International Journal of Forestry and Horticulture (IJFH)
Volume 9, Issue 1, 2023, PP 16-32
ISSN No. (Online) 2454–9487
DOI: http://dx.doi.org/10.20431/2454-9487.0901003
www.arcjournals.org

Shade Tree Composition, Structure and Management in Cocoa Agroforestry Systems in Kumba South West Region, Cameroon

Njoh Roland Ndah[1,2*], Celestine Fonyikeh-Bomboh Lucha[3], Asanghanwa Fuhnwi Nsa'alah[1]

[1]*Department of Agriculture, Higher Technical Teachers Training College (HTTTC), Kumba, P.O. Box 249, Kumba, University of Buea, Cameroon.*
[2]*Forests, Resources and People, Limbe P.O Box 111 Limbe, Cameroon*
[3]*Department of Plant Biology, University of Dschang, P.O. Box 67, Dschang, Cameroon*

Corresponding Author:** ***Njoh Roland Ndah, *Department of Agriculture, Higher Technical Teachers Training College (HTTTC), Kumba, P.O. Box 249, Kumba, University of Buea, Cameroon; Forests, Resources and People, Limbe P.O Box 111 Limbe, Cameroon*

Abstract: *The diversification of trees in cocoa agroforestry plays a major role in ecosystem goods and services. The study investigated shade tree composition, structure, selection criteria and management in cocoa agroforest. Data were collected with the use of structured questionnaires and vegetation analyses of thirty (30) cocoa agroforest farms were randomly selected across three (3) zones namely; zone 1 (Kumba urban, zone 2 (Kake) and zone 3 (Barombi Kang). Data collected were analyzed with the help of Microsoft excel and SPSS version 21. The results showed that 87.30%, of the cocoa agroforestry farmers were males owning farm sizes between 2.5-4.5 hectares and 49.2% inherited. Based on age, 90.5% of the farmers were aged above 50 years and 92.1% were holders of basic level of education. A total of 38 tree species belonging to 25 families were identified in cocoa agroforestry farms. The top (5) five species identified across sites were: Dacryodes edulis (16.78), Persea americana (16.36), Elaeis guinensis (9.73), Mangifera indica (5.5) and Citrus sinensis (5.44). The diameter class distribution of trees showed a reverse J-shaped structure with decreasing densities with increasing diameter class. Zone 3 recorded the highest species richness (35±0.58) and the highest value of Shannon wiener index (2.86±0.06). The majority of the respondents considered the following criteria in selecting shade trees for their farms; shade purpose (17%), income (17%), fuel wood (17%), construction (16%) timber (15%) and medicine (14%). Majority of the respondents across the study area indicated that afforestation (33%), pruning (18%), weeding (18%) and thinning (17%) are the most commonly used management practices for shade trees in the cocoa agroforest. Majority of the respondents presented financial difficulties (19%), pest and diseases (18%) and theft (18%) as the main challenges faced in management of shade trees in cocoa agroforestry.*

Keywords: *Shade trees, cocoa agroforestry, tree diversity, structure, composition*

1. INTRODUCTION

Forest degradation, deforestation and habitat fragmentation are the main causes of losses of biodiversity [1]. These are amongst the top environmental problems that affect ecosystem goods and services globally [2]. Although agriculture is the main bread basket and the back bone for most countries' economy, most of the practices are less sustainable with the used of rudimentary methods which are not environmentally friendly [3]. Practices such as shifting cultivation, slash and burn, bush fire etc are driving most of the biodiversity to become threatened while others are becoming extinct [4]. Most of these species are disappearing in the face of the world before they are being documented [5].

The growing of cocoa under diversified native tree shade is increasingly being viewed as a means of contributing to biodiversity conservation within agricultural landscapes complementing conservation in protected and unprotected areas [6].

Cocoa agroforests can play a role in conservation strategies in fragmented landscapes by providing habitat and resources for plant and animal species and by maintaining connectivity between forest areas [7]. Studies have revealed that cocoa agroforests had showed the ability to conserve birds, bats, insects and other wildlife to a greater extent than alternative land uses such as cocoa with little or no specific shade [8].

The diversity and structural complexity of cocoa shade trees vary widely between cocoa growing regions, between farms within a region, and even between sections within a plantation. Some cocoa shade trees are species rich and structurally complex, with several vertical strata and diverse spatial and temporal configurations [9]. The low cocoa prices during the 1990s in Cameroon encouraged farmers to diversify their income by maintaining and introducing useful species (such as timber species, medicinal species, food crops and fruit trees) in their cocoa agroforests [10].

Farmers of South west, Cameroon have developed a system in which cocoa groves of about 0.7–2 ha are intimately associated with local and exotic tree species [11]. These cocoa agroforests, which in the past were considered "indigenous" or primitive [12], mimic to some extent forest structure and function [13]. It is in this light that this study aimed to look at the potentials of shade trees composition and structure in cocoa agroforestry farms of Kumba I municipality.

2. Materials And Methods

2.1. Description of Study Area

Kumba is a metropolitan city found in the Meme Division, in the South west region of Cameroon (figure, 1). It coordinates 4°38'7'' N and 9°26'57'' S. It is popularly referred to as "K-town". The mean annual rainfall is about 2500 mm. It is characterized by a mono-modal rainfall pattern which is higher in July and September and the dry season which generally extends from November to March. Annual temperature variation is 25°C [14]. It is the largest city in the Meme division and a hop for most businesses. It has an estimated population of about 400,000 inhabitants [15].

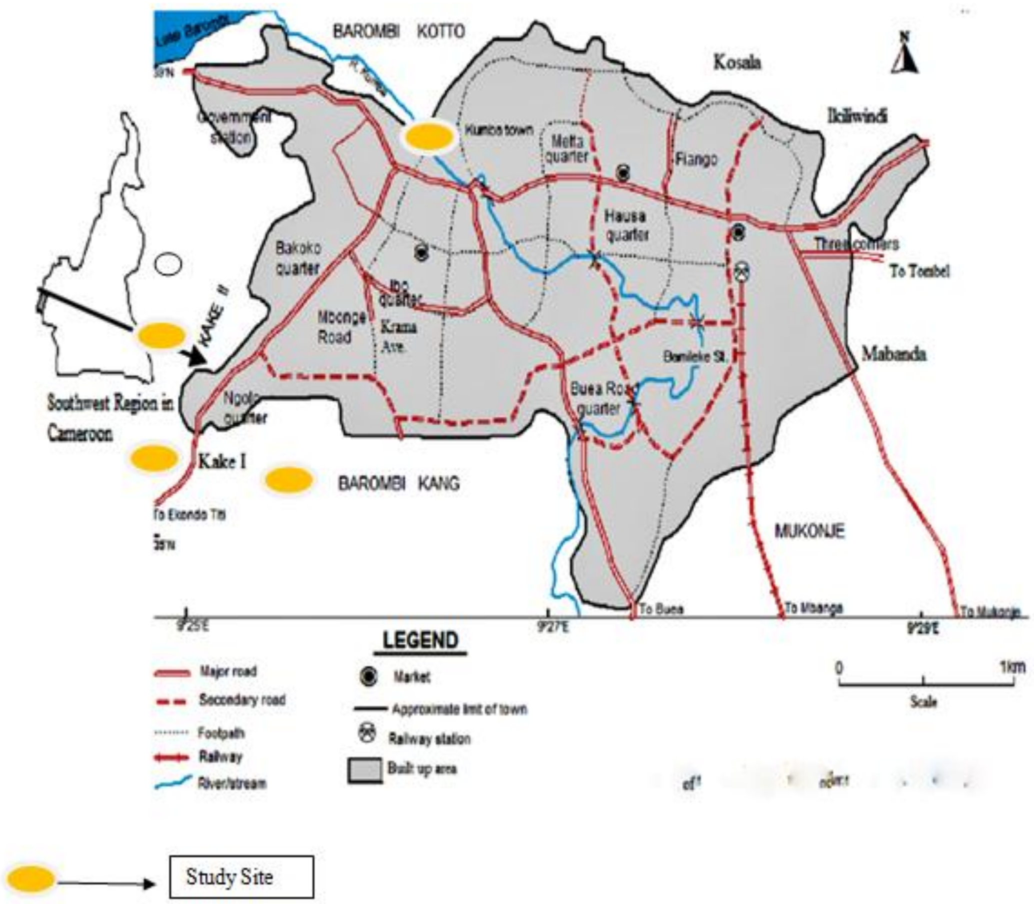

Figure1. *Map shows the studsy site [16]*

2.2. Sampling Design

In the selected areas, stratified random sampling procedure was followed to select targeted cocoa agroforest farmers in the 3 zones. Membership lists of local farmer association (Common Initiative Group) (CIG) were gotten from the Delegation of Agriculture and Rural Development (MINADER) Kumba. The sample populations were obtained for the different zones using the Kredje Morgan table

[17] following the distribution of the Common Initiative Groups (CIG) in Kumba I municipality. This method was choosen for this study because it provides an effective method for determining sample size to address the existing research gap [17].

Table1. *Sample size for studying cocoa agroforest farmers in Kumba I*

Zones	Population of farmers	Expected samples
Zone 1 (Kumba Urban)	18	17
Zone 2 (Kake)	21	20
Zone 3 (Barombi Kang)	27	26
Total	66	63

Adopted from [17]

For tree inventories, ten (10) cocoa agroforest farms were randomly selected in each of the Zones in Kumba 1 municipality.

Questionnaires were administered face-to-face to each farmer to gather information on the cocoa agroforest farms. Farmers who owned more than one farms, only one of the farm was selected based on size and accessibility.

2.3. Consultative Meetings and Clearance of Study

Consultative meetings with the chiefs, head councils and president of the different common initiative groups (CIG) in the different zones were carried out. The main purpose of the meetings were to obtained consents and to explain the purpose of the research work to the communities. A pilot study was carried out to pre-test and validate the questionnaires. Six (6) farmers were selected in the three zones of the study sites. The pre-test questionnaires were administered to test the validity and reliability of the research instrument. The pilot study respondents were not included in the final research work.

2.4. Questionnaire and Data Collection

The field work was carried out from March to July 2023. Data were collected with the use of a semi-structure questionnaire and supplementary data were obtained through field observations and discussion with extension officers at the Divisional Delegation of Agriculture and Rural Development for Meme.

The questionnaires were divided into 4 sections: Section 1 Socio-demographic characteristics of cocoa agroforest farmers (age, education, size of farms inherited, age of the farms etc). Section 2 Criteria for shade trees selection and uses in cocoa agroforest (shade, food, timber etc). Section 3 Management of the shade trees in the cocoa agroforest (pruning, weeding, nursery establishment). Section 4 Constraints faced by farmers in shade trees production in cocoa agroforest.

2.5. Tree Inventories

Vegetation data were collected in a total of 30 cocoa agroforests farms randomly selected across the three zones, representing a total area of 2.5 ha. For collection of vegetation data, the random quadrat method was used in each cocoa farmand trees were sampled in quadrats of 10 x 10 m size, following [18] and [19]. Quadrats were established from the left, centered and right flanks of the cocoa farms to ensured trees from the different habitats in the agroforest farms were collected. The plant species were identified by their local names, for each tree with a height greater than or equal to two meters, the number of individuals of each species within the quadrats were counted, diameter at breast height (DBH 1.3 m) and height were measured and recorded in each sampled plot by super imposing range poles on tree stem.

Local names of all tree species found in the sampled cocoa farms were recorded with the help of cocoa farm owners (local community), and a field guide knowledgeable with the flora of the area. Farmers' local names for tree species were documented and the identification of scientific names of trees was carried out using books as a guideline. Specimens which were not identified were carried in triplicate to the Limbe botanical garden for identification.

Density, Frequency, Abundance, Basal area and Impotence Value Index (IVI) were calculated following [20].

Species richness (number of species per unit area) [21], Shannon wiener index [22] and Simpson's dominance index [23] as a measure of alpha diversity were calculated for each cocoa farm.

2.6. Data Analysis

Data collected were analysed with the help of Microsoft excel and SPSS version 21. The analyses of tree species diversity parameters were carried out with the use of Microsoft Excel. The results were subjected to one-way ANOVA using Tukey's test to compare whether there were significant means difference in tree species diversity among the three zones of the cocoa agroforest in Kumba I municipality Descriptive statistics were used to present the results.

3. Results

3.1. Socio-demographic Characteristics of Respondents in the Study Site

Table 2 presents the gender and age distribution of the respondents. With respect to gender, a majority of the respondents (87.3%) across the study site were males while the rest (12.7%) were female. Cross tabulation across the zones shows that in zone 1(28.6%), zone 2 (23.8%) and Zone 3 (34.9%) male respondents were more represented than female. Of all the respondents in the study site irrespective of gender, a majority (41.3%) were from Zone 3 while the least represented zone was zone 2 (27%).

With respect to age distribution, a majority of the respondents were aged 50 years and above (47.6%) while the least represented age group was 30 to 40 years old (7.9%). In zone 1, the age group 50 years and above (15.9) was the most represented while the least was 20 to 30 years old (1.6%). In zone 2, the age group most represented was 50 years and above (17.5%) while that least represented was 20 to 30 years old (1.6%). Similarly, in zone 3, the age group most represented was 40 to 50 years old, while the least represented was 30 to 40 years old (3.2%).

Chi square test of association between the zones and sex ratio (p = 0.855) and between zones and age distribution (p = 0.534) shows that there is no significant association between the zone and the measured parameters.

Table2. *Sex ratio and age distribution of respondents across the study site*

			Zones (%)			Total (%)	
Variable	**Parameter**	**Frequency**	**Zone 1**	**Zone 2**	**Zone 3**		**χ^2 p value**
Gender	Male	Frequency	18a	15a	22a	55	0.855
		% of Total	28.60%	23.80%	34.90%	87.30%	
	Female	Frequency	2a	2a	4a	8	
		% of Total	3.20%	3.20%	6.30%	12.70%	
	Total	Frequency	20	17	26	63	
		% of Total	31.7%	27.0%	41.3%	100.0%	
Age	20-30	Frequency	1a	1a	4a	6	0.534
		% of Total	1.60%	1.60%	6.30%	9.50%	
	30-40	Frequency	2a	1a	2a	5	
		% of Total	3.20%	1.60%	3.20%	7.90%	
	40-50	Frequency	7a	4a	11a	22	
		% of Total	11.1%	6.30%	17.5%	34.90%	
	>50	Frequency	10a	11a	9a	30	
		% of Total	15.9%	17.5%	14.3%	47.60%	
	Total	Frequency	20	17	26	63	
		% of Total	31.7%	27.0%	41.3%	100.0%	

Each subscript letter denotes a subset of Zone categories whose column proportions do not differ significantly from each other at α = 0.05 (z test).

3.2. Socio-demographic Characteristics of Respondents in the Study Site

Table 2 presents the marital status and religion distribution of the respondents. With respect to marital status, a majority of the respondents (87.3%) across the study site are married while the rest are single (7.9%) and divorced (4.8%). Cross tabulation across the zones shows that in zone 1(25.4%), zone 2 (25.4%) and Zone 3 (36.5%) married respondents were more represented than singles and divorced.

With respect to religion distribution, a majority of the respondents (95.20%) across the study site are Christians while the rest (4.80%) are Muslims. Cross tabulation across the zones shows that in Zone 1(28.6%), Zone 2 (27.0%) and Zone 3 (39.7%) Christian respondents were more represented than Muslims. Of all the respondents in the study site irrespective of religion, a majority (41.3%) were from Zone 3 while the least represented zone was Zone 2 (27%).

Chi square test of association between the zones and marital ratio (p = 0.116) and between zones and religion distribution (p = 0.349) shows that there is no significant association between the zone and the measured parameters.

Table3. *Marital status and religion of respondents across the study site*

			Zones (%)				
Variable	**Parameter**	**Frequency**	**Zone 1**	**Zone 2**	**Zone 3**	**Total (%)**	χ^2
Marital status	Married	Frequency	16a	16a	23a	55	0.116
		% of Total	25.40%	25.40%	36.50%	87.30%	
	Single	Frequency	1a	1a	3a	5	
		% of Total	1.60%	1.60%	4.80%	7.90%	
	Divorced	Frequency	3a	0a, b	0b	3	
		% of Total	4.80%	0.00%	0.00%	4.80%	
	Total	Frequency	20	17	26	63	
		% of Total	31.70%	27.00%	41.30%	100.0%	
Religion	Christian	Frequency	18a	17a	25a	60	0.349
		% of Total	28.60%	27.00%	39.70%	95.20%	
	Moslim	Frequency	2a	0a	1a	3	
		% of Total	3.20%	0.00%	1.60%	4.80%	
	Total	Frequency	20	17	26	63	
		% of Total	31.70%	27.00%	41.30%	100.0%	

Each subscript letter denotes a subset of Zone categories whose column proportions do not differ significantly from each other at $\alpha = 0.05$ (z test).

3.3. Socio-demographic Characteristics of Respondents in the Study Site

Table 3 presents the household size and level of educationdistribution of the respondents. With respect to household size distribution, a majority of the respondents had a household size of 4–6 (49.2%) while the least represented household size was 11-13 (3.2%). In zone 1, the household size 7-10 (14.3%) was the most represented while the least was 11–13 (0.00%) household size. In zone 2, the household size most represented was 7 - 10 (15.90%) while the least represented was 1–3 (0.00%) household size. Similarly, in zone 3, the age group most represented was 4 - 6 (27.0%) household size, while the least represented was 11 - 13 (1.6%) household size.

With respect to Level of education distribution, a majority of the respondents had FSLC (50.8%) while the least represented were first degree holders (0.00%). In zone 1, FSLC(15.9%) was the most represented while the least were first degree holders (0.00%). In zone 2, the level of education most represented was FSLC (15.90%) while that least represented were those with GCE OL (3.2%) and First degree (3.2%). Similarly, in Zone 3, the level of education most represented was FSLC (19.0%), while the least represented were First degree (1.6%) holders and those with No certificates (1.6%).

Chi square test of association between the zones and household number (p = 0.143) and between zones and Level of education distribution (p = 0.21) shows that there is no significant association between the zone and the measured parameters.

Table3. *Household size and level of education of respondents across the study site*

			Zones (%)			Total(%)	
Variable	**Parameter**	**Frequency**	**Zone 1**	**Zone 2**	**Zone 3**		χ^2
Household number	1 - 3	Frequency	3a	0a	2a	5	0.143
		% of Total	4.80%	0.00%	3.20%	7.90%	
	4 - 6	Frequency	8a	6a	17a	31	
		% of Total	12.7%	9.50%	27.0%	49.20%	
	7 - 10	Frequency	9a, b	10b	6a	25	
		% of Total	14.3%	15.9%	9.50%	39.70%	
	11 - 13	Frequency	0a	1a	1a	2	
		% of Total	0.00%	1.60%	1.60%	3.20%	
	Total	Frequency	20	17	26	63	
		% of Total	31.7%	27.0%	41.3%	100.0%	
Level of education	No certificate	Frequency	4a	0a	1a	5	0.21
		% of Total	6.30%	0.00%	1.60%	7.90%	
	FSLC	Frequency	10a	10a	12a	32	
		% of Total	15.9%	15.9%	19.0%	50.80%	
	GCE OL	Frequency	1a	2a	5a	8	
		% of Total	1.60%	3.20%	7.90%	12.70%	
	GCE AL	Frequency	4a	3a	7a	14	
		% of Total	6.32%	4.70%	11.2%	22.22%	
	First degree	Frequency	1a	2a	1a	15	
		% of Total	1.58%	3.20%	1.60%	6.38%	
	Total	Frequency	20	17	26	63	
		% of Total	31.7%	27.0%	41.3%	100.0%	

Each subscript letter denotes a subset of Zone categories whose column proportions do not differ significantly from each other at $\alpha = 0.05$ (z test)

3.4. Socio-demographic Characteristics of Respondents in the Study Site

Table 4 presents the Farm size, age of farm (years) and farm establishment distribution of the respondents. With respect to Farm size distribution, a majority of the respondents had farm size of 2.5-3.5 (38.1%) while the least represented farm size was 0.5-1.5 (15.90%). In zone 1, the Farm size 2.5-3.5 (12.7%) was the most represented while the least was 0.5-1.5 (3.2%) farm size. In zone 2, the farm size most represented was 0.5-1.5 (9.50%) while that least represented was 1.5-2.5 (3.20%) farm size. In Zone 3, the farm size most represented was 2.5-3.5 (17.50%) farm size, while the least represented was 0.5-1.5 (3.2%) farm size.

With respect to the Age of farm distribution of the respondents, a majority of the respondents had Farms aged 16-20 years (63.5%) while the least represented farm age was 1-5 years (1.6%). In zone 1, the Farm aged 16-20 (17.5%) was the most represented while the least farm age was 0.5-1.5 (0.00%) years old. In zone 2, the farm age most represented was 16-20 (23.8%) while that least represented was farm age 1-5 (0.00%) years old. Similarly, in Zone 3, the farm age most represented was 16-20 (22.2%) years, while the least represented was 0.5-1.5 (1.6%) years old.

With respect to farm establishment distribution, a majority of the respondents inherited (49.2%) the farms while the least represented were farmers who received as Gift (3.2%). In zone 1, farms established by farmers by themselves(19.0%) was the most represented while the least were those farmers who received the farms as gift (1.6%). In zone 2, farmers who inherited (22.2%) the farms were the most represented while that least represented were those who received the farms as gift (0.00%).

Similarly, in Zone 3, famers who inherited (49.2%) the farms were the most represented while the least represented were those who received the farms as gift (3.2%).

Chi square test of association between the zones and farm size (p = 0.205), between zones and age of farm (p=0.135) and between the zones and farm establishment distribution (p = 0.113) shows that there is no significant association between the zone and the measured parameters.

Table4. *Characteristics of farms across the study site*

			Zone (%)			Total(%)	
Variable	**Parameters**	**Frequency**	**Zone 1**	**Zone 2**	**Zone 3**		χ^2 **P Value**
Farm sizes (Ha)	0.5-1.5	Frequency	2a,b	6b	2a	10	8.472
		% of Total	3.20%	9.50%	3.20%	15.90%	0.205
	1.5-2.5	Frequency	7a	2a	8a	17	
		% of Total	11.10%	3.20%	12.70%	27%	
	2.5-3.5	Frequency	8a	5a	11a	24	
		% of Total	12.70%	7.90%	17.50%	38.10%	
	3.5-4.5	Frequency	3a	4a	5a	12	
		% of Total	4.80%	6.30%	7.90%	19.00%	
Total		Frequency	20	17	26	63	
		% of Total	31.70%	27%	41.30%	100%	
Age of farm (years)	1-5	Frequency	0a	0a	1a	1	9.769
		% of Total	0.00%	0.00%	1.60%	1.60%	0.135
	6-10	Frequency	1a	0a	4a	5	
		% of Total	1.60%	0.00%	6.30%	7.90%	
	11-15	Frequency	8a	2a	7a	17	
		% of Total	12.70%	3.20%	11.10%	27.00%	
	16-20	Frequency	11a	15b	14a	40	
		% of Total	17.50%	23.8%	22.20%	63.50%	
Total		Frequency	20	17	26	63	
		% of Total	31.70%	27.0%	41.30%	100%	
Farm establishment	Myself	Frequency	12a	3b	15a	30	10.48
		% of Total	19.00%	4.80%	23.80%	47.60%	0.113
	Inherited	Frequency	7a	14b	10a	31	
		% of Total	11.10%	22.20%	15.90%	49.20%	
	Gift	Frequency	1a	0a	1a	2	
		% of Total	1.60%	0.00%	1.60%	3.20%	
Total		Frequency	20	17	26	63	
		% of Total	31.70%	27.00%	41.30%	100%	

Each subscript letter denotes a subset of Zone categories whose column proportions do not differ significantly from each other at $\alpha = 0.05$ (z test)

3.5. Socio-demographic Characteristics of Respondents in the Study Site

Table 5 presents the occupation distribution of the respondents. With respect to occupation, a majority of the respondents (92.10%) across the study site were farmers while the rest (7.90%) had other occupations. Cross tabulation across the zones shows that in zone 1(31.7%), zone 2 (23.8%) and Zone 3 (36.50%) respondents were farmers. Of all the respondents in the study site irrespective of occupation, a majority (36.50%) were from Zone 3 while the least represented zone was zone 2 (23.8%).

Table5. *Occupation of respondents across the study site*

		Zone (%)			Total(%)
Parameter	**Frequency**	**Zone 1**	**Zone 2**	**Zone3**	
Farmer	Frequency	20a	15a	23a	58
	% of Total	31.70%	23.80%	36.50%	92.10%
Other profession	Frequency	0a	2a	3a	5
	% of Total	0.00%	3.20%	4.80%	7.90%
Total	Frequency	20	17	26	63
	% of Total	31.70%	27%	41.30%	100%

Each subscript letter denotes a subset of Zone categories whose column proportions do not differ significantly from each other at α = 0.05 (z test)

Shade Tree Species Composition and Structure across the Zones

3.6. Shade Tree Species Composition Frequency and Density Across the Zones

The study revealed that considerable number of tree species are being managed and conserved in cocoa agroforestry farms. Accordingly, a total of 838 trees belonging to 38 species and 25 families were encountered in cocoa agroforestry farms. The ten most abundant tree species were accounted for about 75% of the total tree counts, while the top five species were *Daryodes edulis*, *Persea Americana*, *Elaeis guinensis*, *Magnifera indica* and *Citrus sinensis*. The family Rutaceae was the largest family having five (5) species recorded. It was closely followed by Myristicaceae and Bombacaceae represented by two (2) species each. The least family were 23 with one specie each (Table 6).

Table6. *Density and frequency of tree species across zones*

Family	Scientific Name	Common name	ZONE 1		ZONE 2		ZONE 3	
			Rel. freq	Rel. Density	Rel. freq	Rel. Density	Rel. freq	Rel. Density
Apocynaceae	*Alstonia boonei*	Mil k stick	0.79	0.36	1.95	0.99	0.69	0.38
Burseraceae	*Aucoumea klaineana*	Akom	4.72	3.64	5.84	5.61	2.08	1.54
	Dacryodes edulis	Plum	7.87	15.64	6.49	16.50	6.94	16.54
Sapotaceae	*Baillonella toxisperma*	Njabe	1.57	0.73	0.65	0.66	2.08	1.54
	Chrysophylum albidum	Udara tree	0.00	0.00	0.00	0.00	0.69	0.38
Caricaceae	*Carica papaya*	Pawpaw	2.36	1.82	0.65	0.33	4.17	3.08
Bombacaceae	*Ceiba pentandra*	Boma tree	0.79	0.36	2.60	1.32	2.08	1.15
Rutaceae	*Citrus aurantiifolia*	Lime	0.00	0.00	0.00	0.00	0.69	0.38
	Citrus limon	Lemon	1.57	0.73	2.60	1.65	1.39	1.15
	Citrus reticulata	Tangerine	0.79	0.36	0.65	0.33	0.69	0.38
	Citrus sinensis	Orange	7.09	4.36	5.84	6.60	6.25	5.38
Arecaceae	*Cocos nucifera*	Coconut	1.57	0.73	4.55	2.64	2.78	1.54
	Elaeis guinensis	Oil Palms	7.09	10.18	5.19	8.25	6.94	10.77
Malvaceae	*Cola accuminata*	Kola nut	2.36	1.09	2.60	1.32	1.39	0.77
Sterculiaceae	*Cola lepidota*	Monkey kola	4.72	3.64	3.90	1.98	2.78	1.54
Fabaceae	*Distemonanthus benthamianus*	Monkey no climb	0.00	0.00	0.00	0.00	0.69	0.38
Meliaceae	*Entandophragma cylindricum*	Sapelle	0.79	0.36	0.00	0.00	1.39	0.77

Family	Scientific Name	Common name	ZONE 1		ZONE 2		ZONE 3	
			Rel. freq	Rel. Density	Rel. freq	Rel. Density	Rel. freq	Rel. Density
Moraceae	*Ficus mucoso*	Sand leaf	3.15	2.55	4.55	5.61	3.47	3.46
Clusiaceae	*Garcinia kola*	Bitter kola	4.72	2.18	3.90	3.30	2.78	1.92
	Guiboutia spp	Bobinga	0.79	0.36	0.65	0.33	0.69	0.38
Euphorbiaceae	*Hevea brasiliensis*	Rubber	0.00	0.00	0.00	0.00	0.69	0.77
Irvingiaceae	*Irvingia gabonensis*	Bush mango	6.30	4.73	4.55	2.97	5.56	3.85
	Khaya ivorensis	Mahogany	2.36	1.09	3.90	1.98	2.78	1.54
Ochnaceae	*Lophira alata*	Iron wood	0.79	0.36	1.95	1.98	0.00	0.00
Anacardiaceae	*Mangifera indica*	Man go	4.72	4.73	5.84	4.95	6.94	6.92
Rosaceae	*Malus domestica*	Apple	1.57	0.73	0.00	0.00	1.39	1.15

	Milicia excels	Iroko	0.79	0.36	2.60	1.32	2.08	1.15
Cecropiaceae	*Musango cecropia*	Umbrella stick	6.30	6.55	1.30	0.66	4.17	3.46
Lauraceae	*Persea americana*	Pear	7.87	20.73	6.49	14.52	6.94	13.85
Lecythidaceae	*Petersianthus macrocarpus*	Small leave	7.09	6.18	6.49	4.95	4.86	5.00
Myrtaceae	*Psidium guajava*	Guava	3.15	1.45	4.55	2.31	4.86	3.08
	Pterocarpus soyauxii	Camwood	1.57	0.73	0.00	0.00	0.69	0.38
Myristicaceae	*Pycnanthus angolensis*	karabot stick	0.00	0.00	0.65	0.33	0.00	0.00
	Ricinodendron heudelotii	Njansang	1.57	1.09	5.84	4.29	2.08	1.15
	Staudtia kamerunensis	Matanda	1.57	1.09	0.00	0.00	2.78	1.54
Combretaceae	*Terminalia ivorensis*	Black afara	1.57	1.09	0.00	0.00	0.69	0.77
Vitaceae	*Vitis vinifera*	Grape	0.00	0.00	3.25	2.31	2.78	1.92

3.7. Structure of Shade Tree Species across Zones

The diameter class distribution showed a reversed J-shaped distribution with increase in diameter class. The result of this study shows the higher tree DBH at the lower diameter class (DBH). Accordingly, most of the trees in the cocoa agroforestry farms had diameter between 0 - 300 and 301 – 600/ha and showed the least DBH/ha in 1501-1800 diameter class of all individual trees in the surveyed cocoa agroforestry farms (Figure 2).The total number of trees in each diameter class relatively decreased with an increasing tree diameter classes.

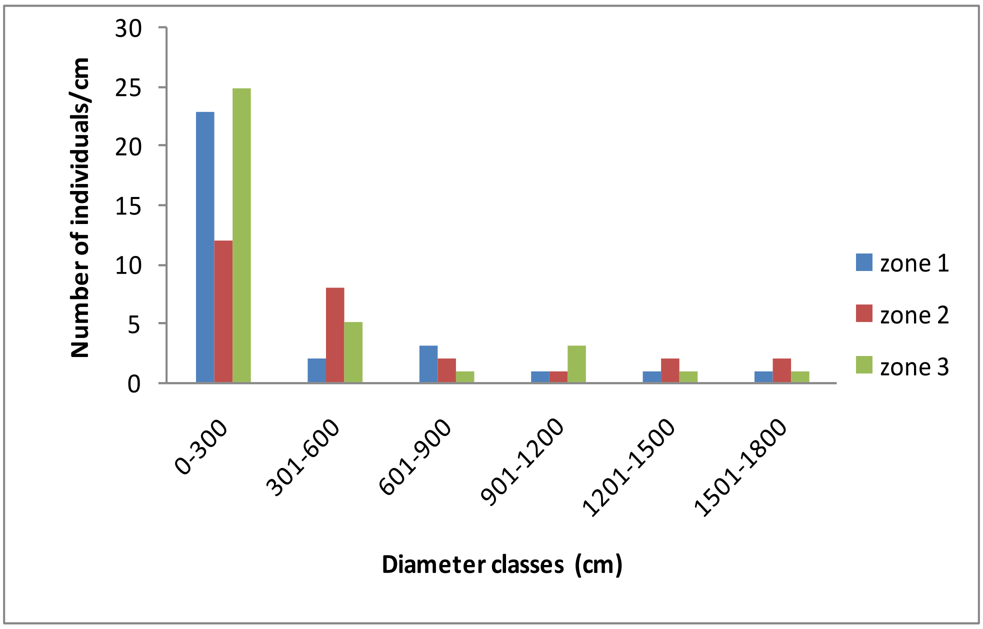

Figure2. *Distribution of total number of trees with their diameter classes*

3.8. Shade Tree Species Diversity Indices across Zones

Species richness, Shannon index, Simpson index, Evenness and abundance were calculated across the three zones for the comparison of the mean values of diversity indices. This study revealed that Zone 3 showed more species richness with 35 species closely followed by Zone 1 with 31 species (Table 11). Species richness, Shannon index, Simpson index and Evenness showed no significant difference across the three zones. Zone 3 recorded the highest value for Shannon index (H=2.92) closely followed by Zone 2 with the value of 2.9. This high Shannon index in Zone 3 could be due to increase in species richness in Zone 3. In addition, Zone 3 had the highest Simpson diversity index of 0.97

closely followed by Zone 2 with Simpson index being 0.92. Zone two (2) showed the highest evenness with a value of 0.87 closely followed by Zone 3. For abundance, Zone 2 had the highest abundance of 303 tree species followed by Zone 1 with 275 species and the least was Zone 3 with a value of 260 for abundance. Abundance showed a significant difference across the three zones.

Table7. *Diversity indices of trees across zones*

Parameter	Zone 1	Zone 2	Zone 3	Whole Zone	P-Value
Species richness	31±0.58	27±2.89	35±1.15	32±0.58	n.s
Shannon index	2.75±0.58	2.9±0.58	2.92±0.06	2.86±0.06	n.s.
Simpson	0.91±0.12	0.92±0.06	0.97±0.06	0.93±0.06	n.s.
Evenness	0.8±0.12	0.87±0.06	0.82±0.06	0.83±0.06	n.s.
Abundance	275±5.77	303±5.77	260±2.89	279±1.15	0.001

P-value is the significance level of the Turkey test, n.s = not significant (P > 0.05)

Criteria for Selection, Management Practices and main Uses of Shade Tree Species

3.9. Criteria for Shade Tree Selection in Cocoa Agroforestry

Figure 3 shows that majority of the respondents in the study site considered shade purpose (17%), income (17%), construction (16%), fuelwood (16%), medicine (14%) and timber (15%) as the main criteria for selection of trees for planting in cocoa agroforest farms while soil conservation (9%) and soil fertility (9%) purpose were the least represented.

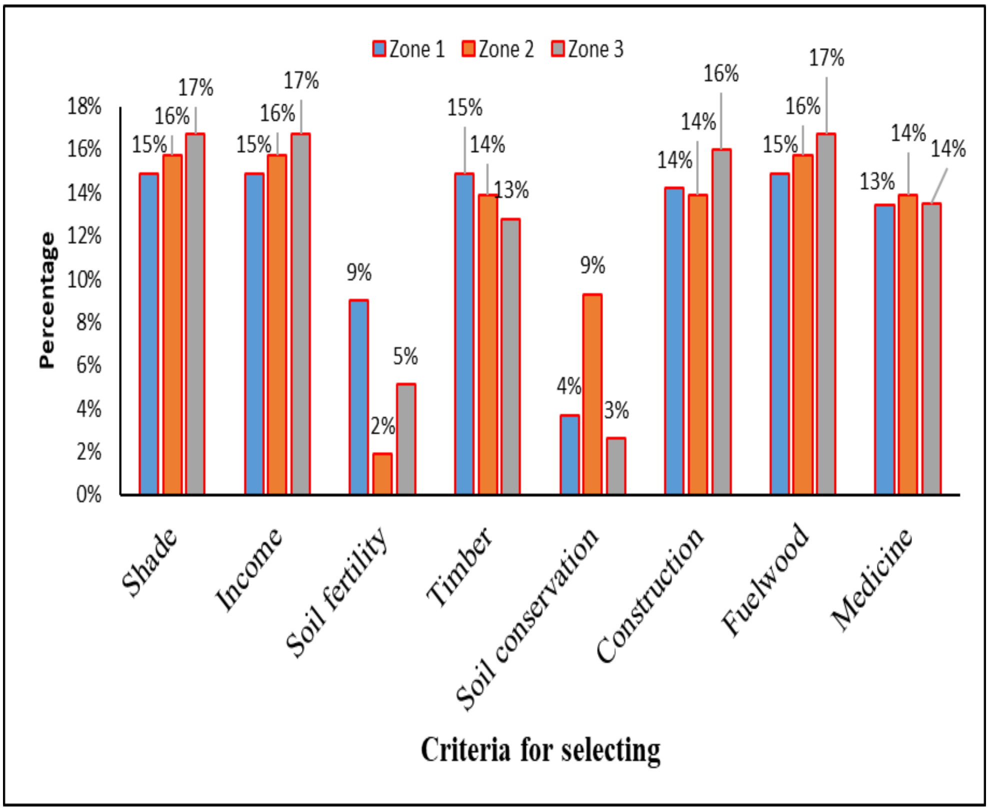

Figure3. *Shows criteria for shade tree selection in cocoa agroforest*

3.10. Management Practices of Shade Trees in Cocoa Agroforestry

Figure 4 shows that majority of the respondents in the study area carry out afforestation (33%) in their cocoa agroforest farms closely followed by pruning (18%), weeding (18%) thinning (16%), as the main management practices of the shade trees in the agroforestry farms while watering (1%) and fertilization (1%) management practices were the least represented in the study site.

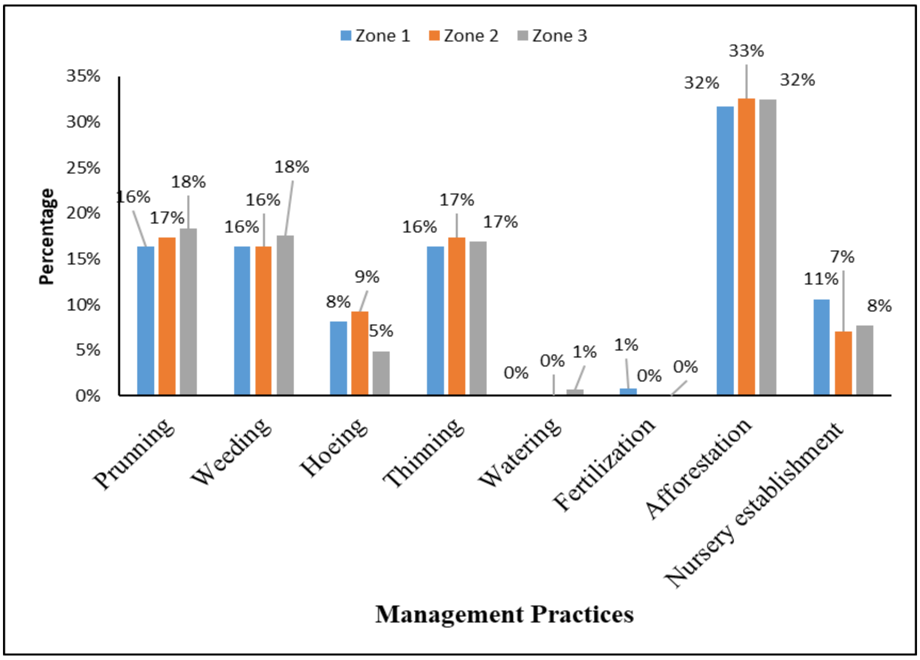

Figure4. *Shows management practices of shade trees in cocoa agroforest*

3.11. Tree Species and their Main Uses

In the study area as a whole, 54% of the tree species associated with cocoa had edible products, 10% (11.1) produces high value timber, 18.5% (21.1) produced low value timber, 6.5% had medicinal uses and 11% (13.02) were NTFPS (Table 12). Among the 54% edible products, 24% (21.1) were indigenous and 30% (34.01) were exotic species. There was no significant difference for Indigenous Edible and Exotic Edible tree species across the three zones. Zone 3 had the highest density of exotic tree species with total density of 39.62. There were also more of both High Value and Low Value Timber species in Zone 1 and Zone 3. High value timber, Low value timber, Medicine and NTFPs showed a significance difference ($p < 0.05$) across the three zones.

Table8. *Tree species and their main uses*

Parameter	Zone 1	Zone 2	Zone 3			
	Total. Density	**Total. Density**	**Total. Density**	**Whole Zone**	**(%)**	**P. value**
Indigenous Edible	27.27±8.33	27.06±0.58	26.92±0.58	27.1±3.65	24	n.s.
Exotic Edible	29.09±8.90	33.33±0.58	39.62±0.58	34.01±3.87	30	n.s.
High Value Timber	8.73±0.12	11.88±0.58	12.69±1.15	11.1±0.71	10	0.021
Low value Timber	25.82±0.58	10.56±0.58	26.92±0.58	21.1±2.65	18.5	0.001
Medicine	9.09±0.58	6.27±0.58	6.92±0.58	7.4±0.51	6.5	0.031
NTFPS	13.82±1.15	14.85±0.58	10.38±0.58	13.02±0.79	11	0.019

P-value is the significance level of the Turkey test, n.s = not significant ($P > 0.05$)

3.12. Constraints of Shade Tree Cultivation

Figure 5 shows that majority of the respondents in the study area presented financial difficulties (19%), pest and diseases (18%), theft (18%), bad roads (15%), lack of extension agents (14%) and climate change (14%) as the main challenges faced in cultivation of shade trees in cocoa agroforestry while seedling failure was the least represented across the study area.

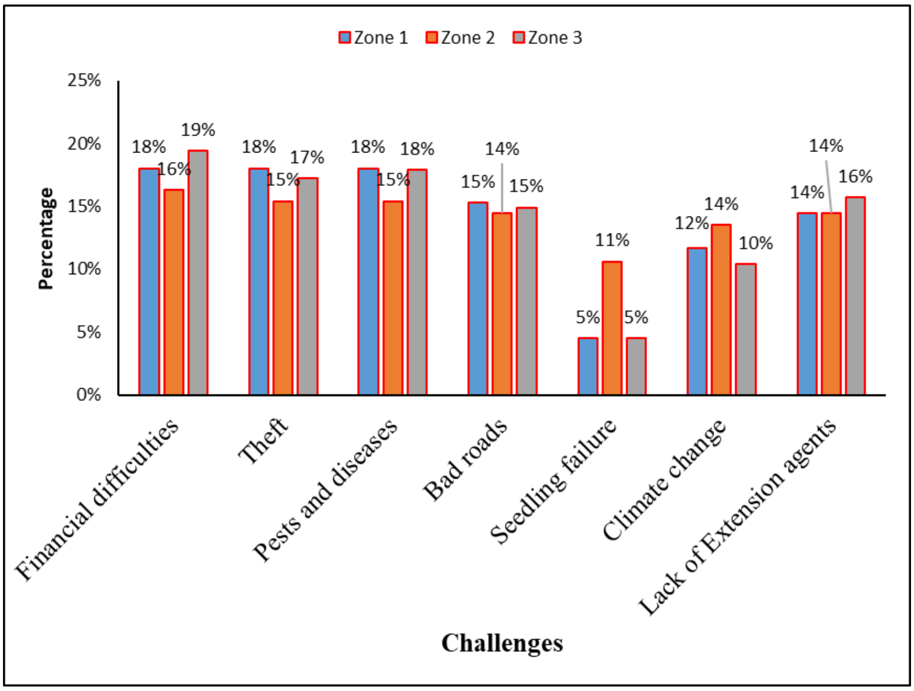

Figure5. *Shows constraints faced by cocoa agroforest farmers across zones*

4. Discussion

4.1. Socio-demographic Characteristics of Farmers Across Zones

From the results, it has been shown that majority of the respondents across the three Zones are males (87.30%) as compared to females (12.7%). This is probably as a result of the labour-intensive activities involve in cultivation of cocoa and customs put in place hindering females from inheriting their parent's wealth especially farm land. These results are in conformity with those presented by [24] who reported that cocoa production in the South West region is dominated by males representing 89.2%.

[25], also reported similar results in Lekie Division of Cameroon, where 86% of the cocoa producers were men.

Majority of the respondents (52.3%) across the zones were aged between 20-50 years and this entails most of the agroforestry farmers were at the active age of their life's therefore capable of providing adequate labour to improve productivity of cocoa, shade trees particularly fruit trees and NTFPs.

Across the study area, most (92.1%) of the respondents had basic education, 32 (50.8 %) of the respondents had primary education (First School Leaving Certificate) and 22 (34.9%) having secondary education. Zone 3 had the highest number of educated respondents and probably this is linked to the high shade tree diversity and species richness in Zone 3 since they were more knowledgeable on adding selected trees species in their farms for income and house hold consumption.

57% of the respondents had farm sizes of 2.5–4.5 hectares reflecting the tree species diversity and richness in the study area. These results are similar to that of [26] who reported that cocoa agroforest farmers in humid forest zone of Southern Cameroon planted or protected different tree species in their cocoa farms. The tree species are retained based on spaces available and their compatibility with cocoa plant and household objectives.

Majority (90.5%) of the respondents in the study area had cocoa agroforest farms aged 11–20 years in accordance to the fact that most of the farmers across the study area inherited the farms from their parents thus the farms were matured to habour substantial tree diversity.

4.2. Shade Tree Species Composition across Zones

From the results it was shown that, a total of 838 trees belonging to 38 species categorized under 25 families were recorded in cocoa agroforest farms. These cocoa agroforests of this study area have a high tree diversity compared to cocoa production systems in other parts of the tropics.For example, [27] found 116 species of trees on 79.1 ha inventoried in the District of the Eastern Region of Ghana.

The family Rutaceae was the largest family having five (5) species recorded. The family Rutaceae is typically represented by fruit tree species. Fruit trees are the most dominant tree species in the study area and were probably planted and/or retained in the cocoa farms for income, nutrition and as a buffer for the ever-present low cocoa productivity that face the cocoa sector. These results are in line with those of [28] who reported that fruit trees are planted within cocoa farms to enable resilience in the economic events such as sudden drop in the price of the main cash crops.

The dominance of this family could also be as a result of habitat adaptation and favourable environmental conditions which encourage establishment of species. Similar situations were reported by [1] on species richness in relation to environment in Takamanda rain forest South West, Cameroon.

The reasons for the poor establishment of some families which showed lowest species may be attributed to competition for nutrients, limited light by canopy trees. [29] mentioned similar reports in a disturbed and natural regeneration forest in Korup National Park.

The top five species in the study area were *Daryodes edulis, Persea Americana, Elaeis guinensis, Magnifera indica* and *Citrus sinensis.* These results are similar to those of [6] and [26] who reported that cocoa farmers of actively retain or plant *Daryodes edulis, Elaeis guinensis* and *Persea americana* to achieve their basic needs of food, income and health.

4.3. Shade Trees Distribution and Structure across the three Zones

From the results it was shown that the diameter class distribution of trees showed a reverse J-shaped structure. The distribution decrease in density with increase in diameter class sizes. The stem density of tree species decreased with increase in diameter class distribution in the study area. This could be due to the fact that cocoa plants at their young stages require about 60-70% of shade therefore little shade management (pruning, deforestation, harvesting). On the other hand, as the cocoa plants approaches maturity the amount of shade required reduces to about 40%. At this level, the shade trees are being pruned and felled for timber to allow the mature cocoa plants receive sunlight. The result of the current study is similar with the finding of [6], [1] and [29] who reported that the total number of trees in each DBH class relatively decreased with an increasing tree diameter classes and the dominance of small trees may be due to the continuity of planting and managing trees.

4.4. Diversity of Shade Tree Species in Cocoa Agroforestry

The present study sites had high species diversity for tree species. The results showed that Zone 3 (Kang Barombi) had the highest species richness (35) and this could be probably because during farm establishments most of the tree species were protected mainly for economic reasons.

Based on the results across the study area, the value of Shannon weaver index (H') were high throughout the three Zones with Zone 3 recording the highest value of Shannon diversity index. The high value of Shannon weaver index (H') in Zone 3 is probably due to the fact that Zone 3 had the highest species richness. There were no significant differences ($P > 0.05$) in Shannon, Evenness and Simpson diversity indices across the three zones. Shannon diversity index depends on species richness. The higher the value of species richness, the higher the value of Shannon diversity index. In support of this finding, [30] and [6] reported higher Shannon diversity index were associated with increase in species richness. In addition to this, [31] also reported that the higher Shannon diversity index were associated with increase in species richness in their study of diversity in home garden agroforestry systems of Southern Ethiopia.

There was significant difference ($P<0.05$) in abundance of tree species across the three Zones.

4.5. Criteria for Selection, Management Practices and main Uses of Shade Tree Species

Criteria for Selection of Shade Trees in Cocoa Agroforestry

The results showed that majority of the respondents considered the following as criteria for selection of shades in their agroforest farms. They are: shade purpose, income (Cash generation), construction, fuel wood, timber and medicine. The first two main criteria for selection of shade trees in cocoa agroforestry were shade purpose and cash generation (income). This is probably because cocoa needs shade of between 30-70% depending on the age of the cocoa trees, diversifying with crops of economic importance to provide shade will improve on yield making cocoa business profitable and sustainable. These results are in conformity with that of [32]and [33] who reported that preserving domestic fruit trees could protect cocoa from sunshine because the cocoa tree grown in direct sunlight without the protection of shade can suffer heat stress. The high temperature and the intense sun rays can therefore affect the health of the plant and ultimately decrease yield and the quality of the harvest. Other criteria for selection included construction purpose, timber, fuelwood and medicine. This set of goods and services were considered a ‘‘bonus’’ in addition to the provision of adequate shade. These results are similar to those of [34) and [35] who reported that preferred shade trees were for the benefits associated with production and for the provisioning of secondary goods, such as timber, firewood and medicine. On the other hand, the respondents in the area presented soil fertility purpose and soil conservation as the least criteria for selection of shade trees for planting. The few farmers who considered soil fertility as a criterion for selecting shade trees presented some tree species known to increase soil fertility particularly *Ceiba pentandra* which sheds a lot of flowers thereby increasing the soil fertility.These results also tie with those of [36] and [37], who reported that shade trees produce significant quantities of organic matter, recycle nutrients and help to maintain the natural fertility of the site. Some respondents also considered soil conservation as criteria for selecting shade trees probably to prevent soil from erosion. These results are also in line with those of [38] who reported that plant diversification in agroforestry systems increases the provision of ecosystem services such as protection against erosion.

4.6. Management Practices of Shade Tree Cultivation in Cocoa Agroforest

From the results it has been shown that Majority of the respondents across the study area indicated afforestation, pruning, thinning, weeding, hoeing and nursery establishment are the most commonly used management practices for shade trees in the study sites. The respondents reported that the main purpose of management practices undertaken are mainly to enhance growth, to provide shade and to reduce competition. These results are similar to those of [39] who reported that managing trees on cocoa fields by using different management activities are used not only to extract output but also to shape the growth of the trees.

The most used management practice presented by the farmers was afforestation which entails planting of trees probably for shade and income. The respondents equally presented pruning, thinning, weeding, hoeing to traditionally managed shade tree species in cocoa farms to get multiple benefits. Pruning management practice was carried out probably to provide sunlight, thinning to avoid overcrowding of shade trees in the farm, weeding and hoeing to prevent competition for nutrients and nursery establishment to have seedlings of shade trees for planting. [30] also hold the same view in Western Wellega Ethiopia, that the purpose of management practices undertaken by agroforest farmers were mainly to enhance growth, to provide shade, and to reduce competition. This result is also in line with that of [40] whonoticed that there is a long local tradition of managing cocoa farms for production by pruning the branch and thinning the canopy.

On the other hand, the least presented management practices in cocoa agroforest system in the study sites were fertilization application and watering (irrigation). These two management practices were carried out by some of the farmers to enhance early survival of the planted seedlings.

4.7. Tree Species and their Main Uses

Trees with edible products were the most common tree species in the cocoa agroforest. The results showed that 54% of the tree species associated with cocoa had edible products. Among the 54% edible products, 24% (21.1) were indigenous and 30% (34.01) were exotic tree species meaning indigenously tree species were being replaced by exotic tree species. This could be due to the fact that most of the farmers were knowledgeable to add selected tree species in their cocoa agroforest farms basically for economic, health and social uses. These results are also in line with that of [26] who reported that from Ebolowa to Yaoundé, the density of native tree species with edible products increased 1.5-fold. On the other hand, those of exotic tree species of the same uses categories increased 2.3-fold, showed a substitution of native trees by exotic species. Zone 3 (Kang Barombi) had the highest density of exotic tree species with a total density of 39.62 and this is probably because majority of the famers in Zone 3 had large farm sizes and were more educated, thus diversifying their farms with tree species.

The results showed that there were both High Value and Low Value Timber tree species accounting for 28.5% (32.2) of the tree species across the zones. Timber is used by the farmers for construction, source of income. Some timber species such as *Ceiba pentandra, Pterocarpus soyauxi* and *Lophira alata* also contribute to the structural diversification of the agroforests, which created habitat for local fauna (e.g., birds and small rodents) and flora (e.g., liana, epiphytes). Timber species occurred in lower densities in agroforest farms and this is probably because timber trees have been replaced by exotic tree species. These results are in conformity with those of [26] who reported low densities of timber trees in the Southern Cameroon. Most of the timber tree species have been logged and replaced with (often exotic) fruit trees which generated fast income within a short period of time.

The results also showed that, 6.5% of the tree species sampled in the study area had medicinal uses. Most of the respondents reported using the tree barks and leaves as medicines. These results also tie with that of [37] and [41] who reported tree species such as *Alstonia boonei* and *Annikia chlorantha* are found in cocoa farms and are commonly used to treat malaria. [42] also reported that from 1985 to 1998, the collection of various medicinal products from the wild increased 2 to 10-fold in Southern Cameroon.

4.8. Constraints in Shade Tree Cultivation

The results of the study sites showed that majority of the respondents presented financial difficulties, pest and diseases, theft, bad roads and climate change as the main challenges faced in cultivation of shade trees in cocoa agroforestry. The farmers indicated that they faced the problem of finances (payment of labour) to manage the shade trees in the agroforest farms. They also faced the problem of pest and diseases attacking the trees affecting the yield of some of the fruit shade trees. These results are also in conformity with those of [30] who reported that diseases, termite infestation, lack of labour and shade tree seedling were some of the challenges encountered in managing and growing shade tree agroforest farms in Western Wellega, Ethiopia. Seedling failure was the least presented constraints faced by the cocoa agroforest farmers in the study areas. This may be due to fact that they have created nurseries in their farms and only the best tree seeds are collected for seedling establishment.

5. CONCLUSION

It was observed that the majority of the cocoa agroforestry farmers in Kumba I Municipality, South West Region, Cameroon were males, owning farm sizes of 2.5-4.5 hectares mostly inherited from parents. Also, most of the farmers were aged above 50 years and were holders of basic level of education. We noticed that most of the farmers depended on past experience and have attended farmer field schools at different levels.

We noticed 38 tree species belonging to 25 families in cocoa agroforestry farms in the study areas. The ten (10) most abundant tree species were accounted for about 75% of the total tree recorded, while the top five species were *Dacryodes edulis, Persea americana, Elaeis guinensis, Mangifera indica* and *Citrus sinensis.* The family Rutaceae was the largest family having five (5) species recorded. It was also observed that the diameter class distribution of trees showed a reverse J-shaped structure with decreasing densities with increasing diameter size.

The results showed that majority of the respondents considered the following criteria in selecting shades for their farms. They are: shade purpose (17%), income (17%), fuel wood (17%), construction (16%), timber (15%) and medicine (14%).It was observed that majority of the respondents across the study area indicated that afforestation (33%), pruning (18%), weeding (18%), thinning (17%) are the most commonly used management practices for shade trees in cocoa agroforestry systems in the study site**.** The results of the study site showed that majority of the respondents presented financial difficulties (19%), pest and diseases (18%), and theft (18%), as the main challenges faced in cultivation of shade trees in cocoa agroforestry.

REFERENCES

[1] Ndah R.N, Egbe E.A and Bechem W., (2014).Species composition, diversity and distribution in a disturbed Takamanda Rainforest, South West, Cameroon. African Journal of Plant Science.Vol. 7(12), pp. 577-585.

[2] Gascon G, Williamson GB, Da Fonseca GAB (2012) receding forest edges and vanishing services. Science 288:1356-1358.

[3] Ahmed Z.Y., Nigatu. L., Mikonnen E., (2021) Tree Species Diversity in Smallholder Coffee Farms of Bedeno District, Eastern Hararghe Zone, Oromia Regional State, Ethiopia. College of Agriculture and Environmental Sciences, School of Natural Resource Management and Environmental Sciences. European Journal of Biophysics. Vol. 9, No. 2, 2021, pp. 72-85.

[4] Ebisa, L., (2014). Tree species diversity in small holder coffee farms of Western Oromia Ethiopia. African Journal of Geo-Science Research, 3(1):01-03.

[5] Asare, R., & Raebild, A. (2006). Tree diversity and canopy cover in cocoa systems in Ghana. New Forests, 47, 287–302.

[6] Gwali S., Agaba H., Balitta P., Hafashiman D., Nkandu J., (2015). Tree species diversity and abundance in coffee farms adjacent to areas of different disturbance histories in Mabira forest system, central Uganda, International Journal of Biodiversity Science, Ecosystem Services and Management, 11: 4, 309-317.

[7] Schroth G, Da Foneseca AB, Harvey CA, Gascon C, Vasconcelos HL, Izac AMN (2004). The role of agroforestry in biodiversity conservation in tropical landscapes. Island Press, Washington, pp 1–12.

[8] Harvey CA, Gonza ´lez JAV (2012). Agroforestry systems conserve species-rich but modified assemblages of tropical birds and bats. Biodivers Conserv 16:2257–2292.

[9] Sonwa, D.; Weise, S.F.; Tchatat, M.; Nkongmeneck, B.; Adesina, A.A.; Ndoye, O.; Gockowski, J. (2001). Rôle des agroforêts cacao dans la foresterie paysanne et communautaire au Sud-Cameroun. Réseau for. Pour Développement Rural, document du réseau. 25g, 1–11.

[10] Donald PF (2004) Biodiversity impacts of some agricultural production systems. Conserv Biol 18:17–37.

[11] Gockowski J, Weise S F, Sonwa DJ, Tchtat M, Ngobo M (2008) Conservation because it pays: shaded cocoa agroforests in West Africa. IITA-HFC, Yaounde.

[12] Asare A, Tetteh DA (2010) The role of complex agroforestry systems in the conservation of forest tree diversity and structure in southeastern Ghana. Agrofor Syst 79:355–368.

[13] FAO (2002) Etude de cas d'ame ´nagement forestier exemplaire en Afrique centrale : les syste `mes agroforestiers cacaoyers, Cameroun. Par Denis J. Sonwa, octobre 2002. http://www.fao.org/DOCREP/006/Y4853E/y4853e07.htm#TopOfPage. Accessed 29 Oct 2018.

[14] Irad Barombi, (2021). Climate of Kumba

[15] KCC, (2016) Map of kumba city council

[16] DTPKUC, (2005). Map of Kumba Department of Town Planning

[17] Kredje R.V, Morgan D.W., (1970). Determining sample size for research activities. Educational and psychological measurement. 30, 607-610.

[18] Saikia, P., Choudhury, B.I and Khan, M.L., (2012). Floristic composition and plant utilization pattern in home gardens of Upper Assam, India. Trop. Ecol. 53(1),105-118

[19] Singh, L., Ghosh, L., Bagali, S.S. and Saxena, R.R., (2008). Influence of naturally occurring trees on field bands and their impact on yield parameters of paddy crop. range manage. Agrofor. 29(2) 134-137.

[20] Cottam G., Curtis. J.T., (1956). The use of measurement in phytosociological sampling. Ecology, 37, 451-460.

[21] Maglef, D.R., (1958). Information Theory in Ecology. Int. J. General *Syst*. Nook, 36-71.

[22] Shannon, C.E. and Weaver, W., (1949). The mathematical theory of information. The University of Illinois Press.

[23] Simpson, E. H, (1949). Measurement of divesity. Nature. 163, 688-692.

[24] Ndah R.N, Ekole P., Agwa M., Taku, J., Lucha E.F and Agbor D.T., (2023). Crop Diversification and Sustainability in a Cocoa Agroforestry System in Meme Division South West Region, Cameroon.

[25] Tchokote J., Matin P., Nguezet P.M.D., (2015). An economic appraisal of cocosa production in Cameroon: the case study of Lekie Division.

[26] Sonwa D.J, Tchatat M., Weise S., Janssen M., (2007). Diverity of plants in cocoa agroforest in the humid forest zone of Southern Cameroon. Biodivers Conserv 12:2047–2061.

[27] Osei-Bonsu K, Ameyaw Oduro C, Tetteh JP (2003). Traditional cocoa agroforestry: Species encountered in the cocoa ecosystem of a typical cocoa growing district in Ghana (poster). 14th International Cocoa Research Conference, 13–18 October 2003, Accra, Ghana.

[28] Jagoret P, Michel I, Ngnogue ´ HT, Lachenaud P, Snoeck D, Male ´zieux E (2017) Structural characteristics determine productivity in complex cocoa agroforestry systems. Agron Sustain Dev 37 :37–60.

[29] Egbe EA, Chuyong GB, Fonge BA, Namuene KS (2012). Forest disturbance and natural regeneration in African rainforest at Korup National Park, Cameroon, Int. J. Biodiver. Conserv. 4(11):377-384.

[30] Tazebew E. and Asfaw, Z., (2018). Tree Species Diversity, Preference and Management in Smallholder Coffee Farms of Western Wellega, Ethiopia. Journal of Biology, Agriculture and Healthcare. 8 (24), 2018.

[31] Tesfaye Abebe, (2005). Diversity in Homegarden Agroforestry Systems of Southern Ethiopia. Tropical Resource Management Papers, No. 59. 143 pp.

[32] Jagoret, P., N.H. Todem, E. Bouambi, J.L. Battini and S. Nyasse. (2006). Caracterization de systemes de cacaoculture du centre-Cameroun. IRAD/CIRAD. Yaounde, Cameroun.

[33] Folefack J.A, Eboutou L.Y, Degrande A. (2015). Benefits from tree speie diversification in cocoa agoforestry in the center region of Cameroon. Agrofor Syst 81:109–121.

[34] Daily G, Postel S, Bawa K, Kaufman L (1997) Nature's services: societal dependence on natural ecosystems. The University of Chicago Press.

[35] Rigal C, Vaast P, Xu J (2018). Using farmers' local knowledge of tree provision of ecosystem services to strengthen the emergence of coffee-agroforestry landscapes in southwest China. One 13 (9): e0204046. https://doi.org/10.1371/journal.

[36] Leakey RRB (2001) Win: win land use strategies for Africa. 2. Capturing economic and environmental benefits with multi-strata agroforests. Int for Rev 3:11–18.

[37] Rousseau GX, Deheuvels O, Rodriguez Arias I, Somarriba E (2012) Indicating soil quality in cacao-based agroforestry systems and old-growth forests: The potential of soil macrofauna assemblage. Ecol Ind 23:535–543.

[38] Meylan L, Gary C, Allinne C, Ortiz J, Jackson L, Rapidel B (2017) Evaluating the effect of shade trees on provision of ecosystem services in intensively managed coffee plantations. Agric Ecosyst Environ 245:32–42.

[39] Zebene, A., (2003). Tree species diversity, topsoil conditions and association in the Sidama traditional agroforestry land use, southern Ethiopia. Forest Management and Products, SLU. Acta Universitatis Sueciae. Silvestria, Vol. 263. 263 pp

[40] Tadesse, W, G., Borsch, T., Denich, M. and Teketay, D., (2008). Floristic composition and environmental factors characterizing coffee forests in southwest Ethiopia. Forest Ecology and Management, 255(7), pp.2138-2150.

[41] Zapfack L, Engwald S, Sonké B, Achoundong G, Madong BA (2002) The impact of land use conversion on plant biodiversity in the forest zone of Cameroon. Biodivers Conserv 11:2047–2061.

[42] Ndoye O, Ruiz Perez M, Armand DM, Lema ND (1999). Les effets de la crise économique et la dévaluation sur l'utilisation des plantes médicinales au Cameroun. Implications pour la gestion durable des forêts. Atelier International FORAFRI-CIRAD- Forêts Denses Humides Africaines Aujourd'hui. Libreville. Gabon, October 1999. 15 pp.

Citation: *Njoh Roland Ndah et al."Shade Tree Composition, Structure and Management in Cocoa Agroforestry Systems in Kumba South West Region, Cameroon", International Journal of Forestry and Horticulture (IJFH), vol. 9, no.1, pp. 16-32, 2023. http://dx.doi.org/10.20431/2454-9487.0901003*