Quest Journals
Journal of Research in Humanities and Social Science
Volume 11 ~ Issue 1 (2023) pp: 218-225
ISSN(Online):2321-9467
www.questjournals.org

Research Paper

Spatio-Temporal Analysis of Land Use/Land Covers Change In Oyimo Forest Reserve, Ondo State, Nigeria

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ABSTRACT: *This work assessed land use/land cover change in Oyimo forest reserve. Detecting change on the face of the globe using (Geographic Information System) GIS aided by remotely sensed imagery is now becoming an indispensable tool in managing the resources of our planet. The present study with the help of GIS and remote sensing (RS) is also a similar attempt in recording and quantifying change in land use and land cover change inOyimo forest reserve both in spatial and temporal extents. Satellite imagery was acquired from the USGS official website from three LANDSAT satellites. Theses satellites are Landsat 5,Landsat7 and Landsat 8 respectively. The data were acquired for the years 1998, 2011 and 2021. Satellite imagery was processed in ERDAS Imaging and maximum likelihood supervised image classification was applied in reaching the goal of detecting change. The result of the analysis revealed that settlement area was increased by 8%; forest was decreased by -17%; farmland 2%, water body was increased by 4% and bare surfaces were increased by 1%. The decrease in the barren surfaces was attributed to the increase in vegetation and settlement area which replaced the barren land in the study area. This paper also shows the significance and potential of digital change detection methods in managing the resources of our environment and keeping an eye on the land use and land cover of our Earth. Thus on the basis of the results rendered by this study, it reveals that geographic information system (GIS) and remote sensing (RS) are currently one of the most effective tools in detection and quantifying change in land use and land cover of particular area.*

KEYWORDS: *Spatial-Temporal, Land/Cover Change, Oyimo forest reserve remote sensing and GIS*

Received 01 Jan., 2023; Revised 09 Jan., 2023; Accepted 11 Jan., 2023 © The author(s) 2023.
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I. INTRODUCTION

Anthropogenic activities along with some natural process have greatly altered the natural state of the face of Oyimo forest reserve. Land use/land cover (LULC) pattern of an area is almost entirely defined by human and natural activities [1]. Therefore, LULC change detection studies have become extremely important for monitoring our environment and using the resources of the mother Earth in a judicious way [2]. Observing Earth from space using satellite imagery is playing decisive role in monitoring and keeping an eye on human influence on Earth's environment and resources available for our utilization [3]. Detecting change digitally helps in determining the changes that have occurred in land use and land cover with the help of geo-referenced multi-dimensional remotely sensed data [4]. Satellite imagery with various spatial, temporal, spectral and radiometric resolutions is used for the purpose of change detection both in spatial and temporal extents in the study area. These images with various data specifications can be acquired in numerous formats from various data providing web sources for free or by paying to the data providers [5]. It should be borne in mind that the data that are available for free are mostly in less spatial resolutions but can effectively be used in land use change detection. For any kind of digital change detection, it is necessary to classify the imagery that is pre-processed and enhanced if necessary [6]. Land use is related to the way humans use land (e.g., agriculture or pasture). Land cover is the biophysical features of the land (e.g., forest, savanna or desert). Land-use change may impact or change the land cover and, likewise, land-cover change may impact or change land use [7]. When considering forests, forest land use is linked to land management and depends on social and economic factors. On the other hand, forest land cover is the biological characteristics of the forest covering land surface[8].

A forest land cover-based concept derives from the idea of vegetation cover observed along the time. A forest land use-based concept usually requires some level of interpretation about the observed data (ground truth) and can depend on an intention of use (final purpose) over a time period. In a monitoring process, those different approaches can lead to different changes observed [9].

Statement of the problems

Land use and land cover changes have significant environmental consequences at local, regional, and global scales. These changes have intense implications at the regional and global scales for global loss of biodiversity, distresses in hydrological cycles, increase in soil erosion, and sediment loads [10]. At the local level, changes in the use of land and its cover affect watershed runoff, microclimatic resources, processes of land degradation and landscape-level biodiversity, soil erosion, and sediment loads [11]. All these have direct impacts on livelihoods of local societies.

Justification

In combination, Remote Sensing(RS) and Geographic Information System GIS serve efficiently for earth observations and associated information analysis [12]. Viewing earth from space enables us to comprehend the cumulative influence of hum an activities on earth surface's natural state. Capturing and analyzing this information by the RS and GIS tools provides a cost effective record of LULC in an accurate and timely manner [13]. Availability of multiple satellite sensors offering image data with fine spatial resolution, high geometric precision and short revisit intervals has made satellite remote sensing more appealing than aerial photography and manual data collection methods for LULC change detection and modeling [14].With the advancement of satellite image analysis tools and ease-of-access to various off-the-shelf images processing software, satellite remote sensing has been gaining wide popularity for investigating LULC change.

Aim and Objectives

Aim: To Analysis Spatio-Temporal of Land use/Land covers Change in Oyimo forest reserve

Objectives are:

I. To classify image of Oyimo forest reserve into land use/land cover of three different years

II. To assess the changes in land use and land cover on remotely sensed satellite imagery within the investigation period

III. STUDY AREA

Study location

Oyimo forest reserve in Supare, Akoko South West Local Government Area of Ondo State, Nigeria is geographical located in Latitude: 7° 22' 17" N and 5° 43' 40" E. It has an area of 226 km2 and a population of 239,486 at the 2006 census.

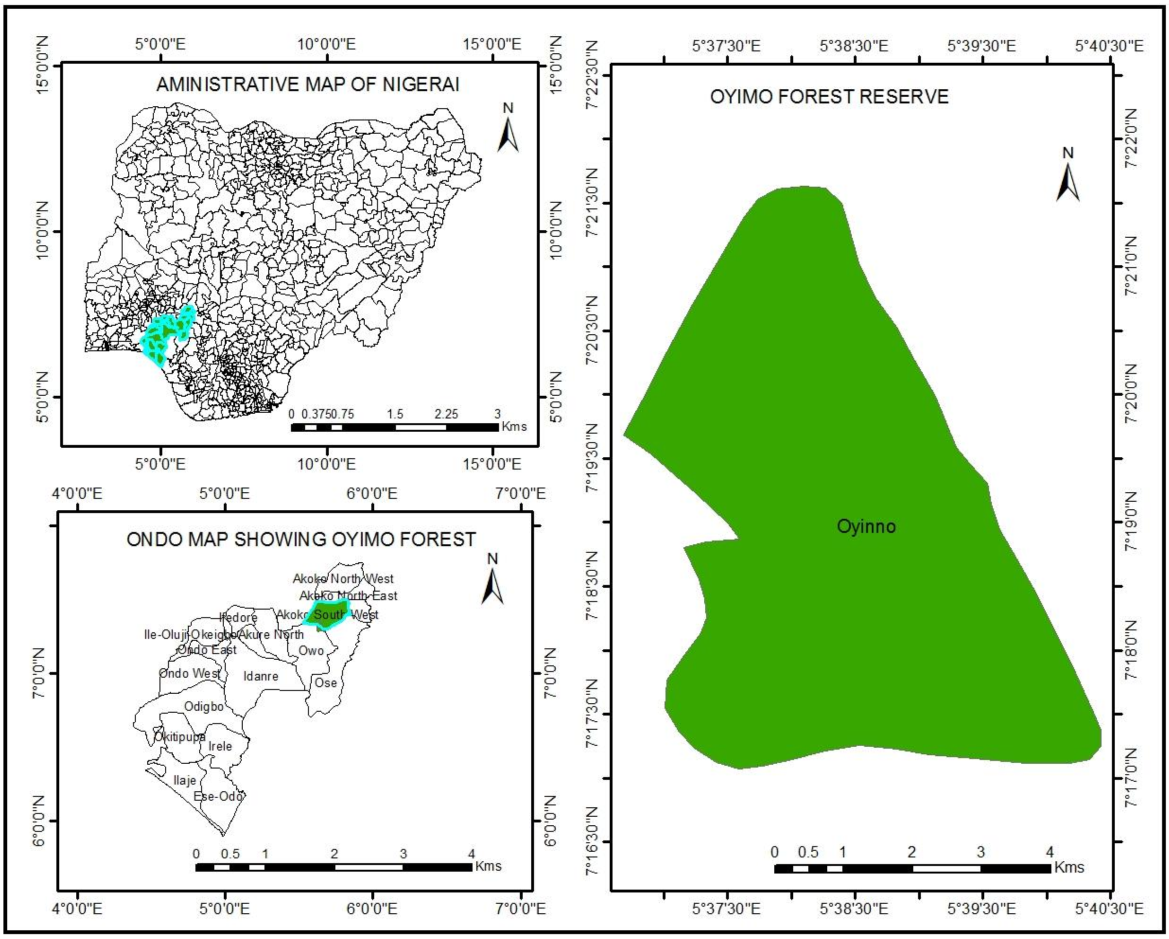

Figure1 Study Area Map

Vegetation

The Oyimo Forest Reserve, which covered an area of 59, 758 hectares at inception [15]. Their crowns touch one another thus forming a complete cover over the layers below. Their crowns were also draped by various climbers, which tended to bind crowns of many trees together. Some characteristics of the trees observed included tall large trunks, light thin barks (peeling off in some species), buttress roots, stilt roots, leaves with drip tips and some leaves with epiphyllous algae. These characteristics are typical for forest trees and they have been observed elsewhere.

III. METHODOLOGY

Data Sources and Acquisition

For the purpose of land use and land cover change detection data from different LANDSAT sensors was used. The data in from of satellite imagery was acquired from the USGS official website from three LANDSAT satellites. The first one is LANDSAT 5 carrying TM (Thematic Mapper) senor. Imagery for the year 1998 was downloaded from this sensor. The second one is LANDSAT7 carrying the ETM+ (Enhanced Thematic Mapper) sensor. Imagery for the year 2011 was downloaded from this sensor, and the third one is LANDSAT 8 carrying OLI (Operational Land Imager) sensor. Imagery for the year 2021 was downloaded from this sensor. The data that was acquired from these sensors was of a fairly larger temporal extent of around 23 years (1998-2021) and also was of considerable spectral resolution.

Data Analysis

Image classification is a joint human and computer attempt to identify land use/land cover classes present in the imagery by using the spectral information that is stores in the imagery in form of digital number values. To find out the land use and land cover change, the satellite imagery was classified in Arc Map 10.4. For this study the process of supervised classification was performed using the maximum likelihood supervised classification script. During this process of supervised classification training samples were selected with great care, and each LULC class was identified with the help of pan-sharpened imagery and topographic maps. It is pertinent to mention that the personal observation and knowledge of the study area also helped in the classification process. Post classification accuracy assessment was performed using the error matrix method. The accuracy assessment confirmed the accuracy of the classification process. Four land use and land cover classes were identified for the detection of change in the study area.

Forest Change

The quantification of change in land use or land cover over time can be expressed as a basic conceptual forest system model.
Forest extent current = Forest extent previous + gross gain - gross loss

IV. RESULTS AND DISCUSSIONS

Results

All the three images that were processed and classified were used to reach the goal of LULC change detection. As mentioned earlier that all the three images of the year 1998, 2011 and 2021 were classified using the maximum likelihood supervised classification. The results of the classification are discussed below in detail.

Results of 1998 Classified Image

According to the results of the classified image (Figure 2) the forest dominates the total area and covers 59% which is followed by farmland area which covers 27%. The bare surface covers the least of land area and covers only 1% of the total area. Accuracy assessment was also performed for the classified image. The results of the image indicate that user's accuracy for all the classes is very good except water which is about 63.45%. This can be attributed to the same spectral responses of some water pixels as that of some darkish rocks in the class bare surfaces. The overall accuracy of classification is also very good, which is around 82.98%.

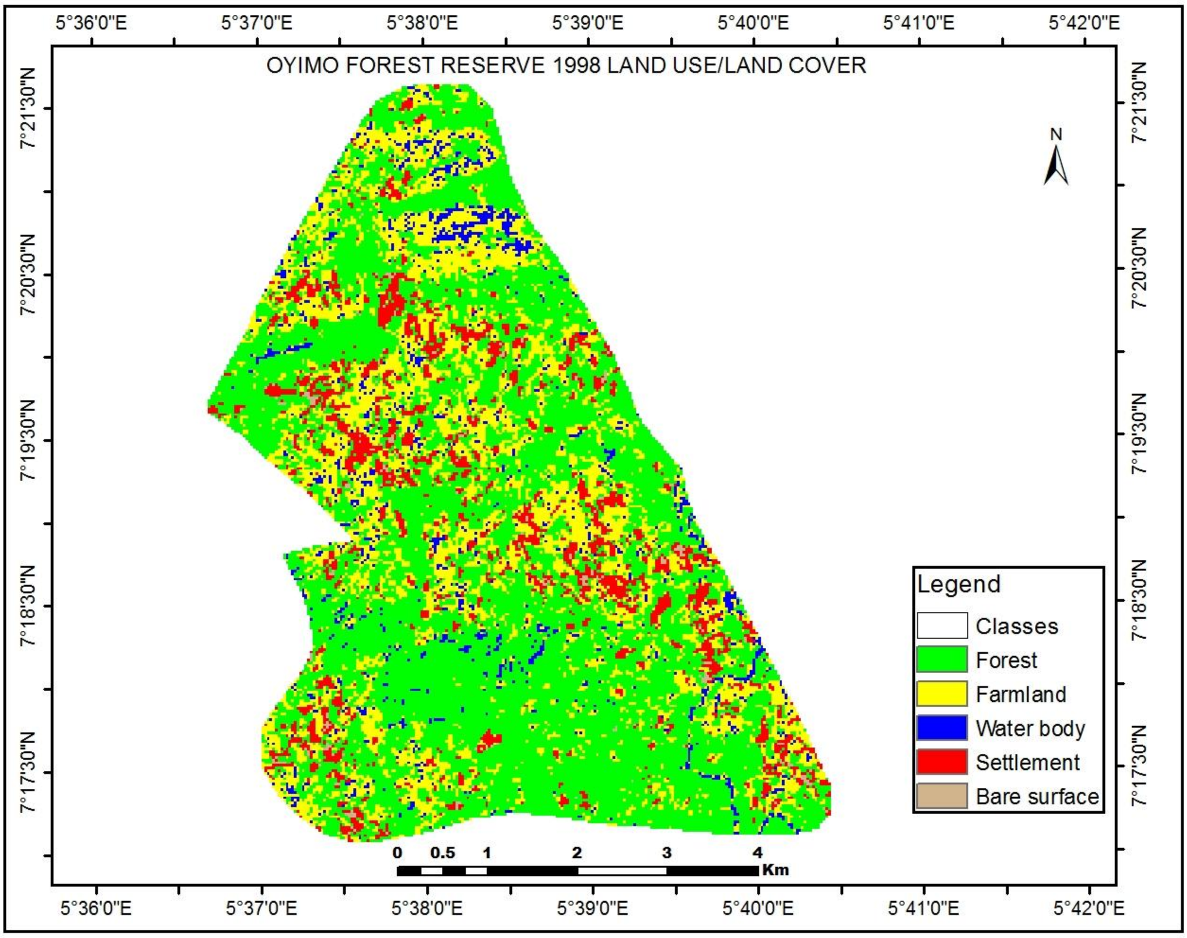

Figure 2 1998 land use/land cover of Oyimo forest (Sources Fieldwork)

Results of 2011 Classified Image

According to the results of the classification (Figure 3) bare surface covers the least part of the total area which is 1% or 597.58 hectares. Forest land covers a major chunk of the total area which is 38% or 22,708.04 hectares. The water body covers 19% or 11,354.02 hectares. The settlement area covers about 9,561.28 hectares or 16% of the total area and farmland covers, .15, 537.08 or 26%. The resultant map of the image of the year 2011 that was classified for the purpose of land use and land cover change detection can be seen in Figure 3. Accuracy assessment of the 2011 image clearly indicates that the bare surfaces were most accurately classified. This can be attributed to the reason that a large portion of the study area comprises this land cover type. The leas accurately class is bare surface which is 67.50% this can be attributed to the reason that some pixels in the image that were covering the mountainous portion of study area were having same spectral characteristics as that of bare surface

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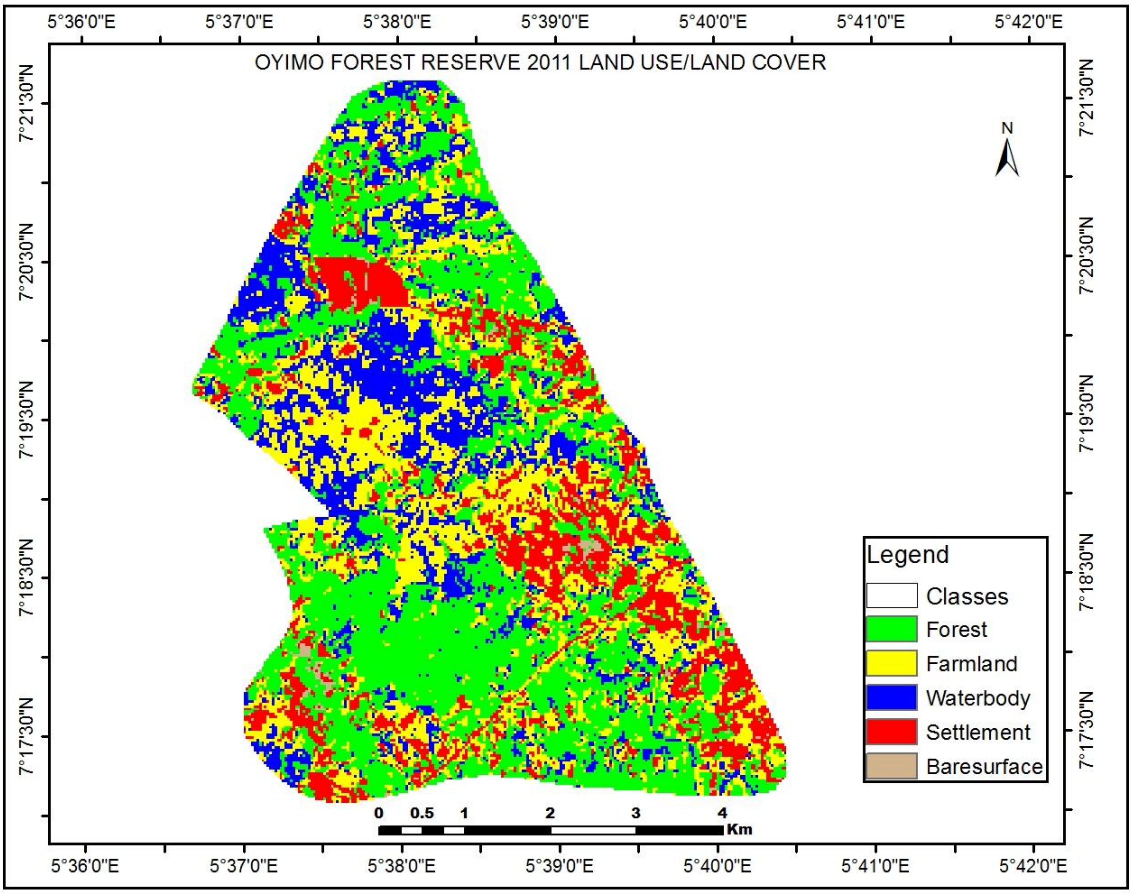

Figure 3: 2011 land use/land cover of forest

Results of 2021 Image Classification

The results of the classification (Figure 4) shows that Forest still occupies a major chunk of the total area which is 40% or 23,903.2 hectares followed by farmland area which covers 29% or 17,329.82 hectares. The settlement covers 18% or 10,756.44 hectares. Water body covers 11% or 6,573.38 hectaresbare surface covers only 2% or 1,195.16 hectares. Accuracy assessment of the classification depicted that most accurately classified class is bare surfaces which constitutes the major portion of the study area.

This means that about 94% of the bare surfaces were classified accurately. The least accurately classified class again is water which is 74% correctly classified. The overall accuracy of the classification is 84.35%.

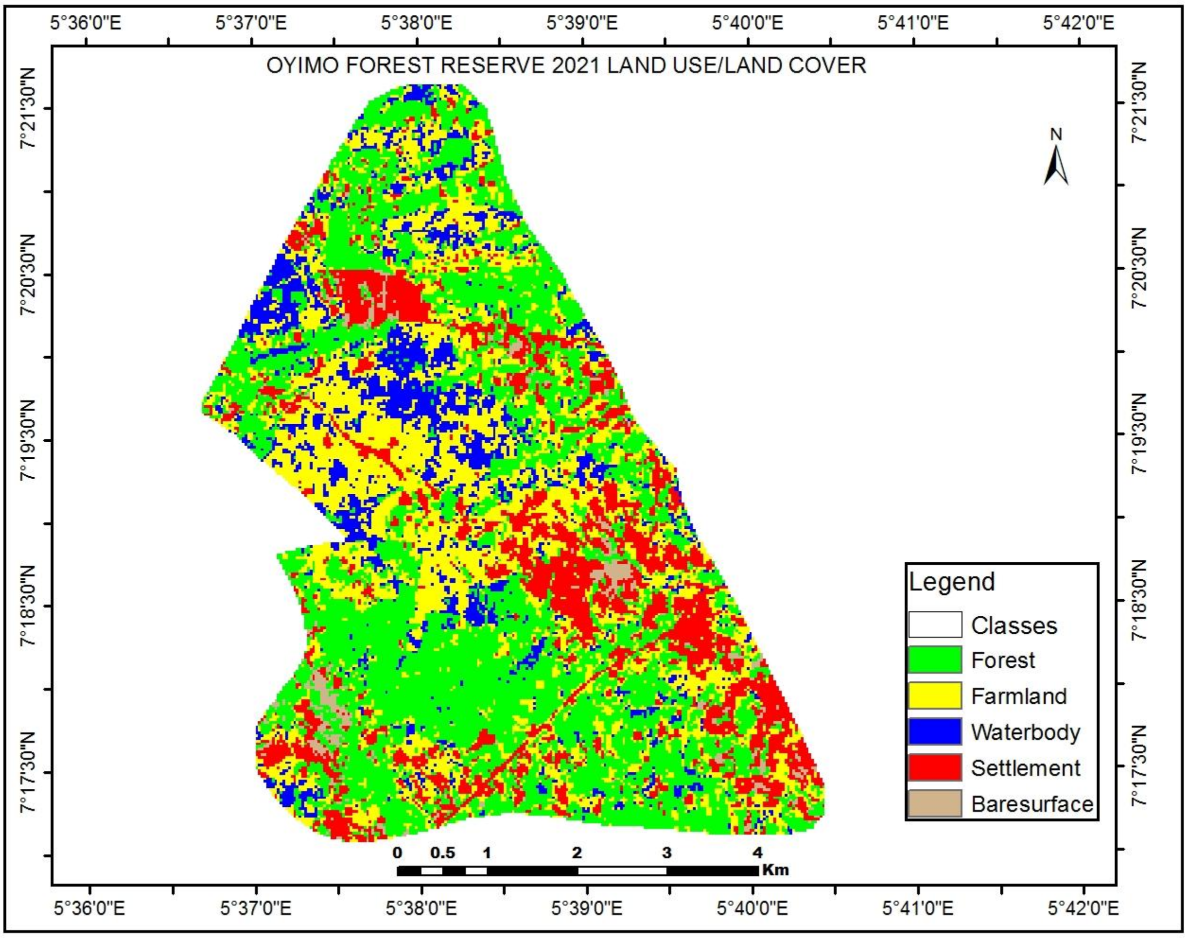

Figure 4 2021 land use/land cover of Oyimo forest

Land Use and Land Cover Change

Table 1. Year wise area covered by each class and percent of change

Land use/Land cover class	1998		2011		2021		Change (%)
	Hectares	(%)	Hectares	(%)	Hectares	(%)	
Forest	35,257..22	59	22,708.04	38	23,903.2	40	-17
Settlement	5,378.22	9	9,561.28	16	10.756.44	18	8
Water body	2,390.32	4	11,354.02	19	6,573.38	11	4
Farmland	16,134.66	27	15,537.08	23	17,329.82	29	2
Bare surfaces	597.58	1	597.58	1	1,195.16	2	1

After this detail analysis using satellite imagery that was covering a relatively long temporal span of around 23years it is found that forest were covering a major chunk of land area which was 59% of the total area of the study area in 1998 this was reduces to 38% in the year 2011 and was increase to 40% in the year 2021. Thus an overall 1% increase in bare surfaces was recorded during the study period. Built-up area was recorded as 9% of the total area in 1998 which was increased to 16% in the year 2011, and this figure was increased to 19% in the year 2021. Thus an overall increase of 9% was recorded in this particular land use class. Farmland was about 27% of the total area in the year 1998 which was reduce to 26% in the year 2011 and increase to 29% in the year 2021. Thus an overall increase of 2% was recorded during the study period. Water bodies was covering 4% in the year 1998 which sharply increased in the year 2011 to 19%, the water bodies was decrease to about 11% of the total area in the year 2021. Thus an overall increase of 7% was recorded during the study period. The detail of the year wise increase or decrease in land use and land cover classification and percent of change is given in Table 1.

V. Discussion

Despite many factors such as availability of imagery for specific time of the year and the availability of recent land use/land cover maps, that created hurdles in finding change in the study area. The present study proved very effective in fulfilling the objectives that were set for the study. The study rendered following findings:

The area that is covered by forest is gradually increasing. This can be attributed to the increase in number of planting more trees as directed by Ondo State Government. It was noted that the increase in forest is almost entirely part of the study area. This is because of the availability of cultivatable land in those parts of the study area.It was noted that settlement area increased the most in terms of its proportion to total area. This can be attributed to the increase in agricultural products which in turn increase economic activities and ultimately human settlements and population in the study area.

The bare surfaces in the study area increased a little bit. This is because the area that was once occupied by the bare surfaces in now covered by vegetation and human settlements.Water bodies in the study area have increased with very high speed, and have decreased only 0.8% in around 21 years. This is because the area is experiencing dry spells in the recent times.

IV. Conclusion

The present study suggests that the use of multi-spectral and multi-temporal imagery can prove very useful for this kind of study. Detecting change using other methods especially using the conventional method often don't works or renders inaccurate results. The study proved that maximum likelihood supervised classification is one of the most suited classification process used for this kind of study. There are many potential possibilities which should be taken in consideration for any future such study. Following recommendations are made in this regard:

Land use and land cover change detection with the help of satellite imagery is important for monitoring environmental changes. The present study that was conducted for the detection of change in land use and land cover in Oyimo forest reserve with the help of multi-temporal and multi-spectral imagery provided by the United States Geological Survey website from LANDSAT series of the satellites strongly advocates that satellite imagery can effectively be used in detecting change in spatial and temporal extents in almost every part of the world. Study of such kind if carried without taking the help of GIS and Remote Sensing otherwise would have been impossible if we were to find change that covers such vast temporal and spatial extents. This study reveals that settlement area was increased by 8%;forest was reduced by -17%; farmland 2%, water bodies were increased by 4% and bare surfaces were increased by 1%. The decrease in the barren surfaces was attributed to the increase in vegetation and settlement area which replaced the barren land in the study area. Thus on the basis of the results rendered by this study, it reveals that geographic information system (GIS) and remote sensing (RS) are currently one of the most effective tools in detection and quantifying change in land use and land cover of particular area.

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