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LAND USE AND LAND COVER CHANGE DETECTION AND ANALYSIS IN MINNA, NIGERIA

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ABSTRACT

To be able to understand the interactions of human activities within the physical environment, it is pertinent to study the land use land cover of the area under investigation. This research therefore, focuses on change detection in Land use Land cover in Minna Nigeria. To analyze the change, Landsat ETM 1990, Landsat ETM 2000, Landsat ETM+ 2005 and Landsat ETM+ 2015 imagery covering the area between 1990 and 2015 were obtained. To interpret and verify the accuracy of the satellite imagery, ground truth observation was conducted on the land use and land cover of the study area. The research employed the use of supervised digital image classification using Arc GIS 10.1 and ERDAS Imagine 9.0 software to classify the area into built-up, vegetation, farmland, water body and bare surface. Result obtained shows some changes in land use land cover classes within the period (1990-2015); built-up area experienced rapid change with an increase of 38.66 km2, and a decrease of -5.32 km2 in vegetation. Decreases were also observed in farmland, water body and bare surface with -1.95 km2, -0.05 km2 and -32.78 km2 respectively. It is therefore, recommended that regional development planning be encouraged to regulate growth in land use land cover for a sustainable urban development be achieved.

Keywords: Land Use, Land Cover, Change Detection, Urban Expansion and Satellite Imagery

INTRODUCTION

The ability to forecast land use and land cover changes and to ultimately predict the consequence of change will depend on the ability to understand the past, present and future state of the land use and land cover condition. This ability is enabled through the use of multi temporal data which provide valuable information on the state of the natural resources like land, water, forests, infrastructure, road network etc.

The land use and land cover of any particular region is an outcome of both natural and socio-economic factors and their utilization by man in time and space. Land is becoming a scarce commodity due to immense agricultural and demographic presence. Therefore, information on land use and land cover is essential for planning purposes to meet the increasing demand for basic human needs. In the South-Western Nigeria, land resources are changing rapidly at a rate local to national scales. As a result, the ecosystems on which the region depends are showing signs of stress (Oyinloye, 2010). Spatially explicit study of land use and land cover changes can lead to a better understanding of the causes of change and their consequences on the environment.

Several studies have been conducted with the integration of remote sensing and geographic information systems to analyse land use and land cover changes; Abiodun, (2015) studied the effect of Urban Sprawl on Forest Areas in Ibadan metropolis from 2000 to 2013. The researcher adopted the use of secondary data to source its information which consist of satellite images (Landsat TM, and Landsat ETM imageries for the years 2000, 2006 and 2013. Beside, ArcGIS 10.0 was used to examine and analyze the image classification in other to determine the level of urban growth and its consequent infringement on the forest resources of Ibadan. Different image processing techniques and standards were carried out ranging from image extraction, rectification, and restoration. The research established that there were incline in in urban built-up area and falling of trees (deforestation), thereby causing a decrease in forest areas by 6.9 percent from 2000-2006, and by 4.6 Percent from 2006-2013. The research concluded that the effect of urban sprawl on the forest areas, if not well and orderly controlled would diminish forest areas drastically.

Manju *et al (*2011), in their study on Dynamic of Urbanization and Its Impact on Land-Use/Land-Cover: A Case Study of Megacity Delhi used data acquired from the LISS-III images of IRS (Indian Remote Sensing) satellite of the years 1997, 2000, 2003, 2004, 2005 and 2008 to detect change. Topographic sheets of the study area, obtained from the Survey of India were used for the ground reference. Geometric correction was performed on all the satellite images using the topographic maps of Survey of India of Delhi (1:50000). The images were geo-referenced by using well scattered ground control points. Results indicated that the city is expanding to-wards its peripheral region with the conversion of rural regions in to urban expansions. In addition, Built-up area of Delhi witnessed an overall increment from 540.7 km² to 791.96 km² or 16.86% of the total city area (1490 km²) during the study period (1997 to 2008). Total area of water bodies has reduced by 52.9% with shallow water bodies having dismal presence.

Oyinloye and Kufoniyi (2011) in their study on Analysis of Land Use Land Cover Change and Urban Expansion in Akure, Nigeria used Land sat Multispectral Scanner (MSS), Thematic Mapper (TM) and Enhanced Thematic Mapper (ETM+) imageries acquired for 1972, 1986 and 2002 respectively. The imageries were geometrically corrected with ground control points obtained through intensive surveys which permitted the co-registration of all images to Universal Transverse Mercator (UTM). The satellite imageries were also subjected to image enhancement, geo-referencing, image classification and digitization. A supervised classification was performed on false colour composite (bands 4, 3 and 2) into land use and land cover classes; Built-up area, vegetation, Bare land, Exposed rocks and water bodies. The result shows that the built-up area has grown rapidly for the periods (1972-2002). It also shows increase in the bare land cultivation and exposed rock out crops. While vegetation decreases, the water bodies were stable within the period. Based on the GIS analysis, future prediction/ trend of the urban land use and land cover and its subsequent development was modeled. The research findings could help city planners and policy makers to attain and sustain future urban development.

Dami, *et.al (*2014), examines land use and land cover change in Kwale Ndokwa-East Local Government area Delta State, Nigeria between 1975 and 2008 using GIS and remote sensing techniques. Their study reveals that urbanization affect land use land cover and those areas covered by thick soil sleek after oil spillage and with time becomes bare. Njike *et.al.* (2011) analyzed Land use and Land Cover Changes of Aba Urban Area using Medium Resolution Satellite Imageries. Satellite imageries (Landsat ETM and Nigeria Sat-1, 2005) were acquired in order to detect the changes that have taken place within the time interval (1991 – 2005). The result of their study reveals that from 1991, 2000 to 2005, Built-up area increased from 21.7% to 26.8% and to 36.5%. There is an observed disparity in vegetation cover due to rapid urbanization and socio-economic activities. Thus, vegetal cover decreased from 63.2% in 1991 to 51.1% in 2000 and in 2005 it further decreased to 41.1%.

Abbas and Muazu (2009) carried out a study on Mapping Land Use-land Cover and Change Detection in Kafur Local Government, Katsina, Nigeria (1995-2008) Using Remote Sensing and GIS. The study made use of Land use/land cover map of the study area for 1995 and Google earth imagery of 2008. The imagery and the map were digitized in GIS environment using Arc view 3.2. The result shows that open space covered 13.56 square kilometers constituting 34.00% in 1995 as the most extensive land use/land cover in the study area. The increasing population and economic activities were noted to be putting pressure on the available land resources.

Yohana *et al* (2015) in their research on Land use land cover change detection of Mubi Metropolis; Adamawa State, Nigeria used Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+). Landsat imagery for three Epochs; 1988, 1999 and 2010 obtained from Global Land Cover Facility (GLCF) were used to classify the land use land cover changes between 1988 and 2010. Global positioning system was used for ground truthing; IDRISI software was used for image classification, area calculation and projecting land use land cover for the year 2030. ArcGIS 9.3 was also used for cartographic visualization. The analysis revealed that vegetation cover has reduced by 85.22% between 1988 and 2010, whereas the built-up area increased by 21.99%.

Dalil (2009) used Landsat imagery (ETM, TM and MSS) to assess the impact of Kiri dam on Land use/Land cover along the lower reaches of River Gongola, Adamawa State. He produced a land use/land cover Map covering the study area for 1975 (pre-dam period), 1986, 1999 and 2007 (post-dam period). To interpret and verify the accuracy of the satellite imagery, ground truth observation was conducted on the land use land cover of the study area. The study revealed that in the post-dam period, the impact of Kiri Dam has resulted in substantial changes in the land use/land cover, with losses in shrub and woodland, water bodies and grassland by 14.96%, 15.11% and 35.04% respectively. Whereas gains occurred in farm and grazing land by 37.77%, bare land soil and mud by 27.34%.

This research is aimed at analyzing the distribution of land use and land cover between 1990 and 2015 in the study area through the following objectives:

1. Identify various land use land cover classes in remotely sensed data sources.
2. Determine the aerial extent and percentage coverage by the land use and land cover classes.
3. Identify the magnitude of change that has occurred in the study area between 1990 and 2015.

Study Area

Niger state was created out of the old north-western state in February 1976 which belong to the second generation state of the military era when the country decide to increase the number of states from 12 to 19. This was achieved through the division of the former north-western state by then Military administration of General Murtala Rahamat Mohammed.

Minna which is the capital of Niger state is located on Latitude 9°37’55’’North and Longitude 6°33’24’’ East. It occupies an area of about 884 hectares of land (Minna Master Plan, 1979). As presented in Figure 1, it is bounded in the North by Shiroro Local Government, in the East by Muyan Local Government, to the West by Bosso Local Government and to the South by Paikoro Local Government areas. The population of the city is estimated at 304,113 (National Population Census 2006).

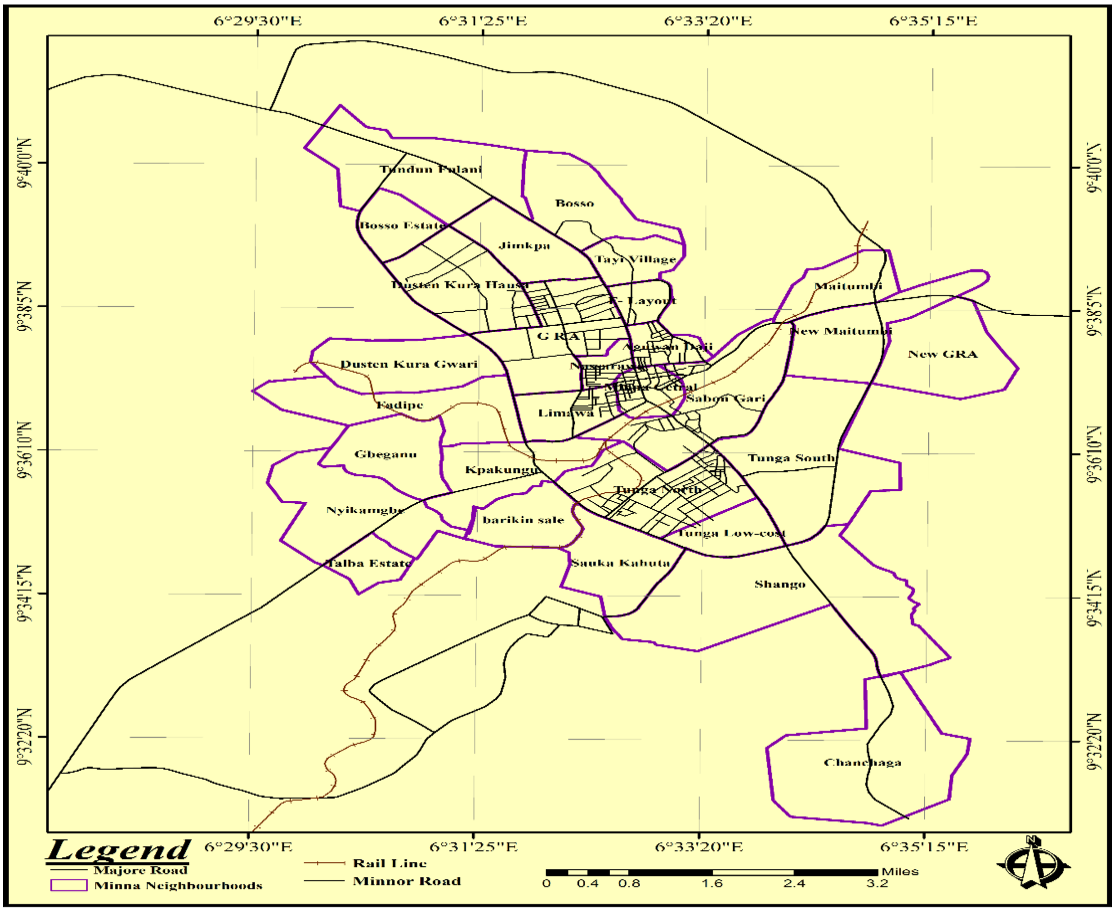

Figure 1: Street Map of Minna-the Study Area

Source: Field Survey July, 2015

MATERIALS AND METHODS

Reconnaissance Survey

The study commenced with several reconnaissance surveys which were made in order to familiarise with the area and to acquire first-hand information. Hand held Global Positioning System (GPS) was used to take readings of the coordinates for geo-referencing. Observations of interest that were relevant to the study were documented.

Primary Data

The research made use of qualitative method to collect field data. This involves processing of satellite imagery of the study area obtained for different periods (1990, 2000, 2005 and 2015) using ArcGIS 10.1and ERDAS Imagine 9.0 software to produce land use land cover maps.

Secondary Data

The secondary data includes information from Institutions and Governmental Organizations relevant to the study and journal publications. A review of existing literature from published materials such as journals, textbooks, conference papers, and unpublished thesis, selected reports, and other relevant articles from internet.

Processing and Analysing of Satellite Imagery

a) **Database Digital Change Creation:** The hardcopy of the topographical map covering the study area was first converted into digital database, using ArcGIS 10.1and ERDAS Imagine 9.0 software. The process involves scanning of the maps, followed by geo-referencing and raster-vector conversion. The final result was a vectorised land use/land cover map.

b) **Rasterisation and Cross operation:** The output from step 1 was rasterised to obtain the required data for the calculation of areas with ArcGIS version 10.1. In addition, computation (cross operation) was performed on the land use land cover maps for the periods (1990, 2000, 2005 and 2015) to measure the rate of changes overtime.

c) **Land use Land cover Area Calculation:** Using the raster database generated the area coverage of each land use land cover class for the periods was calculated and presented in kilometre square. The attribute Table obtained from database shows the number of pixels for each Land use Land cover category and the area for each class in square metre. By applying the column operation function, the area coverage in the respective Land use Land cover classes were computed.

d) **Geometric Correction:** This was conducted to amend distortions due earth curvature, atmospheric refraction and relief displacement.

e) **Appraisal of False Colour Composite (FCC):** Three bands of colour composite (Red, Green and Blue) were assigned to one of the basic colours. These include, Natural Colour Composite (NCC) and false colour composite (FCC) respectively.

RESULTS AND DISCUSSION

The study identified and analyzed five classes of land use land cover distribution; built-up area, farmland, vegetation, water body and bare surface. The classes represented in different colour codes are presented for the studied period in figures 2, 3, 4 and 5 for 1990, 2000, 2005 and 2015 respectively; aerial extents measured in kilometer square (km^2) and the corresponding percentages of coverage are presented in Table 1.

1. Built-up area

This category represented in yellow comprised of areas developed for residential, educational, commercial, industrial, civic and cultural uses. It was observed that the built-up area covered 34.60 km^2 (24.05%) in 1990 and 32.30 km^2 (31.58%) in 2000. besides, the land use category increased to 44.60 km^2 (43.61%) in 2005 and further to 64.70 km^2 (63.26%) in 2015. This increase is attributed to increase in demand for housing and other related urban land use for sustainable growth and development. The Built-up area recorded the highest increase with 38.66 km^2 representing 49.09%.

2. Vegetation

This land cover represented in light green comprised of areas covered by orchards and floral plantation. It was observed to have decreased gradually from 14.00 km^2 (13.69%) in 1990 to 10.76 km^2 (10.52%) in 2000. It further decreased to 9.25 km^2 (9.04%) in 2005 and 8.68 km^2 (8.49%) in 2015. The observed total decrease of 5.32 km^2 in vegetal cover representing -6.75% is attributed to site clearing for sustainable socio-economic development.

3. Farmland

The class represented in deep green comprised mainly cultivated areas. The study area's farmland decreased steadily from 3.02 km^2 (2.95%) to 2.3 km^2 (1.98%) in 1990 and 2000 respectively. It further decreased to 1.46 km^2 (1.43%) in 2005 and 1.07 km^2 (1.05%) in 2015. Clearing of existing farmlands due to urban expansion has resulted in the observed total decrease of -1.95 km^2 representing -2.48% of change.

4. Water Body

This category represented in blue stands for rivers and streams. It covered 1.06 km^2 (1.04%) in 1990 and decreased to 1.02 km^2 (1.00%) in 2000. The water body further decreased to 0.97 km^2 (0.95%) in 2005 and 1.01 km^2 (0.99%) in 2015. The observed decrease of -0.05 km^2 representing 0.06% of total change is attributed to natural dry up resulting to suitable sites for appropriate urban development purposes.

5. Bare surface

This is represented in brown and occupied the largest area with 59.60 km^2 (58.27%) in 1990. It decreased steadily to 56.17 km^2 (54.92%) and 46.00 km^2 (44.97%) in 2000 and 2005 respectively. There was a sharp decrease to 26.82 km^2 (26.21%) in 2015. The observed total rate of change of -32.78 representing -41.62% is attributed to land use conversion for sustainable socio-economic development.

It has been observed that the study area has witnessed significant expansion in the built-up area with 38.66 km^2 representing 49.09% magnitude of change between 1990 and 2015. However, all other classes have shown considerable decreases to the extent of -40.1 km^2 representing 50.91%. These changes implied that there was an upsurge and rapid urban development within the fifteen years period.

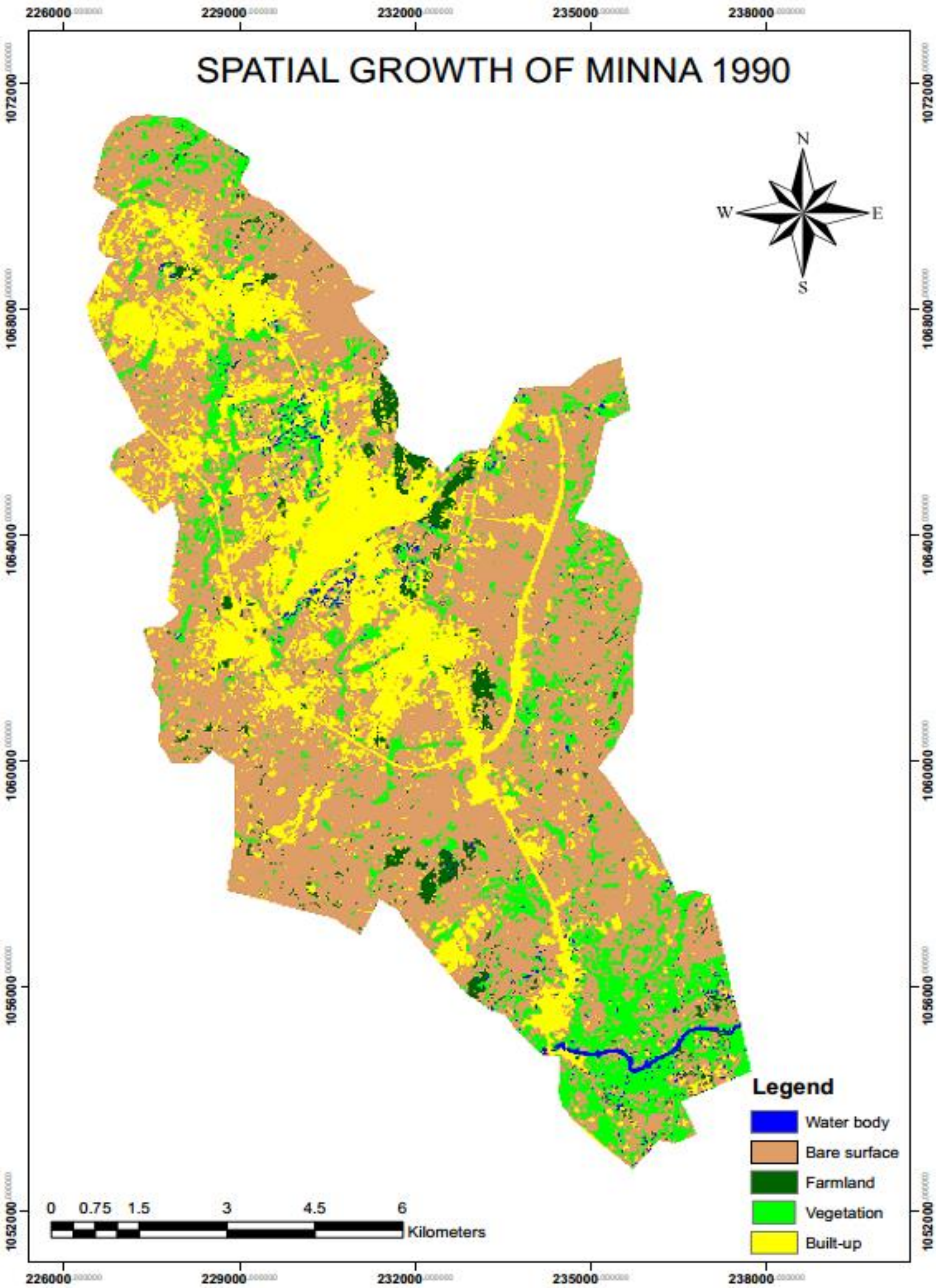

Figure 2: Classified Land use and Land cover map of Minna 1990

Source: Field Survey July, 2015

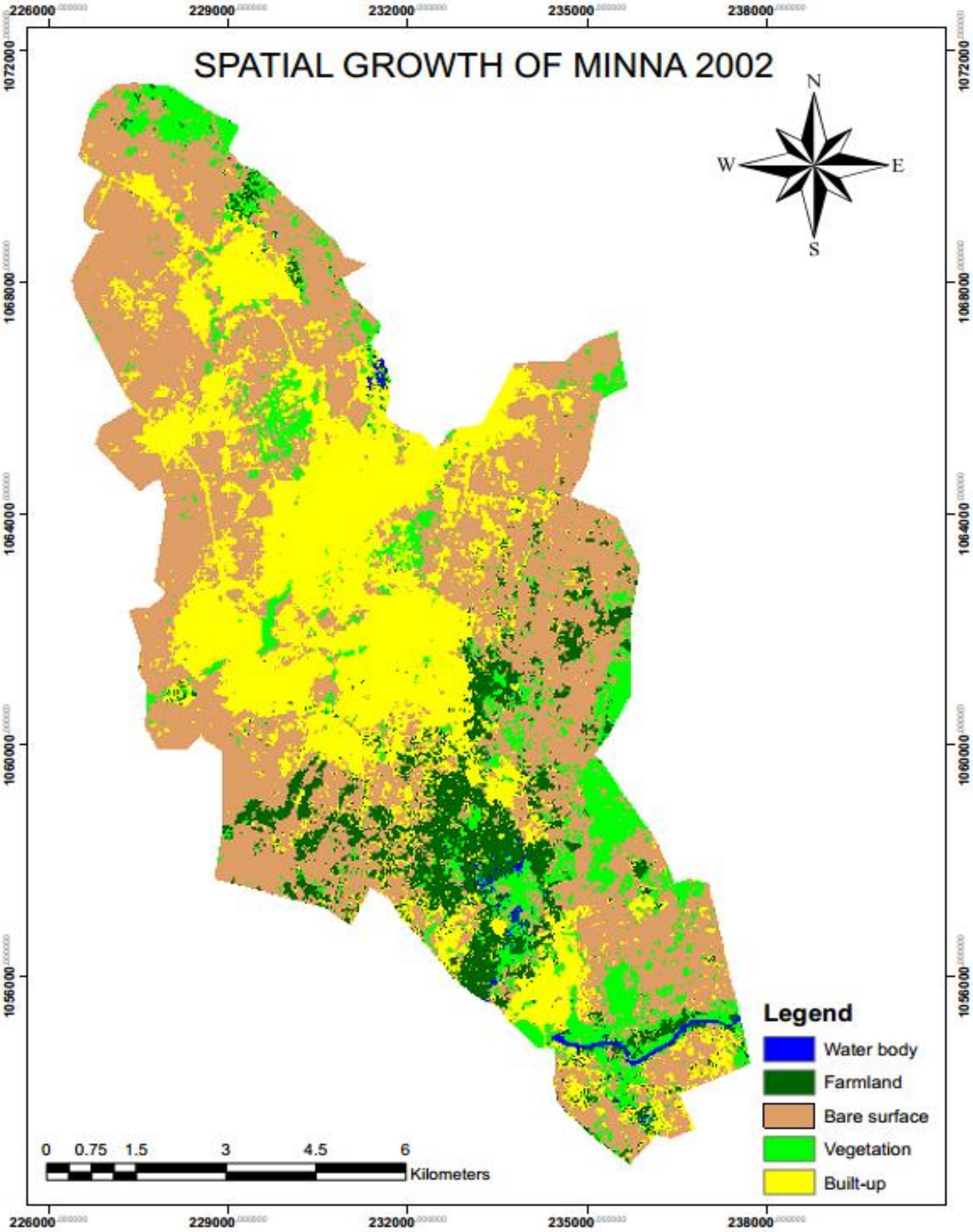

Figure 3: Classified Land use and Land cover map of Minna 2002

Source: Field Survey July, 2015

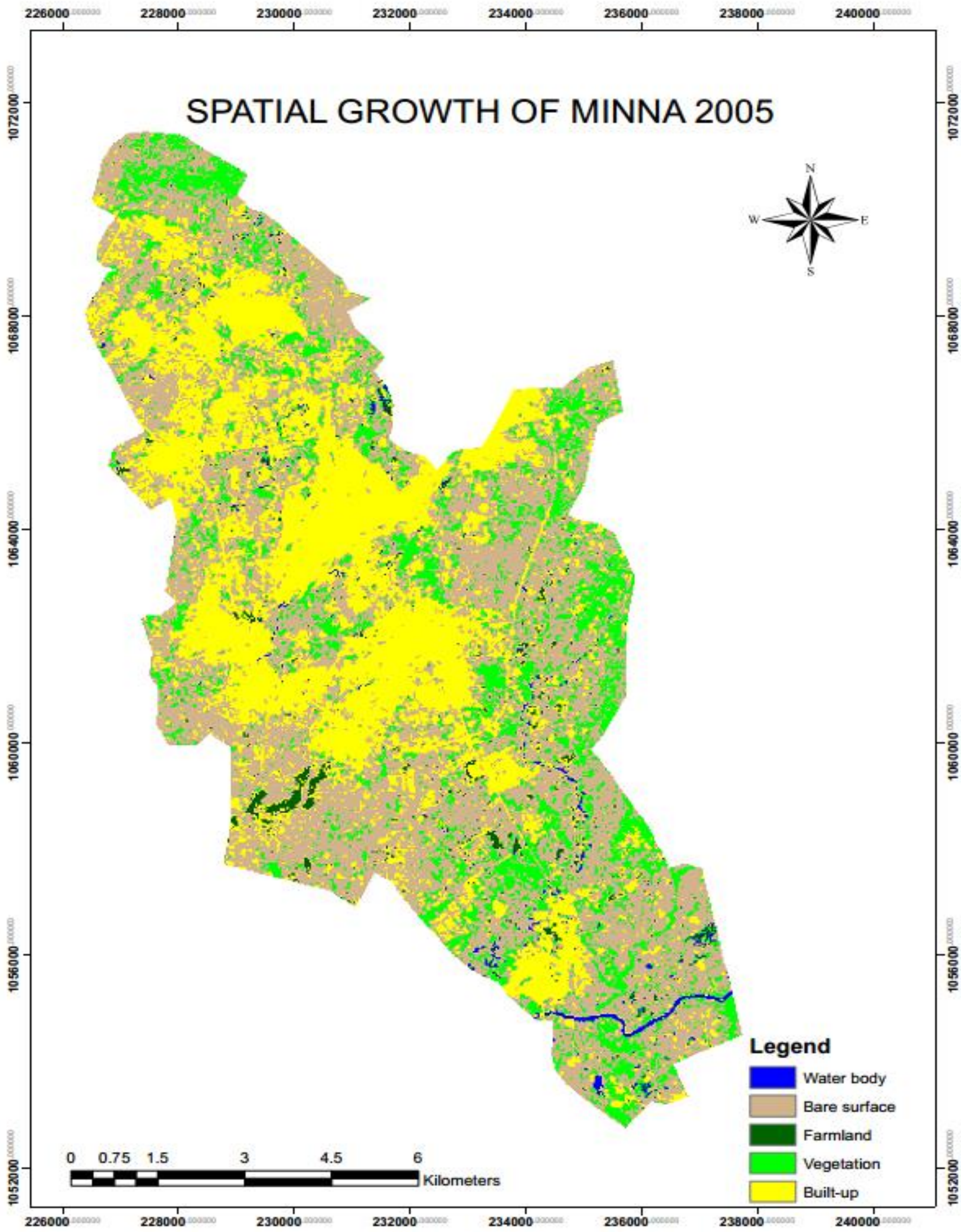

Figure 4: Classified Land use and Land cover map of Minna 2005

Source: Field Survey July, 2015

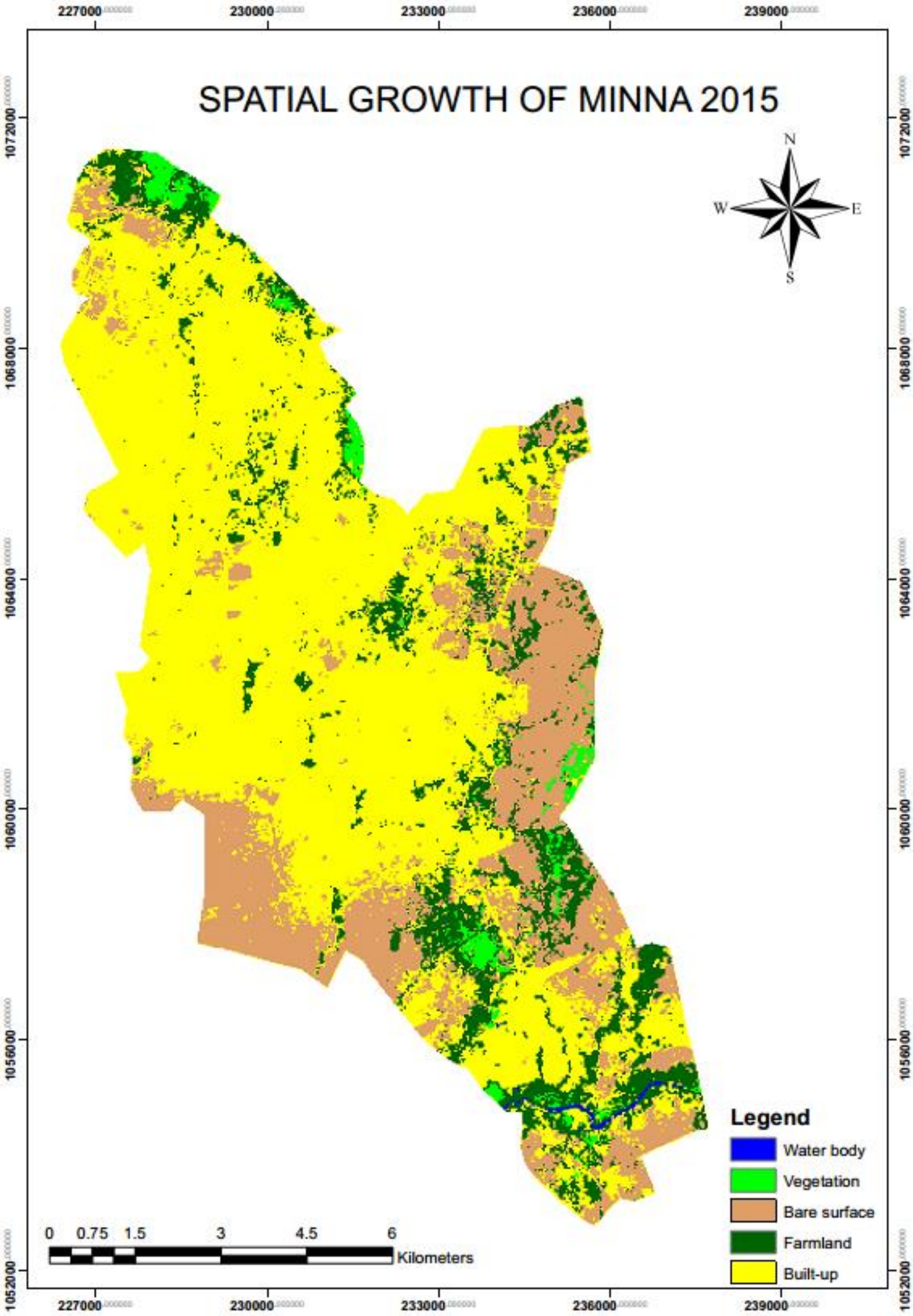

Figure 5: Classified Land use and Land cover map of Minna 2015

Source: Field Survey July, 2015

Table 1: Land use and Land Cover Change Distribution of Minna 1990 - 2015

Land use	1990		2000		2005		2015		Magnitude of change		
	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%	Remark
Built-up	24.60	24.05	32.30	31.58	44.60	43.61	64.70	63.26	38.66	49.09	Increased
Vegetation	14.00	13.69	10.76	10.52	9.25	9.04	8.68	8.49	-5.32	-6.75	Decreased
Farmland	3.02	2.95	2.03	1.98	1.46	1.43	1.07	1.05	-1.95	-2.48	Decreased
Water body	1.06	1.04	1.02	1.00	0.97	0.95	1.01	0.99	-0.05	-0.06	Decreased
Bare surface	59.60	58.27	56.17	54.92	46.00	44.97	26.82	26.21	-32.78	-41.62	Decreased
Total	**102.28**	**100.00**	**102.28**	**100.00**	**102.28**	**100.00**	**102.28**	**100.00**	**78.76**	**100**	

Source: Field Survey July, 2015

CONCLUSION

This research has demonstrated that advancement in GIS and remote sensing technology constitute the much needed tool for mapping and detecting changes in land use land cover. The change detected however, may not constitute a panacea in explaining all the spatial problems relating to changes in land use land cover patterns, rather it provides the bases for understanding patterns of spatial changes and possible causes of change. If the land use land cover change pattern of a place is known, sustainable land use planning can be embarked upon to achieve land management sustainability and development that is eco-friendly.

Therefore, to achieve sustainability in the city growth and development the following recommendations are made;

(a) There is need to control urban expansion on vegetation, farm land and water body to achieve sustainable economic growth and development.

(b) Development and legislative measures be adopted to regulate urban growth and associated sprawl.

(c) Regional development planning should be encouraged to regulate growth in land use land cover for a sustainable urban development.

(d) Growth corridor Plans be developed to serve as a framework in guiding planning of new communities.

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