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Traditional cocoa-based agroforestry and forest species conservation in Ondo State, Nigeria

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Abstract

Cocoa agroforests are a common farming system in the humid zone of West and Central Africa, in which forest trees provide shade and other environmental services as well as marketable products. To determine the extent of these benefits, data were collected in nine cocoa farms located in three major cocoa producing local government areas (LGAs) in Ondo State. Reserved natural forests located in each of the three LGAs were also sampled in a group of three plots of 0.0625 ha (25 m × 25 m) per forest reserve. All trees other than cocoa in the cocoa farms and all trees with a diameter at breast height (dbh) greater than or equal to 10 cm in the forest reserves were identified and measured. A total of 21 ha of cocoa farms and 0.56 ha of natural forest were surveyed. In the 21 ha of cocoa agroforests surveyed 487 non-cocoa trees belonging to 45 species and 24 families were encountered. While the tree density (23 trees/ha) is much greater than in some other farming systems, it represents only about 8.4% of that found in 0.56 ha of nearby natural forest (276 trees/ha), which contained 163 individual trees of 62 species in 29 families. A very high proportion (86.8%) of the trees in the cocoa farms were edible fruit trees. Cocoa agroforests are therefore less diverse and less dense than the reserved natural forest but are enriched with exotic and indigenous fruit tree species producing fruits and other Agroforestry Tree Products (AFTPs) that meet the needs of the farming households.

Keywords: Agroforestry; Cocoa agroforest; Forest conservation

1. Introduction

Agroforestry is often viewed as a land use management system that offers solutions to land and forest degradation and to the loss of biodiversity in the tropics. Michon and de Foresta (1995) however made a distinction between the simple agroforestry systems (such as alley cropping, intercropping and hedgerow systems) and agroforests in their capacity to conserve biodiversity. They defined agroforests as complex agroforestry systems which look like and function as natural forest ecosystems, but are integrated into agricultural management systems.

The cocoa agroforests of West and Central Africa are a very good example of multistrata agroforestry in which tree species produce Agroforestry Tree Products (AFTPs), including high quality timber (Simons and Leakey, 2004). Traditionally, small holder cocoa farmers establish their cocoa farms by removing the forest under-storey and thinning the forest canopy so that cocoa seedlings can grow into productive trees, as for example in Cameroon (Duguma et al., 2001). In areas where the forest has been lost, indigenous fruit and timber trees are grown as companion species to provide environmental services, e.g. shade and soil protection and indigenous fruits (Leakey and Tchoundjeu, 2001). These practices are reported to have great potential for conservation of biodiversity (Leakey, 1999), because they create forest-like habitats, which harbour tropical biodiversity even in rapidly degrading landscapes (Greenberg et al., 2000) and can thus serve as fauna refuges (Griffith, 2000). In southern Cameroon and eastern Brazil, cocoa agroforests have been credited with conserving the biodiversity of the humid forest zone (Ruf and Schroth, 2004), including birds, ants and other wildlife (Rice and Greenberg, 2000). These agroforests also provide forest

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corridors for the movement of animals and dispersal of plant propagules between forest fragments (Saatchi et al., 2001). It has however been pointed out that cocoa agroforests do not equate with primary forests (Donald, 2004). Compared with floristically and climatically similar secondary or primary Atlantic forest in Brazil, they support relatively lower species richness with impaired natural succession and gap dynamics (Rolim and Ciarello, 2004), although this will vary depending on the stage of the agro-ecological succession attained and the scale of implementation (Leakey, 1999).

Cocoa is a major cash crop in Ondo State, which has expanded the State economy and provided employment for thousands of its inhabitants. The State Government is continually making efforts to improve cocoa output by rehabilitating old cocoa farms and expanding the area under cocoa cultivation. Expansion of cocoa farms is, however, being done at the cost of the rich tropical rainforest which provides the fertile land for cocoa cultivation. One study, the Alternatives to Slash and Burn programme in Cameroon (Palm et al., 2005), has evaluated and characterized the environmental, social and economic parameters in various land use systems, including cocoa agroforests. The study found that total biomass in cocoa agroforests (304 t ha^{-1}) was greater than that of food crop fields (85 t ha^{-1}) and ranked third after the biomass in the primary forests (541 t ha^{-1}) and long term fallows (460 t ha^{-1}) (Duguma et al., 2001). Thus agroforests are substantially better for the environment than many other farming systems. Interestingly, they have also been found to be beneficial socially and economically, improving the livelihoods of the local farmers (Gockowski and Dury, 1999; Schreckenberg et al., 2002, 2006; Degrande et al., 2006). This combination of environmental, social and economic benefits arising from agroforests has led to them being promoted as a Win:Win land use system for Africa (Leakey, 2001a,b).

Apart from being a leading producer of cocoa in Nigeria, Ondo State is also a major producer of timber. However, deforestation for agriculture, including cocoa, is a serious concern. In an attempt to curb indiscriminate felling of trees and destruction of forest, Forest Reserves (protected forest) have been gazetted across the State. However these Forest Reserves have continued to shrink in area under the pressure of rapidly growing population and consequent increasing rate of conversion into agricultural lands. Although there is absence of reliable quantitative data, it is clear that a very large proportion has been converted into cocoa farms imposing threats to remnant forest cover.

The present study seeks to evaluate conservation value of cocoa agroforests, as it has been argued that cocoa cultivation under traditional agroforestry systems has minimal effect on the diversity of forest tree species, while Asare (2006) in his review of biodiversity in cocoa agroforests in Ghana noted a gradual shift in cocoa production towards a management system of lower conservation value than the traditional multistrata cocoa agroforests that harboured diverse population of forest species.

2. Methodology

2.1. Study site

This study was carried out in Ondo State, Nigeria (latitude 5°45′–8°15′N and longitude 4°45′–6°00′E). Topographically, the state is composed of lowlands and hills. The climate is of the tropical monsoon type with two distinct seasons—the rainy (April–October) and dry (November–March) seasons. Humidity is high during the rainy season and low during the Harmattan period of the dry season. The soils of the study area are classified as ferruginous tropical soil (Alfisol) on crystalline rock of basement complex.

2.2. Experimental design

Three Forest Reserves – Idanre, Owo and Ala Forest Reserves located in Owena, Owo and Akure North Local Government Areas of the State, respectively – were selected for this study as they are the main cocoa producing areas. In each Local Government Area, three of the villages close to each of these Forest Reserves were selected randomly. Assessment of tree diversity was done in sample plots demarcated within each Reserve, and also on cocoa farms owned by farmers from each of the selected villages.

Three sample plots of 25 m × 25 m were demarcated along transect lines cut through each of the Forest Reserves. The first plot was located 10 m away from the main unsealed road and subsequent plots at a minimum distance of 75 m apart along the transect. On occasions this design had to be modified to exclude areas under illegal cocoa farms. Enumeration of the timber species was done within each of the demarcated sample plots. Diameter at breast height (dbh) of all trees with a stem diameter >10 cm within each sample plot were measured; two mean trees were selected and detailed measurements (diameter at base (db), middle (dm), top (dt) and height (h) measurements) were taken using Spiegel Relaskop—an instrument for measuring tree diameter and height. All the trees in each sample plot were also identified with the assistance of an experienced taxonomist. Leaf and bark samples of the few species which could not be identified on the spot were taken to the Forestry Research Institute of Nigeria (FRIN) herbarium for identification. One productive cocoa farm was selected from each of the three selected villages. The area of each selected cocoa farm was measured and all trees other than cocoa inside the selected farms were identified, counted and measured as described above (dbh, db, dm, dt and h).

2.3. Data analysis

Basal area and volume of all measured trees in the sample plots and cocoa farms were calculated. Tree volume was estimated using Newton's formula of Husch et al. (1982). The rarefaction method (Gotelli and Colwell, 2001) was used to generate the expected number of species in cocoa agroforests

and in natural forest. The free software EstimateS 8.0 (Gotelli, 2006) was used to generate data for the construction of sample-based rarefaction curves and confidence intervals for species richness after re-scaling the *x*-axis to individuals. The basal area and volume in natural forest and cocoa farms were compared using the Student's *t* statistics.

3. Results

Four hundred and eighty-seven individuals belonging to 45 species and 24 families were identified in the 21 ha of cocoa agroforests surveyed (Table 1). The richest families were Caesalpinioideae, Euphorbiaceae, Moraceae and Sterculiaceae each with four species. Families Anacardiaceae, Apocynaceae, Bignoniaceae and Rutaceae had three species each while the families Bursearceae, Palmae and Ulmaceae each had two species.

The predominant 10 species of the non-cocoa tree species present in the cocoa agroforests accounted for 76.6% of their total population. These were fruit yielding species. *Elaeis guineensis* topped the list followed by *Cola nitida*, *Citrus sinensis*, *Mangifera indica*, *Anacardium occidentale*, *Psidium guajava* and *Persea americana*. Overall, 423 edible fruit trees

Table 1
Diversity of non-cocoa tree species in the 21 ha of cocoa agroforests in Ondo State, Nigeria

Species	Family	Frequency	Density (trees/ha)
Elaeis guineensis Jacq	Palmae	60	2.86
Cola nitida (Vent) Schott & Endl	Sterculiaceae	53	2.52
Citrus sinensis (L.) Osbeck	Rutaceae	50	2.38
Mangifera indica Linn	Anacardiaceae	43	2.05
Anacardium occidentale Linn	Anacardiaceae	39	1.86
Psidium guajava Linn	Myrtaceae	33	1.57
Persea americana Mill	Lauraceae	32	1.52
Ricinodendron heudelotii (Baill) Heckel	Euphorbiaceae	25	1.19
Citrus reticulata Blanco	Rutaceae	24	1.14
Cocos nucifera Linn	Palmae	14	0.67
Citrus paradisi Macfad	Rutaceae	14	0.67
Alstonia congensis Engl.	Apocynaceae	10	0.48
Ceiba pentandra (Linn) Gaertn	Bombaceae	8	0.38
Dacroydes edulis (G. Don.) H.J. Lam	Burseraceae	8	0.38
Triplochiton schleroxylon K. Schum	Sterculiaceae	8	0.38
Milicia excelsa (Welw) C.C. Berg	Moraceae	7	0.33
Pterygota macrocarpa K. Schum	Sterculiaceae	6	0.29
Garcinia kola Heckel	Guttiferae	5	0.24
Spondias mombin Linn	Anacardiaceae	5	0.24
Chrysophyllum albidum G. Don	Sapotaceae	4	0.19
Musanga cecropoides R. Br. Ex. Tedlie	Moraceae	3	0.14
Antiaris africana Decne	Moraceae	3	0.14
Spathodea campanulata P.Beauv	Bignoniaceae	3	0.14
Celtis mildbraedii Engl	Ulmaceae	3	0.14
Diallium guineense Willd	Caesalpinioideae	2	0.10
Ficus exasperata (Vahl)	Moraceae	2	0.10
Holarrhena floribunda (G. Don) Dur & Schinz	Apocynaceae	2	0.10
Funtumia elastica (Preuss) Stapf.	Apocynaceae	2	0.10
Bligha sapida Konig	Sapindaceae	2	0.10
Bombax buonopozense P.Beauv	Bombacaceae	2	0.10
Terminalia superba Engl & Diels	Combretaceae	1	0.05
Canarium schweinfurthii Engl	Burseraceae	1	0.05
Celtis zenkeri Engl.	Ulmaceae	1	0.05
Sterculia tragacantha Lindl.	Sterculiaceae	1	0.05
Microdesmis puberula Hook f. ex planch	Pandaceae	1	0.05
Piptadeniastrum africanum (Hook. F.) Brenan	Mimosoideae	1	0.05
Entandrophragma cylindricum (Sprague)	Meliaceae	1	0.05
Drypetes gossweileri S. Moore	Euphorbiaceae	1	0.05
Phyllanthus discoideus (Baill.) Muell. Arg.	Euphorbiaceae	1	0.05
Brachystegia eurycoma Harms	Caesalpinioideae	1	0.05
Dracaena manii Bak.	Agaraceae	1	0.05
Afzelia africana Sm.	Caesalpinioideae	1	0.05
Cleistopolis patens (Benth) Engl & Diels	Annonaceae	1	0.05
Gossweilerodendron balsamiferum (Verm) Harms	Caesalpinioideae	1	0.05
Uapaca heudelotii Baill	Euphorbiaceae	1	0.05
Total		487	

Table 2
Density and diversity of edible fruit tree species in 21 ha of cocoa agroforests and 0.56 ha of natural forest in Ondo State, Nigeria

Species	Family	Indigenous/exotic	Density (trees/ha)	
			Cocoa farm (21 ha)	Natural forest (0.56 ha)
E. guineensis Jacq	Palmae	Indigenous	2.86	0
C. nitida (Vent) Schott & Endl	Sterculiaceae	Exotic	2.52	0
C. sinensis (L) Osbeck	Rutaceae	Exotic	2.38	0
M. indica Linn	Anacardiaceae	Exotic	2.05	0
A. occidentale Linn	Anacardiaceae	Exotic	1.86	0
P. guajava Linn	Myrtaceae	Exotic	1.57	0
P. americana Mill	Lauraceae	Exotic	1.52	0
R. heudelotii (Baill) Heckel	Euphorbiaceae	Indigenous	1.19	0
C. reticulata Blanco	Rutaceae	Exotic	1.14	0
C. nucifera Linn	Palmae	Exotic	0.67	0
C. paradisi Macfad	Rutaceae	Exotic	0.67	0
D. edulis (G. Don.) H.J. Lam	Burseraceae	Indigenous	0.38	0
G. kola Heckel	Guttiferae	Indigenous	0.24	0
S. mombin Linn	Anacardiaceae	Indigenous	0.24	0
C. albidum G. Don	Sapotaceae	Indigenous	0.19	1.17
D. guineense Willd	Caesalpinioideae	Indigenous	0.1	3.4
B. sapida Konig	Sapindaceae	Indigenous	0.1	5.1
Parinari curatelifolia Planch ex Benth	Chrysobalanaceae	Indigenous	0	1.17
Diospyros mespiliformis Hochst	Ebenaceae	Indigenous	0	1.17

of 16 species in 13 families were recorded in the 21 ha of cocoa agroforests. Only 26.3% of these were indigenous (Table 2). Among the non-fruit tree species that were present in substantial proportions were *Alstonia congensis*, *Ceiba pentandra*, *Triplochiton schleroxylon* and *Milicia excelsa*.

In the 0.56 ha of reserved forest surveyed, 163 individual trees belonging to 62 species in 29 families were encountered (Table 3). The richest families were Caesalpinioideae (eight species), Sterculiaceae (six species), Mimosoideae (five species) and Moraceae (five species). The dominant tree species were *Celtis mildbraedii*, *Piptadeniastrum africanum*, *Afzelia africanum*, *Antiaris africana*, *Entandrophragma cylindricum*, *Brachystegia euricoma*, *Canarium schweinfurthii*, *C. pentandra* and *A. congensis*.

The proportion of non-fruit trees to fruit trees in the natural forest is very high with only five edible fruit tree species—*Ricinodendron heudelotii*, *Chrysophyllum albidum*, *Bligha sapida*, *Diospyrous mespiliformis* and *Parinari curatelifolia* (Fig. 1). Tree diversity in the natural forest was higher than in the cocoa agroforests indicating a greater variety of species. Rarefaction curves indicate that cocoa agroforests support relatively lower species richness than a floristically and climatically similar site of primary forest (Fig. 2). Basal area and density of non-cocoa trees in the cocoa agroforests were also low compared to those of the natural forest (Table 4).

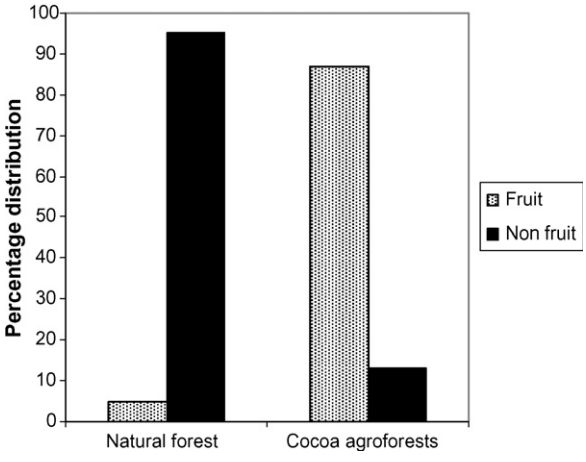

Fig. 1. Distribution of fruit/non-fruit species in the cocoa agroforests and natural rainforest ecosystem.

4. Discussion

This study shows that a number of both native and exotic non-cocoa tree species occur in the traditional cocoa-based agroforestry farms in Ondo State, with exotic species predominant. *E. guineensis* (Oil Palm) was the most

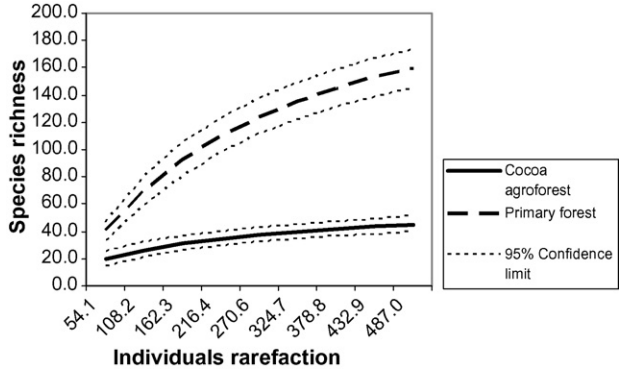

Fig. 2. Tree species richness in cocoa agroforestry and primary forest (Forest Reserve) in Ondo State, Nigeria. Individual rarefaction curves and confidence intervals.

Table 3
Diversity of tree species in the 0.56 ha of natural rainforest ecosystem in Ondo State, Nigeria

Species	Family	Frequency	Density (trees/ha)
C. mildbraedii Engl.	Ulmaceae	8	13.6
P. africanum (Hook f.) Brenan	Mimosoideae	8	13.6
A. africana Sm.	Caesalpinioideae	8	13.6
A. africana Decne	Moraceae	5	8.5
E. cylindricum (Sprague)	Meliaceae	5	8.5
Brachystegia euricoma Harms	Caesalpinioideae	5	8.5
C. schweinfurthii Engl.	Buseraceae	5	8.5
C. pentandra (Linn) Gaertn	Bombacaceae	5	8.5
A. congensis Engl	Apocynaceae	5	8.5
M. excelsa (Welw) C.C. Berg	Moraceae	4	6.8
M. cecropoides R. Br. Ex. Tedlie	Moraceae	4	6.8
Lovoa trichilioides Harms	Meliaceae	4	6.8
Harungana madagascarensis Lam	Guttiferae	4	6.8
D. gossweileri S.Moore	Euphorbiaceae	4	6.8
F. elastica (Preuss) Stapf	Apocynaceae	4	6.8
Cleistopholis patens (Benth) Engl. & Diels	Annonaceae	4	6.8
Blighia sapida Konig	Sapindaceae	3	5.1
Pycnanthus angolensis (Welw) Warb.	Myristicaceae	3	5.1
Bosqueia angolensis Ficalho	Moraceae	3	5.1
Berlinia spp. Hook f & Benth	Caesalpinioideae	3	5.1
Erythrophleum africanum (Benth) Harms	Caesalpinioideae	3	5.1
Gilbertiodendron dewevrei De Wild	Caesalpinioideae	3	5.1
G. balsamiferum (Verm) Harms	Caesalpinioideae	3	5.1
Cordia millenii Bak.	Boraginaceae	3	5.1
Lannea welwitschii (Hiern) Engl.	Anacardiaceae	3	5.1
Deplatsia dewevrei De Wild & Th Dur	Tiliaceae	2	3.4
Triplochiton scleroxylon K. Schum	Sterculiaceae	2	3.4
P. macrocarpa K. Schum	Sterculiaceae	2	3.4
Pachystela brevipes (Bak.) Baill	Sapotaceae	2	3.4
Lecaniodiscus cupanioides Planch ex Benth	Sapindaceae	2	3.4
Mitragyna ciliate Aubrev & Pellegr	Rubiaceae	2	3.4
Pterocarpus erinaceus Poir.	Papilionoideae	2	3.4
F. exasperata (Vahl)	Moraceae	2	3.4
Fagara macrophylla Engl.	Mimosoideae	2	3.4
Penthaclethra macrophylla Benth	Mimosoideae	2	3.4
Acacia sieberiana A.Chev	Mimosoideae	2	3.4
Khaya ivorensis A.Chev	Meliaceae	2	3.4
Caloncoba glauca (P.Beauv.) Gilg	Flacourtiaceae	2	3.4
R. heudelotii (Baill) Heckel	Euphorbiaceae	2	3.4
Antidesma laciniatum Muell. Arg	Euphorbiaceae	2	3.4
Daniella ogea (Harms) Rolfe ex Holl	Caesalpinioideae	2	3.4
S. campanulata P. Beauv.	Bignoniaceae	2	3.4
C. zenkeri Engl	Ulmaceae	1	1.7
Holoptelia grandis (Hutch) Mildbr	Ulmaceae	1	1.7
Nesogodonia papaverifera (A.Chev) R. Capuron	Sterculiaceae	1	1.7
Sterculia rhinopetala K. Schum	Sterculiaceae	1	1.7
S. tragacantha Lindl	Sterculiaceae	1	1.7
Mansonia altissima A. Chev	Sterculiaceae	1	1.7
Chrysophylum albidum G. Don	Sapotaceae	1	1.7
Mitragyna stipulosa (DC) Kuntze	Rubiaceae	1	1.7
Anopyxis klaineana (Pierre) Engl	Rhizophoraceae	1	1.7
Pterocarpus santalinoides L'Herit ex DC	Papilionoideae	1	1.7
Lophira alata Banks ex Gaertn f.	Ochnaceae	1	1.7
Albizia zygia J.F. Macbr	Mimosoideae	1	1.7
Anthocleista vogelii Planch	Loganiaceae	1	1.7
Phyllanthus physocarpus Muell Arg.	Euphorbiaceae	1	1.7
D. mespiliformis Hochst	Ebenaceae	1	1.7
T. superba A.Chev	Combretaceae	1	1.7
Terminalia ivorensis Engl & Diels	Combretaceae	1	1.7
Parinari curatellifolia Planch ex Benth	Chrysobalanaceae	1	1.7
Anthonotha macrophylla P. Beauv	Caesalpinioideae	1	1.7
D. manii Bak.	Agavaceae	1	1.7
		163	276.3

Table 4
Basal area, volume and diversity indices of non-cocoa trees in cocoa agroforests and natural rainforest ecosystem in Ondo State, Nigeria

Parameters	Cocoa agroforest	Natural forest
Density (*n*/ha)	23.2	276.3
Basal area (m^2/ha)	6.2 a ± 2.1	44.2 b ± 7.3
Volume (m^3/ha)	119.9 a ± 31.0	730.9 b ± 112.3
Diversity index	2.71	3.58

Means on the same row followed by same letters are not significantly different ($P < 0.05$).

common species. It regenerated naturally in most cases and its seedlings were protected by farmers because of its important contribution to family income. Other prominent tree species were *C. nitida*, *C. sinensis*, *M. indica*, *A. occidentale*, *P. guajava* and *P. americana*, exotic tree species cultivated by farmers to provide edible fruits in addition to shade for cocoa, as also reported by Leakey and Tchoundjeu (2001), Duguma et al. (2001), Sonwa et al. (2001) and Asare (2006). There was a dominance of exotic tree species in the cocoa farms in contrast to the approximate 50:50 mixtures observed in Cameroon (Schreckenberg et al., 2002).

Further, although the cocoa agroforests contained a wide variety of non-cocoa trees, Shannon's index showed them to have a lower diversity of tree species than the natural forest. The high proportion of fruit trees in the cocoa farms is an indication that farmers were interested in planting or retaining fruit, rather than timber trees. This is probably because of the opportunities to use the products domestically and to sell them in the local markets. Because of these livelihood benefits, current research efforts are geared towards domestication of indigenous wild fruit species for incorporation into farmland, using participatory techniques appropriate for subsistence farmers. The poor attitude of farmers towards the retention of timber trees may be connected with factors such as tree tenure system, the long gestation period of timber species, the need for other sources of income to augment farm income and the damage to cocoa trees that usually accompany timber extraction.

The results of this study agree with the observations of Asare (2006) who noted the gradual shift in cocoa production towards a management system of lower conservation value than the traditional multistrata cocoa agroforests that harboured diverse population of forest species. The timber species encountered on the cocoa farms though few in number were trees of merchantable sizes which could not be harvested because of the fear of destroying many cocoa trees. Quite a number of the rare economic tree species like *M. excelsa*, *B. euricoma*, *A. africana* and *Terminalia superba* were available on cocoa farms. There were indications that some of the farmers were making deliberate efforts to plant some timber tree species on their farms—especially *Terminalia* spp. It can therefore be said that cocoa agroforests of Ondo State has contributed to the conservation of forest tree species. There is however the need to further stimulate the interest of cocoa farmers in planting trees on their farms.

5. Conclusion

The results of this study have shown that the cocoa agroforests of Ondo State contained a variety of useful non-cocoa tree species and that the rich natural forest is rapidly giving way to cocoa farms. Nevertheless cocoa-based agroforestry systems have the capacity to produce timber, edible fruits and conserve many of the forest species under improved management practices.

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