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Remote Sensing And Geographic Information System (GIS) Application In Assessing Desertification Of The Northern Part Of Yobe State, Nigeria

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Abstract: ***Desertification is a phenomena arising from disappearance of large body of water and high activities of dry sand which further aggravated by destruction of arable and soil fertility through three felling for energy, bush burning and overgrazing by herdsmen etc. It is one of the most serious environmental and socio economic problems facing northern part of Yobe state therefore there is need to study and determine the rate of expansion/encroachment so as to provide the decision makers a basic tool to minimize the effect of the menace. This research examines the use of GIS and remote sensing to detect the changes that has taken place between the years 2005 to 2014. In achieving this, 30m resolution satellite imagery of landsat 7 ETM+ for the year 2005 and 2009 and also Landsat 8 (orthorectified) for the year 2014 was acquired, preprocessed, processed and later discussed based on the derived necessary information. The classified image was tested and the accuracy assessment was 89.93%. However, kappa K^ was also used to test the agreement of the data and was found to be 0.8782 which is within the allowable tolerance. The result obtained reveals that; there is an increase in bare surface, Sand dune and water by 10%, 10% and 15% respectively. So also a decrease in Vegetation, Tree plantation and Wet land by 15%, 5% and 6% respectively which shows clearly that desertification has occurred. The research recommends the tree planting in the study area in order to regain the natural vegetation.***

Keywords: Change detection, Desertification, GIS, Remote sensing

I. INTRODUCTION

Northern region of Yobe state experiences low rainfall and high temperature. According to Musa (2013), the heat in the northern part of Yobe rises up to 45°C thereby baking the sand to dusty pitches since there is no vegetation to check the heat. Over time, the wind storm lifts and scatter the sand around. Desertification in Yobe state particularly its Northern part is predominantly dominating the area thereby encroaching the area (Abdulkadir, 1993), It is inadequately address in today's political agenda both at global, regional, national and state level (Musa, 2013). The main source of livelihood in the area is predominantly farming and their major problem is desertification which tend to increase the temperature and decrease the fertility of the soil by increasing the bare soil and sand dunes (Abdulkadir 1993). The need to integrate the GIS and remote sensing technique to determine the rate at which the menace affect the area prompted the need to carry out this work.

The images for the three different years (2005, 2009 and 2014) were acquired and processed thereby analyzing to give true picture of what truly existing on the ground as at the time of the research presentation.

THE STUDY AREA

The study area is located in northern part of Yobe State which comprises of Yusufari, Geidam, Yunusari, Karasuwa, Bade, Machina and Nguru Local Government area of Yobe State. The area lies within latitude 11^0 58' to 12^0 36' N and longitude 11^0 25' to 10^0 45' E. Yobe State borders the Nigerian States of Bauchi, Borno, Gombe and Jigawa. It also borders

the Diffa Region and the Zanders region to the north in the Republic of Niger.

The Yobe State population according to 2011 census is 2,757,000 with a density of 311km^2 (80/sqml). Out of which the Northern part has taken about 60% it has an approximate population of 1,654,200 (NPC, 2006).

The climate of the study area lies in the dry savannah belt with an annual rainfall and temperature of 432.4mm and 34^0 respectively Zemba (2017). The area experiences its rainfall between May to October.

The topography the area is relatively flat with gentle undulating plains in some parts, with river system dissecting the dunes; there are extensive rolling sand plains with superimposed relict dunes. The relict dunes are more pronounced particularly due to change in climatic condition with increase drought (Haruna, 2010). The dunes have started to move in some places, encroaching against villages associated with rivers is the Fadama on flood plains.

There are two vegetation zones in the area. These are the Sahel in the far north and the Sudan savannah in the southern part. The vegetation cover in the area is sparse as the grass grows in individual tufts leaving bare surface in-between. The grasses in the Sahel are shot and tussocky, 0.5m to 1.0m high (Musa, 2012).

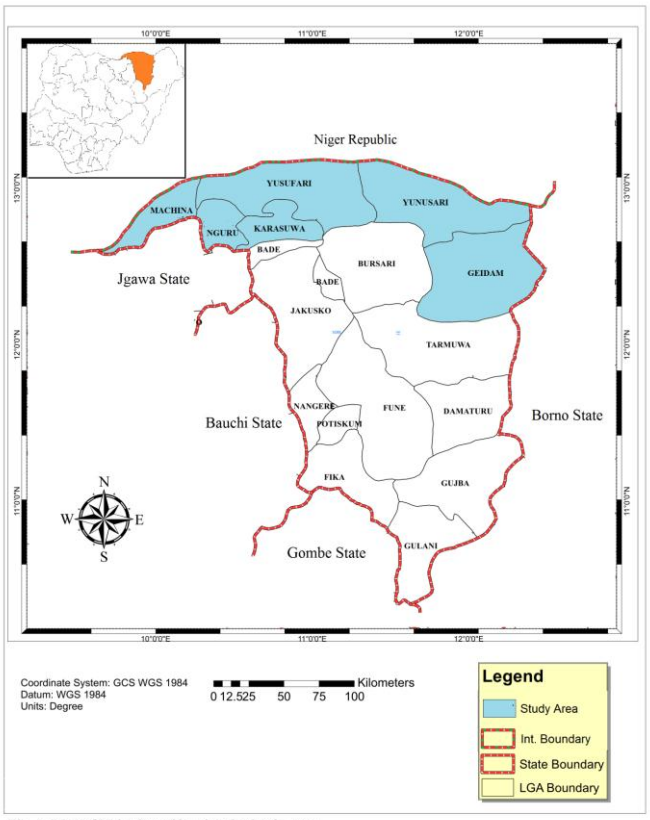

Fig. 1: Map of Yobe State Showing the Study Area
Source: Studio Work (2014)

Figure 1: A Map Showing the Study Area

II. METHODOLOGY

As satellite imagery provides an excellent source of data for performing structure studies of landsc ape (Sachs et al 2001), a Four false color composite (FCC) of the subset imagery from landsat7 ETM+ of the year 2005 and 2009 as well as orthorectified land sat 8 for the year 2014 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.

(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 desertification within the period of the research.

The preprocessing and processing took place using ArcGIS 10.1 and ERDAS imaging 2014 software packages. The changes in desertification was realized, presented and discussed as seen in the tables and figures in results and Discussion below.

III. 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 climatic data, Accuracy Assessment, Image processing and the Change detection with the emphasis on Desertification. However, the respective results were discussed for the purpose of making a conclusion.

A. PRESENTATION OF RESULTS

a. CLIMATIC DATA RESULTS

The tables and the figures that show the results for climatic data (Temperature and Rainfall) were presented below as Tables 3, 4, 5 and 6 as well as Figures 5, 6, 7 and 8 respectively.

S/NO.	Month/year	Min. Temp. (°C)	Max. Temp. (°C)
1	January	13.4	28.9
2	February	19.7	37.5
3	March	23.5	39.2
4	April	24.3	40.6
5	May	25.4	39.3
6	June	25.1	36.3
7	July	23.7	33.2
8	August	23.2	31.9
9	September	24.1	35.0
10	October	22.0	36.5
11	November	18.0	35.4
12	December	15.8	33.1

Table 1: Monthly Minimum and Maximum Temperature in (°C) for the year 2005

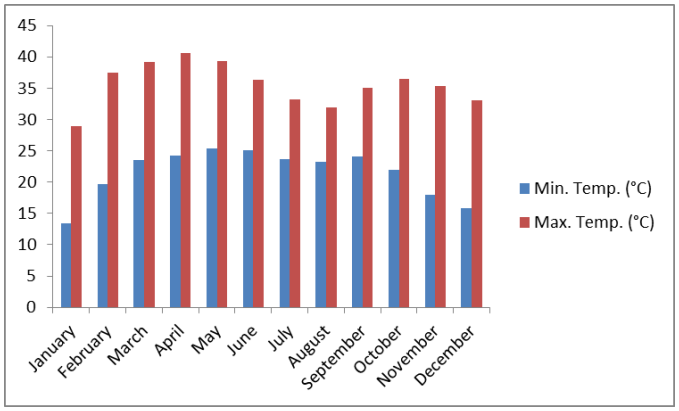

Figure 2: Bar chart for the Minimum and Maximum Temperature for the year 2005

S/NO.	Month/year	Min. Temp. (°C)	Max. Temp. (°C)
1	January	15.4	33.1
2	February	18.0	36.1
3	March	21.3	37.9
4	April	24.2	41.4
5	May	24.7	39.7
6	June	25.4	39.5
7	July	23.5	34.9
8	August	23.1	33.4
9	September	23.5	34.5
10	October	23.4	36.6
11	November	19.3	34.1
12	December	15.6	32.6

Table 2: Monthly minimum and Maximum Temperature in (°C) for the year 2009

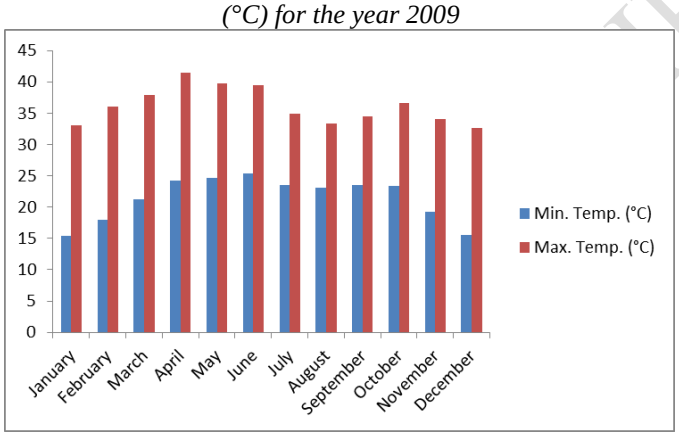

Figure 3: Bar chart for the Minimum and Maximum Temperature for the year 2009

S/NO.	Month/year	Min. Temp. (°C)	Max. Temp. (°C)
1	January	13.8	31.9
2	February	17.5	33.4
3	March	19.9	38.6
4	April	24.6	40.8
5	May	25.5	39.6
6	June	25.8	38.7
7	July	23.1	34.7
8	August	20.9	31.9
9	September	23.0	33.5
10	October	21.7	36.0
11	November	16.7	35.8
12	December	18.0	31.1

Table 5: Monthly minimum and Maximum Temperature in (°C) for the year 2014

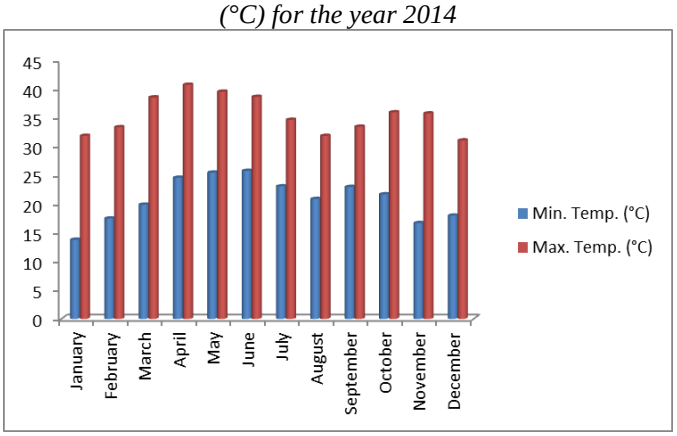

Figure 4: Bar Chart for the Minimum and Maximum Temperature for the year 2014

S/NO.	Month/Year	2005	2009	2014
1	January	0	0	0
2	February	0	0	0
3	March	0	0	0
4	April	0	TR	0
5	May	26.6	15.2	12.6
6	June	74.4	4.3	82.4
7	July	135.1	159.4	145.5
8	August	198.8	89.2	319.8
9	September	57.8	82.0	127.5
10	October	6.5	16.4	24.3
11	November	0	0	0
12	December	0	0	0

Table 4: Monthly Mean Rainfall for the Year 2005, 2009 and 2014 in (mm)

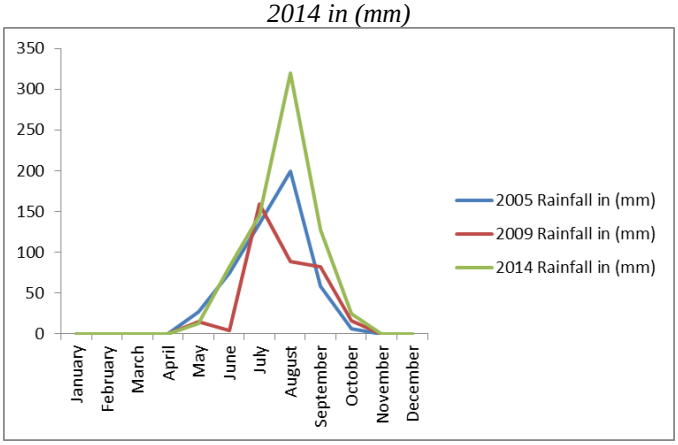

Figure 5: Rainfall Graph for the year 2005, 2009 and 2014 of the Study Area

b. DISCUSSION OF CLIMATIC DATA RESULTS

Based on the Results presented in figures and tables in 4.1 above, it is therefore observed that:

Table 1 and Figure 2 are the results for the climatic data (Temperature) of the study area for the year 2005 which reveals that there is a minimum temperature of 13.4°C in the month January and 40.6°C in the month of April.

Table 2 and Figure 3 are the results for climatic data (Temperature) for the year 2009 of the same area which

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further revealed the minimum and maximum temperature of 15.5°C and 41.0°C at January and April respectively.

Table 3 and Figure 4 represent the temperature results of the year 2014 which indicate a minimum temperature of 13.8°C in the month of January and also maximum of 40.8°C in the month of April.

B. IMAGE PROCESSING RESULTS

After collection, pre-processing and processing of the imageries, the results for the image processing are presented in tables 15, 16, 17, 18 so also in figures 9, 10, 11, 12, 13 and 14 respectively

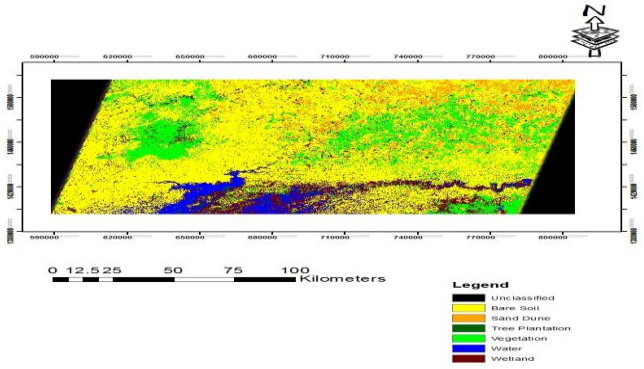

Figure 6: Land use land Cover Class of the Year 2005

Value	Class Name	Pixels	Area(m^2)	Hectares	Percentage
1	Bare Soil	595326	8600559229	860055.9229	44%
2	Sand Dune	294042	646542969.6	64654.29696	3%
3	Tree Plantation	328664	5251478836	525147.8836	9%
4	Vegetation	2171079	323643191.8	32364.31918	27%
5	Water	509420	2966079425	296607.9425	2%
6	Wetland	3272235	1675465858	167546.5858	15%
		TOTAL		2,819,264.9510	100%

Table 5: An area Calculation from Land Cover Class for the year 2005 of the Study Area

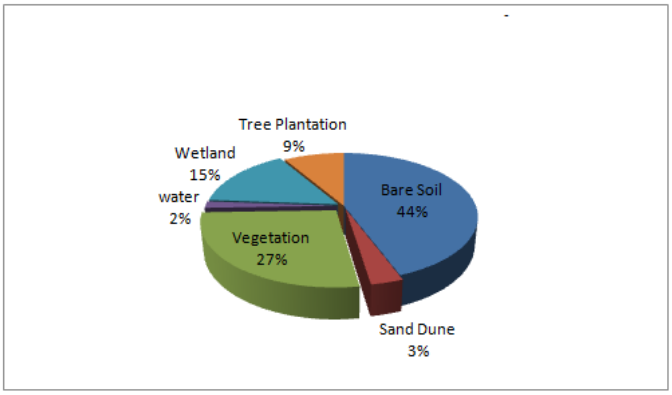

Figure 7: A Pie Chart of a Land Covers Class of the year 2005 of the Study Area

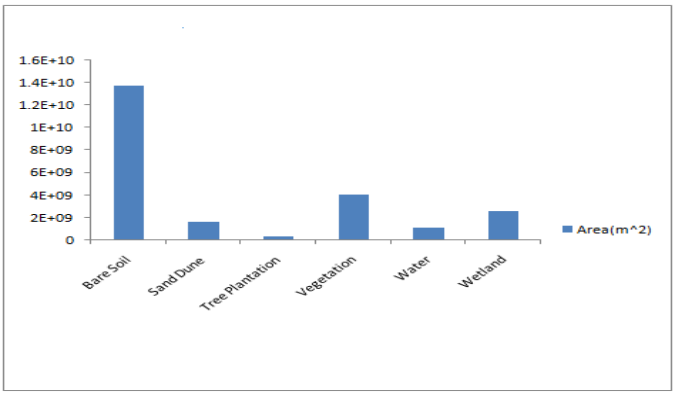

Figure 8: A Bar Chart Representing a Land Cover of the year 2005

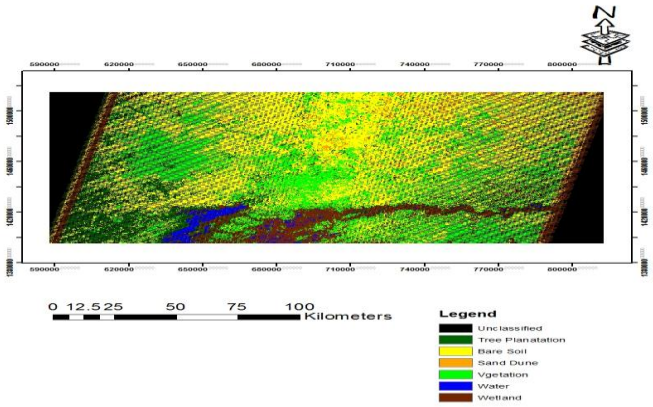

Figure 4: Land use land Cover Class of the year 2009

Value	Class Name	Pixels	Area(m^2)	Hectares	Percentage
1	Bare Soil	595326	14506912340	1450691.234	51%
2	Sand Dune	294042	2408345080	240834.5080	9%
3	Tree Plantation	328664	1089880240	108988.0240	4%
4	Vegetation	2171079	4862444702	486244.4702	17%
5	Water	509420	1919457099	191945.7099	7%
6	Wetland	3272235	3405610065	340561.0065	12%
		TOTAL		2,819,264.9530	100%

Table 6: Area Calculation from Land Cover Class of the year 2009

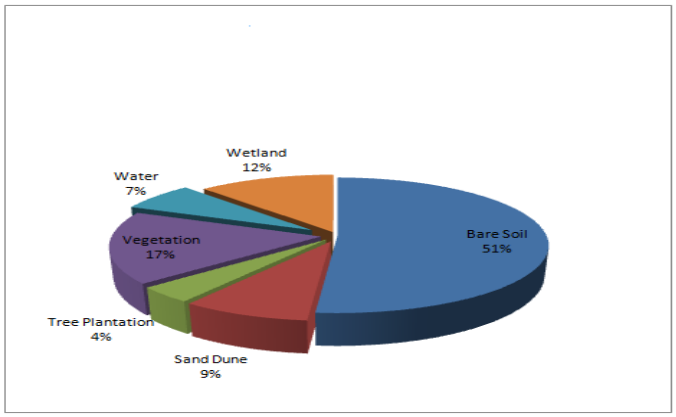

Figure 10: A Pie Chart of the Land Cover Class of the year 2009 of the Study Area.

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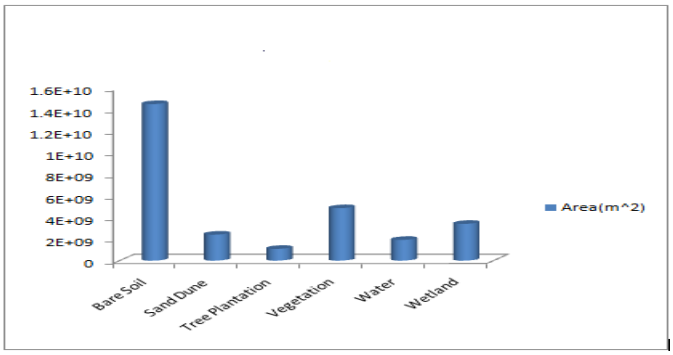

Figure 11: Bar Chart of the Land Cover Class of the year 2009

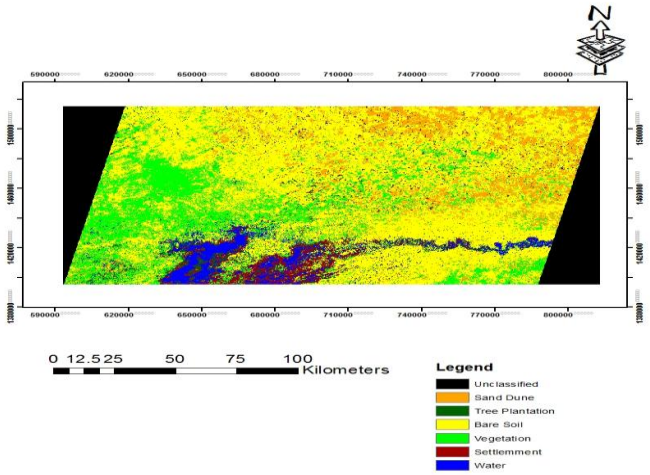

Figure 12: Land use Land Cover Class of the year 2014

Value	Class Name	Count	Area(m^2)	Hectares	Percentage
1	Bare Soil	1756504	15335832020	1533583.2020	54%
2	Sand Dune	1552120	3770721373	377072.1373	13%
3	Tree Plantation	706320	1396174707	139617.4707	5%
4	Vegetation	1515381	3320773050	332077.3050	12%
5	Water	1155869	1840307149	184030.7149	7%
6	Wetland	1497552	2528841204	252884.1204	9%
		TOTAL		2,819,264.9500	100%

Table 7: An Area Calculation for Land Cover Class of the year 2014 of the Study Area

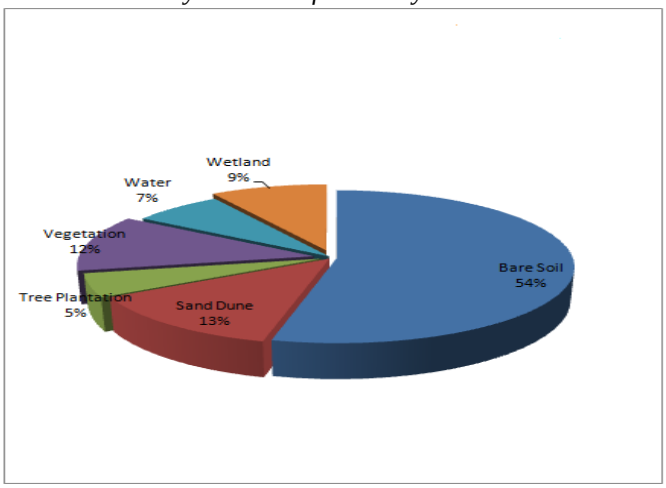

Figure 13: A Pie Chart of the Land Cover Class for the year 2014 of the Study Area

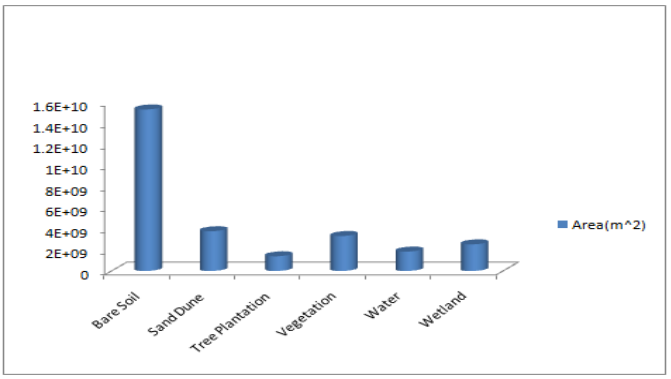

Figure 14: A Bar Chart of the Land Cover Class for the year 2014 of the Study Area

Value	Class Name	2005	2009	2014
1	Bare Soil	44%	51%	54%
2	Sand Dune	3%	9%	13%
3	Tree Plantation	9%	4%	5%
4	Vegetation	27%	17%	12%
5	Water	2%	7%	7%
6	Wetland	15%	12%	9%
	TOTAL	100%	100%	100%

Table 8: A Summary of Land Covers Classification for the 3 Epochs

a. DISCUSSION OF IMAGE PROCESSING RESULTS

Table 5 show the result for the area calculated from the land cower class map of the year 2005. The result was presented in form of pie and bar chart as seen in Figure 7 and 8 respectively which show that bare soil covers an area of 44%, sand dune 3%, Tree plantation 9%, vegetation covers 27%, water cover 2% and wet land cover is 15% of the total area of 2,819, 264.951 ha.

Table 6 show the result for the area calculated from the land lower class map of the year 2009. The result was presented in form of pie and bar chart as seen in Figure 10 and 11 respectively which indicate that bare soil cover 51% of the area, sand dune 9% Tree plantation 4%, vegetation covers 17%, water 7% and wetland 12% of the total area of 2,819,264.953ha.

Table 7gives a result of the area calculated from the land cover class map of the year 2014. The result was also presented in form of pie and bar chart as seen in Figure 13 and 14 respectively. It is noticed that 54% of the total area is bare soil, 13% is sand dune, 5% is Tree plantation, 12% is vegetation cover, 7% is water and 9% is wet land.

C. CHANGE DETECTION RESULTS

Haven successfully processed the images and obtained the results, the changes discovered were presented in tables 9, 10 and 11 below respectively.

Value	Class Name	2005	2009	Difference
1	Bare Soil	44%	51%	+7%
2	Sand Dune	3%	9%	+6%
3	Tree Plantation	9%	4%	-8%
4	Vegetation	27%	17%	-10%
5	Water	2%	7%	+5%
6	Wetland	15%	12%	-3%

Table 9: The Computations of Changes between 2 Epochs (2005 and 2009)

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Value	Class Name	2009	2014	Difference
1	Bare Soil	51%	54%	+3%
2	Sand Dune	9%	13%	+4%
3	Tree Plantation	4%	5%	+1%
4	Vegetation	17%	12%	-5%
5	Water	7%	7%	0%
6	Wetland	12%	9%	-3%

Table 10: The Computation of Changes between 2 Epochs (2009 and 2014)

Value	Class Name	2005	2014	Difference
1	Bare Soil	44%	54%	+10%
2	Sand Dune	3%	13%	+10%
3	Tree Plantation	9%	5%	-4%
4	Vegetation	27%	12%	-15%
5	Water	2%	7%	+5%
6	Wetland	15%	9%	-6%

Table 11: The Overall Computation of Changes between (2005 and 2014)

a. DISCUSSION OF CHANGE DETECTION RESULTS

The result in table 9 revealed that, within the period of 2005 to 2009, there is an increase in bare soil, sand dune and water by 7%, 6% and 5% respectively. Whereas there is a decrease in Tree plantation, vegetation covers and wet land by 8%, 10% and 3% respectively.

The results in table 10 reveals the changes between 2009 to 2014 which show that, there is an increase/rise of bare soil, sand dune and Tree plantation by 3%, 4% and 1% respectively so also, a decrease in vegetation cover and wet land by 5% and 3% respectively. But the water retains its capacity of by 7% i.e no change in water cover recorded as revealed by the result.

The result in table 11 show the results for the changes recorded within a period of the study. It revealed that there is an increased in bare soil and sand dunes by 10% each so also increase in water by 5% but there is a decrease in Tree plantation, vegetation covers and wet land by 4%, 15% and 6% respectively.

IV. CONCLUSION AND RECOMMENDATIONS

The research reveals the changes in desertification of the study area within the period as judge by changes in land use land cover class obtained from imagery used.

Based on these findings, the research recommends that:

- ✓ There is a need for periodic Assessment/Monitoring of the extent of desertification in the area.
- ✓ There is need for measures to reduce the desert encroachment in the area.
- ✓ The policies and practice of Agricultural extension need to be adopted to awake farmers and policy makers to the menace of the catastrophy.

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