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Land use Land Cover Change Detection: A Case Study: Maiduguri Capital City, Borno State, Nigeria, 1984 -2018

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Abstract: This study attempt to detect the land use land cover change in Maiduguri capital city of Borno state Nigeria between 1984and2018 using remote sensing technology, geographical information system and multi temporal imagery to estimate the area of each class of land use in 1984, 1990, 2000 and 2018. Where five classes were defined in this investigation: Built-up area, Water body, Vegetation, Bare land and Farmland .Observations of land use trend and land cover change lead to determine the possible reasons behind these changes. In this study the main area of the research is the expansion in Built-up area, results indicated that about 13.42% (35.22sq.km) and 20.55 %(38.05sq.km) positive growth in built-up area between1984-1992 and 2000-2018 while Water body, areas were also indicates negative growth from 5.635% (0.1718sq.km) to 0.303 %(0.072sq.km) in between 1984-1992 and 2000-2018 respectively. Therefore recommendations were highly made for best benefit from the study in ahead of time land use planning and studies.

Keywords: Remote sensing, geographical information system, landsat imagery data and land use land cover.

I. INTRODUCTION

Land use/land cover (LULC) changes play a major role in the study of global change. Land use/land Cover and human/natural modifications have largely resulted in deforestation, biodiversity loss, global warming and increase of natural disaster-flooding ([1],[2],[3]). These environmental problems are often related to LULC changes. Therefore, available data on LULC changes can provide critical input to decision-making of environmental management and planning the future ([4], [5]).The growing population and increasing socio-economic necessities creates a pressure on land use/land cover. This pressure results in unplanned and uncontrolled changes in LULC [6]. The LUL C alterations are generally caused by mismanagement of agricultural, urban, range and forest lands which lead to severe environmental problems such as landslides, floods etc. Remote sensing and Geographical Information Systems (GIS) are powerful tools to derive accurate and timely information on the spatial distribution of land use/land cover changes over large areas([7], [8],[9],[10])Past and present studies conducted by organizations and institutions around the world, mostly, has concentrated on the application of LULC changes. GIS provides a flexible environment for collecting, storing, displaying and analyzing digital data necessary for change detection ([11], [12], [13]).Remote sensing imagery is the most important data resources of GIS. Satellite imagery is used for recognition of synoptic data of earth's surface [14]. Landsat Multispectral Scanner (MSS), ThematicMapper (TM) and Enhanced Thematic Mapper Plus (ETM+) data have been broadly employed in studies towards the determination of land cover since 1972, the starting year of Landsat program, mainly in forest and agricultural areas [15]. The rich archive and spectral resolution of satellite image are the most important reasons for their use. The aim of change detection process is to recognize LULC on digital images that change features of interest between two or more dates [16]. There are many techniques developed in literature using post classification comparison, conventional image differentiation, using image ratio, image regression, and manual on-screen digitization of change principal components analysis and multi date image classification [17]. A variety of studies have addressed that post-classification comparison was found to be the most accurate procedure and presented the advantage of indicating the nature of the changes([18], [19]). In this study, change detection comparison (pixel by pixel) technique was applied to the Land use\land cover maps derived from satellite imagery.

The aim of the study is to analyze LULC changes using satellite imagery and GIS in Province (North East, Borno state Maiduguri, Nigeria). In order to achieve this objective, Landsat Multispectral Scanner (MSS), Thematic Mapper(TM) and Enhanced Thematic Mapper Plus (ETM+) data acquired on 21 October 1984, 12 December1992, 10 November 2000 and17 September 2018 were used. Maximum likelihood classification and change detection comparison strategy was employed to identify LULC changes.

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II. MATERIALS AND METHODS

A. Study Area

Maiduguri is the capital city of Borno state which is located between latitudes 11 42N and1200N and longitude 12.54 an13 14E [20].She Further claimed that Maiduguri covered an area of 543km^2. The city is bounded in the north by Jere LGA, in the west, south and south-west by Konduga LGA, in the north-west by Mafa LGA. Maiduguri has Mean annual maximum temperature of 34.8 ^{O}C with mean temperature ranging between 30 and 40 ^{O}C. The months of March and April are usually the hottest months, while November and January are the cold and dry periods of harmattan. The city receives rainfall from June to September. However in rainy years, the city records rainfall earlier than June and latter than September. Being a nodal city, trading is the major occupation of the inhabitants with few agrarian practices. The city is situated in a plain area. One of the problems confronting the geography of Maiduguri urban is the non availability of a standard boundary of the urban. Therefore, in this study, the urban is defined to be the areas between latitudes 11˚ 27′30″N and 11˚ 33′30″N and longitudes 13˚ 2′30″E and 13˚ 9′10″E .Below shown the map of Maiduguri.

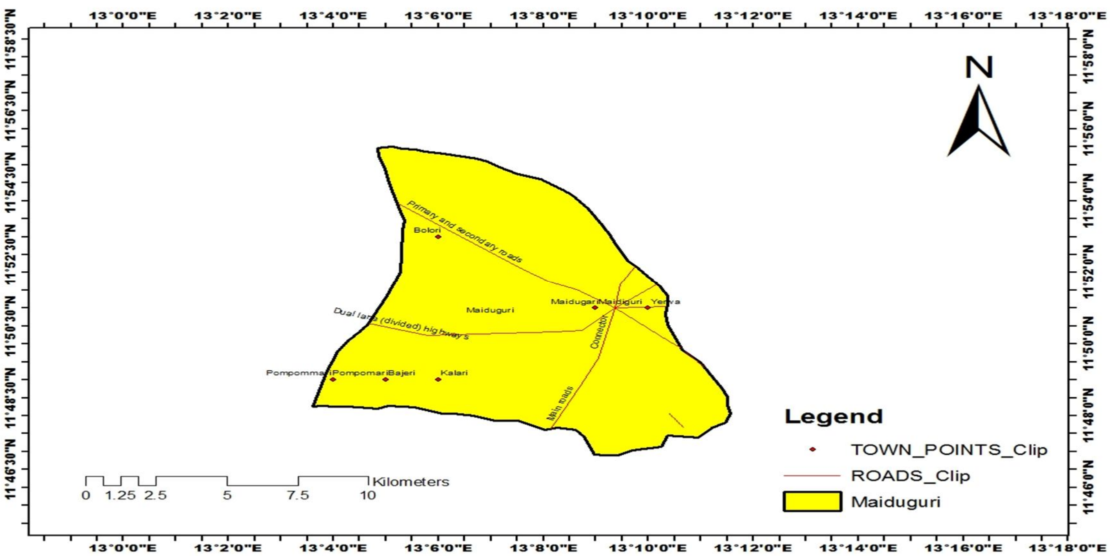

Fig1. Map of Maiduguri city, source by Author

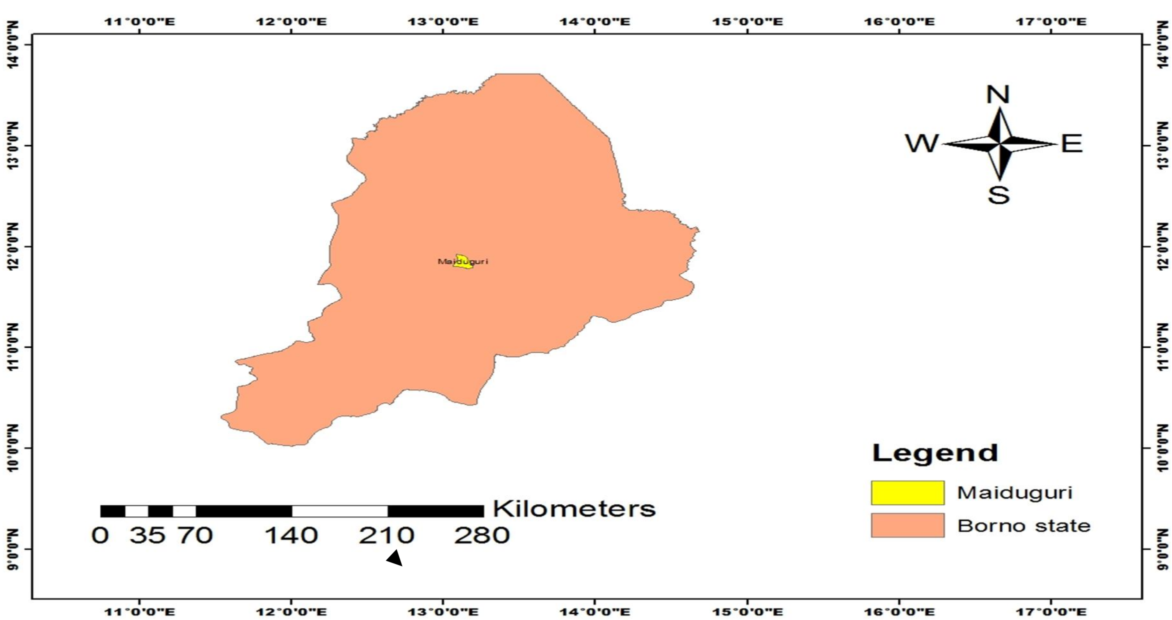

Fig2. Map of Borno State Showing the Capital city Maiduguri, Source by Author.

B. Materials

The material used in this study are:

1) Hardware: personal computer: hp ProBook 4530s Core(TM) i3-3356m CPU@ 2.30GHz, 2.30GHz, 4.00GB of RAM, digital camera HD webcam.
2) *Software:* Arc GIS Imagine 10.3.1 used for the classification process, post- classification process, Microsoft Excel for the charts and presentation and Microsoft word .
3) *Data:* Efficient integration of temporal, spectral and spatial resolution information is important for accurate mapping of change, developing of land cover land use. The satellite data used in this study are:
   a) Land sat image Maiduguri area 1984 (60m resolution)
   b) Land sat image Maiduguri area 1992 (60m resolution)
   c) Land sat image Maiduguri area 2000 (30m resolution)
   d) Land sat image Maiduguri area 2018 (30m resolution)

C. Method

Generally speaking the methods for the change detection can be divided into two three groups (pre- classification methods, supervised classification methods and post- classification methods) where all of them are being used approximately in practice.

D. Image Pre-Processing

Classification process and analysis of the different LULC classes were being done using four Landsat satellite images covering the Landsat 4,5and 7 acquired in different periods. These images includes; L4, TM (path 185, rows 52), L5TM (path 185, rows 52) and L7 ETM (path 185, rows 52). The Landsat images were down-loaded from United States Geological (USGS) Earth Explorer (https://earthexplorer.usgs.gov/). The choosing of the Landsat satellite images dates was influenced by the quality of the image especially for those with limited cloud cover. Each Landsat was georeferenced to the WGS_1984 datum and Universal Transverse Mercator (UTM) Zone 33N North coordinate system. An intensive pre-processing such as geo-referencing and layer- stacking were conducted in order to Ortho-rectify the satellite images. The image was then processed in ARCGIS IMAGE 10.3.1 software. And from the stacked satellite image the study area image was extracted by clipping tool method using ARCGIS 10.3.1 software.

E. Supervised Classification Processes

In this study, four Landsat images were process using supervised classification techniques. Once the training samples were determined, a supervised classification was performed on four images applying Maximum Likelihood algorithm in ARCGIS 10.3.1. The supervised classification technique is more preferred, because the data of the study area is available and the author has a prior knowledge of the study area. The Maximum Likelihood classification rule is still one of the most widely used for supervised classification algorithms. It is considered to give very correct results. Therefore from there the LULC maps were being derived with the following five classes these are: 1. Build-up area, 2. Water body 3.Vegetation 4. Bare land and 5.Farm land.

F. Post-Classification Processes (Smoothing)

Thus classified images frequently manifest a salt-and-pepper appearance due to the intrinsic spectral variability confronted by a classifier when applied on a pixel-by-pixel basis. In such situations it is often suitable to smooth the classified images to indicate only the dominant presumably accurate classification. Moreover, post classification processes or smoothing was applied after supervised classification has been done to remove an isolated pixels and noisy images. In this study about six post classification processes were applied these are: Majority filter tool, Boundary cleaning tool, replacing small cluster, Region group tool, Set null tool and Nibble tool.

G. Data Analysis

The data was analyzed and as a result of images classification the followings are digitally GIS-based land cover land use maps for the study area (1984-1984-2000-2018) each class highlighted by suitable color as shown in figures 2,3,4 and 5).

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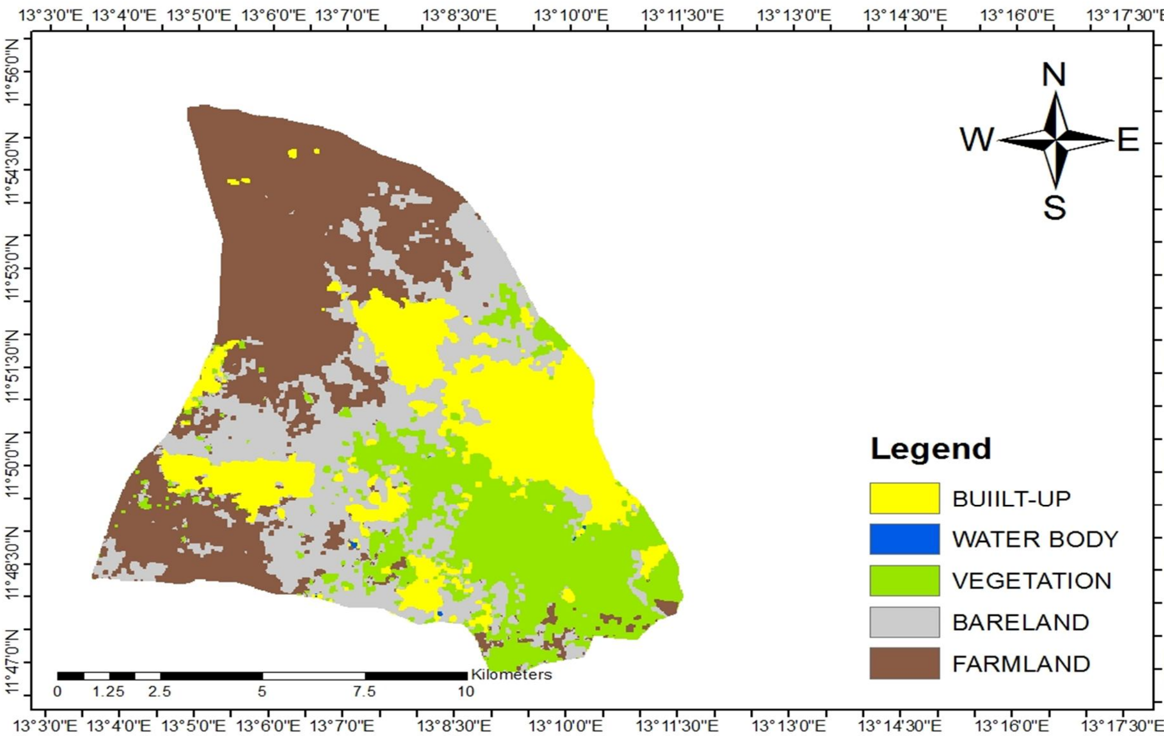

Fig.2 Maiduguri Map 1984

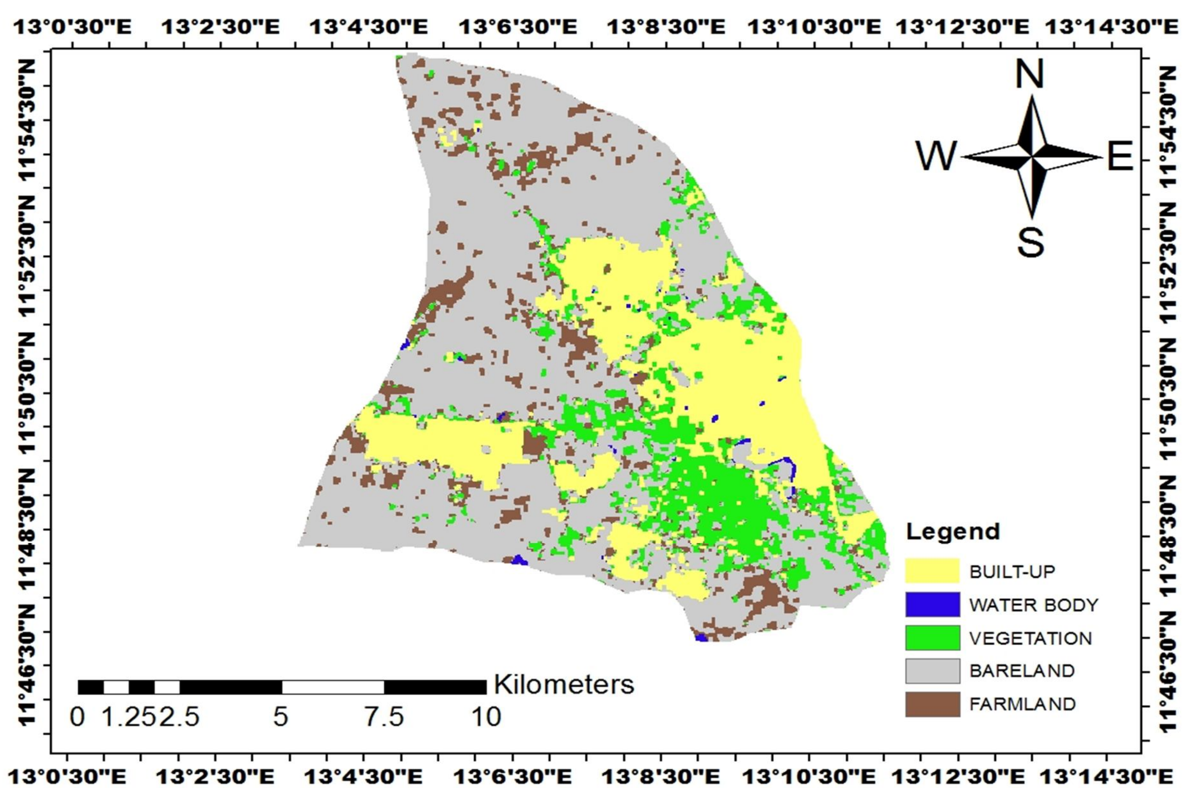

Fig.3 Maiduguri Map 1992

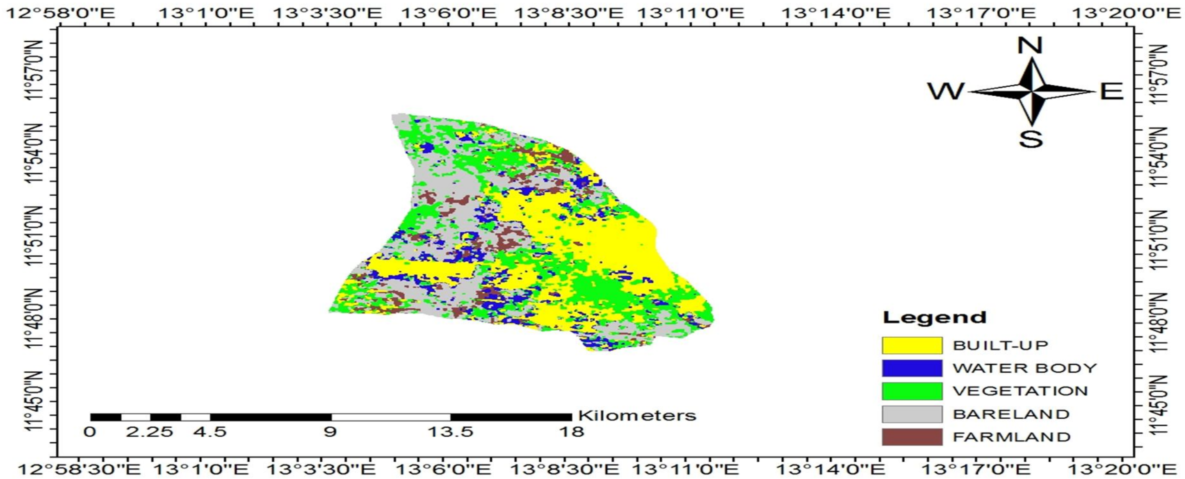

Fig.4 Maiduguri Map 2000

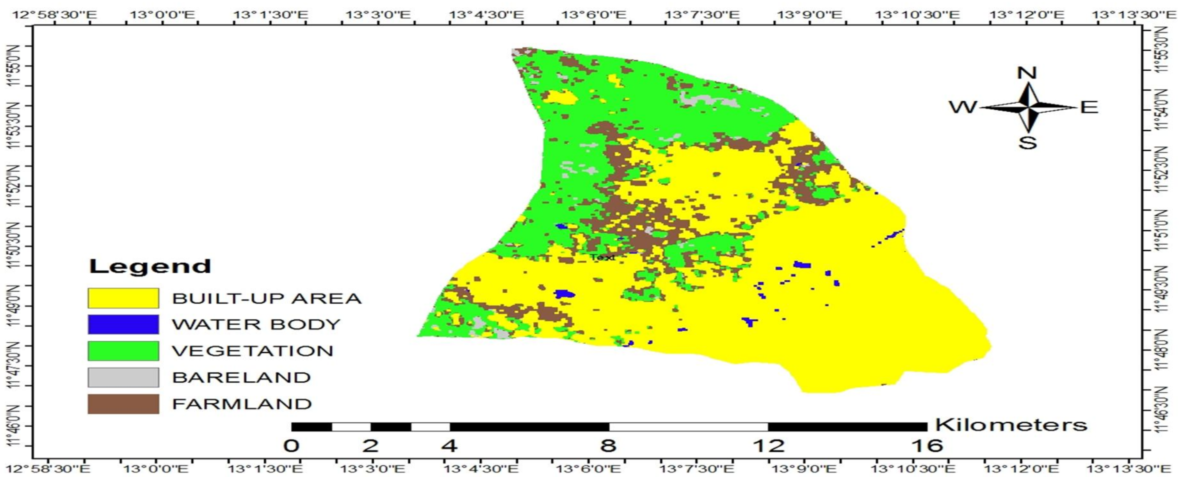

Fig.5 Maiduguri Map 2018

III. RESULT AND DISCUSSION

The images classification provide two outputs first spatial data which is the map in the previous chapter and scanned area in hectare ,percentage and square kilometer for each class of land use in each year in table1,table2 and table3. The numbers are the result of the image classification and they can give a very good indicator for land use land cover change. Figure 6 represent the comparison of the land use during the period of the study. The supervised classification indicates that there is a positive increase in the built up land during the study period. The total percentage area under built up was 15.16% in1984 which increased to 28.58% in 1992, in 2000 it increased to 44.10% and in 2018 it covered an area of 64.65%. That could be the result of many reasons: first of all population increasing because people need settlement, facilities and street as well as other factors. Since Maiduguri (the study area) is the capital city of Borno state that made this city a special case. Built-up area influenced by so many factors such as migration, natural disaster, drought, diseases, civil war and insecurity ….etc. All these enforce people to look better life in the city. The class comprises areas of surface water either impounded in the form of lake and reservoirs or flowing streams, river, cannels etc. These are clearly seen on satellite false color composition imagery in blue color. The total percentages area covered by water bodies in 1984 was 6.369% .which reduced to 0.734% in 1992 and in the year 2000 it covered only 0.998% .In the year 2018 water bodies drastically reduced to 0.695% which is a negative growth. Vegetation cover has been defined as land where the potential natural vegetation is predominantly trees, grasses, glasslike plants, shrubs. The vegetation cover shows a negative growth in terms of area. In the year 1984 the total area covered by vegetation was 32.6%. Which reduced to 23.7% in 1992, in the year 2000 it covered an

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area of 17.7%? and in the year 2018 it slightly increase to an extent of 19.3%.But still compare to 1984 the increment is not much so this indicated that there is negative growth .Bare land are the Areas with no vegetation cover, stock quarry, stony areas, uncultivated agricultural lands. The bare land covered indicates negative growth in the year 1984 the total percentages area was 19.41%which decreases to 13.42% in 1992, in the 2000 the total area was again raised to 24.03% and in the year 2018 was reduced to 5.81% farmland specifically used for agricultural purposes in the raising of crops or livestock .Land cover by farmland are influenced by many factors, there seems to be a negative change a reduction farm land. The total percentages area covered in the year 1984 was 26.42% but in the year 1992 the area cover was increases to 33.59% compare to the previous year. While in 2000 it was reduced to 13.21% and in 2018 it was also reduced to 9.52%.Therefore below are tables of the result showing in hectare, percentage and square kilometer .

Table 1 indicates Land use classes' area in hectare

Period	Built-up	Water Body	Vegetation	Bare land	Farmland
1984	261.6076	109.90586	563.2310	334.9625	455.8874
1992	3784.1580	97.21988	3135.0050	1778.3110	4447.7510
2000	4058.2330	91.83901	1625.7540	2211.7220	1215.7060
2018	7863.0270	84.57472	2350.8810	706.2798	1158.4900

Table 2. Shows land use classes in percentage

Period	1984	1992	2000	2018
Built-up	15.16%	28.58%	44.10%	64.65%
Water Body	6.37%	0.73%	0.998%	0.695%
Vegetation	32.64%	23.67%	17.66%	19.33%
Bare land	19.41%	13.43%	24.03%	5.81%
Farmland	26.42%	33.59%	13.21%	9.52%

Table 3 .indicates land use classes in square kilometer

Period	Built-up Area	Water Body	Vegetation	Bareland	Farmland
1984	2.62sq.km	1.099sq.km	5.63sq.km	3.35sq.km	4.56sq.km
1992	37.84sq.km	0.972sq.km	31.35sq.km	17.78sq.km	44.45sq.km
2000	40.58sq.km	0.918sq.km	16.26sq.km	22.12sq.km	12.16sq.km
2018	78.63sq.km	0.846sq.km	23.51sq.km	7.06sq.km	11.58sq.km

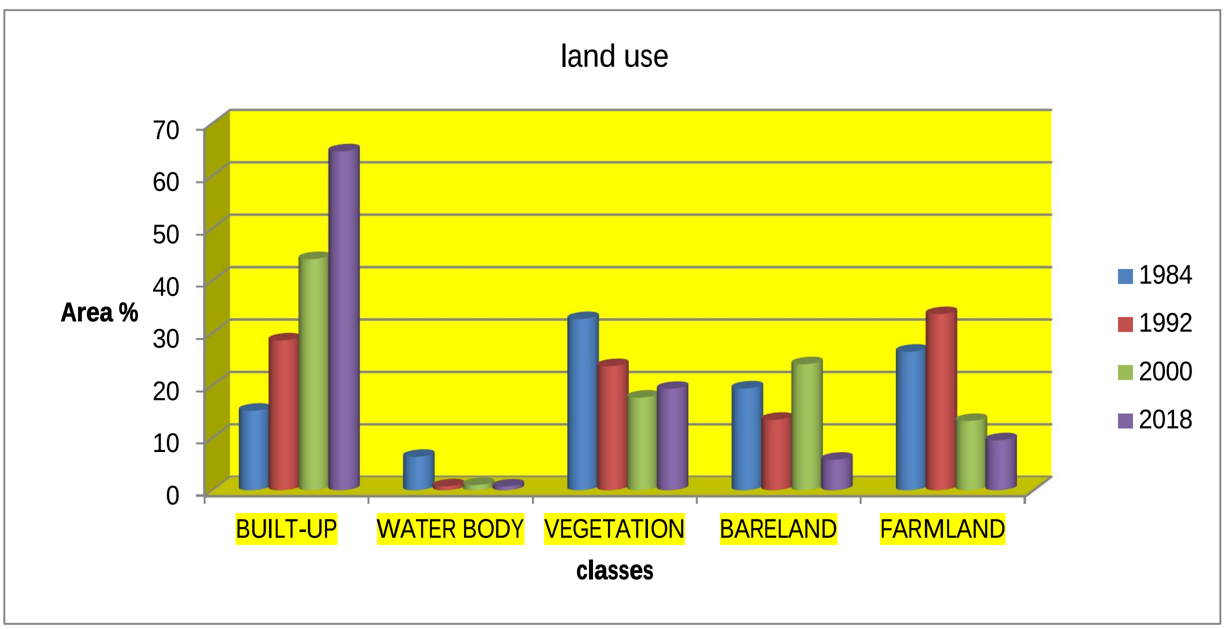

Fig6. Land use Classes

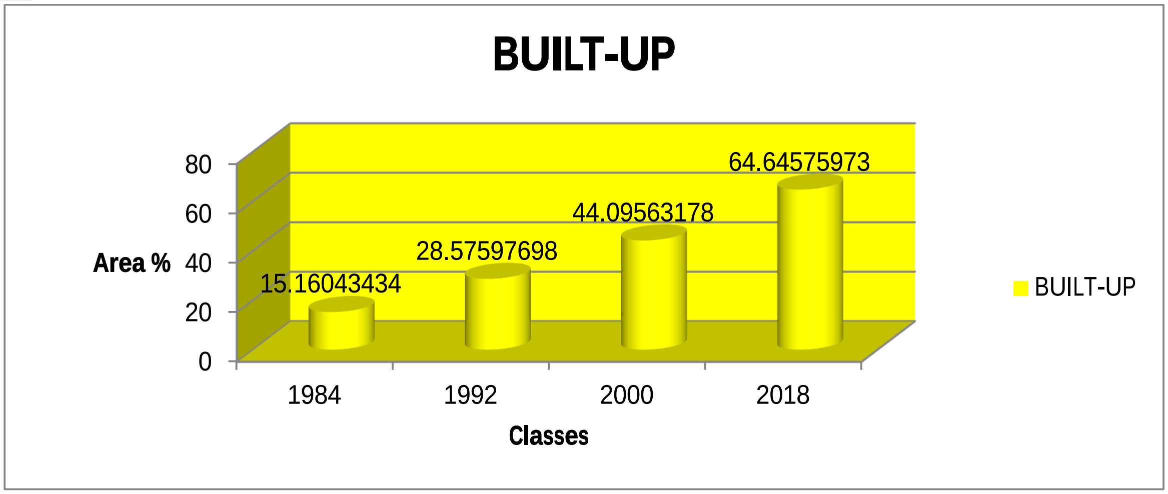

Fig7.Built-up Area in 1984, 1992, 2000 and 2018

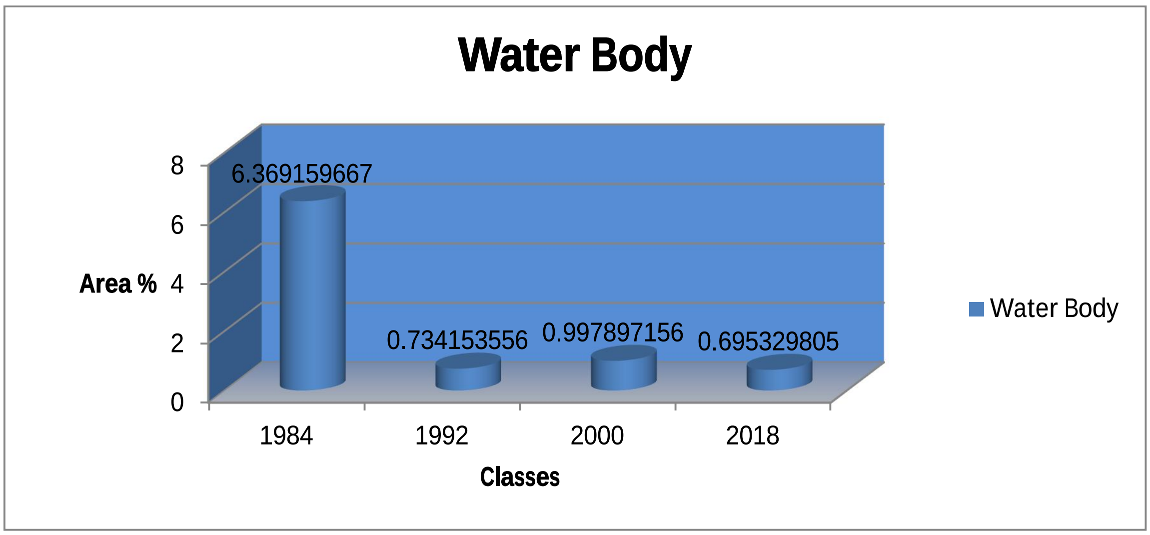

Fig8. Water Body area in 1984, 1992, 2000 and 2018

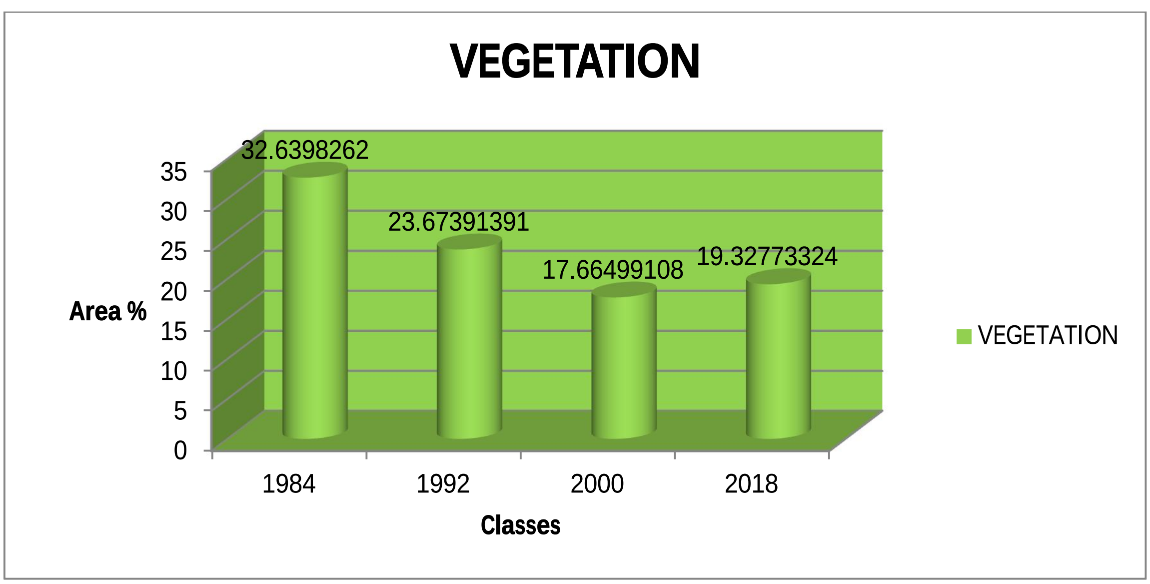

Fig 9. Vegetation area in 1984,1992,2000,2018

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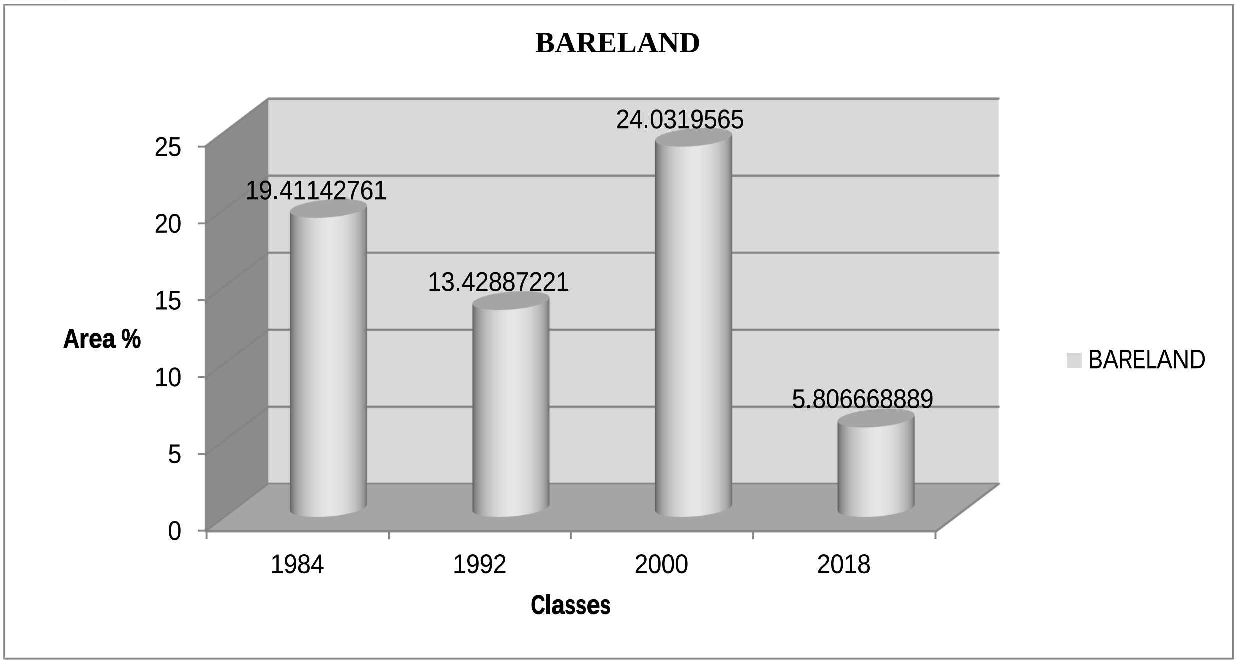

Fig 10 Bare land area in 1984,1992,2000,2018

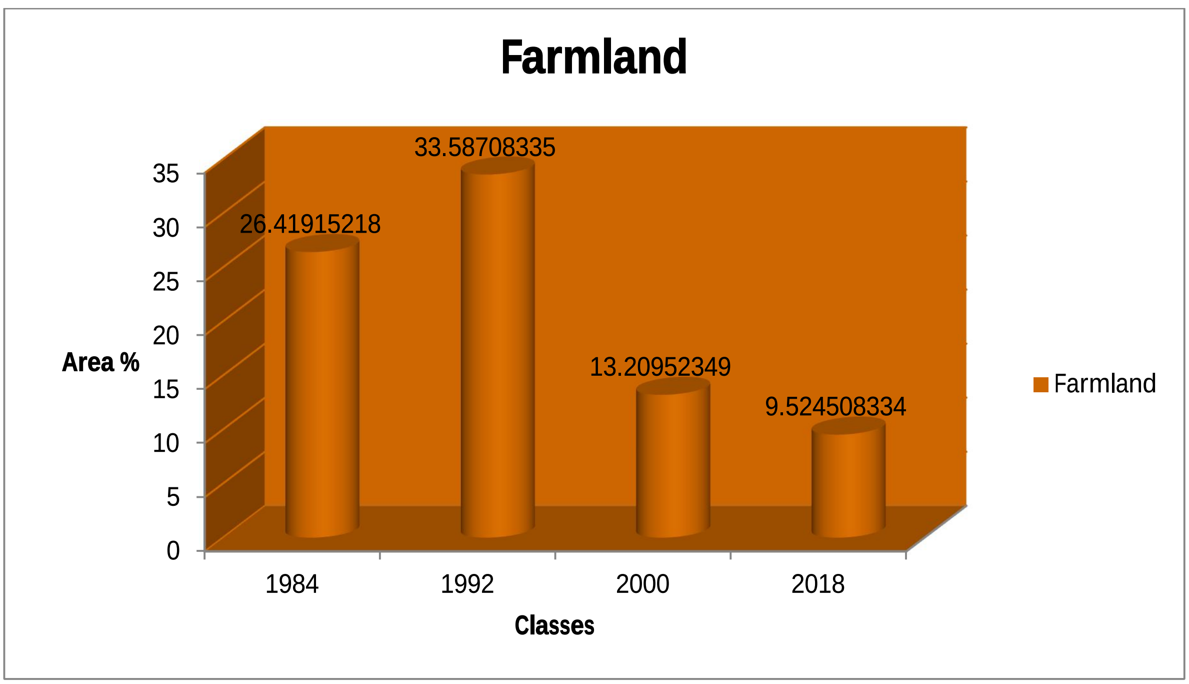

Fig11. Farmland area in 1984,1992,2000,2018

IV. CONCLUSION

This research accomplished its goals by answering land use land cover change detection most important question like where, when, how much and why land use land cover change had taken place in Maiduguri area using geographical information systems and remote sensing techniques and multi temporal imagery. All these questions are being justified by importance of land as a major recourse, to demonstrate that land sustainability is determined by how human use it and to avoid negative impact could've occurred. The research results showed 13.42%and 20.55%positive growth in Built –up area in between the period of1984-1992 and 2000-2018. While negative growth was also indicated in water body which is declining from 5.635% to 0.303% in between 1984-1992 to 2000-2018.

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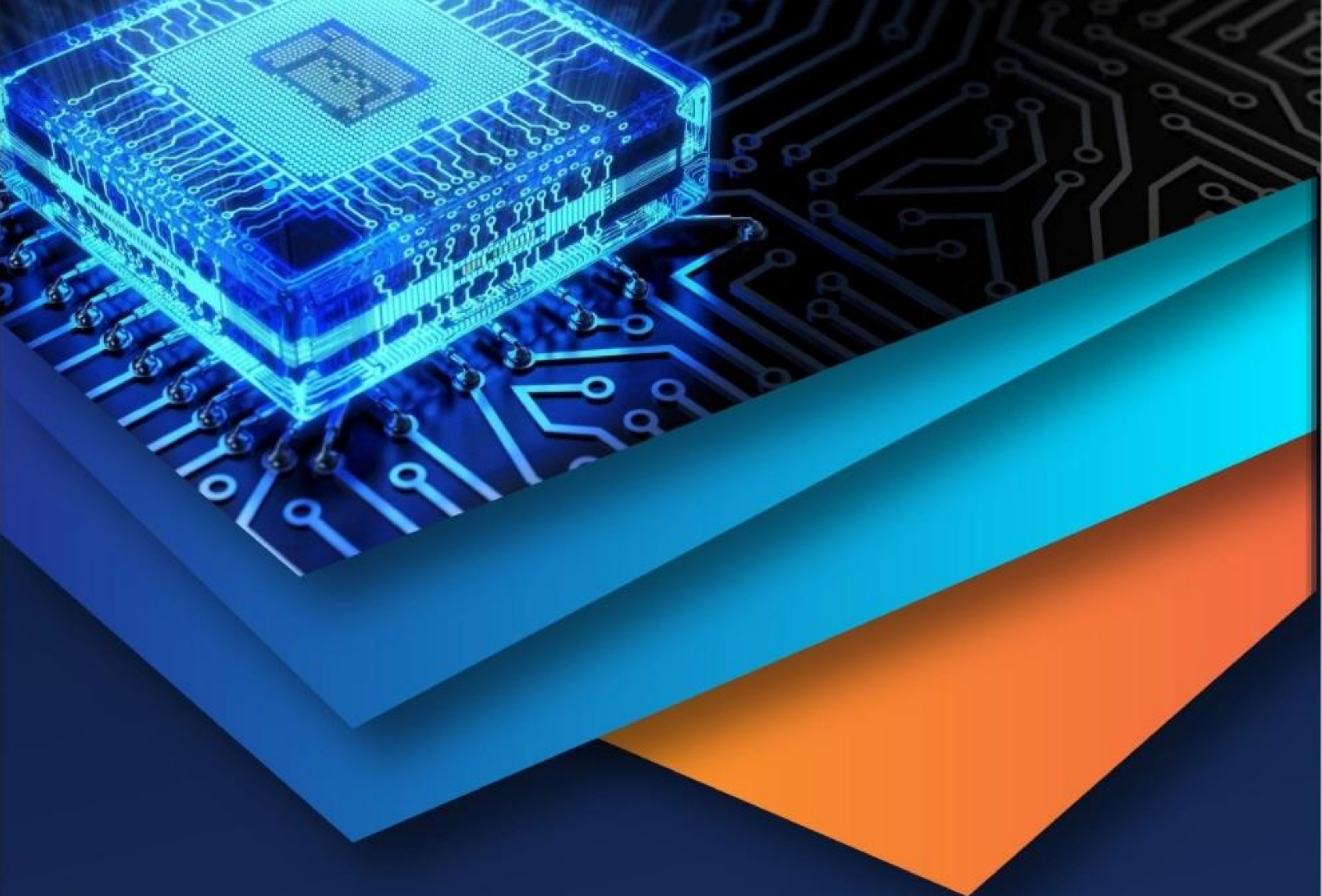

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