

(RESEARCH ARTICLE)



Determination of spatio-temporal pattern of land cover changes in Sokoto-Rima River Basin, Sokoto State, North-Western Nigeria

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Abstract

Natural forest ecosystems provide services that contribute to human well-being such as food, medicines, fuel wood, fresh water and climate regulation. In spite of this, most natural forest ecosystems have been converted or modified into agricultural areas and other human land use to maximize single-purpose use. The objective of this study was to determine spatio-temporal pattern of land cover change in the study area from 1984 to 2019 in Sokoto-Rima River Basin. The methodologies used in the study area include GIS analysis for land use land cover mapping. The result shows that land-use change has taken place in the study area and that human activities had taken a considerable toll on the land-use change. From 1984 to 2019 forest area had decreased at the rates of 7.29% and 9.45%, while grass land increased by 6.69%, also farmland and built-up increase.

Keywords: Land use land cove; United States Geological Survey; Geographic information service; False color composite

1. Introduction

Africa is undergoing unprecedented forest degradation due to human activities and climate change [9, 14, 2]. During the past decades' human population growth and the intensification of land use increased the pressure on forest ecosystems [15]. From some of the studies, land use is the driver of forest changes. Land use as the direct anthropogenic intervention in nature is considered as the major threat to global biodiversity in terrestrial ecosystems [10, 7, 13]. Further, the expansion of agricultural areas causes a rapid conversion, fragmentation and destruction of native habitats and a severe risk of endangerment and extinction of species in the past, present and future [12, 4]. Forests in Nigeria are under pressure due to land use as a result of human population growth. Further, Nigeria loses more than 350,000-400,000 hectares per year [5] due to human activities. Furthermore, logging is one of the most common forest disturbances in Nigeria [11]. For instance; wood is a major source of energy in Nigeria [8]. Moreover, grazing is a principal cause of tropical forest degradation [6]. In general, with increasing population, expansion agriculture, unsustainable forest use and urbanization which are the major leading causes to deforestation in the tropical regions [3]. Deforestation is a major environmental problem in the world [8]. For instance; deforestation is a serious environmental problem in Nigeria

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(Deforestation rate 3.3%) per year [5]. Apart from the land use, climate change affects world’s forest. Further, change in climatic factors can alter tree physiology [1]. Although a number of studies have been conducted on LULC change in several small regions of Nigeria, beyond analyzing the dynamics of LULC in Nigeria. Therefore, monitoring changes in LULC could provide key information for in the decision-making process necessary for sustainable use of land and management of the natural ecosystems in Nigeria. This informed the need to study the land use dynamics of the study area. The aim of the study is to assess the impact of changing land cover on the provision of forest ecosystem services with a view to providing information for the enhancement of sustainable, utilization and environmental management. The objective is determining spatio-temporal pattern of land cover change from 1984 to 2019 in Sokoto-Rima River Basin.

2. Material and methods

2.1 Data used and Sources

The study employed secondary data used for this study with include, multi-temporal data (Landsat satellite images) obtained from earth explorer (USGS) and Administration map obtained from office of the Surveyor-General of Sokoto State as shown in table 1.

Table 1 List of Data Sources

S/N	Data Type	Date	Resolution	Source
1	Landsat image	1984	30m	Earth explorer
2	Landsat image	2002	30m	Earth explorer
3	Landsat image	2019	30m	Earth explorer
4	Administration map			Office of the Surveyor-General of Sokoto State.

2.2 Overview of Approach

Figure 1 shows the summary of methods adopted for the study. Various data from different sources were acquired and used for the study which include multi-temporal data (Landsat satellite images), a structured questionnaire and land use land cover map. Landsat satellite images of 1984 (19840118), 2002 (20020110) and 2019 (20190127) were acquired from United States Geological Survey (USGS) archive (<http://glovis.usgs.gov>), the study area was extracted from the data and ArcMap and Idrisi software was used.

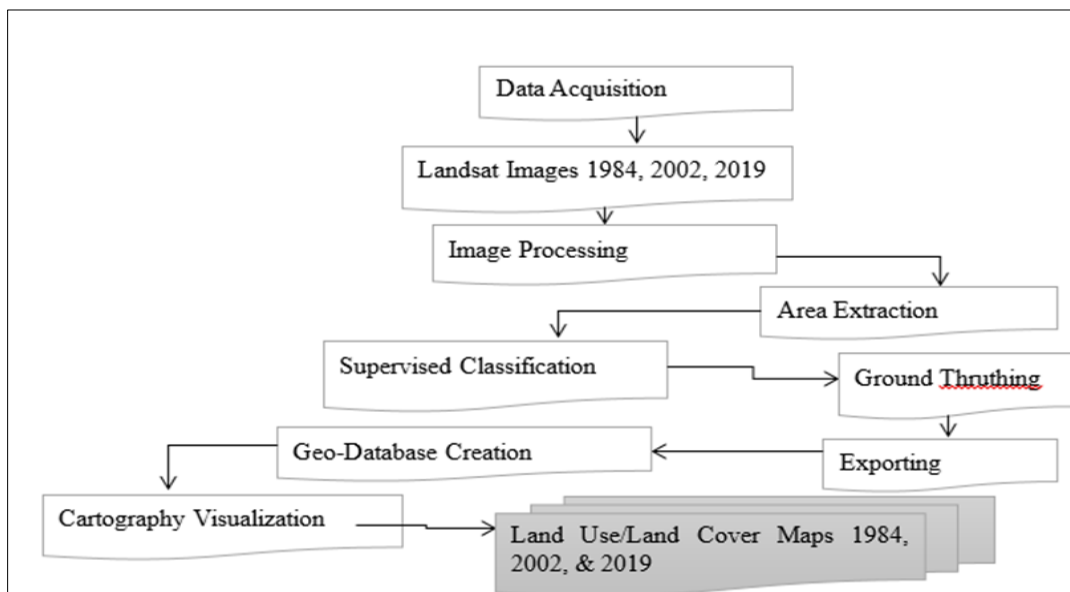


Figure 1 Methodological Flow Chart

2.3 Data Processing

The multi-temporal data (Landsat images) were processed using IDRISI SELVA software package. The Landsat imagery was imported to IDRISI SELVA. The imagery was enhanced using linear stretching method. Multispectral channels were also combined to get false color composite (FCC) for 1984, 2002 and 2019 imageries (bands 4, 3, 2 for Landsat 5 and 7 while bands 5, 4, 3 for Landsat 8). A supervised maximum likelihood classification was implemented for the three images and the final classification products provide an overview of the major land use / land cover features of study area for the year 1984, 2002 and 2019. The images were already Geo-referenced to UTM; this process involves relating the coordinate of the study area. The enhanced scene covering the study area of three years imageries was subject to supervised classification. Supervised classification can be defined normally as the process of samples of known identify to classify pixels of unknown identify and LCLU map was produced. The supervised classification performed using maximum likelihood. A total of six Land use/Landcover classes i.e., Water body, Built-up, Farm land, bare land, Forest and Grassland as shown in table 2.

Table 2 Land Use/Land Cover Classification Scheme

S/N	Class Name	Class Code	Description
1	Bare Surface Land	BSL	Bare surface land soil that is not covered by vegetation, litter, downed woody material, or rocks and is highly susceptible to erosion.
2	Built-up Land	BL	Built-up Land is comprised of areas of intensive use with much of the land covered by structures. Included cities, towns, villages, strip developments along highways, and transportation.
3	Agricultural Land	AL	Agricultural Land may be defined broadly as land used primarily for production of food and fiber. Categories of Agricultural Land are: Cropland and Pasture and Other Agricultural Land.
4	Forest Land	FL	These are the areas covered by forest reserve which are protected by the government and off-reserve trees. Forest is defined as an area covered by trees.
5	Grassland	GL	Grassland, area in which the vegetation is dominated by a nearly continuous cover of grasses. Grasslands occur in environments conducive to the growth of this plant cover but not to that of taller plants, particularly trees and shrubs.
6	Water Body	WB	Water body is any significant accumulation of water, generally on a planet's surface. Includes rivers, streams, canals, and other geographical features where water moves from one place to another are also considered bodies of water.

3. Results and discussion

Figure 2, Figure 3 and Figure 4 shows the spatio-temporal pattern of different land use/land cover changes in 1984, 2002 and 2019. The Figure 2 shows that during 1984 forest covered 40.73%, 45.98% grass land, farm land 9.33%, 2.65% for bare land, 1.20% for built-up, and water body covered 0.04%.

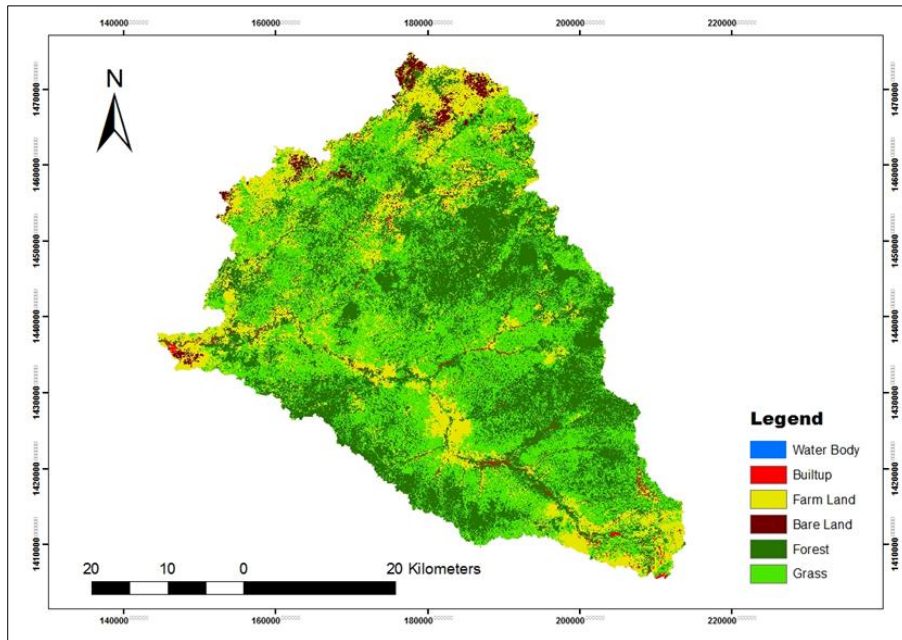


Figure 2 Land Use Land Cover Pattern in 1984

In 2002 the spatio-temporal pattern of land use land cover is 33.44% for forest area, grass land covered 45.43%, 18.09% for farm land, 2.67% for bare land, built-up covered 0.27%, and water body 0.06% as shown in Figure 3.

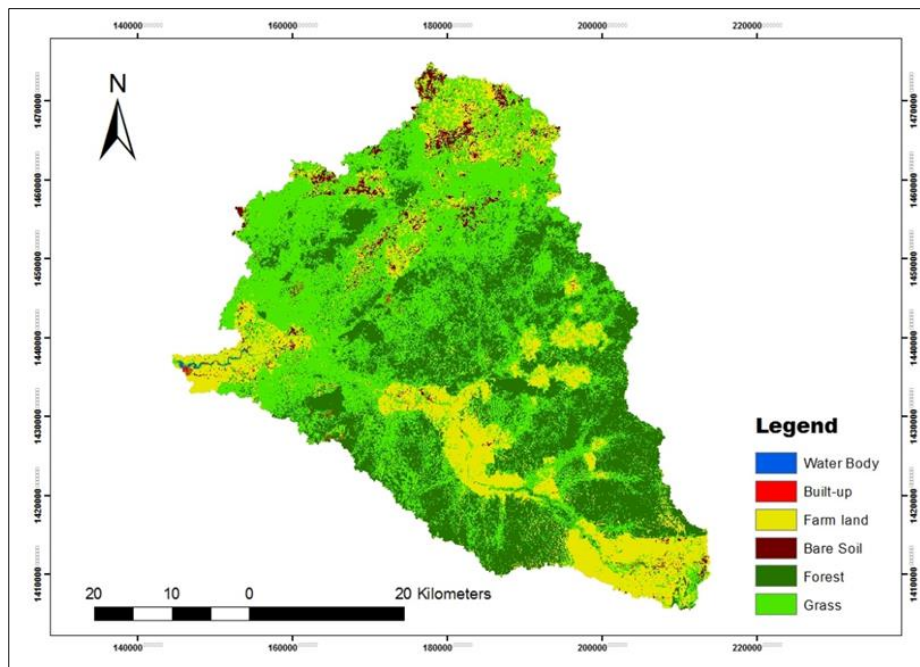


Figure 3 Land Use /Land Cover Pattern in 2002

The spatio-temporal pattern of land use land cover during 2019, forest area covered 23.99%, while 52.12% for grass land, 19.68% for farm land, 2.46% for bare land, built-up covered 1.59%, and 0.11% for water body as shown in Figure 4.

Figure 5 shows the land use land cover change from the period of 1984 to 2019 forest area was decreasing at the rate of 7.29% and 9.45%, while only in 2019 grass land increase 6.69%, also farmland and water body increase at the rate of 8.76% in 2002, 1.59% in 2019 and 0.02% in 2002, 0.05% in 2019 and also bare land increase in 2002 and decrease in 2019 therefore, the forest area has reduced in the study area.

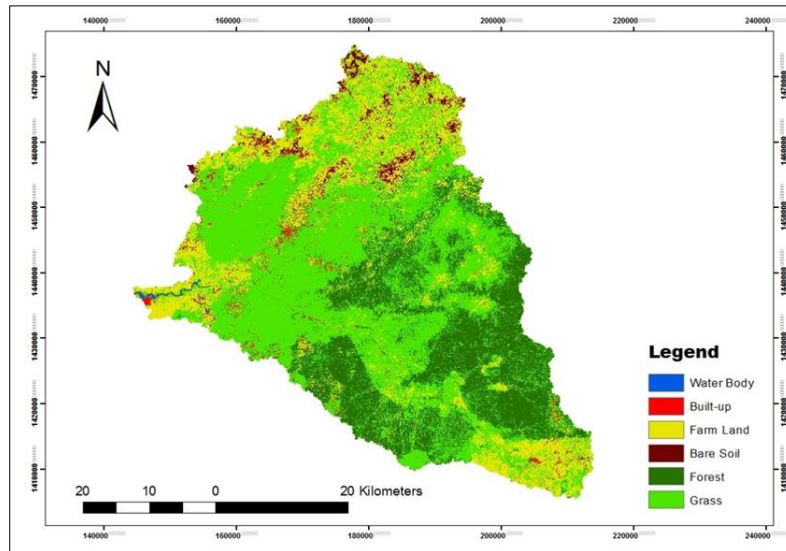


Figure 4 Land Use /Land Cover Pattern in 2019

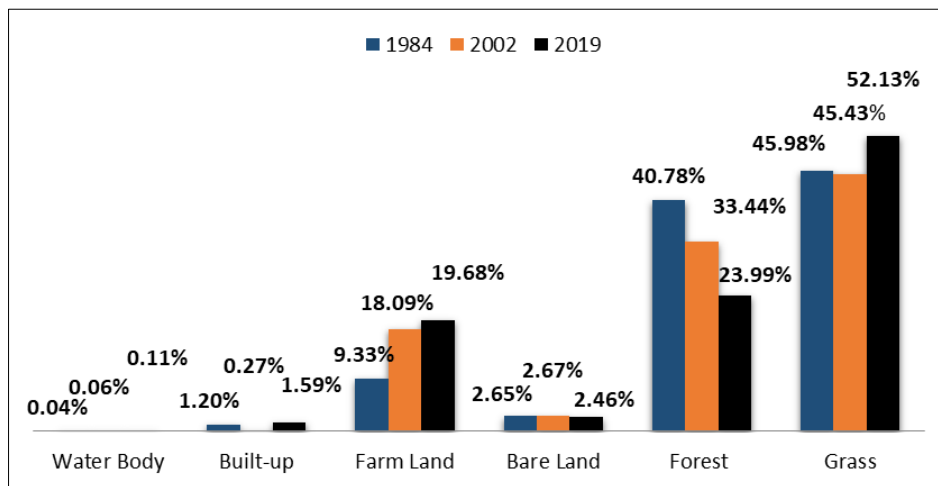


Figure 5 Land Cover Changes

The result showed that in the period (1984-2002) the forest area within the study area continued to decrease in extent, along with grassland, while farm land, bare land and water body increased (8.76%, 0.02%, and 0.02%) during this period. Forest had been converted to agricultural area and eventually farmers replaced their fields with commercial plantations. During the period (2002-2019) forest area continued to decline slightly, while there was a rapid increase in farm land and water body (1.59%, and 0.05%). forest continued to decrease as a result of an effort to rehabilitate the degraded forest influenced by the forest enactment law and increasing awareness about the importance of forest conservation. While, areas under grassland were also found to have increased whereas built-up areas, bare land areas and agricultural areas had increased slightly. The most notable change during the whole study period was the increase in area of agricultural areas. Similarly, built-up areas also increased by about 1.32% during the study period. Most of the increase came from the decrease of forests and grassland areas.

4. Conclusion

The classified images of 1984, 2002 and 2019 were used as a fundamental tool in the analysis of the land cover changes from the study area. According to the changes, during 1984 forest covered 40.73%, while 45.98% grass land, farm land 9.33%, 2.65% for bare land, 1.20% for built-up, and water body covered 0.04%. In 2002, 33.44% for forest area, while grass land covered 45.43%, 18.09% for farm land, 2.67% for bare land, built-up covered 0.27%, and water body 0.06%. During 2019, forest area covered 23.99%, while 52.12% for grass land, 19.68% for farm land, 2.46% for bare land, built-

up covered 1.59%, and 0.11% for water body. For the period of 1984 to 2019 forest area was decrease at the rate of 7.29% and 9.45%, while grass land increase 6.69%, also farmland and water body increase, the forest area has reduced.

The main change observed was land-use change has taken place in the study area and that human activities had taken a considerable toll on the land-use change. For the period of 1984 to 2019 forest area was decreasing at the rate of 7.29% and 9.45%, while grass land increase 6.69%, also farmland and water body increase, the forest area has reduced.

In an attempt to have suitable ecosystem services, land use and land cover over the study area the following recommendations are suggested; Awareness of environmental protection should be carried out so that the people will know the consequences of land-use change. Government should implement appropriate land uses that enhance forest ecosystem services. Strict measures should be taken against those that engaged in environmental degradation such as clearing of vegetation cover, and deforestation.

Compliance with ethical standards

Disclosure of conflict of interest

Authors declared they have no conflicts of interest.

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