas had continued to encroach on other land use/land cover types. For example, open/barren land constituted 22.3% (18.11Km^2) of the total lost in form of conversionto other land use/land cover types, mostly to water bodies and built-up areas within the study period, but gained 45.0% of the total modification from other land use/land cover types in which scrubs and agricultural lands were more affected. In the same perspective, built-up areas lost 0.5% (0.4Km^2) but gained 17.1% (13.84Km^2) in the same period.In case of agricultural land use, the area lost to other land use/land cover typeswas 34.5% (27.99Km^2) in 1978 and gained 8.1% of the total area occupied by others, giving a net decline of 32.7% (26.54Km^2) in area between 1978 and 2007 (see table 6). Scrubs also recorded a net decrease of 26.9% (21.77Km^2) within the study period. It is however significant to observe that Open/barren Land, built-up areas, water bodies and sand have exhibited upward increase in size by 22.7%, 16.6%, 11.2% and 9.0% (see figure 6) within the study period. This suggests that the area is seriously being affected by the southward shift in the boundary of Sahel savanna initiated by desertification effects and physical expansion of the settlements like Yola, Jimeta and Gieri occasioned by the prevailing rapid urbanization process in the study area.

Table 7: Change Detection Analysis of the Study Area between 1978 and 2007

Land use/Land cover (LULC)							
LULC	2007						
1978	Built-up Areas	Agriculture	Sand	Water Bodies	Scrubs	Open/Barren land	**Total 1978**
Built-up Areas	5.66	0	0	0.4	0	0	6.06
	94%	0	0	6%	0	0	100
Agriculture	7.67	13.05	3.12	5.08	2.54	9.58	41.04
	18.69%	31.8%	7.6%	12.4%	6.2%	23.3%	100
Sand	0.32	0	1.97	0.8	0	0.14	3.23
	9.9%	0	61%	24.8%	0	4.3%	100
Water Bodies	0	0.3	1.6	12.72	2.3	4.53	21.45
	0	1.4%	7.5%	59.3%	10.7%	21.1%	100
Scrubs	0.72	4.62	2.41	0.12	18.74	16.76	43.37
	1.7%	10.7%	5.6%	0.28%	43.2%	38.6%	100
Open/Barren land	5.13	0	1.5	11.48	0	45.74	63.85
	8.0%	0	2.3%	18.0%	0	71.6%	100
Total 2007	19.5	14.5	10.6	30.6	21.6	82.2	179

Source: Author's Image Analysis 2011

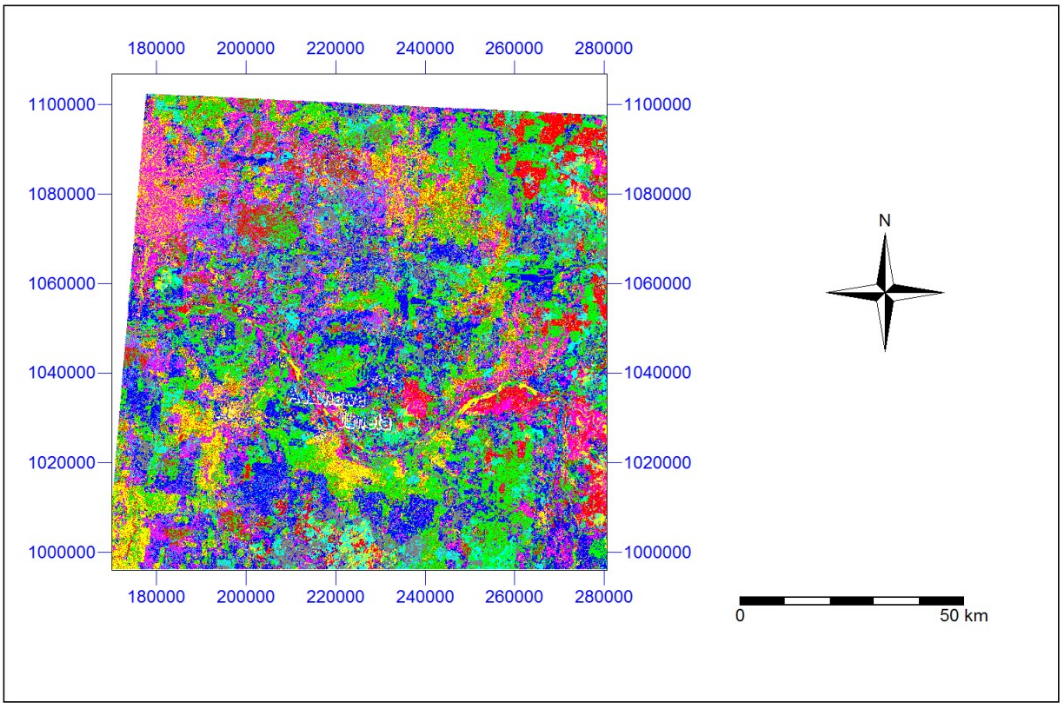


Figure 6: Change Detection Map of the Study area between 1978 and 2007

Conclusion

Remote sensing nowadays has become a modern tool for mapping of land use/land cover for micro, meso, and macro level planning. Remote sensing systems have the capability for respective coverage, which is required for change detection studies. For ensuring planned development and monitoring the land utilization pattern, preparation of land use/land cover map is necessary. The present study demonstrates the usefulness of satellite data for the preparation of accurate and up-to-date land use/land cover maps depicting existing land classes for analyzing their change pattern for Yola metropolis by utilizing digital image processing techniques. Furthermore, the developed spatial databases, map can serve as an efficient technical vehicle for spatial analysis and spatial modeling functions gain insights into development problems, e.g. to evaluate development impacts in the past, and to enhance regional development strategies through facilitating various scenarios. It is expected to be useful for formulating meaningful plans and policies so as to achieve a balanced and sustainable development in any region.

Recommendations

1. The Federal Government should try in their plan to launch more satellite. This is to enable a more constant planning and monitoring of the entire environment for a rewarding sustainable development.
2. This research work can also upgrade and update researchers by incorporating the basic ingredients of land use in form of physio-graphic data e.g. topographic, administrative, land-use, industrial locations as well as transportation and socio – economic indicators.
3. Planning Agencies should constantly monitor our various land uses through change detecting data/information so that, sustainable development plans/procedure are followed.
4. With the establishment of new ministry of environment, this ministry both at federal and state level should encourage the mapping of various land uses, and detection of land use change; so as to avoid any development that may be dangerous to our environment

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