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Assessment of Urban Growth Using Geographic Information System (Gis) and Rem Ote Sensing In Potiskum Town

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Potiskum local government area

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ABSTRACT: The most dynamic region on earth is the urban areas. Their size has been constantly increased during the past and this process will go in future. In less develop countries a strong trend toward concentration of people in urban areas can be observed. To understand urban growth, remote sensing imagery is a reliable source. Potiskum local government with its headquater in Potiskum town is one of the local governments which has the highest population in Yobe state. The need to determine the rate at which the area grow necessitate the application of remote sensing and GIS technique in assessing the urban growth between 1999 and 2018. Land sat 7 ETM+ satellite image of 1999, 2008, and Landsat 8 OLI of 2018 were processed using Arc GIS 10.6 and ERDAS imagine 2014 for analyzing the urban growth. The entire area was classified into four classes that is water body, settlement, bare soil and farmland. The result revealed that within the period of research, there is an increase in settlement and farmland class by 3.42% and 0.44% respectively and a decrease in water body by 0.35% and 3.51% respectively. The accuracy assessment was carried out for the four classified map and it revealed that the overall accuracy and Kappa statistic were 91% and 0.8% respectively. The study provide an insight into understanding of urban growth and aids in subsequently infrastructure planning management and decision making.

Key words: Urban growth, Geographic information system and remote sensing

I. INTRODUCTION

Urban growth is defined as the rate at which the population of an urban area increases. This results from urbanization which is the movement of people from rural areas to urban areas. Urban growth is also defined as the expansion of a metropolitan of a sub-urban area into the surrounding environment. Most urban centers over some years ago have continued to witness unprecedented population growth in most developing countries. This growth is premised on the perceived improvement in living condition and environment (Kembe and Keibichi, 2000). These are mostly caused by high level migration usually from rural areas to urban areas.

Urban growth and urbanization in the last few years have drastically accelerated in many developing countries. According to United Nations in 2011, 3.6 billion of world population 52% were urban dwellers. Universally, the level of urbanization is expected to rise to 67% in 2050. In the less developed nations, the proportion of urban will rise from 47% in 2011 to 64% in 2050. In Africa alone the urban population is expected to triple from 444 million in 2011 to 1.2 billion in 2050 (1bid). Many people prefer to live in or near the urban areas because of availability of different means of easing livelihood in a more or less compact area and the availability of necessary facilities for comfortable living e.g. Utilities and services, shopping, educational facilities, means of communication, recreational facilities etc. Recently, an increasing concern about sustainable development have foster a new interest of the international literature on the physical dimension of cities and, particularly on issue of urban growth pattern and urban form (Huanz et al., 2007; Vande, et al., 2009).

Urban areas developed either through objective planning, guided and regulated by deliberate regulation and control system or spontaneous growth through unplanned isolated construction especially on the edges of cities. Ideally, the growths that take place around urban areas should be channeled in an orderly manner that can produce an economically efficient and personally satisfying living environment.

Geographical Information System (GIS) may be defined as a computer based information system which attempt to capture, store manipulate, analyze and display spatially referenced and associated attribute data for solving complex research, planning and management problem (Duggal, 2006).

Remote sensing is defined as the process or techniques of obtaining information about an object, area or phenomenon through the analysis of data acquired by a device without being in contact with the area or phenomenon being studied (Chandra, 2002). It consists of the interpretation of measurement of electromagnetic energy reflected from or emitted by a target from a vantage point that is distant from the target (Mother, 1999).

GIS and remote sensing are land related technologies and are therefore very useful in the formulation and implementation of the sustainable development strategy. Patterns of growth and analysis of spatial and temporal changes could be done cost effectively and efficiently with the help of Geographical Information System (GIS) and Remote Sensing techniques. Spatial pattern of urban growth over different time period can be systematically mapped, monitored and accurately assessed from satellite data (remotely sensed data) along with conventional ground data (Lata et al., 2001). Modeling urban sprawl/growth provides a “picture” of where this type of growth is occurring, help to identify the environmental and natural resources threatened by such growth, and to suggest the likely future directions and pattern of the sprawling growth.

Various researches have been conducted on urban change using medium resolution landsat images. For example Yuan et al (2005) used multi temporal landsat images to analyze urban growth patterns and to monitor land cover changes of two twin cities in Minnesota metropolitan area. The result shows that it has been possible to quantity the land cover change pattern in the metropolitan area and demonstrates the changes in land cover over time.

Change detection identifies differences in the state of an object or phenomenon by observing it at different times (Singh, 2016). This is carried out in remote sensing by observation of multi-temporal images taken at different periods of time. The result of change detection analysis, mostly change detection statistics and maps are used in urban monitoring, land cover changes analysis and disaster management.

Remotely sense data such as landsat TM, ETM+, MODIS and the like have been used to study land use and detect changes over a period of time using time sequential data by different authors (Attri, Chaudhry, & Sharma, 2015: Nelson, 1983).

Yaung and Lo (2002) used multi-temporal/multi-resolution satellite imageries to successfully extracted land use/cover data in Adanta Georgia metropolitan area for the past 25 years. The result of this research shows that the losses of forest and urban sprawl have the major consequences of Adanta accelerated urban development. Tang et al (2008) used multi temporal satellite images to analyze the dynamic of urban landscape in two petroleum – based cities Houston, Texas in the United State and Daging province in China. Accordingly, both cities expanded rapidly on the basis of the petroleum industries during the study period; however, under varying socio-political setting.

Urban growth generates a lot of problems and challenges economically, socially and environmentally (Omwenga, 2010). It has both negative and positive effect on the ecological and social system. Urbanization when ignored may intimidate sustainable development (Duboryk et al. 2011).

Urban growth, being a land use/cover change phenomena from a non-urban category to an urban category is a dynamic and complex phenomena revealing economic development (Batty and Micheal, 1999).

Challenge by different reasons such as spatial and spectral heterogeneity of urban environments, remote sensing is an appropriate source of data for urban studies (Roberst & Herold 2004). According to a report published by NASA, the advance in satellite-based land surface mapping are contributing to an improved understanding of the underlying forces of urban growth and sprawl, as well as issues relating to territorial management. Nowadays, the physical expansion and patterns of urban growth on landscape can be distinguished, mapped, and analyzed by using remote sensing data (Bhatter, 2010).

Shi , Su, Zhu, Lie & Mie, (2012) used three set of landsat Thematic Mapper (TM) images to characterize the growth types and analyze the growth density patterns in peri-urban areas of Ganyungang city. The result of the research depicted that substantial arable lands were lost by urban peri-urban growth types were edge expansion and infilling growth respectively with important evidence of urbanization from a city central core.

Deka et al (2012) showed that the integration of Remote sensing and Geographical Information System (GIS) technique to effectively detect urban growth, emphasizing on the potential applicability of landsat (TM) data in the urban studies at both regional as well as local level.

Different approach and technique have been developed and applied to quantity and characterize the urban growth processes and patterns. Traditionally, visual interpretations of high-resolution aerial photograph were used to acquire comprehensive information for mapping of urban areas. This mapping technique is expensive and time consuming for the estimation of urban growth.

However, with gradual advancement and availability of high temporal and spatial resolution remote sensing imagery; the possibilities of monitoring urban problems with better accuracy have become more promising. Hence accurate mapping of urban environment and monitoring urban growth is becoming important at global level (Guindon and Zhang, 2009) (page2 T.book).

Tian et al (2011) compared the spatial and temporal dynamic pattern of urban growth for five urban areas of Shangzhou in the Yangtze Delta region of China. The results of their research revealed during the 15 years, urban growth pattern were uneven over the three periods. The size distribution of the five urban areas became more even with the rapid urbanization process.

The unprecedented growth of urban population and built-up area worldwide, have an enormous influence on natural landscape at different spatial scales (Herold, Coudeli & Clarke, 2005). Land use and land cover changes are the process in which the natural environments such as forest and grass lands are replaced by human induced activities such as intensive agriculture and urbanization.

A study on uncontrolled physical expansion of cities by UK-based organization (idea connection) 2011, reveals that in many developing countries, intercity and rural-urban migration coupled with the natural growth of the urban population are causing cities to expand faster than the municipality authorities can copes. This trend leads to unplanned urban expansion characterized by informal settlement, unplanned land transition and reduction in rural land use.

According to Cheng, Masser, & Ottens, (2010), the causes of urban growth include increase in population (ii) high demand for residential, industrial, commercial and other land use activities, (iii) government intense economic activities and land fragmentation without protection of rural open space. Rakodi (2001) posit that effective control of urban physical expansion promotes development, urban management and land use planning.

Urban growth at any level has implication on future urban and rural development policies of such area, but many nations are un-resolve as whether to welcome rapid urban expansion or discourage it. (Angel, et al 2005) observed that, while many will readily agree that urban expansion is an issue of serious concern; there is no consensus among scholars, policy makers on whether further urban expansion should be restricted or encouraged.

Environmental pollution and degradation increased environmental hazards such as flooding, population expansion, insufficient sanitations and water supply, transport problems, poor housing condition, rising cost of living, increase in crime and loss of fertile agricultural and wetlands are some of the most prominent negative effects of rapid urbanization and urban growth (UN-HABITAT, 2012). If not manage properly, these may hinder sustainable development of cities in the long run (Duboryk et al., 2011).

The uncontrolled growth of urban areas in term of population and area coverage have become a very crucial issue stressing planning because of the escalating problem of urban growth , congestion, poor housing, crowded transportation, lack of basic services, ill health, low educational status and high unemployment rate.

Several researchers have employed Remote Sensing (RS) and Geographical Information System (GIS) techniques to study urbanization in different cities of the world. For instance, Mishra et al (2011) conducted a study to analyse urban growth from (1930 – 2005) and land use changes from (2000 – 2005) in Bhubaneswar city of India.

Also, Saravanna and Uangoran (2010) use GIS to investigate the nature and pattern of urban expansion of Madurai city over its surrounding region during the period of 1991 – 2006. Similarly, Teng (2009) employed GIS and Remote Sensing to quantify the urban sprawl in China over the period of (1980 – 2003).

Moreover Adekunle and Richard conduct the mapping urban Growth of Kana Local Government Area in River State using Remote Sensing approach over a period 1986 – 2015. Furthermore Alabi (2009) integrated Remote Sensing and GIS data to examine the sprawl of Lokoja region in north central Nigeria over the period 1987 – 2007.

The need for monitoring the effect of urban growth and providing information using Remote Sensing and Geographical Information System have been proven to be effective methods of data acquisition, time saving, cost effective when compare to other methods of spatial analysis. Remote Sensing data can be effectively integrated with conventional data for analysis, planning and decision making with reasonable accuracy.

Indeed the last two decades have witnessed rapid population growth and outward urban physical expansion that have combined to affect the environment, particularly the existing spatial pattern and functional stability of the rural land use in the adjoining areas of surrounding Potiskum the headquarter of Potiskum Local Government Area. In these years, the outward physical expansion and the implication have continued to increase in magnitude and intensity. The disturbing issue is that the implications of the physical changes due to urban expansion have remained understand thus the need for this research.

II. THE STUDY AREA

Potiskum is the headquarters of Potiskum Local Government in Yobe state. It is located along Kano- Maiduguri road. It is about 100km west of Damaturu capital of Yobe state sharing a common boundary with Nangere Local Government to the north and partly to the West, Fune Local Government to the East and Fika Local Government to the south. It situated with approximate latitude 11 44 03N and 11 03 41N and between longitude 11 41 37E and 11 06 50E. Potiskum is second largest town in the whole of Yobe State.

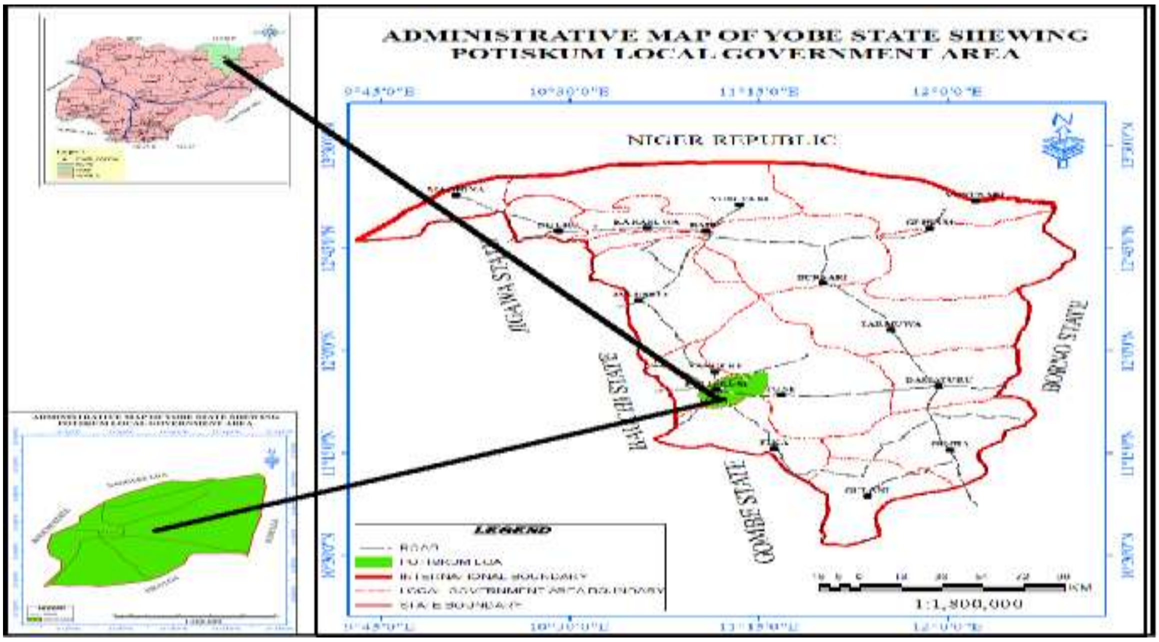

Figure 1: Map showing the study area, (Source: Ministry of Land and Survey, Yobe State).

III. MATERIALS AND METHODS

For the successful execution of this work, the following materials and methods were adopted:

Materials

Hardware Equipment

- Hand held Global positioning system GPS (GPS Map 78sc)
- Landsat 7 ETM+ imagery for the year 1999 and 2008 and also landsat 8 OLI (Orthorectified) for the year 2018.
- Digital camera
- Study Area Map
- Zinox 64 bits Operating system

Software Packages

- Arc GIS 10.6
- ERDAS Imagine 2014
- Microsoft Office

Methodology

A satellite imagery provides an excellent source of data for performing structure studies of land scape (Sachs et al 2001)it is therefore based on this reason that a three false color composite (FCC) imagery from land sat 7 ETM+ of the year1999, 2008 and 2018 were used for this work. The influence of error or inconsistency in image brightness which may limit the ability to interprets or quantitatively process and analyze the image (Lillesand and Kiefer 1994); was removed by radiometric correction. The effect of both systematic and unsystematic error was corrected for using Geometric correction. In addition, the global and linear enhancement was also performed.

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(Lillesand, 2007); suggested that for better analysis of the land cover, there is need for the area to be classified according to its similar spectral signature. It is therefore based on this reason, the Supervised and unsupervised classification was performed then later the post classification change detection based on map calculation was conducted to determine dynamicity of the elements of the growth within the period of the research.

The preprocessing and processing took place using ArcGIS 10.6 and ERDAS imaging 2014 software packages. The changes that took place within the period was realized, presented and discussed below.

IV. RESULST AND DISCUSSION

Generally, this aspect comprises of the presentation and discussions of the results achieved in the course of this work. The results presented include that of Accuracy Assessment, Image processing and the Change detection with the emphasis on population growth. However, the respective results were discussed for the purpose of making a conclusion.

Result Presentation

The results acquired are hereby presented below in form of figures and table as figure 2 to 4 and table 1 to 12 respectively.

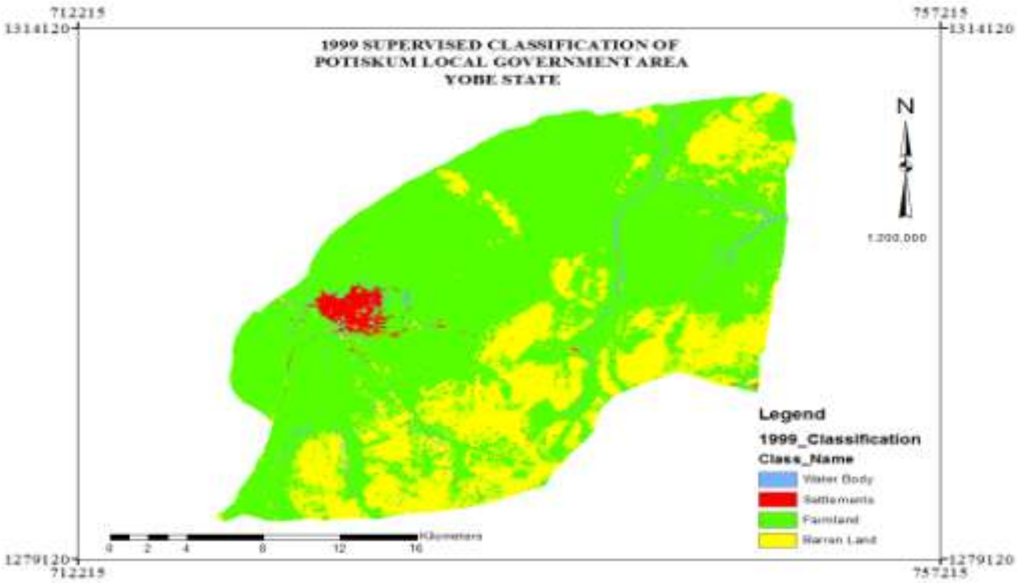

Figure 2: 1999 Supervised Classification for Landsat 7 ETM+

Table 1.0 Classification Accuracy Result for Landsat 7 ETM+ for the year 1999

Class Name	Reference Totals	Classified Totals	Number Correction	Producers Accuracy	Users accuracy
Water Body	3	0	0	-	-
Settlements	2	2	2	100.92%	100.00%
Bare Soil	26	22	20	76.92%	90.91%
Farmland	69	76	67	97.10%	88.16%
Total	100	100	89		
Overall Classification Accuracy = 89.00%					

Table 2.0 The Kappa (K^) Statistics Result for Landsat 7 ETM+ for the year 1999

Class Name	Kappa
Water Body	0.0000
Settlements	1.0000
Bare Soil	0.8771
Farmland	0.7952
Overall Kappa Statistics = 0.7368 Conditional Kappa for each category	

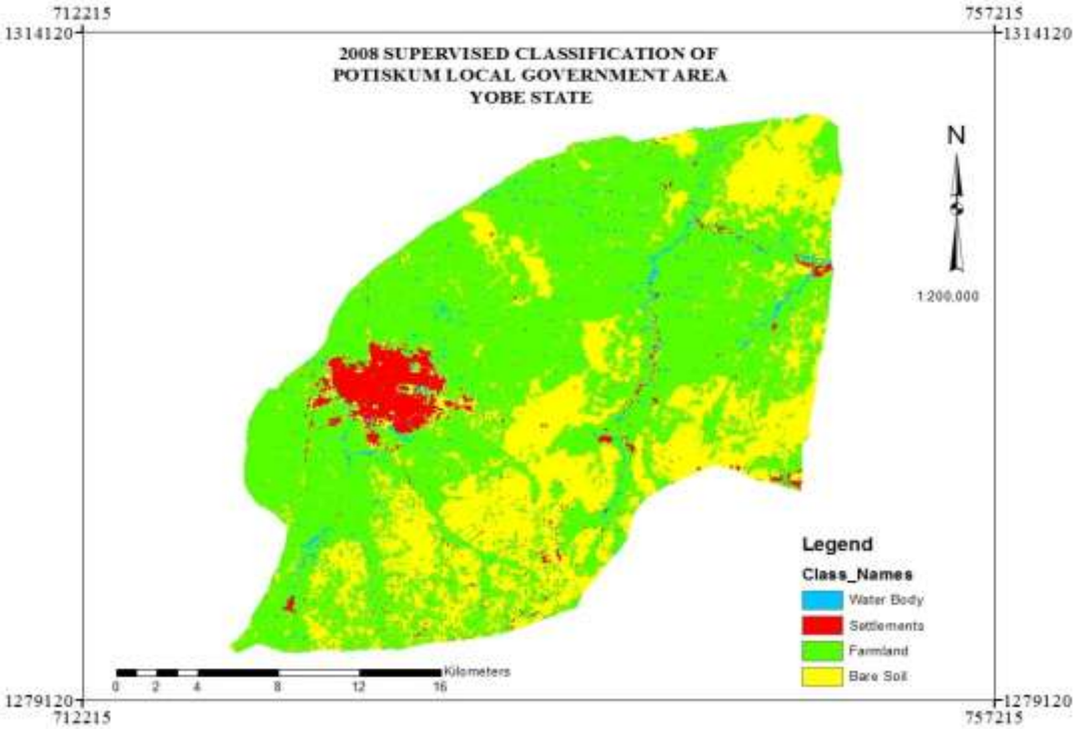

Figure 3: 2008 Supervised Classification for Landsat 7 ETM+

Table 3.0 Classification Accuracy Result for Landsat 7 ETM+ for the year 2008

Class Name	Reference Totals	Classified Totals	Number Correction	Producers Accuracy	Users accuracy
Water Body	1	1	1	100.00%	100.00%
Settlements	3	3	3	100.00%	100.00%
Bare Soil	33	30	28	84.85%	93.33%
Farmland	63	66	61	96.83%	92.42%
Total	100	100	93		
Overall Classification Accuracy = 93.00%					

Class Name	Kappa
Water Body	1.0000

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Settlements	1.0000
Bare Soil	0.9005
Farmland	0.7952
Overall Kappa Statistics = 0.8554 Conditional Kappa for each category	

Table 4.0 The Kappa (K^) Statistics Result for Landsat 7 ETM+ for the year 2008

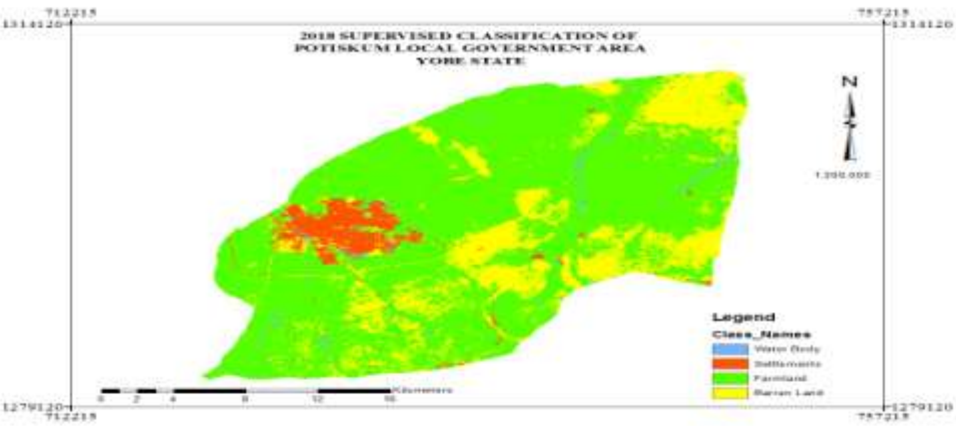

Figure 4: 2018 Supervised Classification for Landsat 8 OLI

Table 5.0 Classification Accuracy Result for Landsat 8 OLI for the year 2018

Class Name	Reference Totals	Classified Totals	Number Correction	Producers Accuracy	Users accuracy
Water Body	1	1	1	100.00%	100.00%
Settlements	12	11	10	86.21%	92.59%
Bare Soil	29	27	25	83.33%	90.91%
Farmland	58	61	55	94.83%	90.16%
Total	100	100	91		
Overall Classification Accuracy = 91.00%					

Table 6.0 The Kappa (K^) Statistics Result for Landsat 8 OLI for the year 2018

Class Name	Kappa
Water Body	1.0000
Settlements	0.8967
Bare Soil	0.8957
Farmland	0.7658
Overall Kappa Statistics = 0.8377 Conditional Kappa for each category	

Table 7.0 An area Calculation from Land Cover Class for the year 1999

S/no.	Class Name	Pixels	Area (Ha)	Percentage
1.	Water Body	9535	858.1500	1.50%

2.	Settlements	8816	793.4400	1.40%
3.	Bare Soil	155094	13958.4600	24.90%
4.	Farmland	448204	40338.3600	72.20%
	Total	55,948.4100		100%

Table 8: An area Calculation from Land Cover Class for the year 2008

S/no.	Class Name	Pixels	Area (Ha)	Percentage
1.	Water Body	12744	1146.9600	2.05%
2.	Settlements	26358	2372.2200	4.24%
3.	Bare Soil	183324	16499.1600	29.49%
4.	Farmland	399223	35930.0700	64.22%
	Total	55,948.4100		100%

Table9: An area Calculation from Land Cover Class for the year 2018

S/no.	Class Name	Pixels	Area (Ha)	Percentage
1.	Water Body	7159	644.3100	1.15%
2.	Settlements	29963	2696.6700	4.82%
3.	Bare Soil	132962	11966.5800	21.39%
4.	Farmland	451565	40640.8500	72.64%
	Total	55,948.4100		100%

Change Detection

Here, the results presented describe the changes that took place within the period of the tresearch.

Table10: Computation of Changes between 2 Epochs (1999 and 2008)

S/no.	Class Name	1999	2008	Difference
1.	Water Body	1.50%	2.05%	+0.55%
2.	Settlements	1.40%	4.24%	+2.84%
3.	Bare Soil	24.90%	29.49%	+4.59%
4.	Farmland	72.20%	64.22%	-7.98%

Table11: Computation of Changes between 2 Epochs (1999 and 2008)

S/no.	Class Name	2008	2018	Difference
1.	Water Body	2.05%	1.15%	-0.90%
2.	Settlements	4.24%	4.82%	+0.58%
3.	Bare Soil	29.49%	21.39%	-8.10%
4.	Farmland	64.22%	72.64%	+8.42%

Table12: Computation of Changes between 2 Epochs (1999 and 2008)

S/no.	Class Name	1999	2018	Difference
1.	Water Body	1.50%	1.15%	-0.35%
2.	Settlements	1.40%	4.82%	+3.42%
3.	Bare Soil	24.90%	21.39%	-3.51%
4.	Farmland	72.20%	72.64%	+0.44%

Discussion of Results

This aspect, generally derived from the results presented above where it is observed that the average statistical results for overall accuracy and Kappa (Kappa K^) from table 1.0 to 6.0 was found to be 91.00% and 0.8099 respectively which falls within a tolerance limit.

The changes derived from the area or land cover class in table 7.0 and 8.0 for the year 1999 and 2008 revealed that there is an increase in water body, settlement and bare soil by 0.55%, 2.84% and 4.59% respectively so also a decrease in farm land by 7.98%. the result of changes derived from an area calculation for land cover class in table 8.0 and 9.0 for the year 2008 and 2018 revealed that there is an increase in settlement and farm land class by 0.58% and 8.42% respectively so also a decrease in water body and bare soil by 0.90% and 8.10% respectively.

However, the results of changes from area calculation of land cover class in table 7.0 and 9.0 which is the beginning and end of the period of the research revealed that there is an increase in settlement and farmland by 3.42% and 0.44%respectively and so also a decrease in water body and bare soil by 0.35% and 3.51% respectively which when compare to the population growth of the study area, there will be too much demand for basic human needs such as farming for food, water for survival and farming, land for settlement and amenities for good health.

V. CONCLUSION AND RECOMMENDATIONS

Conclusion

Satellite remote sensing and GIS technology are useful for understanding the land use and land cover change dynamic. Therefore this kind of study would be time and cost effective method for urban planning and decision making.

The aim of the research was successfully achieved through its set up objectives since the rate of changes in urban growth within the period was determined.

Recommendations

Haven successfully achieved the research aim, the following recommendations are hereby made:

- The need to assess and monitor the rate of urban growth in the study area so as to meet up with the basic human needs
- The need to improve on farming activities which is part of the basic human need so as to meet up with the population /settlement of the study area
- The need to engage into tree planting campaign in the study area so as to reduce the rate of bare soil and regain the water body in the study area.
- Success is a journey not a destination, therefore one man's success may be another's beginning of the journey, as such, there is need for research like this to be carried out and improvement be made upon.

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