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FOREST COVER CHANGES AND LAND USE DYNAMICS IN OLUWA FOREST RESERVE, SOUTHWESTERN NIGERIA

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ABSTRACT

This study examined the extent of resource use and the level of degradation consequent upon land use. Three distinctive trends were observed in terms of forest and land cover dynamics. These are forest degradation, deforestation and regeneration. The paper integrated both, topographical map of 1969 and satellite imageries from Landsat MSS 1972, and Landsat TM 1991 and 2000 with ground truthing and socio-economic surveys to assess changes in forest resource use and land cover in South-western Nigeria. The satellite images were analysed using ILWIS software version 3.4. Based on ground truth data and remotely sensed data, the study area was classified into five categories using the supervised maximum likelihood classification technique. The accuracy assessment was carried out on the remotely sensed data. A total of 30 points for each dataset were selected for this operation and the overall accuracy of 90%, 86.7% and 85% respectively was obtained from the three image datasets. Results showed three dominant ecological communities in Oluwa Forest Reserve while two effects of changes on species were identified. The first was the replacement of what could be considered as the original species by other species tolerant to the 'new' ecosystem. The other was the reduction in the range of the original species that could be found. This was an indication that the area had been fragmented comparing to its original status. Results suggest that resource utilization and land cover change dynamically over time. The study also revealed that the creation of forest reserve to restrict local access and resource use would have been an effective tool for regulating encroachment and logging activities if there was an effective enforcement of regulation. It is therefore obvious that the main aim of environmental management should be the protection of the natural living space of humankind and integration of environmental scarcity in making decision on all economic issues and activities.

Key words: Forest resources, land use, land covers, human activities, sustainability

INTRODUCTION

Land is the stage on which all human activity is being conducted and the source of the materials needed for this conduct (Meyers, 1995; Geist, 1999; Orimoogunje, 2010). According to Barkley & Seckler (1972), "human history is largely written in terms of the struggle between man and nature over the terms of man's existence". This simple statement alludes to the age-long contest between man and the natural environment on which all economic activities are pivoted. Human use of land resources gives rise to “land use” which varies with the purposes it serves, whether they be food production, provision of shelter, recreation, extraction and processing of materials and so on, as well as the biophysical characteristics of land itself. Hence, land use involves both, the manner in which the biophysical attributes of land are manipulated and the intent underlying that manipulation. Land use dynamics are a major determinant of land cover changes. According to Briassoulis (2001) changes in the uses of land occurring at various spatial levels and within various periods are the material expressions, among others, of environmental and human dynamics and of their interactions, which are mediated by land. This has increasingly been recognized as one of the key research imperatives in global environmental change research (e.g. Turner, et al 1990; Turner & Myers, 1994; Salami, 1995; Adesina, 1997; Lambin et al., 1999; Geist, 1999; Salami et al, 1999; Briassoulis, 2001; Lambin et al, 2001).

Land use involves considerations of human behaviour with particularly crucial roles played by decision-makers, institutions, initial conditions of land cover and the inter-level integration of processes at one level with those at the other levels of aggregation. Lambin et al., (1999) describe the processes by which land cover is modified/converted and these include two main components:

- the activities or operations and inputs that are undertaken or restricted on a piece of land with significant land cover consequences; and
- the goals/intentions motivating these operations, including both the output (goods or services) that are expected, and the forces that cause land uses to occur in a certain way, at a certain time in a certain place.

Land use is a description of function and the purpose for which land is being used. Some of the definitions previously purposed include, “the management of land to meet human needs”, and “human activities which are directly related to the land” (Young, 1994). In addition, land use constitutes a series of activities undertaken to produce one or more goods or services. According to McConnell & Moran (2000), the concept has proved to be a robust one, and has withstood the test of time. Bie et al., (1996) defined land use as a series of operations on land, carried out by humans, with the intention to obtain products and/or benefits through using land resources. If this definition is adopted, land use types can be described in terms of a series of activities and their associated inputs and outputs, and the forces causing this use to occur at a particular place and time.

Changes in land cover by land use do not necessarily imply a degradation of land. A case at hand is that of Ondo State Afforestation Project where a large expanse of land has been transformed from secondary forest regrowth cover through afforestation projects. This might be presumed as an improvement, until demonstrated otherwise (Orimoogunje, 2005). And indeed, this has been the dominant attitude around the world through time. Meyers (1995) revealed that damage might be done with the best of intentions when the harm inflicted is too subtle to be perceived by the land user. It may also be done when losses produced by a change in land use spill over the boundaries of the parcel involved, while the gains accrue largely to the land user. Economists refer to the harmful effects of this sort as negative externalities, to mean secondary or unexpected consequences that may reduce the net value of production of an activity or displace of its cost upon other parties.

Over the years, concerns regarding land degradation have taken several overlapping (and occasionally conflicting) forms (Meyers, 1995; Orimoogunje, 2000). Conservationism emphasized the need to guarantee a sustained supply of productive land resources for future generations. Preservationism has sought to protect scenery and ecosystems in a state as little affected by humans as possible. Modern environmentalism subsumes many of these goals and adds new concerns that cover the varied secondary effects of land use both on land cover and on other related of the global environment. In truth, calculating the balance of costs and benefits from many land use and land cover changes is enormously difficult (Meyers, 1995). For instance, South-western Nigeria is an area of exceptional biodiversity but severely threatened by human land use activities. The principal causes of South-western biodiversity destruction have been its exploration for development and agriculture, especially tree crops and arable crops cultivation (Orimoogunje, 2005). With widespread destruction of native vegetation and the consequent replacement largely by tree crops and exotic plantation, a re-assessment of the floristic characteristics of this important ecological zone has become necessary. Therefore, the full extent and consequences of the proposed changes are often less than certain, as is their possible irreversibility and thus their lasting significance for future generation. Therefore, the focus of this paper is to investigate the extent of forest cover changes and the resulting pattern in the context of the current vegetation of the area.

METHODS AND MATERIALS

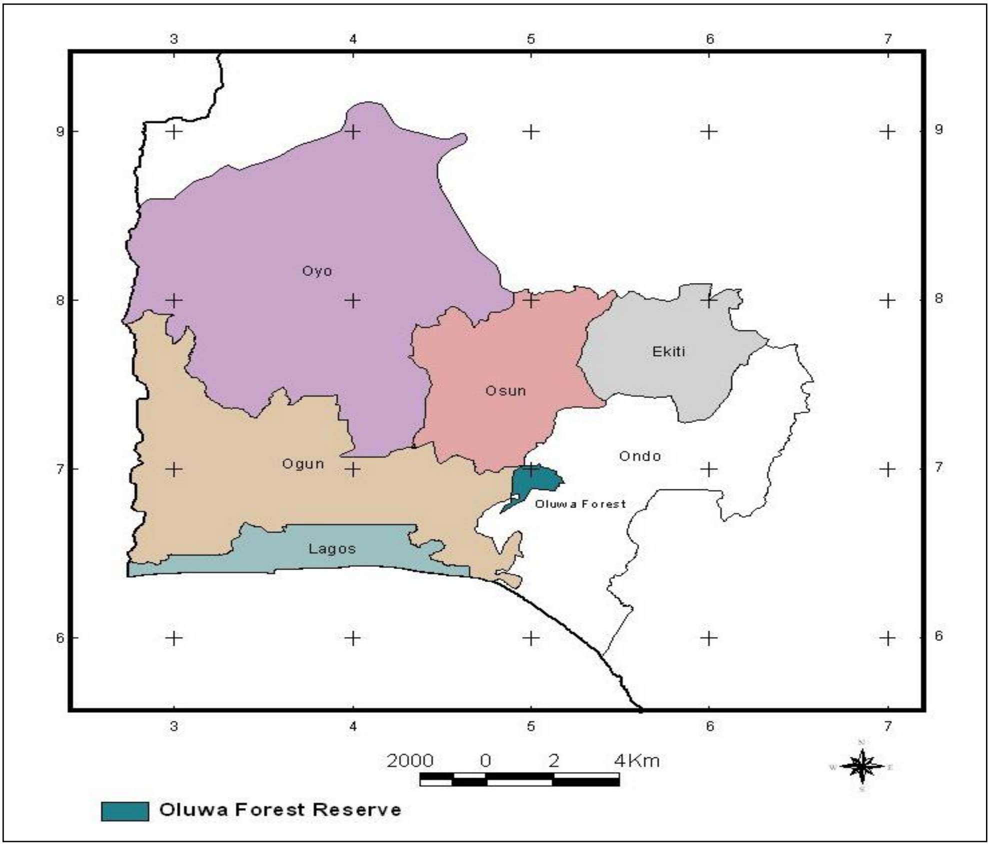
Study Area

The presented study was conducted in Oluwa Forest Reserve, a part of South-western Nigeria. It is located approximately between latitudes 6° 37’ and 7° 20’ north and longitudes 4°27’ and 5° 05’ east (see Figure 1). The area is part of the western plains and ranges of Nigeria with much of it lying approximately between 300 and 600 metres above the sea level (Iloeje, 1981). Most rivers and streams draining this area rise from the southern part of the study area. Notable among the rivers are the Oni, Oluwa, Ominla and Owena. The climate of the study area can be described as humid tropical one (Fosberg, et al, 1961; Garnier, 1961). Mean annual rainfall ranges from 1,200mm to 1,450mm and temperatures are high throughout the year with a mean of about 27°C and an annual range of about 3°C. The natural vegetation of the area is the tropical rainforest characterized by emergents with multiple canopies and lianas. Some of the most commonly found trees in the area include *Melicia excelsa, Afzelia bipindensis, Antiaris africana, Brachystegia nigerica, Lophira alata, Lovoa trichiliodes, Terminalia ivorensis, T. superba, Triplochiton scleroxylon,* etc. However, the natural vegetation of the area with the exception of the areas devoted to forest reserve has now been reduced to secondary regrowth, forest thickets and fallow regrowth at varying stages of development or replaced by perennial and annual crops (Osunade, 1991). These perennial crops include cocoa, kola and citrus.

Methodology

Both, topographical map sheets of 1: 50 000 and satellites imageries were utilized for the study. The study area was demarcated on the map and divided into 5km x 5km grid, which gives 25 square grids out of which 10 square grids were selected using the table of random numbers. Each grid was subdivided into 1km x 1km out of which 10 were again selected randomly. Ten quadrats of 40m x 25m were demarcated from each of the selected 1km x 1km grid for vegetation analysis. In total, hundred quadrats were selected altogether (See, Salami, 1995; Orimoogunje, 2009; Ekanade & Orimoogunje, 2012). In order to gather adequate and up-to-date information necessary for research of this kind, questionnaires were designed and administered to all the farmers within the study area. On the whole, 350 questionnaires were administered using purposive sampling method. The generated data have a specific focus on gathering information about the nature, history and socio-economic aspects of the land use in the study area. The inventory of both, the flora and fauna was also compiled. Land uses were identified and classified based on colour, texture, shape and size using the Integrated Land and Water Information Systems (ILWIS) 3.3 software. In order to minimize the different radiometric properties caused by season, which could affect the classification, the training sites were chosen at the same spatial position where there were the same land covers in different year. Target parcels were sampled based on ground survey after the contrast enhancement. The classes of target sites include: the arable crop cultivation, tree crop cultivation, exotic tree plantation, dense forest and settlement/open space. The maximum probability algorithm was used for final classification. The mathematics of the maximum likelihood decision rule, which was applied, has been explained by Tatsuoka (1971). The result of the classification in 2000 was cross-checked with ground truthing of the land cover in the study area. The precision was above 90%. This shows that the classification method was reliable. Principal Components Analysis was used to analyse vegetation properties.

Fig. 1: The study area in South-western Nigeria



RESULTS AND DISCUSSION

Land use Categorization

Table 1 shows the pattern of vegetation cover and land use type in the study area between 1972, 1991 and 2000 using three remotely sensed imageries. The table shows that the area of coverage by exotic plantation cover class increased from 49,034.4 ha in 1972 to 55,683 ha in 1991, but decreased from 55,683 ha in 1991 to 22, 276 ha in 2000, that is, decreased by 60% in 2000 when compared it with situation in 1991. Its degradation rate is 6.7% per year. The result shows that the degradation of exotic species have been existing in the Oluwa Forest Reserve since 1991 and after 1991 its degradation rate started to increase because of the demand for this product and there was no evidence that new plantation was established after 1996.

Table 1 also shows that the area of coverage by tree crop cover class had an increased trend. Between 1991 and 2000, this cover class has increased by 49,438 ha, which was 85.39% of the area covered in 1991 that is with an increasing rate of 9.49% per year. The result showed that the tree crop cover class has been encroaching into the forest reserve land. If this trend should continue the forest reserve may be totally taken over by this class cover. Table 1 further shows that the area of coverage by settlement cover class has increased by 5,123.4 ha i.e. 50.95% of the area covered in 1991; while in 2000 the same land cover increased by 20,855 ha, i.e. 67.45% of the area covered in 1991. The result shows that settlement cover class was on the increase that is more and more people are settling within the forest reserve enclosure contrary to expectation. According to the field survey most of these settlers are illegal farmers and poachers.

Table 1: Areal coverage of land use types in the study area between 1972 and 2000

Land use Type	**1972**		**1991**		**2000**	
	Areal Extent Ha	**% of Total**	**Areal Extent (Ha)**	**% of Total**	**Areal Extent (Ha)**	**% of Total**
Dense forest	130,774.00	70.79	110,826	59.99	19,383	10.49
Exotic tree plantation	49,034.40	26.54	55,683	30.14	22,276	12.06
Arable crop cultivation	-	-	2,671	1.45	56,229	30.44
Tree crop cultivation	-	-	5,505	2.97	55,943	30.28
Settlement/ open space	4,932.60	2.67	10,056	5.45	30,911	16.73
Total	**184,741**	**100.00**	**184,741**	**100.00**	**184,741**	**100.00**

Table 2: The mean values of vegetation parameters on Oluwa Forest Reserve

	Vegetation variable	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
1	Foliage cover (%)	30	34.1	30.8	41.5	45.3	63.7	59	71.7	48.5	47.6
2	Ground cover (%)	31	26.1	36	31.3	33	46.7	43	39.8	30.5	34
3	Tree density	02	04	03	04	04	06	06	08	05	05
4	Tree girth (m) at breast level	1.35	0.87	1.65	0.40	0.59	0.61	0.69	0.62	0.77	0.57
5	Basal area (m^2) per site	3.66	2.87	9.03	1.38	2.88	3.82	3.14	3.18	2.97	1.94
6	No of species	06	05	05	11	10	17	08	07	09	09
7	Species diversity	20.5	38.9	31.5	43.5	44.2	57	54.6	79.8	49.8	46.1
8	Tree height (m)	16.2	13.7	16.5	7.28	10.1	12.27	10.34	13.34	13.07	12.58
9	Vol. of wood (m^3)	91.03	50.55	205.2	22.24	51.76	55.31	60.01	57.43	60.83	40.33

N.B: S1 – S10 Stand for study site: A site is made up of 10 quadrats of 25m X 40 m

From the girth (circumference) and height of trees were derived the tree basal area and the volume of wood for each plot, using conventional formulas as follows:

(i) to derive radius from circumference the formula used is

(ii) $$r = \frac{C}{2\pi} \qquad \text{(i)}$$

Where = r is the radius
C is the circumference
π is the constant with a value of approximately 3.14

(ii) to compute tree basal area and volume of wood the formulas used are:

(a) $$Ab = \pi r^2 \qquad \text{(ii)}$$

where Ab is tree basal area;

(b) $$Vw = \pi r^2 h \qquad \text{(iii)}$$

Where Vw is volume of wood
h is the height of tree.

While tree basal area is expressed in m^2, volume of wood is expressed in m^3

Table 2 shows the mean values of the vegetation properties measured in the study area. The table shows that the foliage cover is generally lower than 50% except in sites 8 where it is slightly above 70%. The foliage is a parameter that describes some aspects of the physiognomy of the forest. When it is complete, i.e. 100%, it suggests a mature and well preserved vegetation unit. On the other hand, lower cover figures indicate broken crowns associated with human activities. Also, high percentages of foliage cover indicate that soils under the plant covers are protected against erosion and organic matter accumulation may be increased. The generally low values of foliage cover in the forest reserve are a manifestation of vegetation degradation. The physiognomic properties evaluated in this study include tree height, tree girth, tree basal area and volume of wood. The height of trees ranged between 7 metres and 17 metres. All these parameters have moderately high values. The tree species density from the different site ranged from 2 to 8 trees per hectares.

Species distribution in the study area

The eigenvalues of the Principal Component Analysis of the floristic data is shown in Table 3. Nine principal components were defined which account for 74.3% of the total variance in the original data. This suggests that the fifty-nine variables can be summarized into nine components.

The principal component-loading matrix is shown in Table 4. The matrix shows that variables 9 (*Bombax sp),* 24 (*Diallium guinensis*), 26 (*Distemonanthus benthamianus*), 30 (*Ficus asperifola*) and 38 (*Lannea welwitschii*) and 7 (*Berlinia spp.)* load high on component I. These are species that are more frequently cultivated by local farmers. The component can therefore be named "Planted species component". Variables 25 (*Disopyros spp),* 28 (*Entandrophragma spp*.), 33 (*Funtumia spp*), 49 (*Piptadeniastrum africana*) and 51 (*Ricinodendron heudelotti*) load high on the second component. These are trees that are more commonly found as self-propagating. The component may be described as "self-propagating tree" component.

Table 3: P.C.A. of Tree Species abundance data: Eigenvalue and Percentage Explanation

Component	Eigenvalue	% of variance	Cum. % of variance
1.	7.39	12.5	12.5
2.	5.71	09.7	22.2
3.	4.39	07.5	29.7
4.	4.06	06.9	36.6
5.	3.27	05.5	42.1
6.	2.92	05.0	47.1
7.	2.56	04.3	52.1
8.	2.03	03.4	54.8
9.	1.97	03.3	58.1
10.	1.67	02.8	60.9
11.	1.50	02.5	63.4
12.	1.42	02.4	65.8
13.	1.33	02.3	68.1
14.	1.29	02.2	70.3
15.	1.21	02.1	72.4
16.	1.13	01.9	74.3
17.	1.11	01.9	76.2
18.	1.03	01.7	77.9
19.	0.96	01.6	79.5
20.	0.88	01.5	81.0
21.	0.87	01.5	82.5
22.	0.83	01.4	83.9
23.	0.75	01.3	85.2
24.	0.74	01.3	86.5
25.	0.67	01.1	87.6
26.	0.65	01.1	88.7
27.	0.61	01.0	89.7
28.	0.59	00.9	90.6
29.	0.51	00.9	91.5
30.	0.49	00.8	92.3
31.	0.46	00.8	93.1
32.	0.39	00.7	93.8
33.	0.37	00.7	94.5
34.	0.34	00.6	95.1
35.	0.30	00.6	95.7
36.	0.29	00.5	96.2
37.	0.27	00.5	96.7
38.	0.23	00.4	97.1
39.	0.20	00.3	97.4
40.	0.18	00.3	97.7
41.	0.17	00.3	98.0
42.	0.16	00.3	98.3
43.	0.15	00.3	98.6
44.	0.14	00.2	98.8
45.	0.13	00.2	99.0
46.	0.11	00.2	99.2
47.	0.11	00.2	99.4
48.	0.09	00.2	99.6
49.	0.08	00.1	99.7
50.	0.07	00.1	99.8
51.	0.05	00.1	99.9

52.	0.04	00.1	100.00
53.	0.03	00.0	100.00
54.	0.03	00.0	100.00
55.	0.02	00.0	100.00
56.	0.02	00.0	100.00
57.	0.00	00.0	100.00
58.	0.00	00.0	100.00
59.	0.00	0.00	100.00

Table 4: P.C.A. of Tree Species abundance Data Component Loading

S/N	VARIABLE	F 1	F 2
1	Afzelia spp.	0.01	-0.08
2	Albizia spp.	-0.05	0.19
3	Alstonia spp	0.48	0.49
4	Amphimas pterocapoides	-0.01	-0.15
5	Anogeissus leiocarpus	-0.16	0.30
6	Antiaris africana	0.21	0.05
7	Berlinia spp.	0.58	0.27
8	Blighia sapida	-0.12	0.34
9	Bombax spp.	0.69	0.31
10	Brachystegia eurycoma	-0.29	0.14
11	Canarium schweinfurthii	0.32	-0.01
12	Carapa procera	0.58	0.21
13	Carapa spp.	0.49	0.14
14	Carica papaya	0.07	-0.10
15	Ceiba pentandra	0.34	0.20
16	Celtis spp.	-0.00	0.11
17	Chrysophyllum spp.	0.03	0.19
18	Citrus spp.	0.27	0.13
19	Cola spp.	-0.03	-0.04
20	Cordial millenii	0.02	0.02
21	Dacryodes edulis	-0.00	-0.00
22	Daniellia ogea	0.07	-0.06
23	Daniellia oliveri	0.01	-0.27
24	Diallium guinensis	0.63	0.21
25	Disopyros spp.	-0.40	0.77
26	Distemonathus benthamianus	0.85	0.36
27	Elaeis guineensis	0.10	-0.07
28	Entandrophragma spp.	-0.35	0.78
29	Erythrophyllum spp.	-0.19	0.23
30	Ficus asperifola	0.59	0.27
31	Ficus capensis	-0.00	-0.14
32	Ficus exasperate	0.25	-0.14
33	Funtumia spp.	-0.37	0.62
34	Gmelina arborea	0.04	-0.25
35	Holoptelia spp.	0.20	-0.18
36	Irvinga spp.	0.29	0.47
37	Khaya spp.	-0.35	0.56
38	Lannea welwitschii	0.85	0.34
39	Lophira alata	-0.32	0.23
40	Lovoa trichiliodes	-0.37	0.49
41	Mansonia altissima	0.41	0.17
42	Masularia spp.	0.06	0.50

43	Milletia spp.	-0.02	0.05
44	Mitragyna stipulosa	-0.57	-0.12
45	Musanga cecropoides	0.10	0.55
46	Musa spp.	0.19	-0.02
47	Nauclea diderrichii	0.14	0.22
48	Nesogordonia papaverifera	-0.70	0.01
49	Piptadeniastrum africaca	0.03	0.65
50	Pterygota spp.	-0.22	0.24
51	Ricinodendron heudelotti	0.04	0.58
52	Sterculia oblonga	-0.59	0.03
53	Sterculia rhinopetala	-0.13	-0.11
54	Tectona grandis	0.28	-0.17
55	Terminalia ivorensis	-0.49	-0.23
56	Terminalia superba	-0.60	-0.13
57	Theobroma cacao	0.15	-0.03
58	Triplochiton scleroxylon	-0.19	-0.16
59	Xylopia spp.	-0.31	-0.04

The implication of these findings is that both natural and anthropogenic forces are strongly at work in the study area. The significance of plants such as *Theobroma cacao* and *Musa spp*. underscore the potency of anthropic factors. In many locations in the reserve, farmers frequently cultivate these tree crops. Indeed, where clear felling has occurred, *Musa spp.* has very frequently taken over as the dominant plant cover. The significance of the natural regenerating factors is also obvious on the sites. For example, the sizes of trees found in some blocks are indicative that there had been protection of the reserve from human influences over many decades. Wherever it is possible to protect the forest, the floristic as well as physiognomic properties of the forest can be enhanced.

Vegetation characteristics of the Study Area

Table 5 shows that the nine variables can be summarized into two components and that these account for 74.3% of the total variance in the data set. The first component accounts for 44.1% of the total variance and so possesses 59.4% of the strength of the two components. This proportion is reasonably representative of the two components combined and so should be reliable for the explanation of the spatial patterning of the study area on the basis of vegetation variables.

Table 5: Factor Analysis of vegetation characteristics: eigen values and percentage Explanation

Principal component	Eigenvalue	Individual % of variance	Cumulative variance
1	3.97	44.1	44.1
2	2.72	30.2	74.3
3	0.99	11.1	85.4
4	0.71	7.9	93.3
5	0.38	4.2	97.5
6	0.13	1.4	98.9
7	0.08	0.9	99.8
8	0.01	0.2	100.0
9	0.00	0.0	100.0

Table 6 shows the principal component loading matrix, mean number of trees per plot, mean density of trees per plot, mean foliage cover and mean number of tree species per plot load highly on component I. These variables describe the richness of the plant communities. Component I can be described as "Luxuriance-Floristic" Component. Basal area, volume of wood, average girth of trees per plot, and average height of trees per plot affect Component II largely. These variables relate to both, biomass and structure of the plant community. Component II can therefore be described as Biomass/Structural component. The correlation matrix shows that V1, V2 and V6 are significantly correlated in the Component I while V8, V9 and V7 are also significantly correlated in Component II.

Table 6: Principal Component Loading Matrix of vegetation characteristics

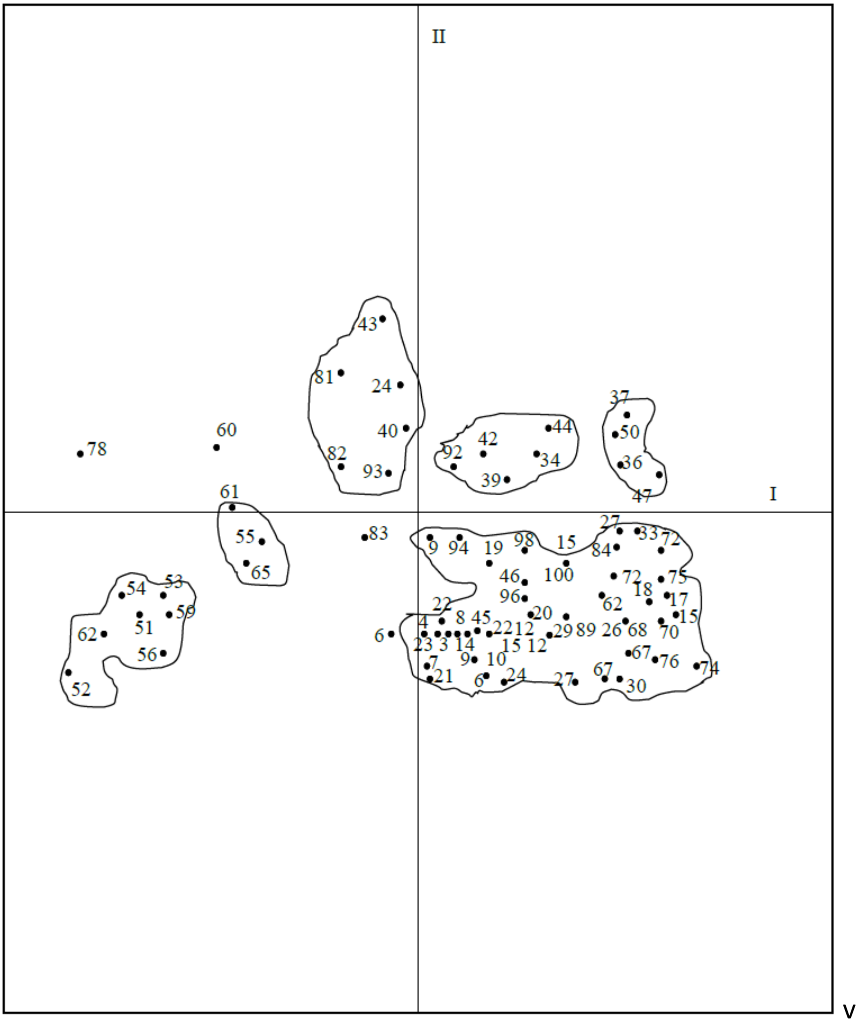
Variable	Principal Component I	Principal Component II
V1	0.80	0.39
V2	0.80	0.39
V3	-0.52	0.51
V4	-0.81	0.52
V5	0.46	0.38
V6	0.78	0.54
V7	0.49	0.63
V8	-0.56	0.74
V9	-0.62	0.70

Spatial Relationships among the selected sites

Components I and II account for the larger percentage of the variance in the data set (74.3%). It is thus reasonable to assess the ecological relationships among the sites in terms of these orthogonal components in terms of specific and physiognomic characteristics of the sites studied. Accordingly, these components were plotted against one another. Figures 2 and 3 show the ecological relationships among the sites from which the data set was generated. On the ordination diagram, sites that show high similarities in terms of species richness are grouped together. In general, sites dominated by trees in which the physiognomic properties have high mean values are located in the upper limits of the two axes while sites that may be described as secondary regrowth including young fallows and sites disturbed by logging occupy the lower limits. Figure 2 is the species ordination while Figure 3 is the physiognomy ordination.

The ordination planes shown by Figures 2 and 3 reveal distinct and simple ecological relationships among species in the study area. Figure 2, which shows the species affinity in terms of attributes, shows three ecological groups. The first group consists of four clusters of forest species and tree crops. The species of both first and second clusters have high loadings on axis I and therefore occupy the upper end of the plane, both, on the right and left. They also cluster around the beginning of the plane. The species compositions of the first cluster are *Milletia spp. and Funtumia spp.* The dominant species in cluster two are *Milletia spp.*, *Pterygota spp.*, *Amphimas pterocarpoides*, *Chrysophyllum spp.* and *Theobroma cacao*. This shows that the area has been opened for tree crop cultivation. The species of the third cluster have high loading on axis I and occupy the left side of the plane. The species composition of this clusters are mainly tree crops. The species of the fourth cluster have high loading on axis II and therefore occupy the lower end of that plane. The second group consists of two clusters of forest species. The species of first cluster have high loading on axis II and therefore occupy the upper end of the plane.

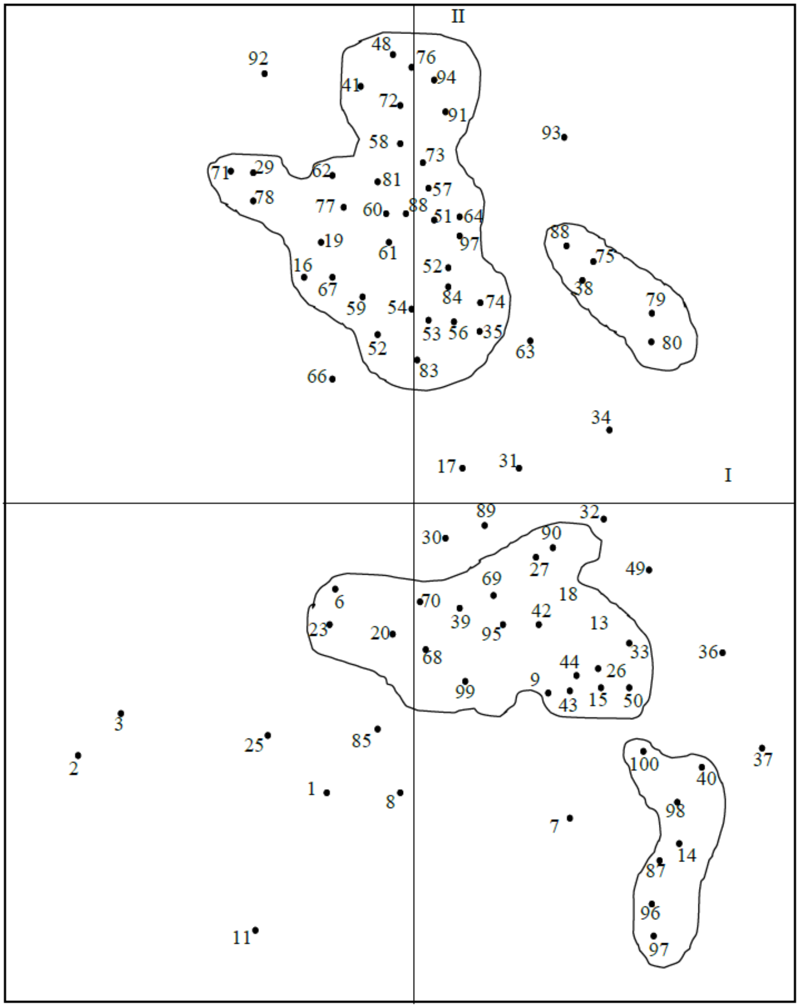
Fig. 2: Species Ordination



N.B: The figures stand for the sampled sites

Forest trees dominate this cluster and some of the dominant species from this cluster are *Nesogordonia papaverifera*, *Teminalia superba*, *T. ivorensis*, *Khaya spp.*, *Erythrophleum spp.* and *Sterculia oblonga*. The species of second cluster have high loading on axis II and occupy the lower end of the plane. The dominant species compositions of this cluster are *Albizia spp.*, *Disopyros mespiliformis*, *Mitragyna stipulosa*, and *Brachystegia spp*.

Fig. 3: Physiognomic Ordination



N.B: The figures stand for the sampled sites

In terms of physiognomic attributes, Figure 3 reveals important ecological relationships among the sampled plots. Figure 3 also shows three ecological groups. The first group is that of forest species that have high loading on axis II. It is made up of tree species whose value for average height; average girth, basal area and volume of wood are on the high side compared with other groups. The second group is that of tree crop species that have high loading on axis II and occupy the right hand side of the plane. These have high value for average height; average girth, basal area and volume of wood but not as high as that of the first group. The third group is a group of mixture of exotic plantation, tree crops and relics of forest species that have high loading on axis II and occupy the lower end of the plane. They have mixture of high and low value for average height, average girth, basal area and volume of wood. It is more on the lower side than on the higher side because these locations have highly been degraded.

On the basis of vegetation characteristic three floristically distinct types of woodland biotopes can be defined in the study area. These are:

- Forest units which include forest species and tree crops;
- Plantation units which include a number of exotic elements and food crops; and
- Vegetation units composed solely of species ecologically associated with the forest ecosystem.

Two effects of changes on species were identified. The first was the replacement of what could be considered as the original species by the other species tolerant of the new ecosystem. This is demonstrated in the blending of forest and tree crops species in the ecotones. The other was the reduction in the range of the original species that could be found.

Forest Reserve Transformation and the Resulting Derivatives

The main processes by which most of the present vegetation categories have been derived are considered in this section.

Shifting Cultivation

The study revealed that 42% of the people interviewed were arable cultivators who engaged in the planting of *Xanthosomas* spp, *Zea mays*, *Manihot* spp. and *Musa* spp. The major elements in the resulting anthropic derivatives of these processes of cover changes in the study area are classified as:

i. Farmland - Cocoa – Kola – Secondary Forest mosaic
ii. Farmland - Secondary forest mosaic
iii. Farmland - Plantation mosaic
iv. Farmland - wooded shrub mosaic

Tree Crop Cultivation

The study shows that 56% of the people interviewed in the study area engaged in tree crop cultivation. Tree crops such as cocoa, kolanut, oil palm and rubber have replaced a large portion of the main forest in the same area. Also most of the plots sampled were composed of various mixtures of cocoa, banana and kolanut, which exist in a mosaic in which food crops farmlands were present either as a subsidiary or as a dominant component.

Establishment of Timber Plantation

In the study area, the system known as *Taungya* is adopted in upgrading the timber productivity of the existing forest reserve. This confirmed Adeyanju's (1975) assertion about the establishment of timber plantation in the reserves. In its essential features, it is not different from the cultivation of tree crops except that instead of crops such rubber, cocoa, kolanut or oil palm, it is either *Tectona grandis or Gmelina arborea* that is planted. Within the study area considerable areas have been brought under *Gmelina arborea* to provide the feedstock for the already commissioned or proposed paper mills like Iwopin Paper Mill in Ogun State.

Timber and Firewood Production

Another process of change identified in the study area is caused by the exploitation of the timber resources of the forest reserve. This involves selective removal of the larger elements of certain species for timber or firewood. The process results in considerable modification of the structure and floristic composition of the natural vegetation. The closed canopy of the forest becomes open. Full sunlight reaches the floor in patches to encourage the profuse growth and the development of heliophytic species. With the removal of their usual hosts and support, the large woody climbers form thick tangles on the floor which make movement through the vegetation difficult. The resulting vegetation is usually described as disturbed mature forests.

Analysis of Socio-Economic Data

Table 7 shows that 38.3% of the farmers cultivate the existing sites because of the soil fertility. The farmers revealed that they have to move to the site because of low yield resulting from nutrient depletion, which occurred in their former site. However, 34.3% of the farmers cultivate the site on which they are presently because of the availability of space and as a result of land scarcity due to population growth, while 27.4% of the farmers cultivate their current site in order to earn their living.

Table 7: Reasons for choice of site for cultivation

Reasons	Frequency	% of Total
Availability of space	120	34.3
Soil fertility	134	38.3
Poverty	96	27.4
Total	350	100.00

Source: Author’s Field Survey

Table 8 shows that tree cropland in the reserve area has been giving way to arable cropland. In 1975 tree crops occupied 96.4% of the farmlands while only 3.6% of the farmlands were covered with arable crops. However, by 2005, out of the land occupied by farming, 50.4% of the farmlands were cultivated with arable crops while tree crops were retained on only 49.6% of the farmlands. In 2010 the area covered by arable crops had tripled that covered by tree crops. The trend revealed by this study continues at a faster rate, on the part of arable crops, due to environmental and economic factors manifesting in the study area. Some of these are nutrient depletion, derelict nature of the tree crops, scarcity of land, poverty, increase in the price of foodstuff, etc.

Table 8: Changes in crop types planted in the study area

Years	Tree Crops	Arable Crops
1975	96.4	3.6
1985	84.6	15.4
1995	72.8	27.3
2000	63.6	36.4
2005	49.6	50.4
2010	25.5	74.5

Source: Author’s Field Survey

Table 9: Vegetation types on the study site Before Full Colonization

Types of Vegetation	Frequency	Percentage of Total
High thicket forest	198	56.57
Secondary regrowth	94	26.86
Mixture of trees & grasses	14	4.00
Fallow land	44	12.57
Total	**350**	**100.00**

Source: Author’s Field Survey

Table 9 shows that before the rise of human activities in the study area, the area has been selected as a forest reserve and 56.57% of the farmers agreed that the area is covered with high thicket forest species while 26.86% contended that the study area has witnessed human activities which has led to secondary regrowth in the area in place of the original vegetation. And 12.57% of the farmers revealed that the land given to them to cultivate was a fallow land which has just recovered from human activities.

Table 10 shows that 48% of the respondents engaged in farming activities for commercial purpose and majority of them engaged in cocoa and plantain cultivation. However, 29% of the farmers engaged in farming in order to feed their families and to meet their immediate needs such as financial one. The remaining 23% farmers engaged in both commercial and arable farming. This shows that the major contributors to forest reserve degradation are the tree crops cultivators.

Table 10: Purpose of farming in the study area

Reasons	Frequency	Percentage of total
Commercial	168	48
Subsistence	102	29
Both	80	23
Total	**350**	**100**

Source: Author's Field Survey

Table 11 shows that 56% of the farmers in the study area are involved in tree harvesting system while 31.43% of the farmers engaged in taungya system of land cultivation. The latter farmers plant their crops mainly in between *Tectona grandis*, *Gmelina arborea* and *Nauclea diderrichii*. The forester allowed these farmers to do so because it is cheaper that way to maintain and manage the forest reserve. Shifting and continuous cultivation is relatively low within the study area.

Table 11: Farming Systems in the Study Area

Farming system	Frequency	Percentage of total
Continuous cultivation	20	5.71
Shifting cultivation	24	6.86
Tree crops	196	56.00
Taungya system	110	31.43
Total	**350**	**100.00**

Source: Author's Field Survey

Table 12 shows that the dominant crops in the area are tree crops with 51.43% of the respondents engaged in their cultivation. Examples include *Theobroma cacao*, *Cola spp* and *Elaeis guineensis.* Arable crops followed this with 27.14% followed by those who practice both.

Table 12: The Dominant Crops in the Study Area

Crop planted	Frequency	Percentage of total
Tree crops	180	51.43
Arable crops	95	27.14
Both	75	21.43
Total	**350**	**100.00**

Source: Author's Field Survey

Problems Militating against Sustainable Forest Management in the Study Area

Inadequate funding: It is elicited that inadequate funding is the major constraint of effective management of forest reserve in the study area. The financial allocation to the forestry sector in this area is quite small to bring about a worthwhile result.

Inadequate infrastructural facilities: These facilities include office and residential accommodation, technical equipment such as measuring chains, ranging poles and other survey equipment, patrol motorbikes and vehicles. In fact, the number of available motorbikes and vehicles was grossly inadequate for the workload at the outdoor station.

Problems of encroachment: Another problem facing sustainable management is that of encroachment mainly by cocoa farmers. These people have destroyed most of the forested areas through their nefarious activities, such as uncoordinated farming activities, illegal timber exploitation, illegal settlement, etc., within the study area.

Inadequate information on existing forest resources: This is another constraint to effective planning and management of forest reserve in the study area. Management of forest reserve requires reliable base-line data which is critical to planning, monitoring and management of forest reserve sustainably. Dunster (1990) justifies this fact that without such information, it is impossible to determine what intensity and mix of activities the forest can be expected to support sustainably or to carry out effective monitoring of the changes wrought by these activities. According to Ola-Adams (1981), most of the difficulties encountered in both *in situ* and *ex situ* conservation are mainly due to lack of adequate information on forestry inventory and species distribution as well as lack of precise information on the reproductive biology, phenology of the flowering and fruiting, population genetic structure and inter- and intra- specific variations in the various forest ecosystems and constituent species.

Ecological Implications of Land Use

The study area, which falls within the tropical rain forest, was once described by White (1983) as an area consisting essentially of a continuous stands of varied trees with canopies varying in height from 10 to 50 metres. He further revealed that the crowns of individual trees overlap each other and were often interlaced with lianas. This description contradicts the present state of the study area.

The high forest is highly variable with regard to species composition and stocking. Hall (1977) suggested that the variation could be associated with soil differences. But as a result of agricultural land use and timber exploitation in the study area, intensive plantation was embarked upon which would have adverse effect on the major economic species. Hall (1977) shows further that the use of ferralitic soil for intensive plantation establishment is not advisable unless adequate precautions are taken to compensate for substantial nutrient removal from the cycle during harvest.

Also from the inventory of fauna compiled from the study area there is an absence of monkeys on the list and monkeys are indicator of the presence of original forest. This shows that the natural forest is dwindling in the study area. Buffalos and antelope are also at the point of extinction in the study area. This shows that the problem of forest destruction is directly related to loss of biodiversity.

As a result of low yield and problems encountered in improving the productivity of the natural forest and increasing demand for wood and wood products, large area of the study area has been converted into monoculture plantations of exotic and indigenous tree species.

The following hectares of high forest have been cleared and replaced with pulpwood plantations within the last 19 years:

- 1980 –1996: 8,201 hectares were cleared and planted to *Gmelina*
- 1989 – 1996: 6,546 hectares were cleared and planted to *Gmelina*
- 1989 – 1996: 119 hectares were cleared and planted to *Pines*
- 1987 – 1996: 197 hectares were cleared and planted to *Cattapa* and *Cashew*
- 1987 – 1996: 1,100 hectares were cleared and planted to *Tectona grandis*
- 1989 – 1996: 843 hectares were cleared and planted to *Terminalia superba, Terminalia ivorensis and Melicia excelsa*; 20 hectares were cleared and planted with *Elaeis guineensis (*Author's fieldwork)

The study shows that the mode of incursion into the forest reserve is mainly through tree and arable crops. This finding confirms the view of the World Bank (1991) that most of the tropical forests cleared each year are due to agricultural practices. It also lends credence to the hypothesis of Bilsborrow (1994) that deforestation is largely due to intensification of agriculture, involving clearing the land of trees to plant crops. Although taungya system, which was encouraged by the Forestry Department, has been noted to be similar in its physiognomic appearance to forest ecosystem (Adejuwon & Ekanade, 1988), its cover closure is obviously not the same as mature or high forest. Adams (1978) and Chijioke (1980) also reported that total biomass removal, which invariably is the practice in tree harvesting for industrial use accounts for a tremendous loss in the nutrient status of the soil environment in the forest region.

CONCLUSION

The study showed that the most significant contributor to the forest cover change of the study area was the use of land for arable crop, which accounted for more than 30% of the total agricultural land use. The forest reserve declined by more than a factor of six from its original size from 130,774 hectares in 1972 to 19,382 hectares in 2000. Over 1,121 km^2 of the forestlands got transformed to agricultural land use over the 28 years period. The species ordination showed three dominant kind of forest communities in Oluwa Forest Reserve. The first was mainly made up of relics of forest species and tree crops; the second comprised plantation, which included a number of exotic elements and food crops; and the third group, was made up of forest units composed mainly of species ecologically associated with the forest ecosystem. Two effects of changes on species were identified. The first was the replacement of what could be considered as the original species by other species tolerant of the 'new' ecosystem. The other was the reduction in the range of the original species that could be found. This was an indication that the area had been fragmented from its original status. This confirmed that the original species components of the Oluwa Forest Reserve were degraded at a relatively fast rate.

Finally, the results of the floristic and physiognomic ordination of the sites demonstrate the ongoing ecological processes in the forest reserve. It is obvious that the study area is no longer an area substantially covered by a continuous stretch of the tropical rain forest, as it was a number of decades ago. Although it is designated a protected area by law, incursion into the reserve areas has been considerable over the years as much of the pristine vegetation of the forest reserve has disappeared. Although government has responded by encouraging the cultivation of fast growing exotic species to enhance the process of the forest rebuilding, the impact of man in other aspects including expansion of farm holding, establishment of villages and hamlets in the reserve have continued to reduce the extent and luxury of plant cover in the reserve and reduced the number of timber species and in some situation, threatening the survival of the whole forest reserve as an important ecological unit in south-western Nigeria. Effort must be made by government and all the stakeholders to control further incursion through rigorous implementation of what the law provides for the protection of forests. It follows therefore that the major thrust of environmental management should be the protection of the natural living space of humankind and integration of environmental scarcity in making decision on all economic issues and activities.

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