Makerere University Journal of Agricultural and Environmental Sciences
Vol. 10 (1). pp. 47 - 59, 2021
Printed in Uganda.
ISSN 1563-3721

Mapping riparian vegetation change in the Omo Biosphere reserve, Ogun State, Nigeria

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Abstract

The uniqueness of riparian forest and its variation in landscape, geomorphology, contours of the water ways and drainage flow is of great ecological importance, and provides benefits to aquatic, terrestrial habitats and the species that live there. This study addressed the rate of degradation of the riparian vegetation of Omo Biosphere Reserve. The objective of this study was to determine the level of changes in the forest along the riparian zone of Omo Biosphere Reserve in Nigeria, as a basis for effective planning and sustainable management of riparian vegetation. Both primary and secondary data sources were exploited in this study. The primary data included the satellite images acquired over the study area from 1986 to 2016; while the secondary data included topographical maps, administrative boundary and limits of the biosphere reserves acquired from various sources. The satellite images included Landsat images of 1986, 1996, 2006; and 2016 of the study area. Digital image processing was carried out on all the remote sensed imageries; to enhance features of interest and for easy interpretation. The satellite images were processed, using the Erdas Imagine version 2014. The maximum likelihood algorithm classifier was used in classifying the images using the trained pixels into Forest, Settlement, Waterbody, Grassland/Shrubland, Riparian and Cultivation class. The trends of land-cover change showed gradual reduction in forest features, with overall loss of 30.57% of the initial forest cover in the 30-year period; while built-up, cultivations and shrubland/woodland experienced gains with cultivated land having the highest gains. It is concluded that decrease in riparian vegetation is a result of expansion in cultivated land and built-up areas. This implies the need for adopting management plans such as public education in biodiversity conservation, routine maintenance and strict adherence to conservation rules.

Key words: Built-up, cultivation, forest, remote sensing, shrubland, sustainable management

Introduction

Riparian vegetation has an important role to play in the creation of aquatic habitat and provision of quality water (Mollot and Bilby, 2008). They serve as wind breaks for livestock and crops, a habitat for pollinating insects, provides wood products (e.g. timber, poles, charcoal), seeds, essential oils, foliage, honey, bush foods and pharmaceuticals (Robins, 2002; Lovett *et al*., 2004). Unfortunately, they are under severe threat worldwide and management strategies particularly in the tropics seem to have limited effects on mitigating this menace (Sparovek *et. al.,* 2002).

These vegetations are affected by fluvial processes such as flooding and deposition, naturally sustain a distinctive flora that varies in structure and function from neighbouring terrestrial vegetation (Gregory *et al.,* 2005). Human modifications affect riparian vegetation directly and indirectly through land conversion and regulation of the hydrological regime (Chatzinikolaou *et al*., 2011). The elimination and alteration of vegetation in sensitive riparian areas have been common land management practices in the past, and have had a number of deleterious impacts on the health of both terrestrial and aquatic ecosystems. Throughout the world, the ecological condition of natural riparian systems has declined (Naiman *et al*., 2005). Consequently, restoration of riparian vegetation has become a global resource management priority (Holmes *et al*., 2005; Hughes *et al*., 2005).

Despite the beneficial role of riparian vegetation, it is jeopardised by constant degradation by human activities at an unprecedented rate. These activities have resulted into serious ecological problems that may take several years to restore; or may even be irreversible. Rapid population growth has created need for natural resources exploitation, especially in developing countries where demands for energy and food have accelerated the extraction of fuel wood and expansion of arable lands for agricultural production (Population Reference Bureau, 1992). Presently, cultivated lands have increased at the detriment of grazing and woodlands, such that some indigenous pastures have almost disappeared. The objective of this study was to determine the level of changes in the forest along the riparian zone of Omo Biosphere Reserve in Nigeria, as a basis for effective planning and sustainable management of riparian vegetation.

Methodology

Study area

The study was conducted in Omo Biosphere Reserve in Nigeria, which is an internationally recognised unique habitat, whose landscape has been partitioned as a result of biological population protection to meet the requirement of a typical biosphere reserve. This study was carried out within the zonation of the reserve *viz*: the core (Strict Nature Reserve), the buffer zone and the transition zone within Omo Biosphere Reserve in Ogun State, Southwestern Nigeria.

The core zone covers about 460 hectares; while the buffer zone surrounds the core area with an area of 8,165 hectares. On the other hand, the transition zone trans-borders the buffer zone and covers an area of 666,498.75 hectares. Each of these zones are separated by forest road, foot path, river streams or enclaves. Riparian areas within the biosphere consist of vegetations along major rivers, streams and wetlands. Based on accessibility to the sites, representative sites were chosen along the major river, streams and uplands in each of the core, buffer, and transition zone. This study area stretches North from latitudes $6^{o}\ 35^{1}$ to $7^{o}\ 05^{1}$ N and East $4^{o}\ 19^{1}$ to $4^{o}\ 40^{1}$ E in Ijebu area of Ogun State, Southwestern Nigeria (Fig. 1)

Data collection

Both primary and secondary data sources were exploited in this study. The primary data included the satellite images acquired over the study area from 1986- 2016; while the secondary data included topographical maps, administrative boundary and limits of the forest reserves acquired from various sources. The satellite images included Landsat images of 1986, 1996, 2006, and 2016 of the study area. Digital image processing was carried out on all the remote sensed imageries to enhance features of interest and for easy interpretation. The satellite images were processed using Erdas Imagine version 2014. Colour composite was performed on three bands of each of the satellite images while subsetting them to the study area size.

The bands of the acquired satellite images were combined to make a false colour composite. This required use of near infrared band, the red band and the green band of the image. The bands of the satellite images were assigned following colour scheme: Landsat TM, Landsat ETM and Landsat OLI with the RGB 321, RGB 432 and RGB 543 to make the false colour composite. Further processing was done involving enhancement of images and subsetting them to the size of the study area. Supervised classification was adopted for image processing where training of pixels for classification algorithm was performed. Maximum likelihood algorithm classifier was used to classify the images using the trained pixels into Forest, Settlement, Waterbody, Grassland/Shrubland, Riparian and Cultivation class (Fig. 2).

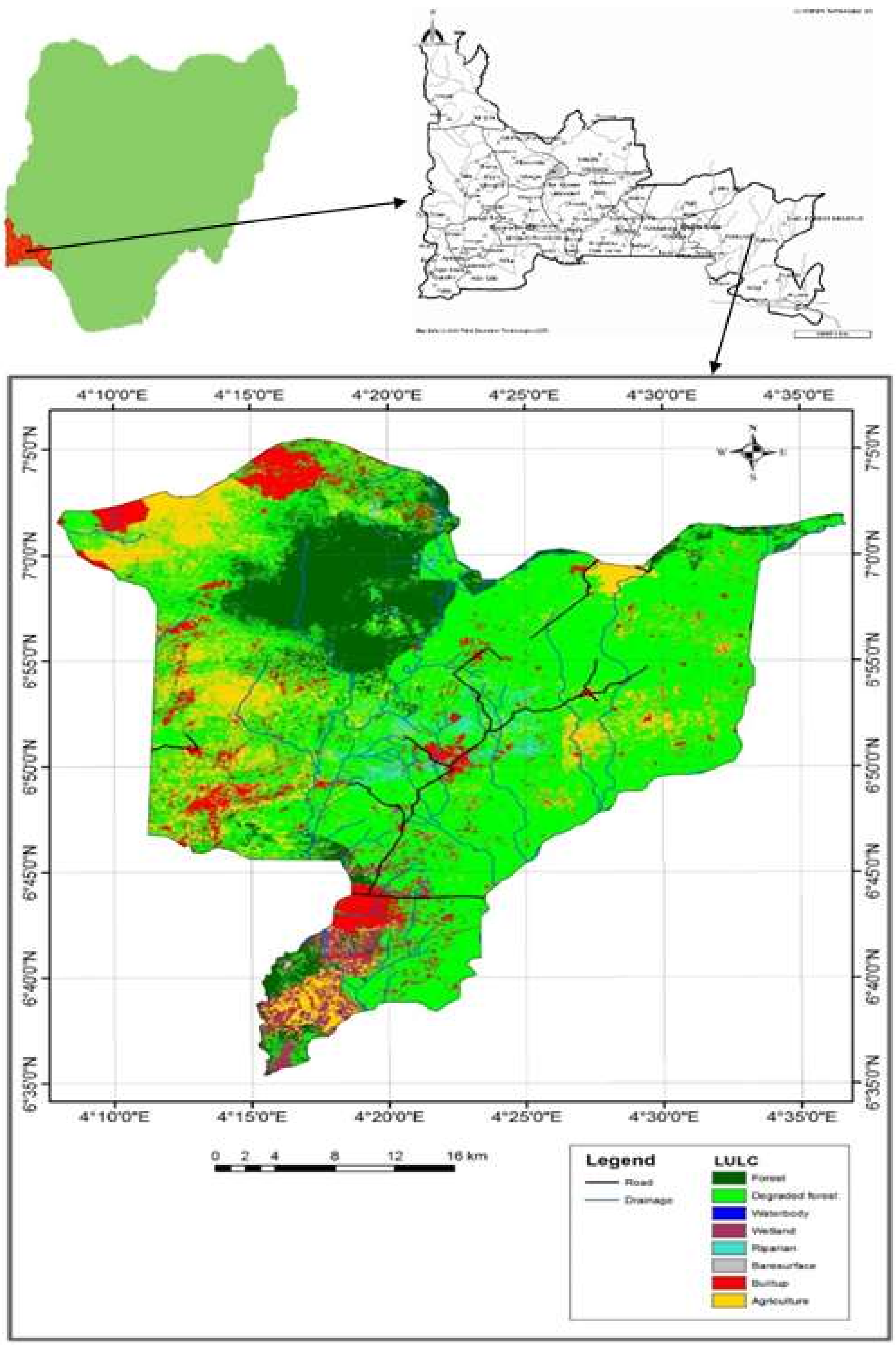

Figure 1. Map of Nigeria showing Ogun state and Omo Biosphere Reserve which was used in this study

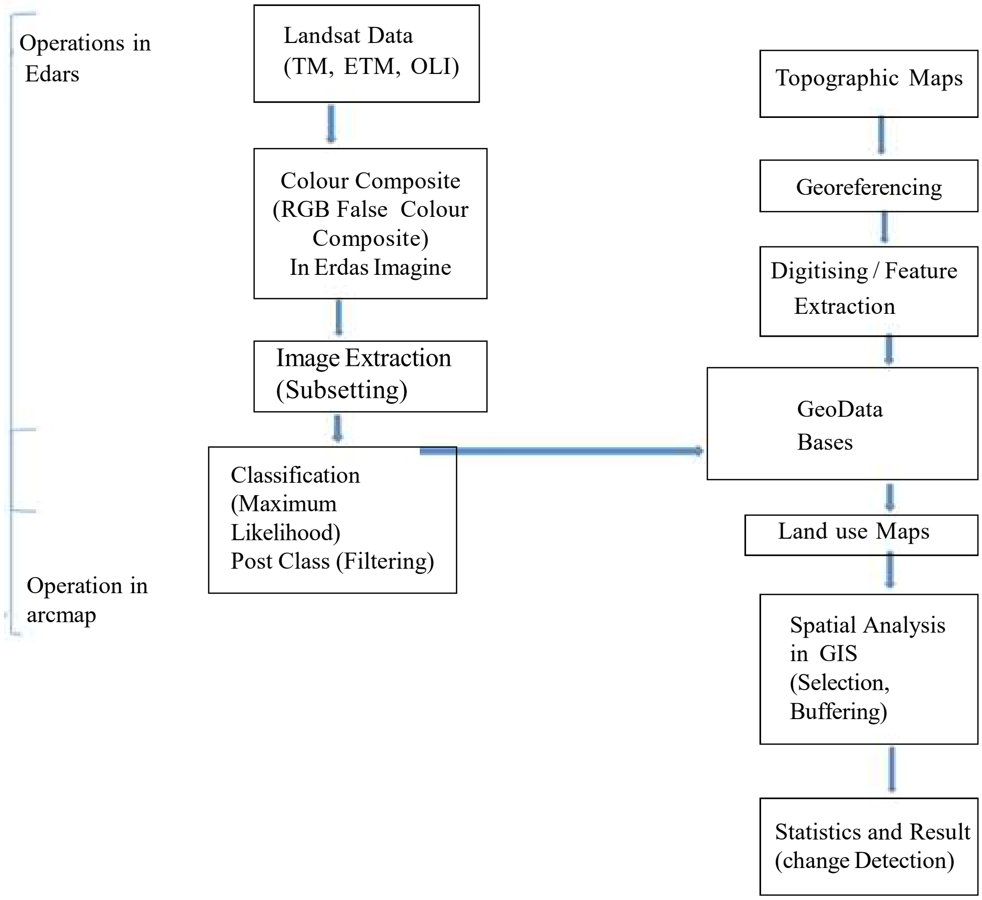

Figure 2. Flow chart showing the process used to determine changes in riparian vegetation mapping in Nigeria.

Each classified image was filtered using median (3×3) so as to clearly identify the various lands in the study area. This was done to reduce the salt and pepper appearance of the classified image, which is due to the fragmented nature of land use found in the area. The same operation was done on the four satellite images that were used for this study.

The accuracy of the classification was obtained using confusion matrix. The classified images were then exported to ArcMap where land use maps were produced for the area in order to determine the extent of change taking place (Fig. 2).

GIS analysis

GIS operations involving digitizing rivers in the study area was buffered to identify the extent of riparian vegetation. The width of riparian forest varies depending on what the buffer is supposed to protect or provide (Chang, 2008). A width of 100 feet (30.48 metres) is necessary for filtering dissolved nutrients and pesticides from runoff. It is also recommended for protecting fisheries and at least 300 feet (91.44 meters) is required for protecting wildlife habitat.

For this study, buffering of 150 metres was adopted and performed on river layers because riparian vegetation within this reach has great influences on the vegetation and river system in terms of ecological services. This width was chosen since it falls within the average of suggested width for all the riparian functions.

Results

Land-use Land-cover Classification for 1986

The classification of the year 1986 Landsat satellite image (Landsat 5 MSS) produced the land-use and land-cover data sets presented in Figure 3. The statistics (Table 1) indicated that at this time, most of the area was forest land-cover with surface area of 1,171.24 Km^2 accounting for 87.76% of the total area. There was also abundance of shrub land/woodland and riparian vegetation covering 58.85 Km^2 (4.41%) and 99.26 Km^2 (7.44%), respectively. The data also showed traces of cultivation covering an area of 0.06 Km^2 (0.01%); while the built-up area in the reserves covered an area of 3.63 Km^2 (0.27%) and water bodies 1.54 Km^2 (0.11%).

Land-use Land-cover Classification for 1996

The classification of the year 1996 Landsat satellite image (Landsat 7 ETM) is shown in Figure 3. The statistics (Table 1) indicates then that most of the area was still forest land-cover with surface area 1041.51 Km^2 (76.02%). Shrub land/woodland, built-up and cultivation land-use and land-cover classes increased to 224.25 (16.81%), 4.12 (0.31%) and 1.37 (0.10%) Km^2, respectively. The riparian vegetation in 1996 covered an area of 88.57 Km^2 (6.64%), which was a reduction from 99.26 Km^2 in 1986.

Land-use Land-cover Classification for Year 2006

The classification of the year 2006 Landsat satellite image (Landsat 7 ETM) is presented in Figure 3. The statistics (Table 1) showed that, most of the area was still forest land-cover with surface area 923.65 Km^2 (69.23%). Following from above results, shrubland/woodland, builtup and cultivation land-use and land-cover classes increased to 303.26 Km^2 (22.73%), 5.38 Km^2 (0.40%) and 19.85 Km^2 (1.49%), respectively. The riparian vegetation in 1996 covered an area of 80.39 Km^2 (6.02%) which was a reduction from 88.57 Km^2 in the year 1996 (9.24% loss).

Table 1. Statistics of land-use and land-cover datasets in Omo Biosphere Reserve in Nigeria (1986-2016)

	1986		1996		2006		2016	
Land-use/land-cover	Area (Km^2)	% Cover	Area (Km^2)	% Cover	Area (Km^2)	% Cover	Area (Km^2)	% Cover
Forest	1171.24	87.76	1014.5	76.02	923.65	69.23	813.2	60.95
Built up	3.63	0.27	4.12	0.31	5.38	0.4	11.2	0.84
Cultivations	0.06	0.01	1.37	0.1	19.85	1.49	35.63	2.67
Shrubland/woodland	58.85	4.41	224.5	16.81	303.26	22.73	392.4	29.41
Riparian	99.26	7.44	88.57	6.64	80.39	6.02	80.04	6
Waterbody	1.54	0.11	1.66	0.12	1.7	0.13	1.75	0.13

1986: Overall Accuracy: 99.41%, Kappa coefficient: 0.8838
1996: Overall Accuracy: 99.37%, Kappa coefficient: 0.9707
2006: Overall Accuracy: 96.33%, Kappa coefficient: 0.9123
2016: Overall Accuracy:90.02 %, Kappa coefficient: 0.7886

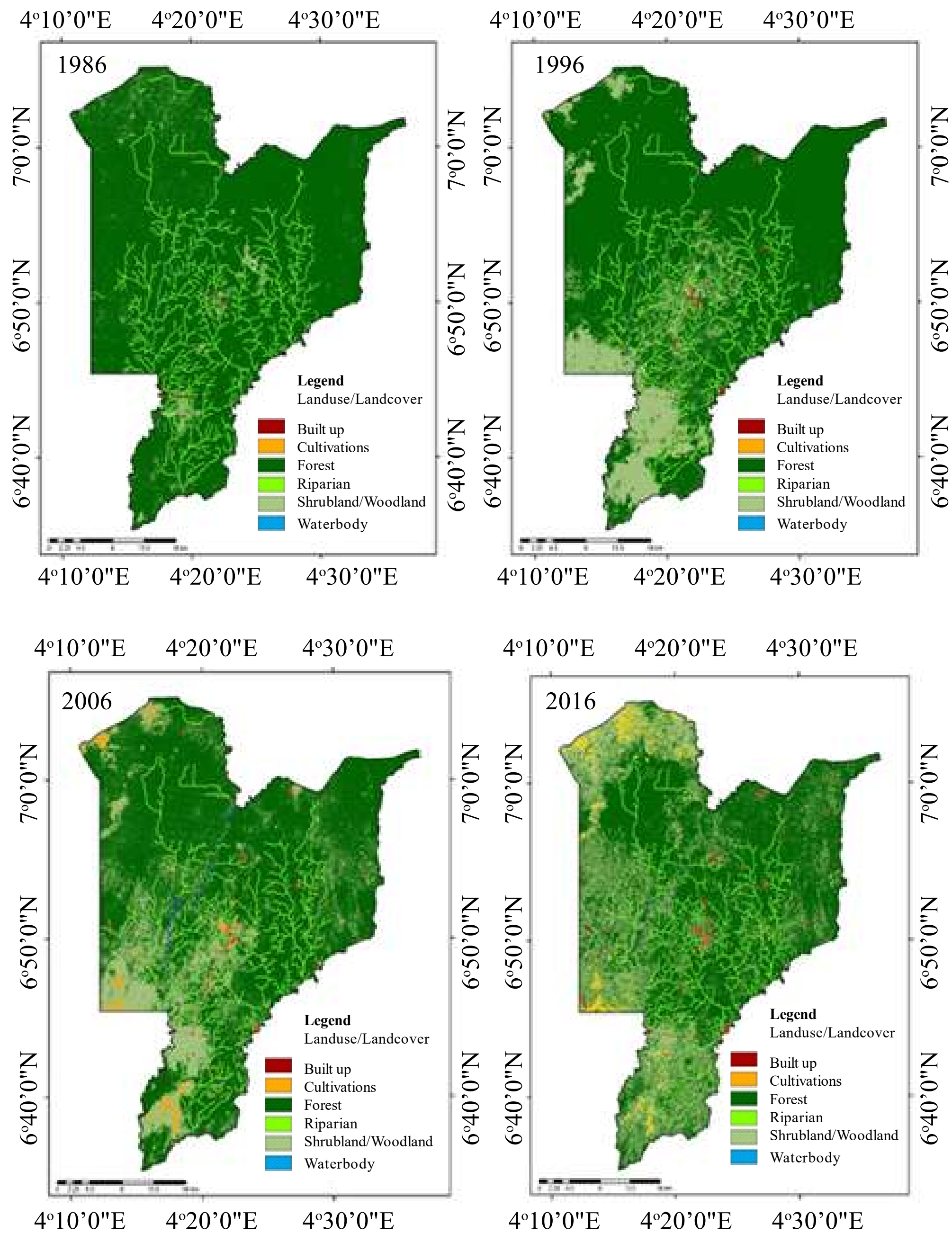

Figure 3. Land-use and land-cover map of Omo Biosphere Reserve in Nigeria (1986-2016).

Land-use Land-cover Classification for Year 2016

The classification of the year 2016 Landsat satellite image (Landsat 8 OLI) is shown in Figure 3. The statistics (Table 1) showed that in 2006, most of the area was still forest land-cover with surface area 813.20 Km^2 (60.95%). Shrubland/woodland, built-up and cultivation land-use and land-cover classes increased to 392.40 (29.41%), 11.20 (0.84%) and 35.63 (2.67%) Km^2, respectively. The area covered by the riparian vegetation in 2016 stands at 80.04 Km^2 (6.00%), which is a reduction from 88.57 Km^2 in 2006 (0.43% loss).

Land-use and Land-cover Change and Trends between 1986 and 2016

The nature of changes in the various land-use and land-cover of the study area is as presented in Figure 4. The trends of land-cover change showed gradual reduction in forest features, with overall loss of 30.57% (Table 2a and b) of the initial forest cover in the 30-year period. The data also showed a considerable loss of the riparian vegetation with overall loss of 19.36% of the initial 99.26 Km^2 (Table 2b) of the land-cover lost between 1986 and 2016 (Fig. 5). However, the rate of removal of the riparian vegetation slowed down gradually from 1986-2016.

Other land-uses and land-cover types such as built-up, cultivations and shrubland/woodland experienced gains, with cultivated land having the highest gains. Cultivated land in the study area covered a meagre area of 0.07 Km^2 at 1986. But by 2016, the areas cultivated was 35.63 Km^2. Furthermore, shrubland/woodland also showed

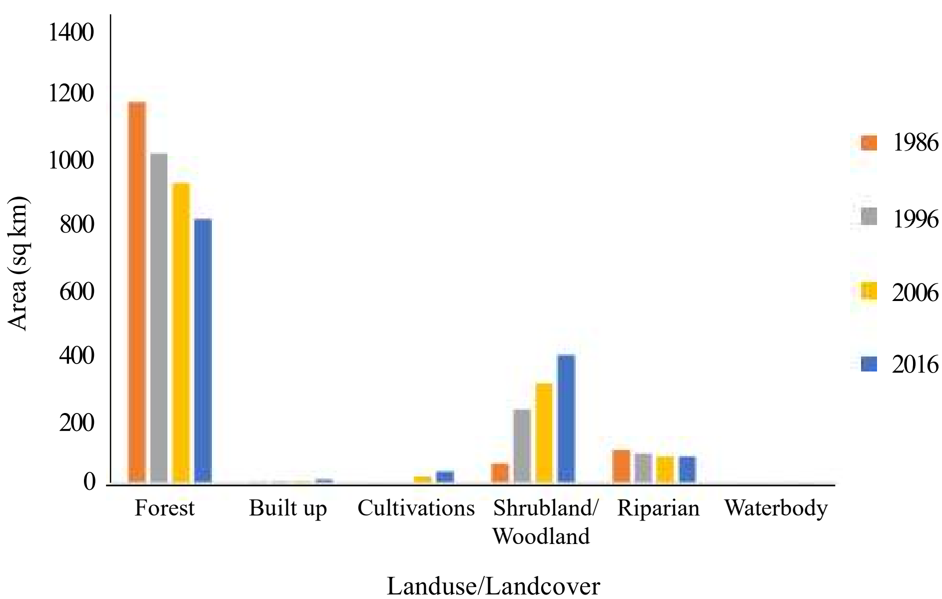

Figure 4. Comparison of the Land-use and Land-cover classes in Omo Biosphere Reserve, Ogun State, Nigeria.

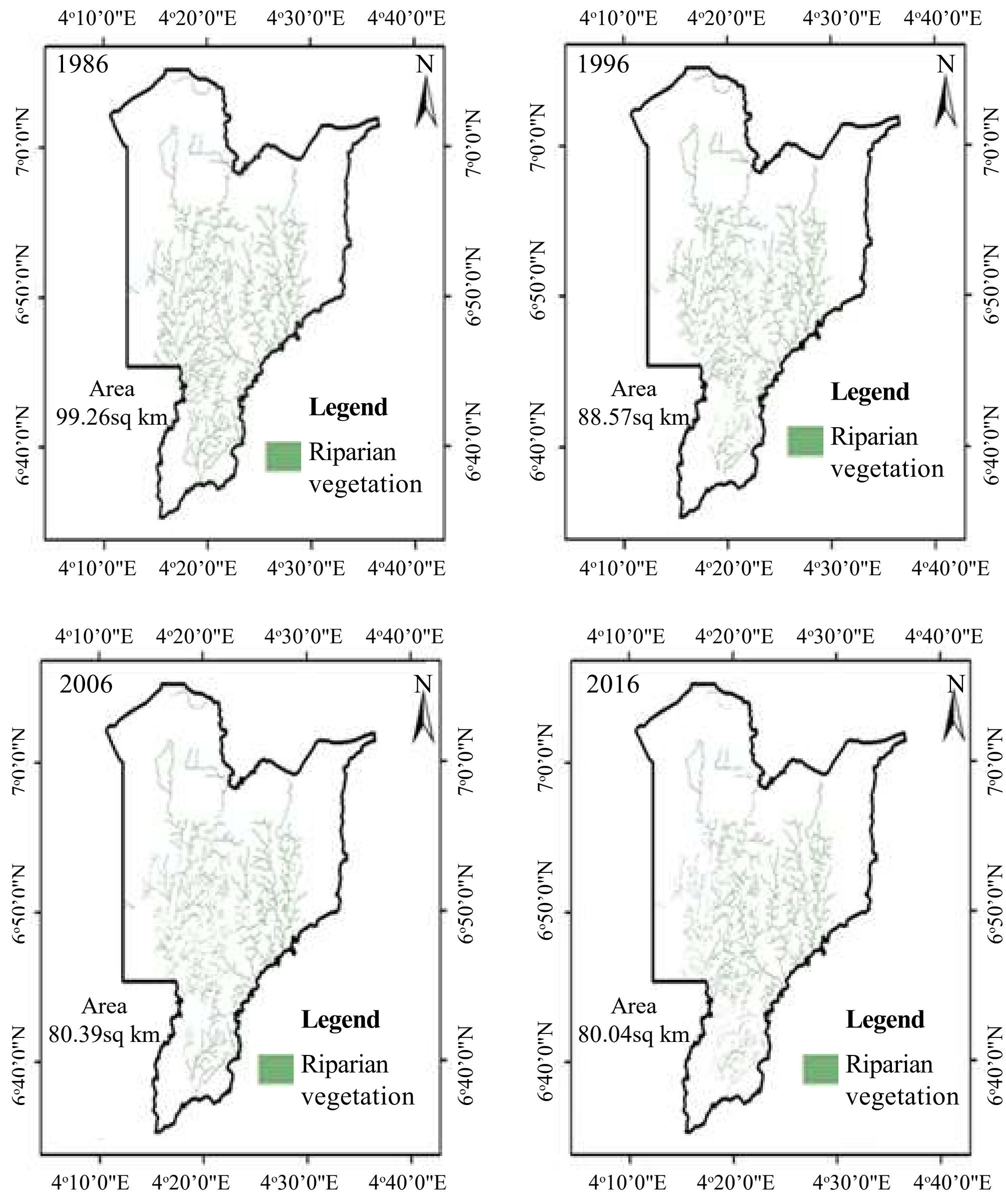

Figure 5. Riparian Vegetation Changes of Omo Biosphere Reserve, Ogun State, Nigeria. (1986-2016).

rapid increase over the years, with an overall 35.23% increase. The trend also showed that the extension of shrubland/woodland land-cover was more rapid in earlier years and slowed down in recent years. In the same vein, built-up areas marginally increased in size whereas waterbody remained nearly constant in area.

Table 2a. Land-use and Land-cover change between in Omo Biosphere Reserve Ogun State, Nigeria (1986 and 2006)

Land-use/Land-cover	Change 1986 and 1996 (sq Km)	% Change 1986 and 1996	Change 1996 and 2006(sq Km)	% Change 1996 and 2006
Forest	-156.73	-13.38	-90.86	-8.96
Built-up	0.48	13.18	1.27	30.9
Cultivations	1.31	2178.95	18.48	1348.75
Shrubland/Woodland	165.40	281.07	79.01	35.23
Riparian	-10.70	-10.78	-8.18	-9.24
Waterbody	0.12	7.65	0.05	2.93

Table 2b. Land-use and Land-cover and overall change of Omo Biosphere Reserve, Ogun State, Nigeria between 2006 and 2016

Landuse/Landcover	Change 2006 and 2016 (sq Km)	% change 2006 and 2016	Overall change 1986 and 2016 (sq Km)	% change 1986 and 2016
Forest	-110.45	-11.96	-358.03	-30.57
Builtup	5.82	108.15	7.57	208.39
Cultivations	15.78	79.54	35.57	59178.28
Shrubland/Woodland	89.12	29.40	333.557	566.80
Riparian	-0.34	-0.43	-19.22	-19.36
Waterbody	0.048	2.80	0.21	13.90

*A negative values indicate decrease in the land-cover value over the years being compared

Discussion

The land use and land cover change analysis of Omo Biosphere Reserve, Ogun State, Nigeria showed reduction in forest and riparian ecosystem and increase in built-up, cultivations and shrubland/woodland as anthropogenic activities increase in the area. The datasets showed an overall 30.57% loss of forested area over 30 years (1986-2016).This illustrates a similarity in percentage loss of riparian vegetation change in the upper Yedzeram Basin of the Mubi region in Adamawa State, Nigeria having a loss of 16.7% between 1975 and 1987 and 13.05% between 1987 and

1999 (Orimoogunje and Gadiga 2011). Majority of the areas originally with forest cover were converted to lower vegetation, or replaced by human created land use such as built-up or cultivation. There was a similar relationship with respect to the reduction in the percentage cover between the forest cover and the riparian vegetation as shown in Tables 1 and 2. Habitually, the forest cover protects the riparian ecosystem from exposure to deforestation. Thus, in the study area, a similar trend of reduction in the forest cover is observed along the riparian vegetation ecosystem. The gradual proliferations of farmlands and the expansion of built-up has resulted in the loss of forest cover and ultimately, reduction in the riparian vegetation in the study area from 99.26 Km^2 in 1986, to 80.04 Km^2 in 2016; 19.36% loss in riparian forest was obtained by difference of loss from 1986 to 2016 (99.26-80.04) divided by the initial 99.26 sq. km multiplied by 100 of the initial riparian vegetation in the study area.

The north-west, south-west and south-south part of the study area showed a steady increase in cultivation (Fig. 3); while the southern part showed a massive destruction of riparian vegetation along with the forest cover. In the central and several localised parts of the study area were built-up areas which increased from 3.63 Km^2 in 1986, to 11.20 Km^2 in 2016 and cultivations which increased from 0.06 Km^2 in 1986 to 35.63 Km^2 in 2016; within a period of 30 years. This is the result of various demands for the forest resources including expansion of farmlands, firewood, and bush burning for game including grazing activities.

Hence, the rate of degradation of the forest and riparian vegetation of Omo Biosphere Reserve is frightening and could eventually lead to total loss of biodiversity and deforestation, which will jeopardize the needs of the future generation and contribute to increase in the menace of global warming if mitigation measures are not put in place. This implies the need to adopt efficient environmental approaches for sustainable management plans such as public education in biodiversity conservation, routine maintenance and strict adherence to conservation rules at the local, state and national levels to protect the ecosystem as well as embarking on ecological restoration projects on degraded sites to replace the lost indigenous species naturally endowed in the reserve to ensure better survival rates in this ecosystem.

Conclusion

The study of riparian vegetation in the study area has provided useful information on the extent to which vegetation has progressively been lost during 1986 to 2016. The cause is mainly increased cultivation in the region. Remote sensing and Geographic Information System serve as valuable aid in providing fast, effective and precise information to detect changes with the riparian environment.

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