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# Geospatial Assessment of Desertification and Predictive Modeling in North West Nigeria - A Case Study of Sokoto

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## ABSTRACT

This paper examined the causes and extent of desertification in Sokoto state of Nigeria from 1986 to 2015 and also make prediction of how the land use and Landcover of the area will look like in next twenty years (20 years). The data used for examining the extent of desertification were downloaded from USGS. The main objective of this research work is to examine the extent of desertification and determine the primary agent of desertification and to predict how the land use and land cover of the area will look like in the nearest feature. A well-structured questionnaire was used to collect data in order to know the resources being mined in the study area. The result of the questionnaire was analyze in SPSS using regression analysis in order to know the relationship between the local population and the resources being harvested. LandSat images for 1986, 2000 and 2015 were used to examine the extent of desertification. The classified images for 1986 and 2015 were used to predict the land use and land cover in the next 20years. The paper suggests for massive tree plantings in the study area and Nigeria in general. The Federal and State Departments of Forestry need to be empowered with adequate revenue for massive reforestation programme. Regulation to discourage dependence on wood for local energy should be put in place, while other sources of energy such as kerosene should be adequately provided. Grazing land should also be created for the Fulani headmen to avoid the destruction of farmland and environment.

**Keywords**: Desertification, Grazing, Reforestry

## I. INTRODUCTION

The environment is important to man's existence, and he is dependent on it to make a livelihood and take care of his basic needs; but the environment is undergoing changes that have implications to man's existence. Nigeria like some other countries of the world is experiencing various forms of environmental problems which range from oil spillage, flood, erosion, desertification among others.

Desertification is one of the most glaring of these environmental hazards and the phenomenon has affected some states in the northern part of Nigeria, but the impact has been more glaring since the famine of 1971-1973 in this part of the country. By location, Northern Nigeria is situated in the semi-arid areas with average annual rainfall or less than 600 mm bordering on the Sahara desert (Folaji, 2007) which is considered as the hottest and longest desert in the world.

The soil in this area face a lot of threat ranging from deforestation for domestic fuel, overgrazing by livestock and agricultural practices that fail to conserve soils such pollution from the improper use of agricultural pesticides, herbicides and chemical spills from both liquid and solid fertilizers.

Generally, desertification affects eleven (11) northern States of Nigeria referred to as the frontline state, these include: Adamawa, Borno, Yobe, Jigawa, Kano, Katsina, Zamfara, Sokoto, Kebbi, Bauchi and Gombe. These states are agricultural producing areas and are affected by desert encroachment that is fast moving

southwards. Desertification is attributed to loss of the lands biological productivity in arid, semi-arid and dry sub humid areas (Cunningham and Saigo, 2001). The impact is significant in developing countries especially Africa which is the most affected because its economy is predominantly agrarian, rain fed and fundamentally dependent on the vagaries of weather (Bello et al., 2012). However, it has been difficult for Africans to take advantage of their environment because of the lack of adequate technology to convert negative aspects of their environment to best uses.

Being a global phenomenon, many of the affected countries ratified the United Nations Convention to Combat Desertification (UNCCD) in 1994 which is important to the discourse on desertification. With the adoption of the Convention agreement, parties were expected to prepare and implement the National Action Programme (NAP) on desertification in their respective countries.

The term desertification has been defined by United Nation Convention to Combat Desertification (UNCCD) as land degradation in arid, semi- arid and dry sub- humid area through natural process as well as human activities. The natural factors are largely associated with climate variability especially drought, while some human activities in the dry lands is the major cause, especially in Africa. The drylands cover over 40% of the total land area of the world, and in Africa most areas may be arid and semi-arid lands. (ASALS). Ouma etal. Desertification is one of the most serious problems facing the northern Nigeria with dire economic consequences for the nation. Deserts are extremely dry areas with sparse vegetation. The word desert was derived from the Latin word *desertus* meaning abandoned (Lalley, 2013). Scholars have viewed this concept from diverse perspectives social, economic, cultural, among others and the concept has often been thought of as desert encroachment. Medugu (2009) defines the term as land degradation in arid, semi-arid and sub-humid areas resulting from various factors including climatic variations and human activity. A dynamic process observed in dry and fragile ecosystems affecting ground water resources, animal and plants, soil human settlements and their activities.
Desertification could also be seen as a process whereby the productivity of arid or semi-arid land falls by 10% or more. It is explained that mild desertification is about 10-25% drop in productivity, serious desertification is 25-50% drop and very serious desertification is a drop of 50% or more which may lead to serious gullies and sand dunes (Emordi, 2013).
Dregne (1986) explained that desertification is a land degradation process that involves a continuum of change from slight to very severe degradation of the plant and soil resources and is due to man's activities. He clarified the concept as the improvement of terrestrial ecosystems under the impact of man, the process of deterioration in these ecosystems that can be measured by reduced productivity of desirable plants, undesirable alteration in the biomass and the diversity of the micro and macro fauna and flora, accelerated soil deterioration and increased hazards for human occupancy. Barrow (1999) stated that desertification is a process whereby the ecosystem losses its capacity to maintain and repair itself.

The effect of desertification is very glaring on the agricultural sector. Farmers have been deprived of farm lands by sand dunes, inadequate water as most of the sources have shrank in volume, low income, etc. All these have negative impact on farming. Many farmers have abandoned the profession for other more lucrative activities to enable them meet their basic needs. A lot of national and international interventions have been made to ameliorate the condition. Despite these efforts, desertification persists.

### 1.1 Aim and Objectives

The aim of this research work is to examine the level of desertification in Sokoto State for a period of twenty nine (29) years.

**Specific Objectives are**

1) Examine the level of desertification for a period of 29 years in Sokoto State.
2) The effect of rainfall on desertification in Sokoto State.

### 1.2 Study Area

Sokoto state is a state in North -western Nigeria. Its capital is Sokoto. Sokoto State lies to the north-west of Nigeria and shares its borders with Niger Republic to the North, Katsina State to the East, Niger State to the South-East, Kwara State to the South and Benin Republic to the West. Sokoto state lies between

13°4'60" N and 5°15'0" E. Sokoto state covers a total land area of 25,973Km$^2$,

### 1.3 Climate

Sokoto State is in the dry Sahel surrounded by sandy savannah and isolated hills. With an annual average temperature of 28.3 °C (82.9 °F), Sokoto is, on the whole, a very hot area. However, maximum daytime temperatures are for most of the year generally under 40 °C (104.0 °F) and the dryness makes the heat bearable. The warmest months are February to April when daytime temperatures can exceed 45 °C (113.0 °F). The rainy season is from June to October during which showers are a daily occurrence. The showers rarely last long and are a far cry from the regular torrential rain known in wet tropical regions. From late October to February, during the *cold season*, the climate is dominated by the harmmatan wind blowing Sahara dust over the land. The dust dims the sunlight thereby lowering temperatures significantly and also leading to the inconvenience of dust everywhere in houses.

The region's lifeline for growing crops is the floodplains of the Sokoto-Rima river system, which are covered with rich alluvia soil. For the rest, the general dryness of the region allows for few crops, millet perhaps being the most abundant, complemented by rice, corn, other cereals and beans. Apart from tomatoes few vegetables grow in the region.

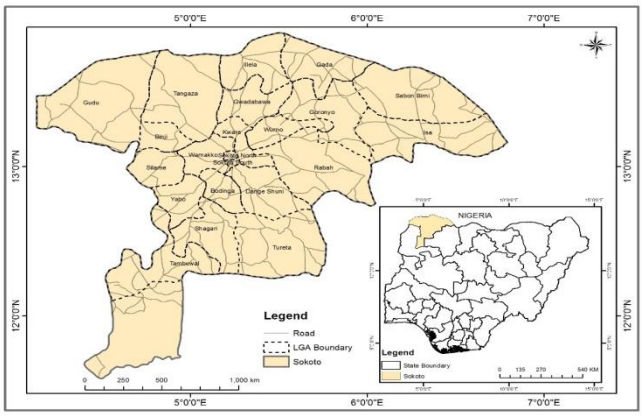



**Figure 1.** Map of the study area

## II. METHODS AND MATERIAL

This chapter described the methodology employed in executing this research work. In determining the level of desertification. The study relied on land use land cover change of the study area. The landsat images for 1986, 2000 and 2015 were subseted in ERDAS imagine 9.3 to determine the region of interest.

### 2.1 Data Source

Landsat images for 1986, 2000 and 2015 were downloaded from GLCF (Global land cover facility). Rainfall data of Sokoto State from 1979 to 2014 was also obtained from NIMET (Nigeria Metrological Agency). This is to analyze the rainfall pattern in the area.

**Table 1.** Data Used

| LANDSAT SCENE | ACQUISITION DATE | LOCATION ON WRS | SPATIAL RESOLUTION |
|---|---|---|---|
| TM | 1986 | P191R51,P190R51, P191R52, P190R52 | 30m x 30m |
| ETM | 2000 | P191R51,P190R51, P191R52, P190R52 | 30m x 30m |
| LANDSAT 8 | 2015 | P191R51,P190R51, P191R52, P190R52 | 30m x 30m |

A map of land use land cover of Sokoto was generated after the supervised classification, the road network was overlaid as line feature while the settlement was overlaid as point feature. The supervised classification of the imageries was performed using Maximum Likelihood algorithm that is based on Gaussian normal distribution (Swain and Davis, 1978) as cited in Oyinloye, 2008.

### 2.2 Selection of Feature Classes

An eight category Land_use/ Land_cover was employed as a result of the restrictions by low spatial

resolution of LANDSAT data. These categories which were equivalent to level one of the United States Geological Survey (USGS) scheme:

1. Extensive field cropland
2. Intensive markets garden
3. New agricultural land
4. Steppe shrubland and grassland
5. Mixed deciduous and evergreen forest
6. Urban or built-up land
7. Bog and Marsh land
8. Rivers, stream and lake

The classes were modify to suit the study, these eight categories were reduced to seven classes namely: forest, cultivation, riparian, water body, bare surface, water body, shrubland.

### 2.3 Data Processing

The Landsat images were processed in ERDAS imagine 9.3. The following operation were performed: image processing, image subseting, supervised classification. The images were recorded in ERDAS imagine 9.3 and exported to Idrisi Taiga where the statistics and charts were generated.

## III. RESULTS AND DISCUSSION

### 1. Results

**Table 2.** Change in area of LandUse Land cover in Sq. Km

| Classes | 1986 | 2000 | 2015 |
|---|---|---|---|
| Forest | 15019.575300 | 9060.256566 | 6306.204600 |
| Waterbody | 164.097000 | 554.164873 | 1088.261100 |
| Riparian | 864.315900 | 1315.269927 | 165.424500 |
| Wetland | 1315.269927 | 1993.962472 | 165.424500 |
| Farmland | 11928.669300 | 17792.823600 | 16312.740300 |
| Baresurface | 809.923500 | 3689.138080 | 16323.131800 |
| Shrubland | 2584.442700 | 8398.323043 | 12628.604100 |

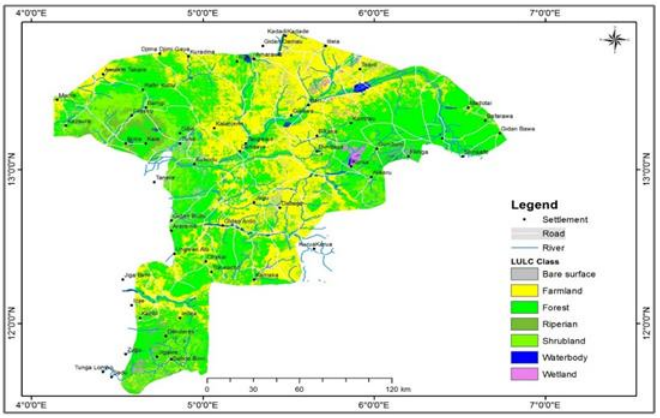



**Figure 2.** Composed map of Sokoto in 1986

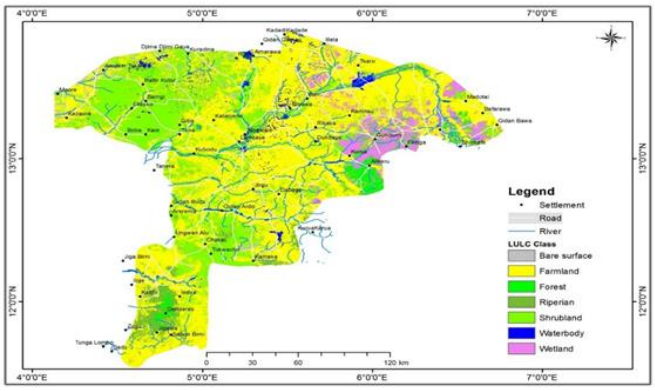



**Figure 3.** Composed map of Sokoto in 2000

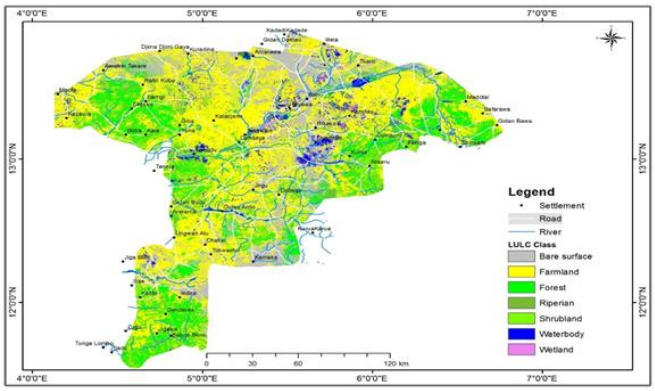
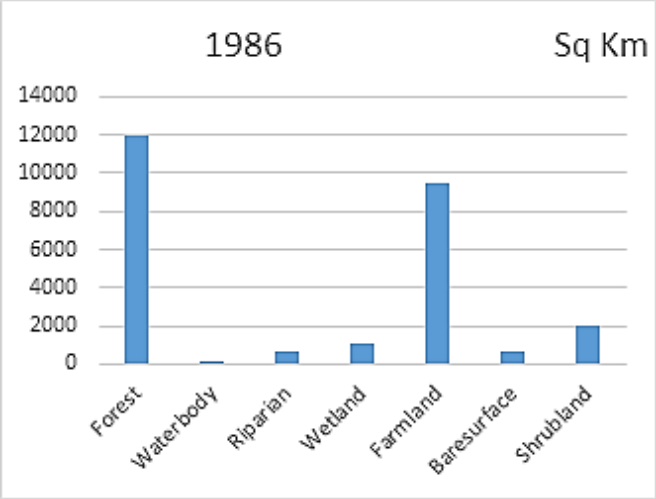
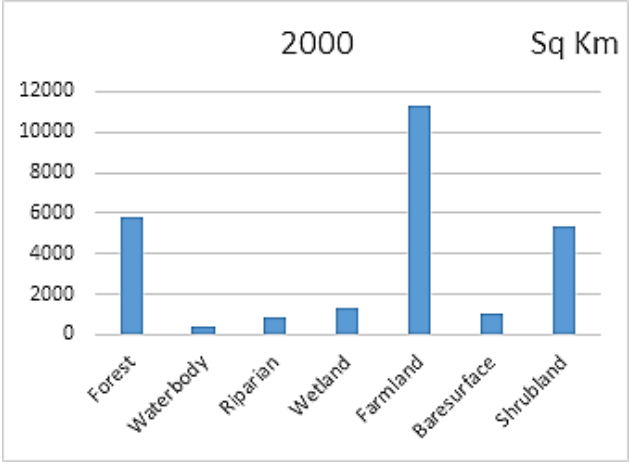



**Figure 4.** Composed map of Sokoto in 2015





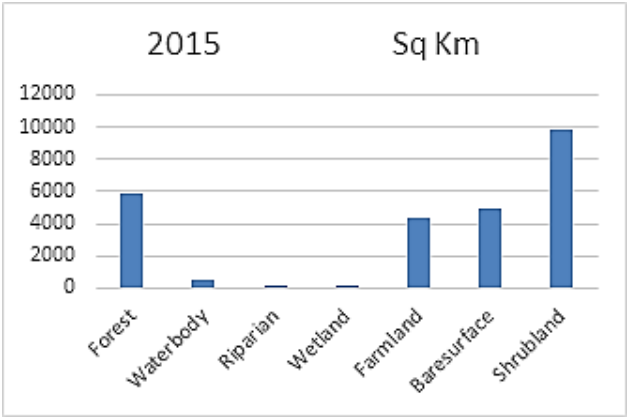




**Figure 5.** Histogram showing the Land use Land cover from 1986, 2000 and 2015.

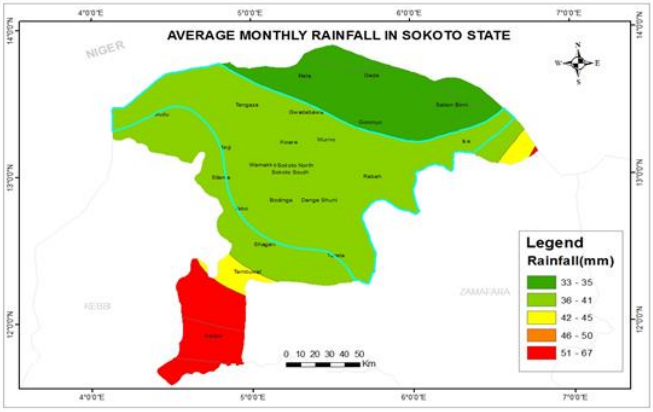



**Figure 6.** Average Monthly Rainfall in Sokoto State from 1986 o 2015

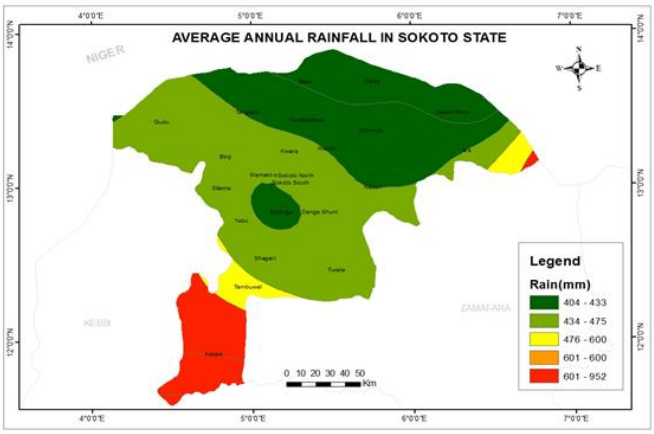



**Figure 7.** Average Annual Rainfall in Sokoto State from 1986 o 2015

## 2. Discussion

In order to examine the level of desertification in Sokoto State, the LandSat images were processed and classified using Erdas Imagine 9.3. The classified images were exported to Idrisi Taiga where the statistics were extracted and charts were generated.

From the statistics, it shows that forest covers a total area of 15,019Sq.Km in 1986, the figure later dropped to 9060Sq.Km in 2000 and 6306Sq.Km in 2015. Nigeria is presently losing about 351,000km2 of its landmass to the desert which is advancing Southward at the rate of 0.6km per year (FGN, 1997).

This study observed that the major cause of desertification in Sokoto State is due to anthropogenic activities and rainfall pattern, anthropogenic activities, like felling down of trees without replacement, overexploitation of natural resources, overgrazing of grasses by the Fulani headsmen etc.

The study also reveals that farmland was 11928 Sq. Km in 1986, it increases to 17792 Sq. Km and dropped to 16312 Sq. Km. The reduction of farmland can be attributed to so many factors like; increase in bare surface, insecurity in the northern part of the country, access to fertilizer etc.

The study also reveals that bare surface is gradually take over the area, this can be seen in table 2 where bare surface covers a total land area of 809 Sq. Km, 3689 Sq. Km and 16323Sq. Km in 1986, 2000 and 2015 respectively.

The study also reveals that the forest are turning to shrubland, this can be seen in table 2 where shrubland covers a total land area of 2584 Sq. Km, 8398 Sq. Km and 12628 Sq. Km in 1986, 2000, and 2015 respectively.

Figure 7 and 7 shows the composed map of the average monthly and average annual rainfall of Sokoto State from 1986 to 2015.

Figure 6 shows the average monthly rainfall map of Sokoto state from 1986 to 2015.From the legend, the red color indicate the area with highest rainfall, the yellow color indicate areas with moderate rainfall, light green indicate the area with marginal rainfall while area with dark green indicate area with the least rainfall, Areas like Tangaga, Gwadabawa, Sabon Birni, Gada and Illela are likely to have severe desertification.

Figure 7. shows the average annual rainfall map of Sokoto from 1986 to 2015..From the legend, the red color indicate the area with highest rainfall, the yellow color indicate areas with moderate rainfall, light green indicate the area with marginal rainfall while area with dark green indicate area with the least rainfall, Areas like Tangaga, Gwadabawa, Sabon Birni, Gada and Illela are likely to have severe desertification while areas like Kebbe, Tambuwal are not likely to have desertification.

## IV. CONCLUSSION AND RECOMMENDATION

The effect of desertification on the frontline especially Sokoto state is devastating with serious implications on food production which is exacerbated by shrinking water levels in dams, overgrazing by the Fulani headsman, over exploitation, deforestation etc. Though government and other stakeholders have put in a lot of efforts to mitigate the effects of desertification in these areas but the problem persists. Thus urgent measures should be taken to check its continued south wards movement.

## V. RECOMMENDATIONS

1. The federal government should create some grazing land for the Fulani herdsmen to avoid clash between them and farmers.
2. As agriculture has transcended from development strategy to agric business, the private sector should partner with government and non-government organization to make the best of the situation. Government should intensify efforts in the Public Private Partnership (PPP) between local and foreign companies. This partnership could import some necessary technology that could be used to harness some benefits from desertification: especially with Israel that has made a breakthrough in agriculture in the desert.
3. Federal and state government should intensify poverty alleviation programs especially to provide adequate water for the farmers.
4. Fadama on irrigation to ensure all year round planting (dry season agriculture).
5. Government should invest on the planting of trees and some exotic trees that have economic benefits and which would add value to the livelihood of the people.
6. Adequate funds should be provided by the federal, state governments and other stakeholders, for the frontline states to fight desert encroachment and set up a desertification monitoring center.

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