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ASSESSING THE FOREST COVER CHANGES OF YANKARI GAME RESERVE USING REMOTE SENSING AND GIS TECHNIQUES

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ABSTRACT

This paper aim at assessing the Forest cover changes of Yankari game reserve in Nigeria using remote sensing and GIS techniques. The vegetation of the area consist of Savannah grass land with-developed patches of woodland. The study determine the land cover changes of the area using Land sat 4 imagery for the year 1990 and Land sat 7 Enhanced Thematic Mapper (ETM+7) for 2001 and 2011. The imageries were processed and classified using maximum likelihood classifier. The results revealed that there is a drastic decline in the vegetation cover over the period of the study. The percentage changes from forest cover to grassland was 22.93% from 1990-2001, 24.48% from 2001-2011 and 35.52% from 1990-2011.Also forest changes to open space was 18.29%, from 1990-2001, 7.78% from 2001-2011 and 13.64% from 1990-2011.While forest change to agriculture was 0.50% from 1990-2001, 2.15% from 2001-2011 and 2.98% from 1990-2011. An overall accuracy assessment of 71% for Landsat 1990, 65%, and 64% for ETM+ for 2001 and 2011 respectively. The game reserve is facing a threat in the disappearance of its forest cover and wildlife extinction in no distance time. The use remote sensing and GIS approach allowed us to quantify the extent of the forest cover changes in terms of percentages of the area affected, the rate of change as well as the nature of the change in terms of impact on natural vegetation.

Keywords: forest cover change, remote sensing, GIS.

INTRODUCTION

Forest cover is define as an ‘Areas dominated by trees >5m tall and >20 percent of the total vegetation cover’ [1]. The Food and Agricultural Organization of the United Nation (FAO), have estimated that about 13 million hectares of forest are being cut down and converted to other land cover types [2]. In another study by[3] estimated that the global forest and wood land cover about 31% of the total land area. Natural resources are decreasing rapidly in both developed and developing countries as a result of the impact of human activities. Assessing the state of the earth surface is the basic requirement for global change research [4-6]. It is only areas that are far away from human interference that their natural resources are found undisturbed. Population growth which is associated with climate change is found to be a contributing factor in forest lost over time [7]. Despite an improvement in land cover characterization, it was made possible through the use of satellite imagery global and regional land covers are poorly enumerated [8, 9]. The global expansion of cropland since 1850 has converted about 6 million square kilometers of forest/woodlands and 4.7 million square kilometers of savannas/grassland [3]. Land cover change (i.e. location, extent and causes) have been identified as the most important and challenging research theme for many of the programs initiated by monitoring agencies [10, 11]. Although, remote sensing provides a comprehensive and synoptic view of an environment, repetitive data acquisition and data coverage in an inaccessible terrain. It has also emerged as being the most useful data source for a quantitative measurement of land cover changes [12].While, GIS in the other hand provides a quick, efficient and cost effective in data acquisition, storage, archiving, manipulation and analysis . The use of satellite imagery have been found useful in assessing a damage done in an areas such as wetlands and forest heat by hurricanes. It was also found to be a valuable tool for acquiring information on Land use and Land cover types and in monitoring these changes over a period of time [13]. The study of land cover changes have being recognized as an agent of global change via their interaction with climate, ecosystem process and human activities [9]. Change detection in another way is the concept of identifying contrast or discrepancies in the state of an object or phenomenon by observing it at different times [14]. It is mainly centered in identifying the biotic component of the spectral and temporal changes that are occurring within ecosystem[15]. It also involves the ability to quantify temporal alteration and transformation using multi-temporal data sets.

Therefore, understanding Forest cover changes is very important for sustainable development as these changes can lead to land use conflicts due to need for resources, space, land absorption and in support of these needs [16]. Forest cover change have been recognized as an important driver of global environmental changes [17]. Statistics from the global scale revealed that almost 120 million hectares of forest and woodland and 560 hectares of grassland and pasture have been converted to another various land uses in the last three centuries[18] . Human have transformed hugged portions of the earth’s land surface [18]. Conversion of grasslands, woodlands and forest in to croplands and pasture has dramatically rises in the tropic during the last few decades [19-21]. The tropical region have lost about 15.2 million hectares of forest per annum during the 1990s. Population growth was identified as one of the causes of rural migration in search of suitable farmland. It was recommended by [22] that a 30m lowest

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spatial resolution can be used when studying land use/land cover changes can be used. The advantage of using Land sat imagery is that, it has an expansive spectral resolution that allowed for enhanced precision when used in identifying features. Previous research have also recommended Land sat imagery been the standard when tracking change in tropical regions which Nigeria inclusive [23, 24]. Nigeria has lost 57% of its forest cover between 2005 and 2010 with a deforestation rate of 3.5% per annum. This has been adjudge the highest in the world [3]. In Nigeria, approximately between 350,000 to 400,000 hectares of forest is being lost annually [25]. This exploitation is due to the demand for food, energy, illegal logging and non-replacement of the natural vegetation. Forest is important in the provision of habitat wildlife, watershed function, general conservation such as soil erosion and production of wood for various uses [26]. The land development programs and projects have just been evolved with no appreciation of the value of the forest cover change [27]. This has resulted to uncontrolled conversion of forest to other land cover types. In some areas trees are seen as an obstacle to their development and their removal is considered as a first stage of development. The attention here is mostly focused on the disappearance of the tropical rain forest due to their wealth of biodiversity. The disappearance of such forest have increased the rate of deforestation and forest degradation in most part of the tropical countries as a result of human interference. Deforestation as defined by the World Food and Agriculture Organization [28] as the removal of forest cover, has increased at the rate of 2.38% per annum in 2000 to 3.12% in 2005. This translate to an increase of 31.2% in the rate of deforestation within 5 years period. Therefore, it has become difficult for Nigeria to anticipate any possibility in socio-economic and environmental consequence of any development due to absent of baseline for land cover/vegetation for most of the development project in the country.

Significance of game reserves

The significance of game reserve usually lies in the objective in which they were created. Game reserves in Nigeria are mostly establish to balance the network of protected areas under the control of the state or Federal Government. The services rendered by such game reserves includes the following:

a) Conservation of wildlife so that abundance and diversity of species are being maintained.
b) Preserving of scenic, scientific, natural, recreational and other values in the game reserves.
c) Promote and educate about wildlife and nature of the conservation.
d) Conserving the biodiversity of the area, and they are also expected to play a vital role in preserving, conserving, protecting and managing the biodiversity in the country.

STUDY AREA

Yankari game reserve is located between latitudes 9^o 35′ and 10^o 10′ N and longitudes 10^o10′ and 10^o 50′ E (Figure-1). It is a premier game reserve in Nigeria which was gazette in 1956. It also covers an area of about 2, 244.20 square kilometers which spread through Duguri, Pali and Gwana districts in Alkaleri Local Government Area of Bauchi state, in the North-eastern part of Nigeria. The major watersheds found in the area are the Yashi and Gaji rivers and their tributaries. The game features five warm springs namely, Dimil, Wikki, Gwana, Mawulgo and Tudun Maliki water springs with Wikki as the largest which flavors the reserve’s beauty. It has a constant temperature of 31.1^o C all the year around which make it the most fascinating sites of the reserve. The two major habitat-types namely dry savannah Woodlands and Riparian vegetation occur which includes area of Fadama or Flood plains (Figure-1).

The game reserve is located in the Northern Sudan savanna region of the country (Figure-2), with an open woodlands rising from 215-369 meters above sea level [29]. Therefore, this offers the reserve a beautiful environment for tourists to see wildlife in their natural undisturbed habitat. The annual rainfall in the area ranges between 900mm to 1,000mm, with the wet season starting in May and end in September with a temperature ranges from 18^o to 30^o C. The dry season start from October to early May, but from October to February the temperature fall at night to 12^0 to 18^o C and warm in the day time (30^o to 36^o C). The hot period is from March to early May with night temperatures between 25^o and 30^o to 42^o C, respectively [29]. The game reserve is endowed with a number of wildlife (animals) such as Elephants, Lions, Buffaloes, Baboons, Monkeys, Hippotamus and Antelopes among others. The vegetation of Yankari can be categorized as thus; to the east of Gaji river as Sudan type (Tropical Xerophyte woodland), while these to the west of the river, the vegetation is a transitional type of the Guinea Savannah dry (deciduous woodland) [30]. Also due to the lying nature of the reserve, couple with the high average rainfall in the area, the soil moisture is appreciably high. Consequently, the growth nature of the vegetation in the reserve is luxuriant than the surrounding areas.

The vegetation of the area can be categorized as thus; to the east of Gaji river are of classical Sudan type (Tropical woodland), while these to the west of the river are transitional type of the Guinea Savannah (dry deciduous woodlands). Therefore, due to the lying nature of the reserve, and high average annual rainfall in the area, the soil moisture is appreciably high. Consequently, the growth and nature of the vegetation in the reserve is more luxuriant than the surrounding areas. The reserve vegetation can said to be of trees and shrubs that form an open canopy with a continuous layer of annual and perennial grasses. Yankari is not all fauna, but there is also some flora there. The vegetation of the reserve consist of Afzelia savannah woodland and shrub savannah.

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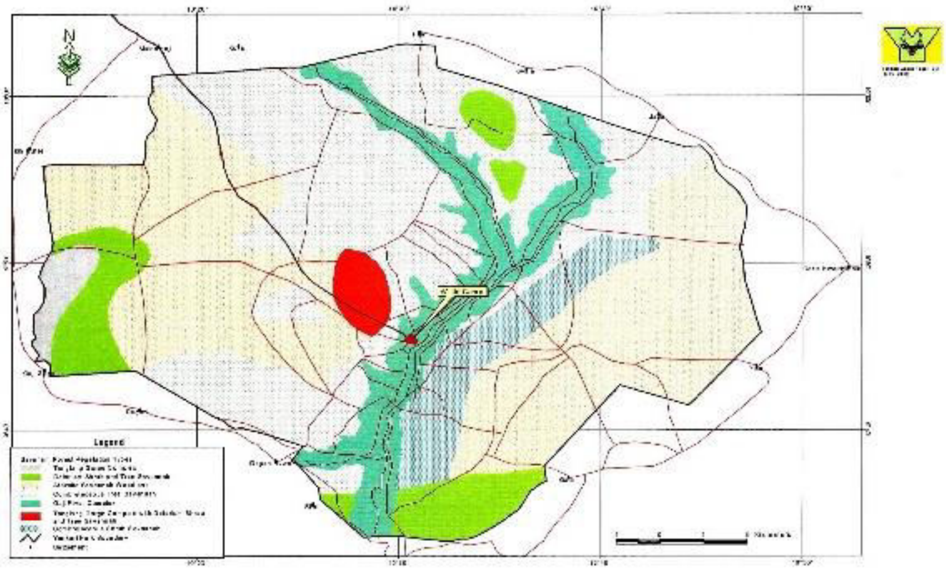

Figure 4.13: Vegetation Map of the Study Area

Figure-1. Vegetation map of Yankari game reserve. Source. Yankari game reserve.

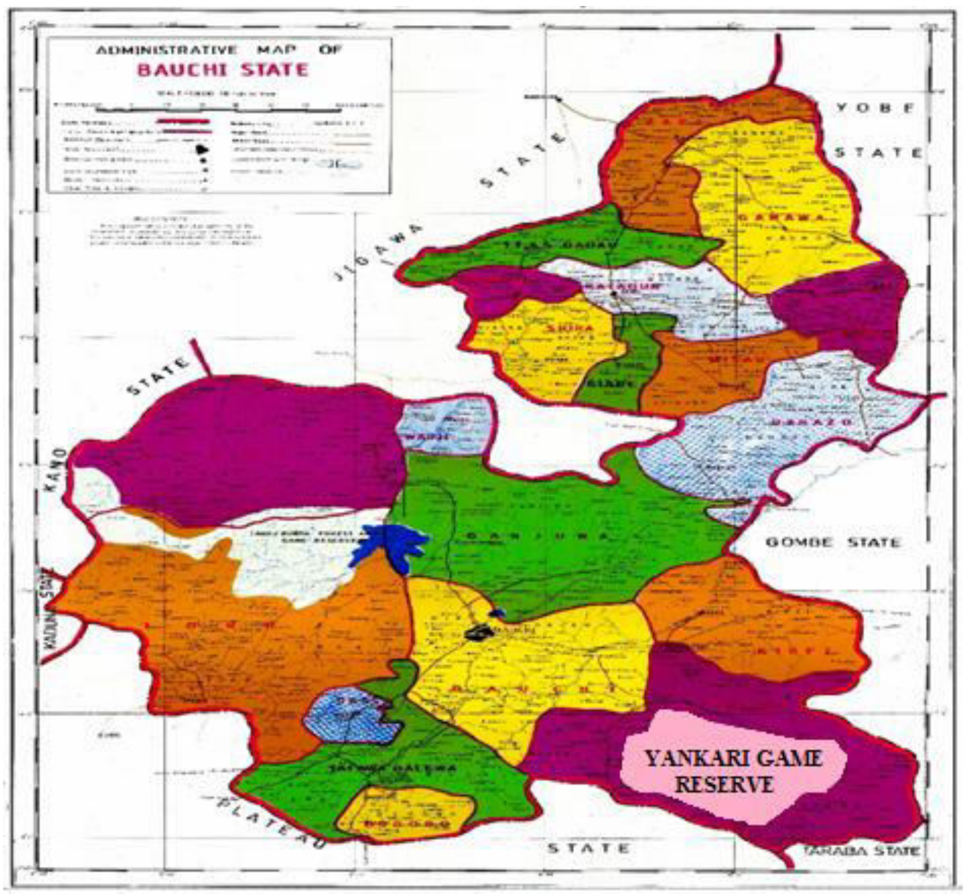

Figure-2. Map of Bauchi state showing Yankari game reserve.
Source. Ministry of Land and Survey, Bauchi state.

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MATERIALS AND METHODS

Materials

The study made use of Landsat imagery of 1990, 2001 and 2011 (Table-1). The selection of the images was based on similar seasonality and minimum cloud cover. They were the best available satellites images for the study period. There are other satellite images such as SPOT, QUICK BIRD and IKONOS which may likely give a better accuracy but were not available at that time. The accuracy was assessed using error matrices (Overall, user's and producer's accuracies as well as kappa statistics).

Table-1. Characteristics of the satellites images used.

Year	Image	Date	Bands	Path &Row	Resolution
1990	Landsat 4	11/29/1990	432 (RGB)	187 & 053	30m
2001	ETM+ 7	01/27/2001	432 (RGB)	187 & 053	30m
2011	ETM+ 7	12/22/2011	432 (RGB)	187 & 053	30m

Methods

Image pre- processing

The subsets of Yankari game reserve was extracted from the full scene of Landsat 4 of 1990 and Enhanced Thematic Mapper (ETM+) of 2001 and 2011 respectively. The raw data were subjected to atmospheric correction and geometric calibration using Dark Object Subtraction (DOS). All images were atmospherically corrected (due to their difference in months and sun angle) using Atcor2 program in the Erdas Imagine Software. The data (Level 1T) were downloaded from the earth explorer website and both were corrected for geometric and topographic errors. There was no need for geometric correction because the images have coordinates and 'USGS' has done the correction. This is perhaps the simplest method of atmospheric correction and most widely used image approach in image classification and change detection application [12, 16]. It assumes the existence of dark objects (zero or small surface reflectance) throughout the land sat TM scene and a horizontal homogeneous atmosphere. The choice of a particular technique to be used depends on the user requirement and the goal of each individual projects. ENvi software was used in the pre-processing.

Image classification

This refers to the extraction of information class from a multiband raster image. Layer stacking was performed for the recognition of the vegetation reflectance of band 4, 3 and 2 (False color composite) for the TM and ETM+. This stage was performed to identify the land cover types of interest in the image. These are called the training sites. An IDRISI Selva software version 7.0 was used in preparing the training sites which were used in identifying the various land cover classes in the entire images which was later used in classifying these images for each year. The results obtained from this raster images were used to create thematic maps as shown in Figures 3(a), (b) and (c). Supervised classification technique was employed with a maximum likelihood algorithm. The classification was based on the spectral signatures defined in the training sites. Pixels located within these areas were term as the training samples areas used to guide the classification. Layer subset was done in ENVI and was later imported to IDRISSI. Five main classes were identified and they are; Forest, Grassland, Open space, Agriculture and Gallery forest.

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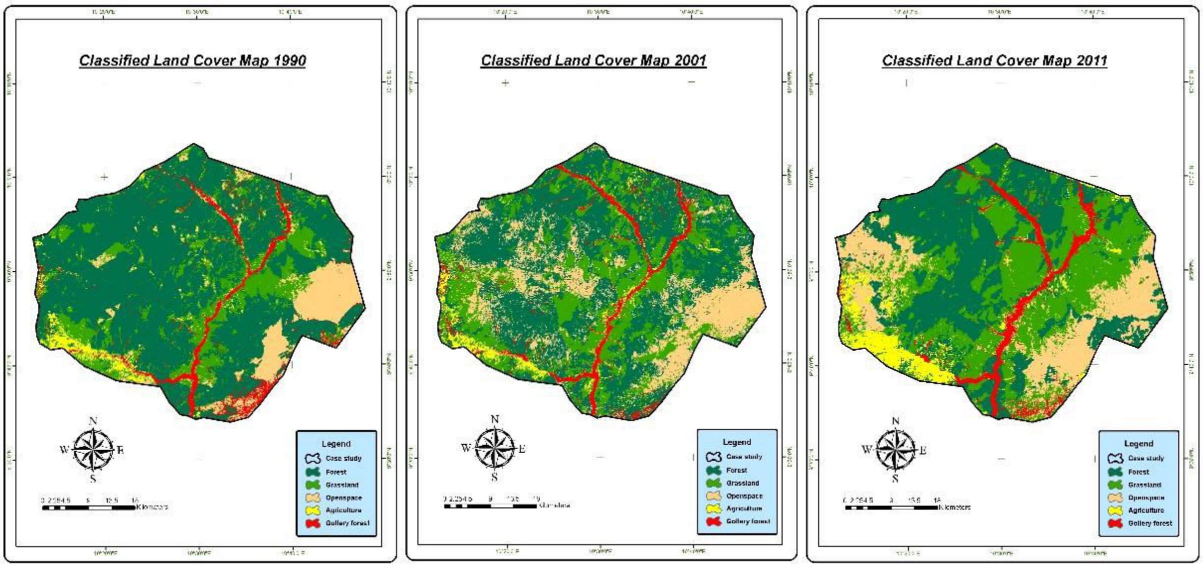

Figure-3. (a) Classified image of 1990, (b) Classified image of 2001 and (c) Classified image of 2011.

The change detection approach used was the Principal Component Analysis (PCA), post classification image differencing [8, 15]. It helps in enhancing the differences between images by reducing the spectral complexities to a few principle components. This method was used by many reseachers in the past in forest cover change research [15]. The m ethod was found to be appropriate in detecting land use and land cover changes when using multi-sensor data[12].

RESULTS AND DISUSSIONS

The results of the analysis are presented in the tables below for the study periods, 1990, 2001 and 2011 respectively.

The results of the analysis as presented in Table-2 below, showed that the areal extent of each land cover type in 1990, 2001 and 2011. It can be seen that the forest cover of the game reserve is decreasing through out the period of the study. The decrease in the forest cover have given rise.

Table-2. Area covered by each Land cover types for the difference years used.

Land cover type	1990 (km^2)	2001 (km^2)	2011 (km^2)
Forest	1498.857	1070.496	853.438
Grassland	443.232	624.116	797.200
Openspace	241.312	466.067	414.278
Agriculture	63.812	95.040	162.119
Gallery forest	117.534	109.015	137.690

to an increase in both the Grassland, Openspace and Agricultural land. But the gallery forest which is mostly found along Gaji river have increased in 2011 (see Figure a, b and c above classified image). The game reserve have been a destination for many migrants in the recents years, with people coming from different parts of the country to settled there in order take the advantages of therelatively good soils of the area [14]. The reserve boundary is indeed an “ecological island” which is surrounded by areas of intense cultivation and human occupation [11]. It was also observed that the regular movement of the Fulani herders freely with their animals inside the reserve is another causes in the decreased in forest cover. The Afzelia trees that form part of the woodland in the area used to be cut by the Fulani’s for their animals to feed.

Table-3 below shows the change maps for the period under study. These maps show how forest have change to other land cover types and the areal change over the period. In 1990, the change in agricultural land cover was negligible about 8.33km^2 representing 0.5% of the total forest cover. This have incresed to 37.85km^2 between 1990 to 2001 representing 2.15% mostly along the Southwestern part of the reserve. This further increased to 46.18km^2 repr-

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Table-3. Forest change to others Land covers in area and percentages change.

Land cover type	**Area** (km^2) **1990-2001**	**% Change**	**Area** (km^2) **2001-2011**	**% Change**	**Area** (km^2) **1990-2011**	**% Change**
Forest to Grass land	380.10	22.93	430.76	24.48	550.76	35.52
Forest to Openspace	303.10	18.29	136.85	7.78	211.54	13.64
Forest to Agriculture	8.33	0.50	37.85	2.15	46.18	2.98

-esenting 2.98%. A little agricultural land was observed along the boundary at the Northern part of the reserve and at the Southeastern part. Forest change to grassland was 380.10km^2 from 1990 to 2001 representing 22.93%, from 2001 to 2011 was 430.76km^2 representing 24.48%, while from 1990 to 2011 it was 550.76km^2 representing35.52%. Therefore, forest change to grass land was at an increased through out the period of the study. This may be attributed to the cutting of the Afzelia trees which were replace with grassland especially at the Eastern part of the reserve boundary(Figures 4 (a), (b) and (c)).

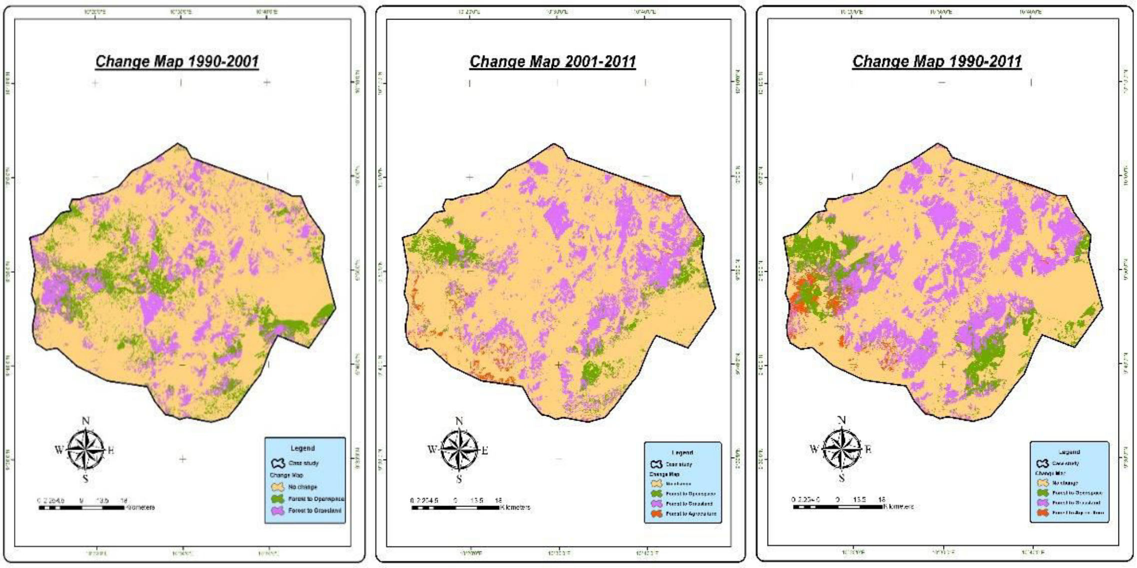

Figure-4. (a)Change map 1990-2001, (b) Change map 2001-2011 and (c) Change map 1990-2011.

Forest change to openspace have decreased between 2001 and 2011 from 303.14km^2 representing 18.29% from 1990-2001 and 136.85km^2 from 2001-2011representing 7.78% (see Figure ii change map). This change again increased between 1990 to 2011 to 211.54km^2 representing 13.64%. The overall accuracy assessment was 71% for 1990, 65% for 2001 and 64% for 2011 respectively. The kappa statistics were 0.5312, 0.4867 and 0.4880 for 1990, 2001 and 2011 respectively. The use of fire and range grazing were identified as some of the causes of this open spaces. Hunters usually set fire at the begiining of the dry season between December and January to burn the grasses in the area. These fire also burnt some woodland which make them more difficult to regrowth thereby forming an open space in the game reserve.

CONCLUSIONS

The study shows that the forest cover of the game reserve is decreasing at alarming rate. This trend will likely continue in the near future unless precautionary measures are being taken to reverse the ugly situation. When this allowed to persits then, the animals in the game reserve will extint in some years to come. Some of the forest cover change was a result of cutting the woodlands that form part of the forest cover. Therefore, remote sensing was found to be very useful approach in assessing forest cover change due its repetitive coverage. The game reserve patrol unit should intensify more effort in stopping the Fulani herders from entering the reserves with their animals so that the cutting of Afzelia trees should be minimize or stop. They should also be more vigilant along the reserve boundary so that farmers can not encroached in to the reserve. The use of fire in clearing the forest should be discourage or even stop were necessary.

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