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Land Use Change Analysis in a Derived Savannah Zone of South Western Nigeria and Challenges for Agricultural land

Oluwabunmi Denton [1]* Ayoade Ogunkunle[2]
1.Land and Water Resources Management Program, Institute of Agricultural Research and Training, PMB 5029 Moor Plantation Ibadan, Nigeria
2.Department of Agronomy, Faculty of Agriculture and Forestry, University of Ibadan, Nigeria
*Email of the corresponding author: bunmidenton@gmail.com

Abstract
The land use pattern of a region is the outcome of the natural and socio –economic factors and their utilization by man in time and space. These changes in land use patterns have impact on the local and global environmental conditions as well as economic and social welfare. The aim of this study was to examine change in land use and its effect on the amount of land available for agricultural production as basis for decisions on land use planning for sustainable agriculture. The study was carried out in Ido local government area, LandSat images of Oyo State for the years 1984, 2000 and 2010 were used for the land use classification covering a period of 26 years. Supervised classification was done using the maximum likelihood algorithm to classify into different land use categories such as forested areas, bare lands, urban areas, water bodies and agricultural lands.From 1984 to 2010 the urban areas in Ido LGA increased by 8.29%, forested areas decreased by 4.38% and the agricultural lands also decreased by 3.86%. Such losses are permanent since the urban lands cannot be converted again to farming; the consequence is increasing reduction in the agricultural production. This trend must be checked so as to enhance sustainable agricultural production and thereby avoid food insecurity in future.
Keywords: land use, land use pattern, agricultural land

1. Introduction

Land use can be defined as the activities of man on land which has a direct relationship to it. It is a product of interactions between a society's cultural background, skill and its physical needs on one hand, and the natural potential of land on the other (Ram and Kolakar 1993). It is the use into which a piece of land is put. Studies have shown that only few landscapes on the earth still remains in their natural, original state (Riebsame, 1994). Di Gregorio and Jansen (1998) stated that land use is characterized by the arrangements, activities and inputs by people to produce change or maintain a certain land cover type. Therefore, land use defined in this way establishes a direct link between the land cover and the actions of people in their environment (Lillesand and Kiefer 2002), while land cover is the observed biophysical cover on the earth's surface. In other words, it can be stated as land use = land cover + land utilization (Di Gregorio and Jansen 1998). Furthermore, land use can be described as the arrangements, activities and inputs that people undertake on a certain land cover type (FAO 2000). According to these definitions land use reflects human activities such as the use of the land like industrial zones, residential zones, and agricultural fields and so on.

Anthropogenic activities on the earth surface play a significant role in altering man's presence on the earth and his use of land which has had a profound effect upon the natural environment thus resulting into an observable pattern in the land use.

1.1 Factors responsible for land use change: Land use is not static: it has been evolving gradually over the years and these changes can be attributed to several factors. Identifying the causes of land-use change requires understanding how people influence decisions pertaining to the utilization of land for various purposes. Many factors can be responsible for the changes in the land use pattern of an area; one is increase (or decrease) in population which is a very important factor or agent. For instance, as population increases, construction of dwellings also increases thus engendering conversion of cropland and forest land to settlements. According to Cunningham, Cunningham and Siago (2005) it has been noted that rapidly increasing human populations and expanding agricultural activities have brought about extensive land use changes throughout the world. Hence, it is necessary to have information on land use and possibilities for their optimal use which is essential for the selection, planning and implementation of land use schemes to meet the increasing demands for basic human needs and welfare.

As stated by Lambin et al., (2003) the factors responsible for land-use change can be divided into two categories:

a. **Proximate** (which is also referred to as direct, or local) and
b. **Underlying** (also known as indirect or root).

The proximate causes of land-use change refer to how and why local land-cover and ecosystem processes are modified directly by humans. The underlying causes explain the factors responsible for these local actions. In general, proximate causes are a local land-use which is as a result of land-use decisions made by individual landowner or other entity that controls individual piece of land.

The actual change occurs when the land is converted into a built-up one or other uses without consideration for other uses such as agriculture which is highly discriminatory in terms of fertility and productivity, which are the key factors necessary in choosing agricultural lands. By so doing most of the prime agricultural lands have been put to other uses other than agriculture. According to Ayoade (1988), an enormous amount of changes in vegetation and rural land use have been taking place in the tropics since the beginning of the last century. Unfortunately, land use changes by deforestation have not been given attention as an important environmental change in the same way as urbanization.

Fasona and Omojola et al., (2005) stated that studying land use dynamics is essential in order to examine various ecological and developmental consequences of land use change over a space of time. Therefore making land use mapping and change detection relevant inputs in decision-making for implementing appropriate policy responses. As observed by Rahman et al. (2005), for studying land use changes pattern, remotely sensed data such as aerial photograph and satellite imageries are undoubtedly the most dependable for extracting information. Therefore this study made use of remotely sensed data for identifying the changes in the land use pattern. Change detection is a suitable technique to find out the rate of land use change (Singh 1989) it is a technique that is used to highlight conversion of land from one use to another within a given time frame (Jaysal and Ram 1999). In this study an attempt was made to detect the land use changes over a period of time through satellite image processing and (GIS) geographical information system techniques (Rahman and Saha 2009). Hence, this study identifies the various land uses, examines the changes that have occurred among them and the rates of such changes in a derived savannah zone of Southwestern Nigeria.

The specific objectives therefore are:

a) To identify the existing land use pattern in the study area,
b) To detect the land use change pattern,
c) To find out the challenges for agricultural land and how much of it has been lost.

2. Methodology:

This study was carried out in Ido Local Government area (LGA) of Oyo state which is located between latitudes $7^0$45N, $7^0$15N and longitudes $3^0$30E, $3^0$50E covers about 986 km^2 (fig,1); it is located in the forest belt zone and supports mostly food crops. Ido Local Government was created during the Second Republic on May 29, 1989 with its headquarters at Ido. It shares boundaries with Oluyole Local Government, Ibarapa East Local Government, Akinyele Local Government, Ibadan North West Local Government, Ibadan South West Local Government, Ibadan North Local Government areas of Oyo State and Odeda Local Government in Ogun State. Like most locations in Southern Nigeria, Ido is characterized by two distinct seasons: the dry season which lasts from November to March and the rainy season which starts from April and ends in October. Ido enjoys abundant rainfall of over 1800mm annually and the south-westerly winds blow over the LGA most of the year. Ido has a relatively high humidity and average daily temperature ranges between 25 °C (77 °F) and 35 °C (95 °F), almost throughout the year. The vegetation pattern consists of rain forest in the south and guinea savannah in the north. The climate in the local government area favors the cultivation of crops like maize, yam, cassava, millet, rice, plantain, cocoa, oil palm and cashew.

2.1 Data sources and pre-processing: Three sets of satellite images were used in the study. They are images of Oyo State for the years 1984, 2000 and 2010. These were used for the land use classification covering a period of 26 years. All three images were obtained from Global Land Cover Facility (GLCF), an Earth Science Data Interface. The selection of images of the same season was to minimize the influence of seasonal variation on the result. (Table 1) The bands of the acquired imageries were enhanced using histogram equalization, rectified to a common UTM coordinate system (WGS84) based on the 1: 250000 Topographic landuse map of Oyo state and then radiometrically corrected. A supervised classification with a maximum likelihood algorithm was conducted to classify the imageries using three bands of red (4), green (3) and blue (2). Training sample sets were collected based on ground truth data gathered during field checks and on completion it was run on mosaic.

2.2 Development of a classification scheme: Based on the reconnaissance survey carried out in the study area and the prior knowledge of the area, a classification scheme was developed for the study area after Anderson et al (1967). The classification scheme developed gives a rather broad classification where the land use was identified by a single digit. In order to classify the rectified images, five classes of interest were specified in the images namely, urban areas, forest, agricultural lands, bare land and water bodies. These classes were identified using sets of high resolution ortho-photographs over the area and USGS land classification map as ground references. The land use classification scheme was used as the input in the selection of the training sites that were used in the supervised classification using ERDAS Imagine. The classified images were then vectorised by digitizing and the map for each year was captured.

2.3 Methods of Data Analysis

Three methods of data analysis were adopted in this study.

(i) Supervised Classification with maximum likelihood algorithm was used for creating the land use maps.

(ii) Markov Chain and Cellular Automata Analysis was used for predicting change

(iii) Calculation of the Area in hectares of the resulting land use/land cover types for each study year and subsequently comparing the results.

The first method was used after the signatures had been created for the land use classes making use of the training data and subsequently generating land use maps. While the rest of the methods have been combined to evaluate the change in the land use types.

The comparison of the land use statistics assisted in identifying the percentage change, trend and rate of change between 1984 and 2010.In order to achieve this, the first task was to develop a table showing the area in hectares and the percentage change for each year (1984, 2000 and 2010) measured against each land use type. Percentage change (to determine the magnitude of change) was then calculated.

For obtaining annual rate of change, the percentage change was divided by the number of study years: 1984 – 2000 (16years); 2000 – 2010 (10years)

For the second method: Markov Chain Analysis and Cellular Automata Analysis, Markov Chain Analysis is a convenient tool for modeling land use change when changes and processes in the landscape are difficult to describe. A Markovian process is one in which the future state of a system can be modelled purely on the basis of the immediately preceding state. Markovian chain analysis describes land use changes from one period to another and uses this as the basis to project future changes. This is achieved by developing a transition probability matrix of land use change from one time to another time, which shows the nature of change while still serving as the basis for projecting to a later time period. The transition probability may be accurate on a per-category basis, but because there is no knowledge of the spatial distribution of occurrences within each land use category. Therefore, Cellular Automata (CA) was used to add spatial character to the model. In essence, the CA will develop a spatially explicit weighting more heavily in areas that proximate to existing land uses. This will ensure that land use change occurs proximate to existing similar land use classes, and not wholly random.

3. Results and Discussion

3.1 Land use pattern of the study area: The major land use pattern of Ido LGA has been categorized into the following classes: agricultural land, urban areas, forests, water bodies and bare lands. Total land area of Ido LGA is 106,590.45 hectares. Of this, agricultural land is 81,227.5 hectares, urban areas 553.22 hectares, forests 23,950.15 hectares, bare land 108.93 hectares and water bodies 750.65 hectares. The land use pattern of the study area in 1984, 2000 and 2010 is shown in Figures 2, 3 and 4.

3.2 Changes in land use pattern in the study area: Land use pattern changes in three different time periods have been examined for detecting the land use changes in Ido LGA. It is clear from the results that the agricultural land, bare land and forests have decreased, whereas the urban areas have increased proportionately (Table 2). The agricultural land of Ido LGA in 1984 was 81,227.5 ha (*i.e.*76.21% of the total land area) and in 2010 it became 77,114.07 ha (72.35%). It has therefore been decreased to 3.85% during the last 26 years, indicating 0.15% decline per year. The urban area was 553.22 ha (0.52%) in 1984 and 9385.85 ha (8.81%) in 2010, suggesting that it has increased 8.29% during the period; which is 0.32% increase per year. Likewise, the area under forests was 23,950.15 ha (22.47%) in 1984 and 19,245.27 ha (18.06%) in 2010; which indicates a decrease in forests lands of up to 0.70% decrease per year. The bare land was 108.93 ha (0.10%) in 1984 and 94.84 ha (0.08%) in 2010. The water bodies did not decrease significantly over the course of the years there was just a slight decrease (Fig 5).

3.3 Challenges for agricultural land: The land use changing pattern of Ido LGA described above revealed that the agricultural land is facing a greater challenge. Although the rate of decline is small, its vast amount is of great concern more than other changes. The agricultural land of the study area has been decreased 3.85% during the past 26 years and at a rate of 0.15% per year which is shown in Table 3.

3.4 Forecast on the changing pattern in Ido LGA: According to the Millennium Development Goals of the Federal Government of Nigeria to achieve agricultural sustainability and attain food security by the year 2020. A forecast was done on the study area while considering the following hypotheses; (i) the agricultural land losing rate will be constant; (ii) the urban areas development rate will also be constant; and (iii) there would be no action taken to protect the arable land. If this happens, the agricultural land would be reduced drastically to

71,872.81 ha (67.43%) by year 2020 (Fig. 6) while urban areas would have increased to 17.85% i.e 19,023.84 ha. That means the agricultural land of Ido LGA will constantly be on the decline if not checked. From the above forecasting it is clear that the agricultural land of Ido is facing a great challenge.

4. Conclusions

This study has shown that prime agricultural land is increasingly being lost to urbanization thereby leading to the loss of valuable farm lands. With uncontrolled population growth and economic development in the study area, the land use pattern is changing rapidly. This is especially true for urban areas which have increasingly expanded and encroached upon agricultural land during the last few years. Using remote sensing data integrated with GIS, it was found that from 1984 to 2010 the urban areas in Ido LGA increased by 8.29% while forested areas decreased by 4.38% and the agricultural lands also decreased by 3.86%. Such losses are permanent since the urban lands cannot be converted again to farming or forest. From the estimated 10 year projection, i.e. by the year 2020, the study has shown that a lot of land would have been lost to urbanization thereby reducing the amount of lands available for agriculture.

Even though urban and other developments are 'good' for the wellbeing of the people, the study has shown that, unless the trend is checked and controlled, most of the agricultural and forest lands would be overtaken by urbanization. This has a serious negative implication for food and environmental security in the areas and the nation at large. Therefore adequate land use planning is required in such areas so as to conserve the prime agricultural lands to preserve the future generation.

Table 1: Data types and sources

S/N	Data type	Date of Production	Bands	Resolution	Source
1	Landsat -TM	1984	R(4), G(3), B(2)	30	GLCF
2	Landsat-TM	2000	R(4), G(3), B(2)	30	GLCF
3	Landsat-MSS	2010	R(7), G(4), B(4)	57	GLCF
4	Topographical map	2006		1:50,000	Geography Dept. UI

Table 2: Land use changes of Ido LGA during 1984-2010.

Land use pattern	Area in 1984 (ha)	Area in 2000 (ha)	Area in 2010 (ha)	Changes in Area (1984-2000)	% Change in area (1984-2000)	Changes in Area (2000-2010)	% Change in area (2000-2010)	Changes in Area (1984-2010)	% Change in area (1984-2010)
Agricultural	81,227.5	78,916.45	77,114.07	2311.05	2.17	1802.38	1.69	4113.43	3.86
Urban	553.22	4306.54	9385.95	3753.32	-3.52	-5079.41	-4.77	-8832.73	8.29
Forests	23,950.15	22,529.04	19,245.27	1421.11	1.33	3283.77	3.08	4704.88	4.41
Bare	108.93	88.2	94.84	20.73	0.02	-6.64	-0.006	14.09	0.01
Waterbodies	750.65	750.22	750.32	0.43	0.0004	-0.1	-0.00009	0.33	0.0003

Table 3: Loss of agricultural land in Ido LGA during 1984-2010.

Year	Agricultural Land (ha)	Duration	% Decreased	% Changes/Yr
1984	81,227.5	-	-	-
2000	78,916.45	1984-2000	2.17	0.13
2010	77,114.07	2000-2010	1.69	0.17
		1984-2010	3.85	0.15

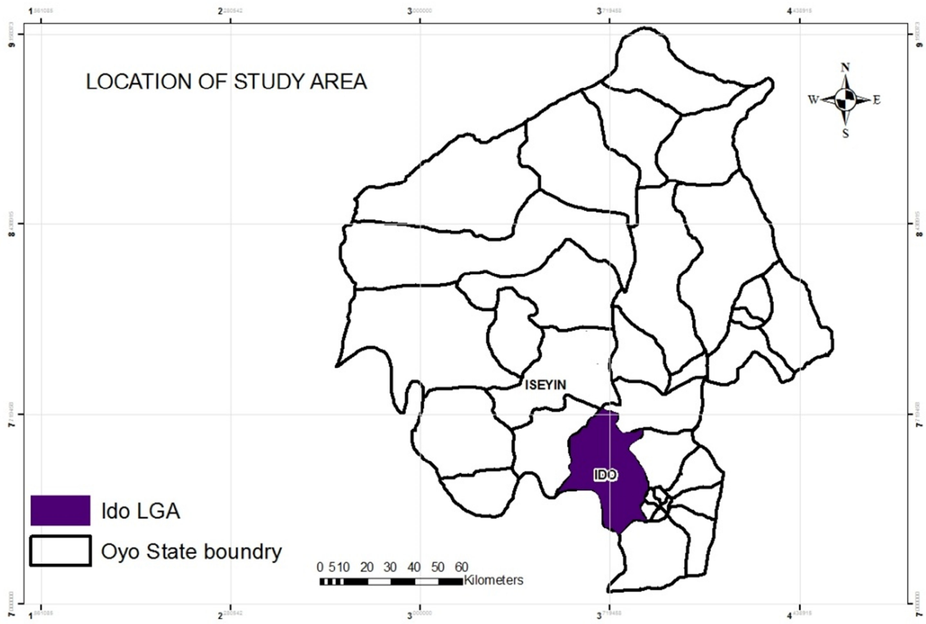

Figure 1: Location of study area

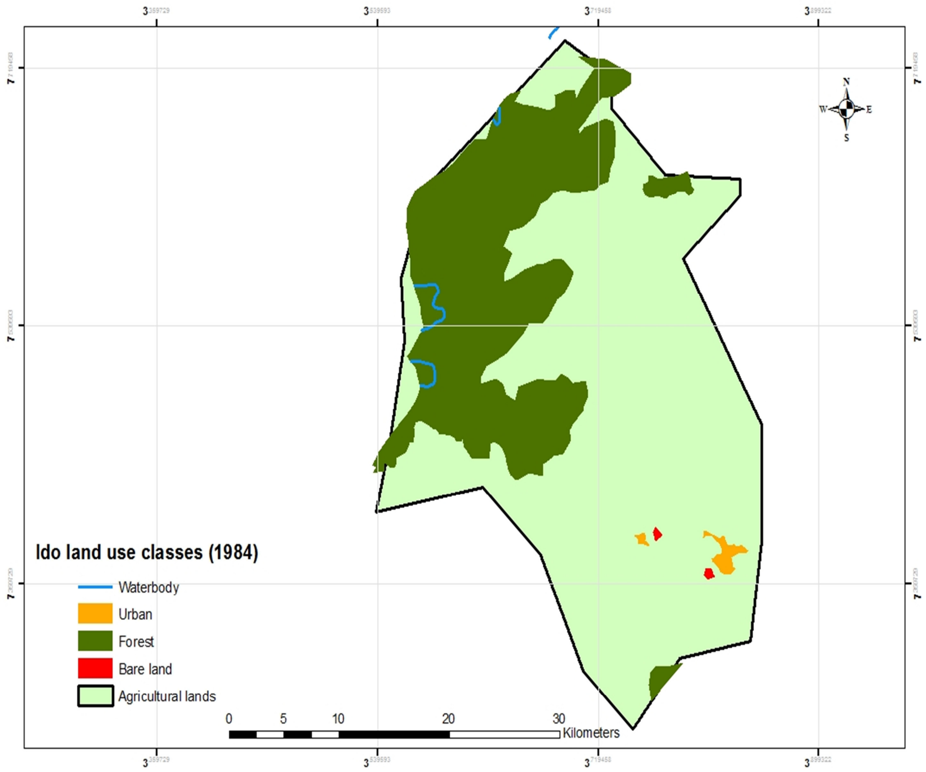

Figure 2: Land use map of Ido LGA (1984) (*Derived from landsat imagery)*

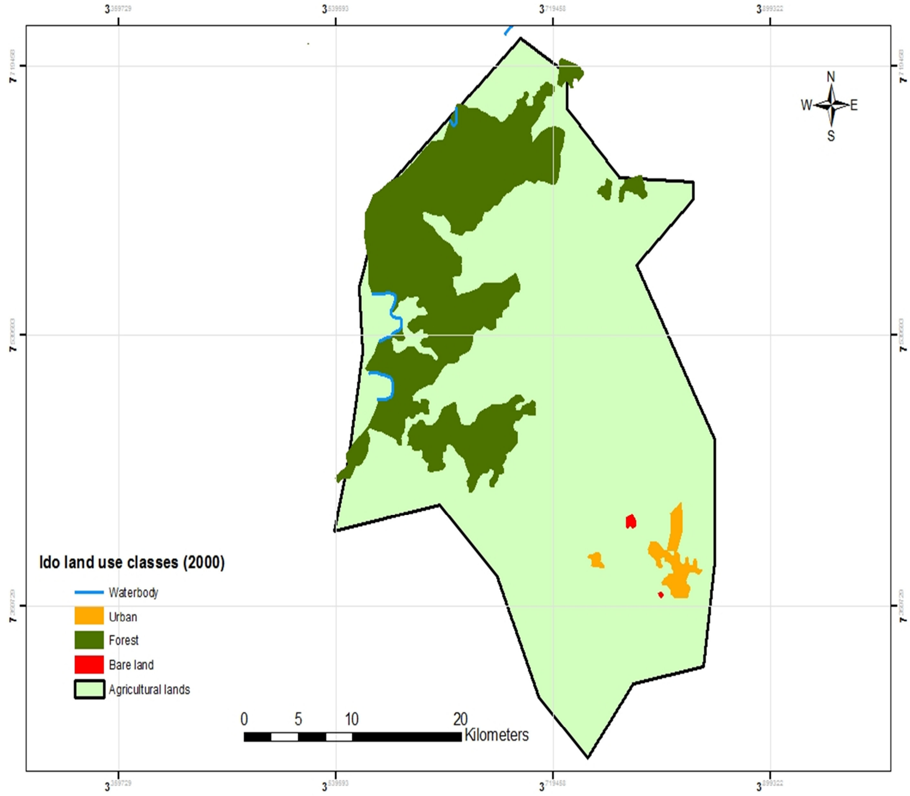

Figure 3: Land use map of Ido LGA (2000). (*Derived from landsat imagery)*

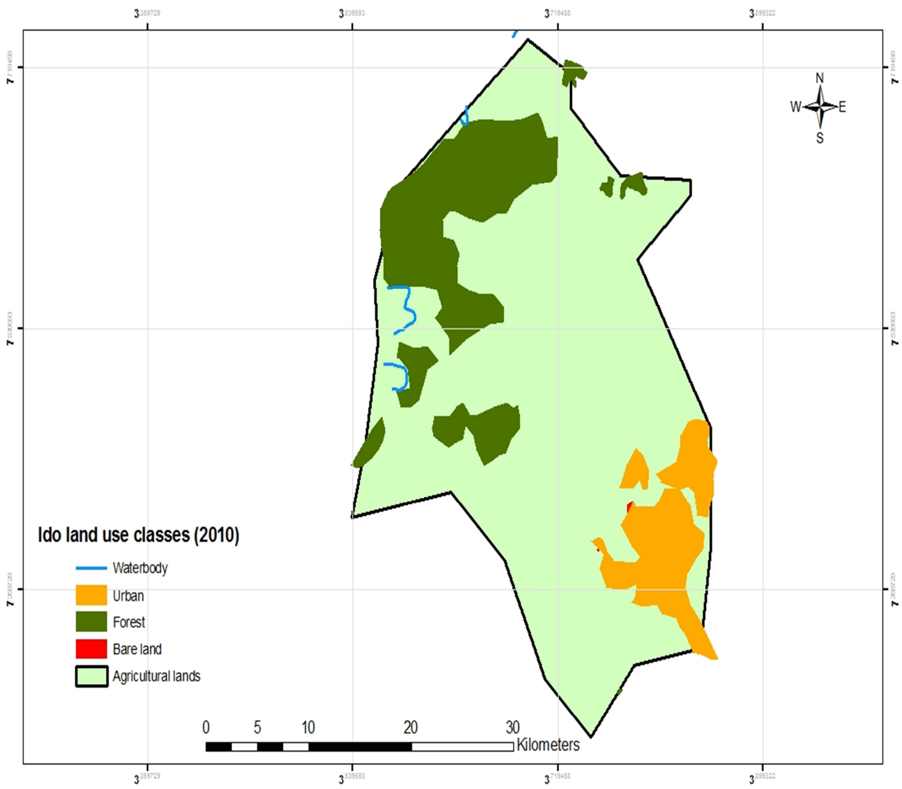

Figure 4: Land use map of Ido LGA (2010) (*Derived from landsat imagery)*

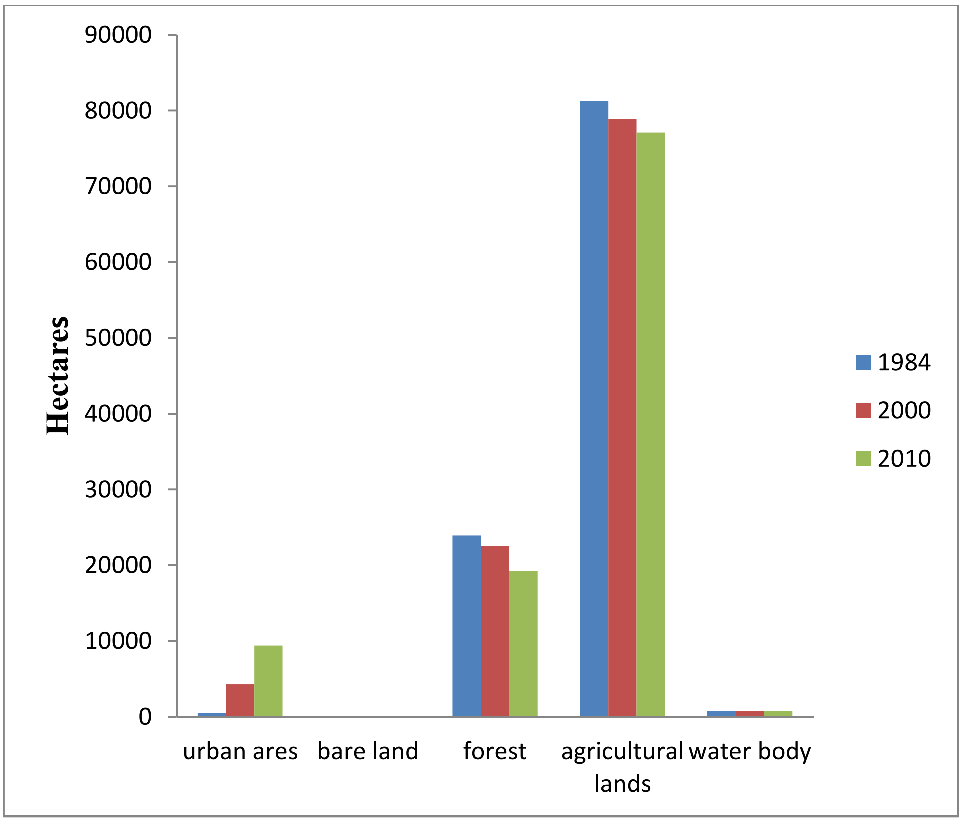

Figure 5: The classified land use pattern of Ido LGA in 1984, 2000 and 2010 (*Source: Landsat TM-1984, Landsat TM-2000 and Landsat MSS-2010).*

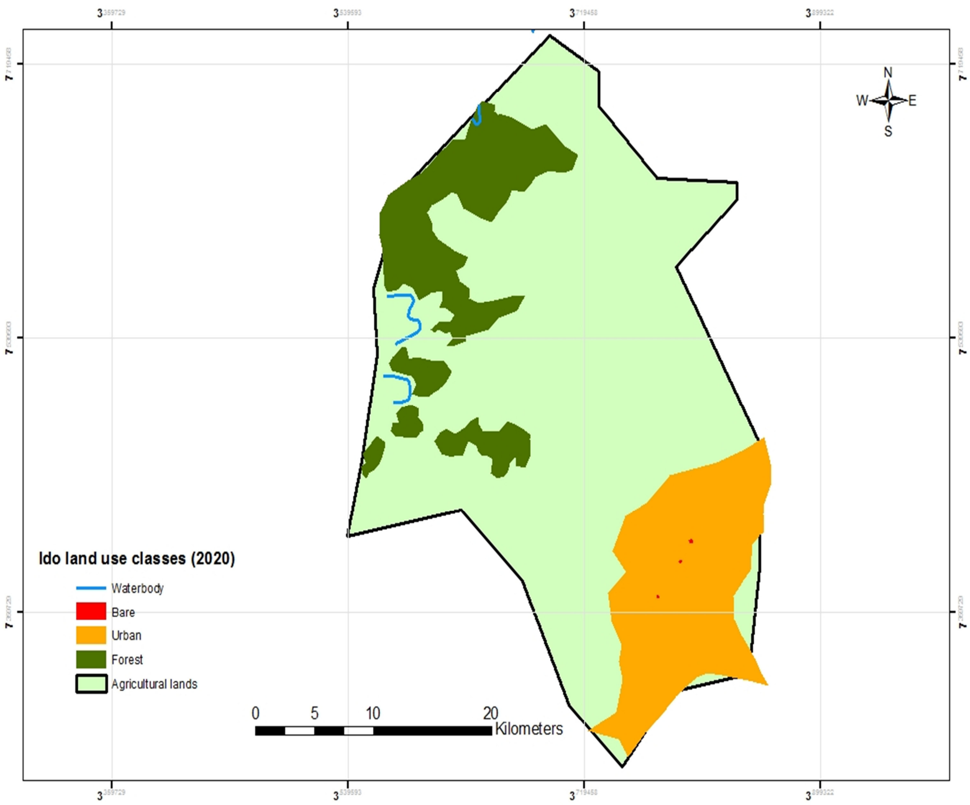

Figure 6: Projected Ido LGA land use classes in 2020.

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