NATURAL FOREST CONVERSION AND ITS IMPACT ON POPULATIONS OF KEY LIVELIHOOD TREE SPECIES IN OMO BIOSPHERE RESERVE, NIGERIA

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ABSTRACT

Natural forest conversion and unsustainable use of forest resources are on the increase without adequate consideration of their implications for sustainable livelihoods. This study examined the impact of natural forest conversion on key livelihood tree species in Omo Biosphere Reserve, by examining their populations in the Strict Nature Reserve (SNR), Nauclea diderrichii Plantation (NDP), Tectona grandis Plantation (TGP), Pinus caribaea Plantation, Gmelina arborea Plantation, Theobroma cacao Plantation (CP), and three age-sequences of arable farmland – AF_1, AF_2, and AF_3. The SNR was the most species rich (n = 17) and diverse (H = 2.6210; Simpson 1- D = 0.9127) of all the land use types. Key livelihood tree species diversity was higher in the arable farmlands (H = 0.7608 to 1.3810; Simpson 1- D = 0.3765 to 0.7111) than in the monoculture plantations (H = 0.0313 to 1.311; Simpson 1- D = 0.0099 to 0.6701) with GAP being the least diverse. The NDP was more similar to the SNR (SI = 21.74) than any other land use type. The NDP showed a closer association with AF_1 and AF_2 in its key livelihood tree species than with other monoculture plantations. The CP was ecologically the farthest from the other land use types with respect to key livelihood tree species composition. The study showed that natural forest conversion to monoculture plantations and arable farm reduce key livelihood tree species richness and diversity, and that higher degree of disturbance as a result of high impact logging and longer period of cultivation, beyond thirty years, exacerbates the problem.

Key words: Land use, deforestation, livelihood, tree diversity, monoculture, farming

INTRODUCTION

The burgeoning population of humans in Nigeria and other developing countries has led to indiscriminate use of land resources not minding the short and long term socio-economic and ecological consequences. Deforestation has continued unabated despite the apparently enormous environmental consequences associated with it.

Forests provide sources of livelihood like food, shelter, clothing and heating and a great majority of people living in poverty depend on forests and trees outside forests to generate income through employment and through the sale of forest goods and services. It has been observed that more than 25% of the world's population – an estimated 1.6 billion people – rely on forest resources for their livelihoods, and of these, almost 1.2 billion live in extreme poverty (World Bank (2001); and lack the basic necessities to maintain a decent standard of living, for instance, sufficient and nutritious food, adequate shelter, access to health services, energy sources, safe drinking water, education and a healthy environment (FAO, 2006).

In Nigeria, forests provide invaluable services to the nation. But over the last half century, the Nigerian rainforest has experienced unprecedented reduction due to deforestation and degradation, which now pose intractable ecological, land use, biodiversity and sustainable management problems (Ikhuoria *et al.*, 2006). This has negative implications on rural livelihoods due to the near-absolute dependence of the rural populace on biodiversity, for their sustenance.

Chima *et al.* (2012) had documented and prioritized the key livelihood tree species in the reserve using the user preference approach. The human populations in Omo Biosphere Reserve which is mainly rural depend to a large extent, on forest resources, for their living. However, despite the high spate of deforestation and the conversion of the natural forests to other land uses like monoculture plantations of exotic tree species, cocoa plantations and arable farms, no empirical study had been carried out to ascertain the impact on the populations of trees that support rural livelihoods.

This study therefore, examined the impact of natural forest conversion on the populations of key livelihood tree species by comparing them between a natural forest and introduced land use types in the reserve. It is hoped that the information provided in this study will enable management decisions that will enhance the conservation of the key livelihood tree species.

MATERIALS AND METHODS

The Study Area

Omo Biosphere Reserve is located between latitudes 6^o 35' to 7^o 05' N and longitudes 4^o 19' to 4^o 40' E in the South-west of Nigeria, and covers an area of about 130,500 hectares (Ojo, 2004). The reserve is in the mixed moist semi-evergreen rainforest zone (Ola-Adams, 1999). However, anthropogenic activities, mainly logging, establishment of monoculture plantations, and farming, have changed the original vegetation of the reserve to a large extent. Geologically, the reserve lies on crystalline rocks of the undifferentiated basement complex which in the southern parts is overlain by Eocene deposits of sand, clay and gravel (Isichei, 1995). It has an undulating terrain with maximum elevation of 150 m above sea level towards the west while the lowest parts of the reserve are in the south. The Lagos-Ore-Benin Highway passes through the southern tip of the reserve. The reserve falls within the tropical wet-and-dry climate characterized by two rainfall peaks separated by a relatively less humid period usually in the month of August (Ola-Adams, 1999). Figure 1 is the map of Omo Biosphere Reserve showing the study sites and surrounding reserves.

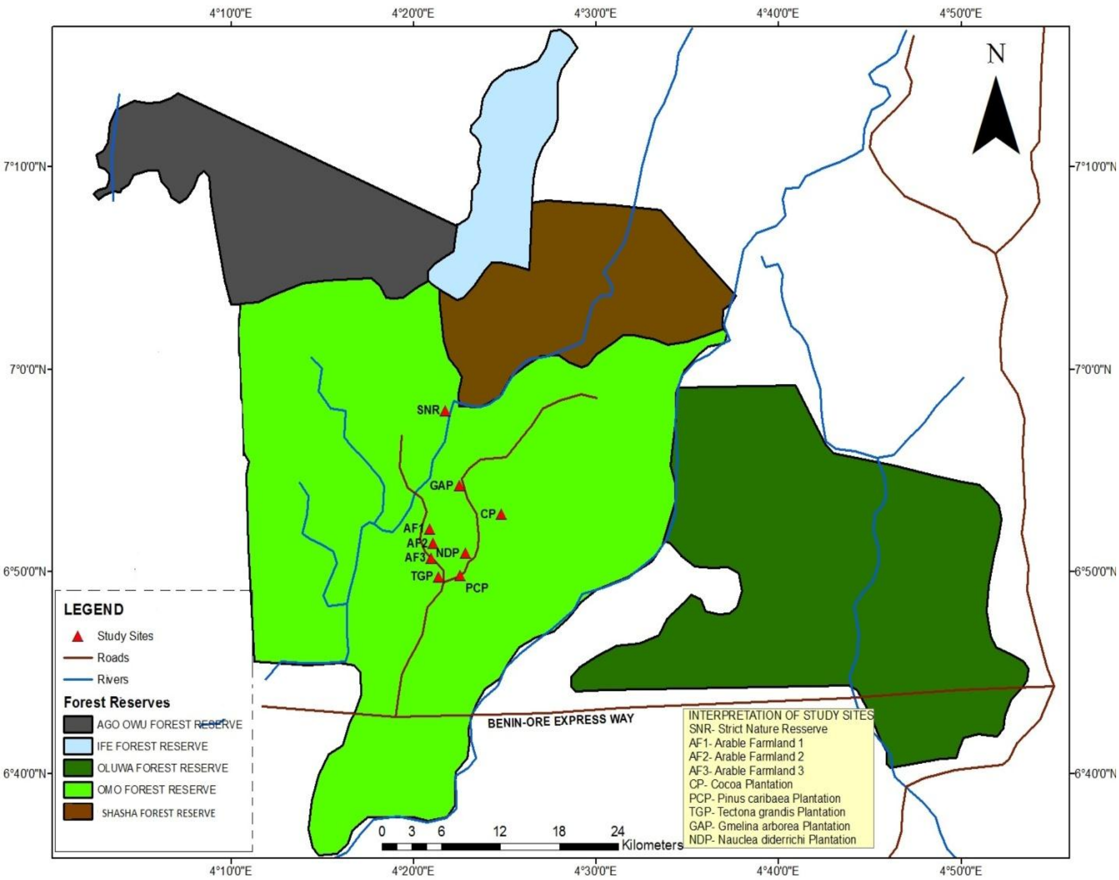

Figure 1: Map showing Omo Biosphere Reserve, the study sites and surrounding reserves
Source: Adapted from Ola-Adams (1999)

Selection of Study Sites

Nine sites representing different land use/land cover types were purposively chosen for the study. The histories of the sites were obtained from the Ogun State Forestry Department's Office at Area J4 of the reserve. The reference site (6.96598^{o}N and 4.36245^{o}E) was taken from the Strict Nature Reserve at Etemi. This site represents part of the reserve that has not been modified either by agricultural activities of the smallholders, plantation establishment or timber exploitation. Three other sites - AF_1 (6^{o}50'26.77"N and 4^{o}21'37.03"E), AF_2 (6^{o}50'29.71"N and 4^{o}21'37.61"E) and AF_3 (6^{o}50'32.80"N and 4^{o}21'38.85"E); were selected from around Mile 1 enclave in Area J4, to reflect three chronosequences of arable farmland. Sites AF_1, AF_2 and AF_3 were originally established as taungya farms and have been under cultivation since they were given out to farmers in 2000, 1990, and 1975 respectively. Site CP (6^{o}52'49.82"N and 4^{o}24'48.91"E) was chosen from a pure Cocoa Plantation established in the year 2000, near Temidire Camp. Four other sites – *Pinus caribaea* Plantation (PCP - 6^{o}50'03.54"N and 4^{o}22'00.65"E); *Tectona grandis* Plantation (TGP - 6^{o}50'08.37"N and 4^{o}21'39.92"E); *Gmelina arborea* Plantation (GAP - 6^{o}54'13.94"N and 4^{o}22'30.44"E); and *Nauclea diderichii* Plantation (NDP - 6^{o}50'16.11"N and 4^{o}22'05.56"E); were chosen to represent monoculture plantations of different species and ages. PCP was established in 1997, TGP in 1989, GAP in 1983, and NDP in 1975. PCP has not been logged since establishment but bears a pineapple orchard. TGP had been logged and now bears mainly coppices on the felled stumps. GAP had been logged extensively, though mature trees and saplings abound. NDP has not been logged since it was established.

Data Collection

Ten 35 m ×35 m quadrats were randomly distributed in each of the sites for the enumeration of the key livelihood tree species (Table 1). This quadrat size falls within the range specified in the literature for ecological studies in the humid tropics (Salami, 2006). Narrow cut lines were used to demarcate plot boundaries. Species identification was done by an expert taxonomist from the Forestry Research Institute of Nigeria (FRIN), Ibadan, with the aid of keys provided by Keay (1989). All single-stem woody plants of erect posture with a minimum height of 5 m and diameter at breast height (dbh) of 5 cm were identified to species level and the number of individuals counted and recorded. This tree size was considered to ensure that only mature trees were captured. Specimens of species that could not be identified in the field were taken to the Forest Research Institute of Nigeria Herbarium, for identification.

Table 1: Checklist of key livelihood tree species and their ranking

S/No.	Species	Common or Local name	Family	Total Score	Rank
1	*Khaya ivorensis*	Lagos mahogany	Meliaceae	1295	1st
2	*Nauclea diderrichii*	Opepe	Rubiaceae	1240	2nd
3	*Terminalia ivorensis*	Black afara	Combretaceae	850	3rd
4	*Cordia millenii*	Omo	Boraginaceae	690	4th
5	*Alstonia boonei*	Pattern wood	Apocynaceae	465	5th
6	*Terminalia superba*	White afara	Combretaceae	375	6th
7	*Erythropleum suaveolens*	Erun-obo	Leguminosae - Caesalpinioideae	330	7th
8	*Mangifera indica*	Mango	Anacardiaceae	265	8th
9	*Entandrophragma utile*	Jebo	Meliaceae	260	9th
10	*Anacardium occidentale*	Cashew	Anacardiaceae	260	9th
11	*Milicia excelsa*	Iroko	Moraceae	255	11th
12	*Lophira alata*	Ekki	Ochnaceae	190	12th
13	*Triplochiton schleroxylon*	Obeche	Sterculiaceae	190	12th
14	*Piptadeniastrum africanum*	Agboyin	Leguminosae - Mimosoideae	175	14th
15	*Theobroma cacao*	Cocao	Malvaceae	145	15th
16	*Mitragyna ciliata*	African linden	Rubiaceae	140	16th
17	*Mansonia altissima*	Mansonia	Sterculiaceae	140	16th
18	*Ceiba pentandra*	Kapok tree	Malvaceae	130	18th
19	*Enantia chlorantha*	Osopupa, Yaru	Annonaceae	130	18th
20	*Cedrela odorata*	Honduras cedar	Meliaceae	110	20th
21	*Anthonotha macrophylla*	Abara	Leguminosae - Caesalpinioideae	110	20th
22	*Elaeis guineensis*	Palm tree	Arecaceae	110	20th
23	*Citrus sinensis*	Sweet orange	Rutaceae	100	23rd
24	*Cola nitida*	Kola nut	Sterculiaceae	90	24th
25	*Buchholzia coriacea*	Wonderful kola	Capparidaceae	85	25th
26	*Gmelina arborea*	Gmelina	Verbenaceae	80	26th
27	*Entandrophragma angolense*	Ijebo	Meliaceae	75	27th
28	*Nesogordonia papaverifera*	Danta	Sterculiaceae	55	28th
29	*Newbouldia laevis*	Boundary tree	Bignoniaceae	55	28th
30	*Citrus aurantifolia*	Lime	Rutaceae	55	28th
31	*Garcinia kola*	Bitter kola	Guttiferae	40	31st
32	*Azadirachta indica*	Neem	Meliaceae	40	31st
33	*Daniellia ogea*	Ogea	Leguminosae - Caesalpinioideae	35	33rd
34	*Tectona grandis*	Teak	Verbenaceae	25	34th
35	*Cleistopholis patens*	Apako	Annonacae	25	34th
36	*Terminalia catappa*	Indian almond	Combretaceae	20	36th
37	*Chrysophyllum albidum*	African star apple	Sapotaceae	15	37th
38	*Parinari sp.*	Abere	Chrysobalanaceae	15	37th

Source: Adapted from Chima *et al.* (2012).

Data analysis

Measurement of Alpha Diversity

In this study, Simpson Index (Simpson, 1949) and Shannon-Wiener Index (Odum, 1971) were used to measure the diversity of key livelihood tree species in each land use type. These indices were chosen because they provide measures of the different components of diversity. The Shannon-Wiener index reflects the manner in which abundance is distributed amongst the different species constituting the community. The index is based on the relative frequencies of species in the population (Giramet-Carpentier *et al*., 1998), thus taking into account both species richness and evenness. However, Magurran, (1988) notes that the value of the index is most strongly related to species richness. Simpson's index is a dominance measure since it is weighted towards the abundance of the most common species in a sample rather than providing a measure of species richness. According to Magurran (1988), it reflects the probability of any two individuals drawn at random from an infinitely large population belonging to different species, and the index is less sensitive to species richness.

- Simpson's Index is expressed as:

$$D = \frac{\sum_{i=1}^{q} ni(ni-1)}{N(N-1)} \text{ --------------------- Eqn. 1}$$

Where:

N = total number of individuals encountered

ni = number of individuals of ith species enumerated for i=1……q

q = number of different species enumerated.

Since Simpson's index as expressed above is not directly related to diversity (i.e. the lower the index, the higher the diversity and *vice versa*), it is expressed in this study as (1 – D) to allow for a direct relationship.

- Shannon-Wiener Index is expressed as:

$$H = -\sum_{i=1}^{s} \text{pi} \log \text{pi} \text{ --------------- Eqn. 2}$$

Where:

pi = the proportion of individuals in the ith species

s = the total number of species

Both Simpson and Shannon-Wiener diversity indices were computed using the PAleontological

Software.

Measurement of Beta Diversity/Similarity

Beta diversity is a measure of the extent to which the diversity of two or more spatial units differs (Magurran, 2004) and is generally used to characterise the degree of spatial heterogeneity in diversity at the landscape scale, or to measure the change in diversity along transects of environmental gradients. Wolda (1983) suggested the use of similarity indices for measuring beta diversity. However, Jansen and Vegelius (1981) observed that, of the many similarity indices, only three of them (the Ochiai, the Jaccard and the Sorensen) are worth considering. Hence, Sorensen's similarity index (Pielou, 1969) was used to determine the similarity in species composition of land use types considered in this study. Recent studies (e.g. Ogunleye *et al.*, 2004; Ojo, 2004; Ihuma *et al.*, 2011; Chima *et al.*, 2011) have also employed the Sorensen's index to measure beta diversity.

Sorensen's Similarity Index is expressed as:

$$SI = \frac{a}{a+b+c} * 100 \quad \text{----------------------- Eqn. 3}$$

Where: a = number of species present in both land use types

b = number of species present in land use type 1 but absent in land use type 2

c = number of species present in land use type 2 but absent in land use type 1

Cluster Analysis

Cluster analysis was performed using the PAleontological STatistics (PAST) software to provide a hierarchical classification of the various land use types, such that land use types with more similar key livelihood tree species are grouped into the same cluster while dissimilar ones are grouped into different clusters. In performing the cluster analysis, the Sorensen's similarity index was used to measure the ecological distances between land use types.

RESULTS

Diversity of key Livelihood Tree Species at different Land use Types

Key livelihood tree species diversity indices for all land use types are presented in Table 2. The SNR was the most diverse of all the land use types. Key livelihood tree species diversity was higher in the arable farmlands than in the monoculture plantations with GAP being the least diverse.

Table 2: Diversity indices for key livelihood tree species in different land use types

	SNR	GAP	CP	PCP	NDP	TGP	AF_1	AF_2	AF_3
No. of species	17	2	4	5	12	5	7	6	4
Individuals	65	1007	1278	24	1278	1089	75	33	18
Dominance	0.0873	0.9901	0.9225	0.3299	0.8284	0.8893	0.2889	0.3939	0.6235
Shannon H	2.6210	0.0313	0.2041	1.311	0.4690	0.2683	1.3810	1.1420	0.7608
Simpson 1-D	0.9127	0.0099	0.0775	0.6701	0.1716	0.1107	0.7111	0.6061	0.3765

Source: Field Survey, 2012

Similarity of land use types in terms of key livelihood tree species composition

Similarity and associations between land use types are shown in Table 3 and Figure 2 respectively. The NDP was more similar to the SNR than both the other monoculture plantations and arable farmlands. The NDP showed a closer association to AF_1 and AF_2 (Figure 2). The CP was ecologically the farthest from the other land use types with respect to the key livelihood tree species.

Table 3: Sorensen's Similarity Indices for key livelihood tree species at different sites

	SNR	GAP	CP	PCP	NDP	TGP	AF_1	AF_2	AF_3
SNR	*	5.56	5.00	4.76	21.74	4.76	20.00	21.00	16.67
GAP		*	0.00	16.67	7.69	16.67	28.57	33.33	0.00
CP			*	12.50	14.29	12.50	10.00	0.00	14.29
PCP				*	30.77	66.67	33.33	10.00	28.57
NDP					*	30.77	35.71	38.46	33.33
TGP						*	50.00	22.22	12.50
AF_1							*	62.50	37.50
AF_2								*	25.00
AF_3									*

Source: Field Survey, 2012

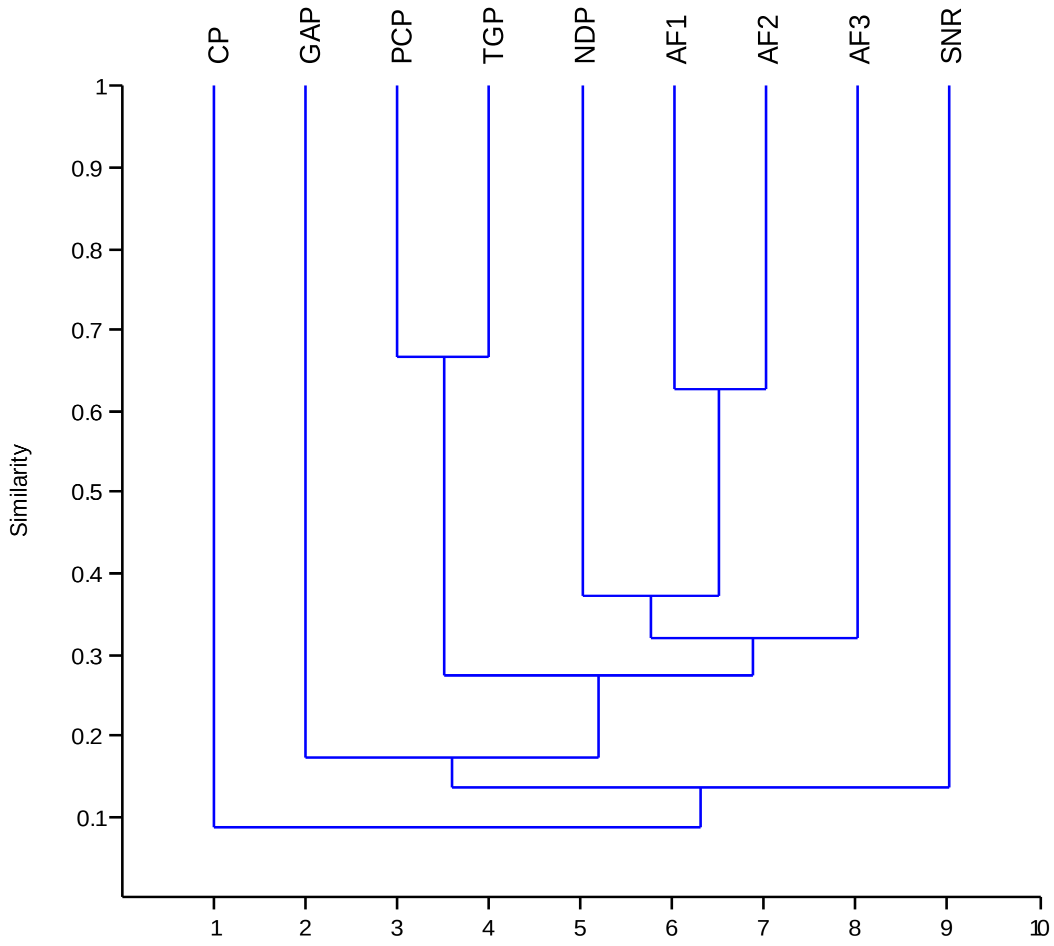

Figure 2: Classification of land use types based on similarity in their key livelihood tree species composition
Source: Field Survey, 2012

DISCUSSION

Key livelihood tree species richness and alpha diversity were higher in the SNR than any of the introduced land use types. Anthropogenic impacts of habitat destruction have been known to cause biodiversity decay worldwide. Several studies (e.g. Wilson, 1988; Ihuma, *et al*., 2011; Chima and Omoemu, 2012; Chima and Uwaegbulem, 2012) lend credence to this assertion. The NDP was next to the SNR in terms of key livelihood tree species richness. About 70% of the tree species found in NDP was among the key livelihood tree species documented by Chima *et al*. (2012). There may be two possible reasons for this. First, NDP has the lowest degree of human-induced modification, having not been logged since its establishment in 1975. Second, it is located within the residential quarters of the Ogun State Plantation Project in Area J4; the occupants of which may have enhanced the species richness of the key livelihood trees through the dispersal of seeds of eaten fruits. Diversity of the key livelihood tree species was higher in the arable farmlands (especially AF_1 and AF_2) than in the monoculture plantations except PCP. This could be explained by the high species dominance in the monoculture plantations since diversity takes into account the evenness in the distribution of individuals among the species encountered. It should be noted that *Pinus caribaea* was not listed as one of the key livelihood species, hence diversity was higher and dominance lower in PCP than in other monoculture plantations.

Harris and Silva-Lopez (1992) observed that habitat fragmentation is one of the most serious causes of diminishing biological diversity; while habitat loss is responsible for biodiversity loss and ultimate extinction of species (IUCN, 2002). Thus, the very high ecological distance observed between the SNR and most of the introduced land use types could be attributed to habitat fragmentation/modification and varying degrees of protection and management. This is made evident in the least similarity recorded between the SNR and CP and the highest between SNR and NDP, when the monoculture plantations were compared with the SNR. Although, the Cocoa plantation is protected, management practices favour only the preferred species while in NDP, diversity of species is tolerated since it acts as a buffer to the residential quarters and not managed for commercial purposes.

In the arable farmlands too (especially AF_1 and AF_2), more key livelihood tree species were encountered than in most of the monoculture plantations. Apart from the fact that the farms were started as Taungya farms, the farmers also encouraged the growth of trees that contribute to their livelihoods. This explains why AF_1 and AF_2 were more similar to the SNR than most of the monoculture plantations. Also, the closer ecological distance between AF_1 and AF_2 than with AF_3 could be attributed to more years of cultivation in AF_3. Chima and Omoemu (2012) made a similar observation in tree species composition between a 14-year and 28-year chronosequences of arable farmland, than with the one that had been under cultivation since over 50-years. However, the closest ecological distance between TGP and PCP, than with any other monoculture plantation, could be attributed to the fact that both sites lie adjacent to each other. The closeness of the sites may have enhanced the exchange of seeds by agents of dispersal.

CONCLUSION AND RECOMMENDATION

This study has shown that natural forest conversion to monoculture plantations and arable farm reduce key livelihood tree species richness and diversity, and that higher degree of disturbance as a result of high impact logging and longer period of cultivation (beyond thirty years) exacerbates the problem. The absence of *Triplochiton schleroxylon*, *Piptadeniastrum africanum*, *Mansonia altissima*, *Bulchozia coriacea* and *Daniella ogea* (documented as key livelihood tree species) in all land use types enumerated, calls for an all encompassing survey of their populations to include land use/cover types not covered in this study to truly ascertain their level of rarity in the reserve.

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