Original Research Article

CROP DIVERSIFICATION AND SUSTAINABILITY IN A COCOA AGROFORESTRY SYSTEM IN MEME DIVISION SOUTH WEST REGION, CAMEROON

ABSTRACT

The diversification of crops and trees in cocoa agroforestry plays a major role in ecosystem services and goods. This study investigated the effects of crop diversification in ~~a~~ cocoa agroforestry farms and is aimed at identifying the different diversified crops, ~~crops~~ their preference and profitability in a cocoa agroforestry in Meme Division. Primary data were collected with the help of a structured questionnaires and field observations. A sample size of 118 respondents was identified from a population of 170 cocoa farmers ~~in Meme Division.~~ Forty (40) farmers each were interviewed in Matoh, and Bole and 38 farmers interviewed in Njombe Mbonge. The ~~raw~~ data w~~ere~~as analyzed using IBM SPSS Statistics 21. Descriptive statistics were used to calculate frequencies and percentages and Chi square (X^2). Goodness-of–fit test was performed to check for association and determined significance levels at $\alpha = 0.05$. Results showed that 65 % of farmers had farm sizes between 2-5 hectares and 8.5 % of the farmers had farms of sizes between 10-15 hactares with majority of the farmers being males (72.8 %). The major crops farmers diversified in cocoa agroforestry were; plantain, cocoyam, cassava, maize, bush mango, bitter cola and Njangsang. The preferences for cultivation of these crops were mainly for food, income and shades for cocoa with 91.4 % of the farmers plant~~ed~~ing plantain (X^{2cal} = 83.56, x^{2tab}= 7.81), 61.0 % planted cocoyam (X^{2cal} = 70.33 x^{2tab}=7.81), 46.6 % planted cassava (X^{2cal}= 62.85, x^{2tab}=7.81), and 29.6 % planted maize (X^2= 36.42, p=7.81) all of which were significant to the preference for diversifying Too long sentence.. All respondents (100%) cultivated cocoa for income ($X^{2\ cal}$=113.5, x^{2tab}=7.81). NTFPs were cultivated mainly for income with 61.0 %, for Njangsang ($X^{2\ cal}$=25.1, x^{2tab}=7.81), 37.3 % for Bitter cola (X^{2cal}=17.8, x^{2tab}=7.81) and 47.5 % f~~F~~or Bush mango (X^{2cal}=28.5, x^{2tab}=7.81). An average net farm income (NFI) of

187699.8 FCFA and 238252.9 FCFA was obtained per hectare just for cocoa only and cocoa +diversified crops respectively. A net profit margin of 0.49 and 0.54 were obtained for cocoa only and cocoa + diversified crops respectively. Diversifying cocoa with crops and some economic trees yielded better income and improved biodiversity. Recommendations missing

Keywords: Cocoa agroforestry, NTFPs, sustainability, ~~36~~profitability, diversification.

1. Introduction

Cocoa agroforestry is progressively being viewed as a sustainable land-use practice that complements the conservation of biodiversity [1,2]. Cocoa agroforestry has been noted to meet ecological, biological and economic objectives. In particular, cocoa agroforest can create forest-like habitats, which harbour tropical biodiversity in rapidly degrading landscapes [3]. According to [4], world cocoa production stood at approximately 4.2 million metric tons in 2014/2015, with a worldwide market value of US$12 billion. West Africa produced 73%, South and Central America 17%, and 10% from Asia [4]). The top five cocoa-producing countries in 2016 as reported by [5], were Ivory Coast with 33.0% of global production (1,472,313 tons), Ghana with 19.2% (858,729 tons), Indonesia with 14.7% (656,817 tons), Cameroon with 6.5% (291,512 tons), and Nigeria with 5.3% (236,521 tons). Approximately two million smallholder farming households in both Central and West Africa depend on cocoa for sustenance [6].

In Cameroon, the agricultural sector employs approximately 70% of its active population, about 7.8 million people, of which about 400,000–600,000 families are cocoa producers [7]. The cocoa sector comprises about 95% of smallholder farmers with farm sizes ranging from

2.5-5 hectares [7]. In the South West Region, about 90% of households in cocoa-producing communities are dependent on cocoa proceeds for their livelihood [8]. Household members use the proceeds from cocoa sales to acquire food, clothes, shelter, healthcare and education [9].

The liberalization of the marketing of cocoa products in the early 1990's worsened the farmer livelihoods with a sudden drop of their incomes without any guarantee of reversing the situation [10]. The dependent of mono-cropping over the years have limited farmers output, thus farmers rely on a single crop to harvest and sell during few months of the year [11].

The diversification of crops and trees in cocoa agroforestry cannot be left un-emphasized [1]. Mainly the role it plays in increasing revenue for the household and the part it plays in ecosystem services (carbon sequenciation, water cycling habitats and shelter for most animals, goods it provides (fruits, medicine, timber) as well as gene they conserved [12]. Price dwindling in local and international market of dried cocoa beans in recent years is becoming serious [9]. Diversification of crops in cocoa agroforestry could play a major role in supporting household income with other produce from farms and in protecting nature. It is on this note this study aimed at studying the role of crop diversification in a cocoa agroforestry system.

2. MATERIALS AND METHODS

2.1 Description of the Study Site

This study was carried out in Meme Division, which is one of the six divisions of the South West Region of Cameroon. Meme Division has a total land area of 3,105 km^2 and a total

population of 426,734 [13]. The division lies between latitude 4^0 and 6^0 East of the Greenwich Meridian, and between longitude 9^0 and 10^0 north of the Equator [13]. Meme division falls within agro-ecological zone IV. The climate falls within the equatorial climate with an annual rainfall of 3000mm-4000mm. It is characterized by the wet and dry season, the dry season last from November to February, while the rainy season extends from March to October. The average annual temperature is 27 ° C [13]).

Meme Division consists of five sub divisions namely; Mbonge, Kumba I, Kumba II, Kumba III and Konye Subdivisions. Mbonge and Konye Sub Divisions produces majority of the cocoa in Meme Division [14].

2.2 Study Population

The villages selected were: Matoh in Konye Sub Division, NjombeMbonge and Bole Bakundu Villages in the Mbonge Sub Division (Figure 1). These villages were selected on the bases of their size, accessibility and involvement in cocoa agroforestry [14].

2.3 Economic activities

The socio-economic activities of these two sub divisions are characterized by the farmers engaged in cocoa business, collection and petty trading in NTFPs, provision stores, liquor, drug stores, motor-taxi (okada) and catering activities [14].

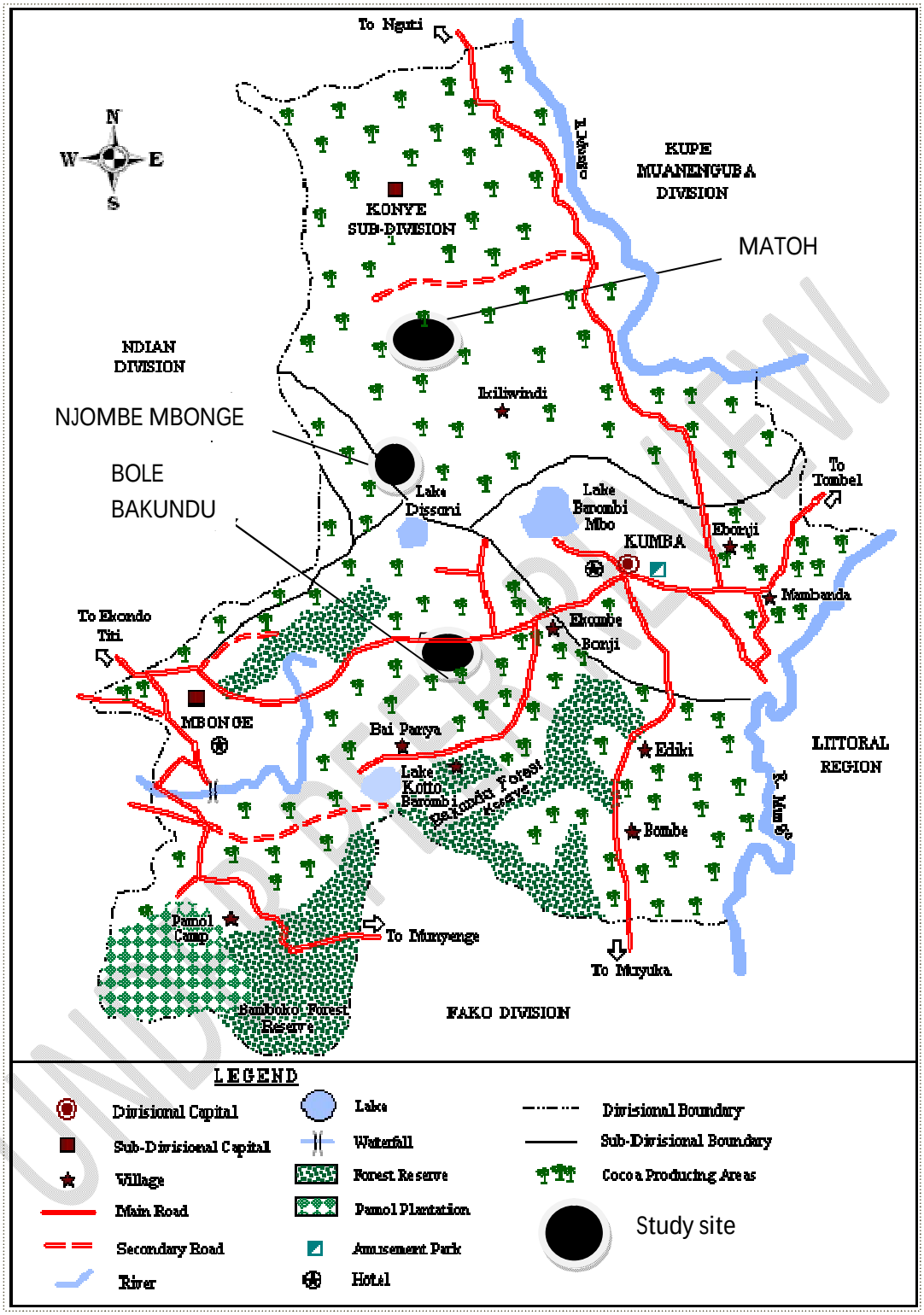

Figure 1. Map of the study ~~ied~~ site. (extracted from Spatial Distribution of Cocoa)

2 .4 Flora and fauna

T he vegetation is mainly forest, characterized with cocoa, Timber, Rubber, Palms and fruit tr ees. It also consists of vast wetland areas consisting mainly of mangroves and a vast ex panse of cocoa farms. Forest also provides non-timber products, including *Ricinodendron heudelotii, Cola accuminata, Capsicum* spp, *Bambusa vulgaris* [14].

The following animal species are significantly found in the study areas. Bush pig (*Potamochoerus porcus*), Antelope (*Antilocapra americana*), Monkey (Cercopithedae), Porcupine(*Erethison dorsatum*), Deer (*Odocoileus hemionus*), Cutting grass (thryonomyidae), rat mould (*Rattus rattus*), squirrel (*Rodentia sciurus*), and snakes. Livestock include goats, sheep, pigs, fowls, rabbits, snails etc [14].

2 .5 Sampling procedure

T–his study utilized the multi-stage random sampling technique to collect primary and secondary data.

The first stage of the sampling process was the selection of the main cocoa-producing Sub Divisions given their percentage contributions in the Division. The sub divisions selected were Mbonge and Konye Sub divisions that produces over 80 % of the cocoa in Meme division [14].

The second stage was the random selection of 3 villages in the selected sub division's based on their population size, percentage of farmers involves in crop diversification and accessibility to the sites. The villages selected were Njombe Mbonge and Bole Bakundu in Mbonge Sub Division and Matoh village in Konye Sub Division.

The last stage involves having consultative meeting with village heads (Chiefs, Head councilors, Development Organization Presidents, Youth presidents), key informants (large farm owners, produce buyers) and some elites of the selected villages. The major purpose of the meeting was, firstly, to clearly explain the purpose of the research work.

The populations identified for the study were those who had practiced crop diversification in cocoa farm for more than 5 years.

A pilot study was carried out to pre-test and validate the questionnaires. Six (6) farmers were selected in Kumba III sub division and the pre-test questionnaires administered to test the validity and reliability of the research instrument. The pilot study respondents were not included in the final research.

The study population constituted 170 farmers consist of men, women and youths. From the study population, the sample size was calculated at 118 farmers using the formula below by [15].

$$s = X^2NP(1-P) + d^2(N-1) + X^2P(1-P)$$

Where:

s = is the required sample size

X^2 = the table value of chi-square for 1degree of freedom at the desired confidence level (3.841)

N= population size

P= the population proportion (assume to be 0.05)

d^2= the degree of accuracy expressed as a proportion (0.05)

2.6 Questionnaire and data collection

The field work was carried out from February 2021 to May 2022. Data was 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 four sections: socio-demographic characteristics of farmers, crop preference for diversification, reasons for diversification and assessment of the profitability of the agroforestry crops.

The sample size of 118 farmers was distributed as follow:

Table 1. Sample size distribution

Division	Sub division	Village	Sample size (n = 118)
Meme	Konye	Matoh	40
	Mbonge	Bole Bakundu	40
		NjombeMbonge	38

The primary data were obtained by face-to-face interviews of the respondents and field visit to farms observation and inspection.

During field visits, the focus were centered on the age and density of the cocoa trees in the farm, other crops present in the farms, their agronomic practices in the management of the cocoa agroforestry and the composition of the canopy cover in the farm.

$$s = X^2NP(1-P) + d^2(N-1) + X^2P(1-P) \ldots\ldots\ldots\ldots\ldots\ldots$$

Where:

s = is the required sample size

X^2 = the table value of chi-square for 1vdegree of freedom at the desired confidence level (3.841)

N= population size

P= the population proportion (assume to be 0.05)

3. Data Analysis

Data were collected with the help of the questionnaire and check for completeness. The collected data were numbered and responses entered into IBM SPSS Statistics 21. Using descriptive statistics, the demographic information, crops used in diversification and profitability of a cocoa agroforestry. Frequencies, Percentages and tables, Chi square Goodness-of –fit test for one variable was performed using Minitab 17 Statistical Software to check for significant difference at $\alpha = 0.05$ probability level.

Budgetary analysis approach (gross margin) was used to compute the profitability in a farm. This method amounts to calculating profitability indicators, which are used to compare profitability across time or similar farms (Ngwang and Meliko, 2021).

The farm budgeting model was specified as follows:

$$\mathbf{TR} = TR_c + TR_{dc}$$

$$\mathbf{TC} = TC_c + TC_{dc}$$

Net farm income: NFI = TR -TC

$$\textbf{Economic Efficiency (Return on Investment): EE (ROI)} = \frac{\mathbf{NFI}}{\mathbf{TC}}$$

$$\textbf{Benefit Cost Ratio}: BCR = \frac{\mathbf{TR}}{\mathbf{TC}}$$

$$\textbf{Net Profit Margin}: NPM = \frac{\mathbf{NFI}}{\mathbf{TR}}$$

Where:

TR_c = Total revenue from sales of cocoa.

TR_{dc}= Total revenue from diversified crops.

TC_c = Total cost on the production of cocoa.

TC_{dc}= Total cost on the production of diversified crops.

TC= total cost; and TR = total revenue.

4. RESULTS

4.1 Socio-demographic description of the farmers

As shown in Table 2 the sex ratio of the farmers shows 86 (72.8 %) were males and 32 (27.2%) were females. Education wise, 23 (19.5 %) of the farmers had no formal education, 58 (49.20 %) had primary education, 17 (14.4 %) had secondary education and 12 (10.2 %) of the farmers had tertiary education.

The results also showed that 48 (40.7 %) of the farmers had farming experiences between 6 – 10 years, 36 (30.6 %) of the farmers had experiences between 11- 15 years and 34 (28.7 %) of the farmers had more than 16 years of farming experience. Most of the famers had family sizes of between 4 – 6 members, 55 (46.6%) and 1- 3 members, 26 (22.0 %). The results shows that family sizes of between 7- 10, 24 (20.3 %), 11- 13 (9.3 %) and 14-17 (1.7 %). The farmers had ages between 36 – 50 (46.6 %) years, 23.7 % of the farmers were aged above 50 years and 29.7 % were aged between 18- 34 years.

As shown in table 2, majority of the farmers 65 (55.1 %) had farm sizes between 2 – 5 hectares. Small farm owners of less than 2 hectares constitute 19.1 % of the sampled population while large farm owners constitute 20 (16.9 %) and 10 (8.5 %) with farm sizes of between 5 -10 and 11-15 hectares respectively.

Table 2: Socio-demographic characteristics of farmers

	Frequency (n=118)	Percentages (%)
Sex ratio		
Male	76	64.4
Female	42	35.6
Level of formal education		
No formal Education	23	19.5
Primary education	58	49.2
Secondary education 1	17	14.4
High school	8	6.8
Tertiary education	12	10.2
Farming experience		
6-10	48	40.7
11-15	36	30.5
15 and above	34	28.7
farm sizes		
0.5 -2	23	19.5
2-5	65	55.1
5-10	20	16.9
10-15	10	8.5
Family sizes		
1-3	26	22.0
4-6	55	46.6
7-10	24	20.3
11-13	11	9.3
13-17	2	1.7
Age Group		
18-35	35	29.7
36-50	55	46.6
51 and above	28	23.7

4.2 Crop diversification in Cocoa agroforestry

4.2.1 Common crops and trees identified

Crop diversification in cocoa agroforestry was practiced in all the farms surveyed. No farmer practiced mono-cropping with only cocoa as the lone crop (Table 3). Most of the farmers derived their household food and other benefits from the crops they diversified in their cocoa farm. It was observed that most of the focuses were on crops with more e

conomic values. Overall, all crops of economic importance that were identified in the different farms are shown in table 3. They have been classified into cash crops, food crops, Non-Timber Forest Products (NTFPs), Timber products and fruit trees.

Table 3: Common crops identified in the study sites

Cash crops	**Scientific name**	**Part used**	**Common uses**
Cocoa	*Theobroma cacao* L	Seeds	Income
Coffee	*Coffea* spp	Seeds	Income
Oil palm	*Elaeis guineensis* Jacq	Seeds	Income and household consumption
Rubber	*Hevea brasiliensis*	Latex	Income
Food crops			
Plantain	*Musa* spp	Fruit	For income and household consumption
Cocoyam	*Collocasia esulenta*	Tubers	For income and household consumption
Banana	*Musa* spp	Fruit	For income and household consumption
Maize	*Zea mays* L	Seeds	For income and household consumption
Cassava	*Manihot esculenta* Crantz	Tubers	For income and household consumption
Yam	*Dioscorea* spp	Tubers	For income and household consumption
Sweet Potatoes	*Ipomoea batatas* (L) Lam	Tubers	For income and household consumption
Pepper	*Capsicum* spp	Fruits	For income and household consumption
Groundnut	*Arachis hypogaea*	Seeds	For income and household consumption
Egusi	*Cucumeropsis mannii*	Seeds	For income and household consumption
NTFPs			
Njansang	*Ricinodendron heudelotii*(Baill.) Heckel	Seeds	Seeds are used for food and sold for income
Bush Mango	*Irvingia gabonensis* (Aubry-Lecomte ex O'Rorke) *Baill.*	Seeds	Seeds is used as spice for consumption and also sold locally
Bitter cola	*Garcinia kola* Heckel	Seeds	Fruits consumed and sold locally. It's also use for medicinal purpose

Bush Pepper	*Piper guinensis*	Seeds	Fruits consumed and sold locally as a spice.
Bush Onion	*Afrostyrax lepidophyllusMildbr*	Seeds	Its Fruit and bark are used as spice. Also serves as a shade crop
Cola nut	*Cola accuminata*	Seeds	Fruit is used as stimulant and t onic and sold locally. Also serve as a shade crop
Eru	*Gnetumafricanum*	Leaves	Leafy vine used for food and s old income
Monkey Kola	*Cola lepidota K. Schum*	Fruits	Seed sold for income, used in t raditional medicine and tree serves a shade crop
Timber products			
Black afara	*Terminalia ivorensis*	Entire plant	For timber mostly and branches for fuel wood
Bobinga	*Guiboutia spp*	Entire plant	Fr Timber, fuel wood
Okoume	*Aucoumea klaineana*	Entire plant	Plywood
Sapele	*Entandophragmacylindricum*	Entire plant	Furniture, joinery, decorative applications
Teak	*Tectona grandis*	Entire plant	High quality furniture, joinery, garden furniture
Padauk	*Pterocarpus soyauxii*	Entire plant	Joinery, flooring, boat-building
Iroko	*Milicia excelsa*	Entire plant	Garden furniture, boatbuilding, flooring and joinery woodblock flooring
Mahogany	*Khaya ivorensis*	Entire plant	Utility and decorative work, indoors and outdoors, from boatbuilding to furniture and joinery
Ilomba	*Pycnanthus angolensis*	Entire plant	General utility timber, furniture compone nts, interior joinery, plywood
Fruit tree crops			
Oranges	*Citrus sinensis* (L.) Osbeck	Fruits	Use as a fruit. Can be sold and a lso serve as a shade tree
Plum	*Dacryode sedulis* (G. Don) H.J.Lam	Fruits	Use as a fruit. Can be sold and also serve as a shade tree
mango	*Magnifera indica*	Fruits	Use as a fruit. Can be sold and also serve as a shade tree
Pear	*Pyrus communis*	Fruits	Use as a fruit. Can be sold and

	also serve as a shade tree

4.3 Cash crops

Results indicated that 93 (78.8 %) of the farmers had cocoa as the lone cash crop in their farms and 21 (17.8 %) of the farmers had cocoa and oil palm as cash crop (Table 4). Palm oil was extracted from the oil palm nuts either for sale or for subsistence. Some farmers (3.4 %) diversified rubber and cocoa in their farms. All the respondents had cocoa as their main cash crop. (X^{2cal} = 113.50 and $X^{2\ table\ value}$=7.81) (Table 4).

4.4 Food crops

The major food crops that had the highest frequency (percentages) of cultivation by farmers include plantain 111(94.5 %), cocoyam 72 (61 %) cassava 55 (46.6 %) and 35 (29.6 %) had maize in their farm (Table 4).

Almost the entire farmer 116 (98.3 %) had food crops in their farms. Farmers who diversified plantain and cocoyam in their cocoa farms constitute the majority of the farmers, 30 (25.4 %) followed by farmers who had a combination of plantain, cassava and maize 28(23.7 %). Farmers who did not have any food crops in their farms constitute only 1.7 % of the sample population (X^{2cal} = 23.34 and $X^{2\ table\ value}$=12.59) as shown in Table 4.

4.5 Non-timber forest products (NTFPs)

As shown in table 4, 76(64.4 %) of the farmers utilized the NTFPs they collected in their farms for income or for household consumption. Bush mango, Bitter cola and Njangsang were the major NTFPs cultivated and gathered ~~(Table 4)~~. Some farmers had a combination

of this NTFPs: Bush Mango, Bitter cola and Njangsang 15 (12.7 %), Bush Mango and Bitter Cola 17 (14.4 %), Bush Mango and Njangsang16 (13.6 %) and Njangsang and Bitter Cola 6 (5.1 %) (X^{2cal} =6.73 and $X^{2\ table\ value}$=11.07).

4.5 Fruit trees and timber products

The common fruit trees of economic value that were cultivated and harvested were oranges, mangoes, plum and pear. They are cultivated or protected for income and/or household consumption. Plum and pear were found in 36 (30.5 %) of respondents' farm as indicated in Table 4. The results also showed that Oranges 3 (2.5 %), Plum 19 (16.1 %), Mango, Plum, Pear and Oranges 28 (23.7 %), and lastly Mango, Plum and Pear 26 (22.0 %) were also found in the sampled farms (Table 4.3) (X^{2cal} =27.55 and $X^{2\ table\ value}$=9.48).

Timber trees were mostly used to provide fuel wood for the drying of the cocoa beans and also to remove timber from the trees. They also served as shade trees. The most common timber products that were found are displayed in table 4.3 (X^{2cal}= 19.62$X^{2\ table\ value}$ =7.81).

Table 4: The various crops sampled in the study site

Cash Crops	Frequency n = 118	Percent (%) =100	X^{2cal}	$X^{2\ table\ value}$
Cocoa Only	93	78.8	113.50	7.81***
Cocoa And Oil Palm	21	17.8		
Cocoa And Rubber	4	3.4		
Sub-total	118			
Food Crops				
Plantain, Cocoyam, Maize And Cassava	11	9.3	23.34	12.59 *
Plantain And Cocoyam	30	25.4		
Plantain, Cassava And Maize	28	23.7		
Plantain Only	18	15.3		
Cassava Only	6	5.1		
Plantain, Cocoyam And Cassava	23	19.5		
Respondents with no food crops	2	1.4		
Sub-total	118	1.7		
NTFPs				
Bush Mango	11	9.3	6.73	11.07^{ns}
Njangsang	11	9.3		
Bush Mango, Bitter Cola And Njangsang	15	12.7		
Bush Mango And Bitter Cola	17	14.4		
Bush Mango And Njangsang	16	13.6		
Njangsang And Bitter Cola	6	5.1		
Respondents with no NTFPs	42	35.6		
Sub-total	118			
Fruit Trees				
Plum And Pear	36	30.5	27.55	9.48**
Oranges	3	2.5		
Plum	19	16.1		
Mango, Plum, Pear And Oranges	28	23.7		
Mango, Plum And Pear	26	22.0		
Respondents with no fruit trees	6	5.1		
Sub-total	118			
Timber Products			19.62	7.815 **
Matanda,, Small Leaves, Camwood And Others	50	42.39		
Iroko, Sappelle, Mahogany and Others	22	18.6		
Iroko, Matanda, Small Leave	26	22.0		
Sapelle,Mahogany And Small Leaves	20	16.9		
Sub-total	118			

($x^{2calculated}$, $x^{2tabulated;}$ if $x^{2calculated} > x^{2tabulated}$ then test is significant then reverse is true)

($p<0.05$, * significance, $p<0.01$ **significant, ns not significant)

4.3 Preference for diversification of crops

Cocoa	Reasons	Frequency n=118	X^{2cal}	$X^{2\ table\ value}$

This table should be deletedMany farmers diversified crops in their farms for different reasons. Top on the list for diversifications are: household consumption (food), income, shade, medicinal purpose and for timber products derived from them.

From table 5, 91.4 % of sampled farmers had plantains in their farm, with 52.5 % using for both food and income and 38.9 % using for food only. 2.5 % of the farmers also hold that it could be used as a shade crop as well as for food and for income. (X^{2cal}= 354$X^{2\ table\ value}$= 7.81)

Majority of cocoa farmers planted cocoyam 72 (61.0 %), cassava 55 (46.6 %) and maize 35 (29.6 %) in their farm mainly for food 40 (33.8 %), 36 (30.5%) and 20 (16.9 %) respectively with less than 1 % of the respondent using their food crops solely for income (Table 5).

The NTFPs had three purposes: for food, income and shade crop. The number of respondents that were producing and gathering NTFPs include; Njangsang 72 (61.0 %) Bitter cola 44 (37.3 %) and Bush mango 56 (47.5 %) ~~as shown in Table 5~~.

Table 5: Preference of producing some important crops

	For food only	0	354	7.81***
	For income only	118		
	For food and income only	0		
	For food, income and shade	0		
	Sub total	118		
	No plantain in the farm	-		
Plantain				
	For food only	46	83.56	7.81**
	For income only	0		
	For food and income only	46		
	For food, income and shade	3		
	Sub total	111		
	No plantain in the farm	07		
Cocoyam				
	For food only	40	70.33	7.81**
	For income only	01		
	For food and income only	31		
	For food, income and shade	0		
	Sub total	72		
	No cocoyam in the farm	46		
Cassava				
	For food only	36	62.89	7.81**
	For income only	01		
	For food and income only	18		
	For food, income and shade	0		
	Sub total	55		
	No cassava in the farm	63		
Maize				
	For food only	20	36.42	7.81**
	For income only	0		
	For food and income only	15		
	For food, income and shade	0		
	Sub total	35		
	No maize in the farm	83		

($x^{2calculated}$, $x^{2tabulated;}$ if $x^{2calculated} > x^{2tabulated}$ then test is significant then reverse is true)

($p<0.05$, * significance, $p<0.01$ **significant, ns not significant)

4.4 Profitability in cocoa agroforestry

4.4.1 Cost of production

Profitability is the main objective for most business and a factor for sustainability on every production system. The costs of production and net income were used to determine the profitability and the cost structures of a hectare production of cocoa in the study sites. The cost of production includes: labor wages (cleaning of farm, harvesting and processing of cocoa bean etc.), cost of chemicals (Insecticides, fungicides, herbicides, fertilizers etc), oven charges, transportation cost, marketing cost ~~etc~~.

The cost of processing the diversified crops were also considered in the cost of production

Results from data obtained for the years 2019, 2020 and 2021 (Table 6) indicate that the cost of production per hectare for the year 2019 was 184489.8 FCFA (171632.6 + 12857.1), 2020 was188936.3 FCFA (175300 + 13636.3) and 2021 was 174819 FCFA(164601.7 + 10217.3)

4.4.2 Farm Income

The income of the farm was gotten from two sources; from the sale of processed cocoa beans, and from the diversified crop (food crops, NTFPs, fruit trees and timber products). Income from sale of cocoa beans and diversified products per hectare for 2019 was 421767.1 FCFA (362,449 + 59318.1), 2020 437412.3 FCFA (370918.3 + 66494.8) and 2021 384912.2 FCFA (341486.3 + 43425.9).

Table 6. The cost of production and sales per hectare of a cocoa farm agroforest

Year/	parameter	Total cocoa sales (TS_c)	Total Cost of cocoa production (TC_c)	Profit from cocoa TR_c	Sales of diversified crops TS_d	Cost of production of diversified crops TC_d	Income from diversified cropsTR_d	Net farm income $NFI = TRc + T$
2019	**Mean FCFA**	362,449	171632.6	189795.9	71769.5	12857.1	59318.1	238581.6
	±±SD	4216.578	1130.026	3637.763	1346.8	1010.15	2414.4	4257.9
2020	**Mean FCFA**	380918.3	172300	198100	78799.7	13636.3	66494.8	257892.8
	± SD	4156.3	1500.5	4110.8	1126.8	980.2	1359.3	4656.9
2021	**Mean FCFA**	341486.3	164601.7	175203.5	54087.8	10217.3	43425.9	218284.4
	± SD	3508.4	1352.6	2869.3	123.9	217.3	1045.5	3513.0

SD= Standard Deviation, NFI =Net farm income, ROI=Return on investment, BCR=Benefit cost ratio, NPM =Net Profit Margin

4.4.3 Profitability

Table 7. Profitability per hectare of cocoa farm production system.

	2019			2020			2021			Average	
	A	**B**	**Diff.**	**A**	**B**	**Diff.**	**A**	**B**	**Diff.**	**A**	**B**
Annual price	950 **FCFA FCFA**			875 **FCFA**			900 **FCFA**			902 **FCFA**	
Weight per hectare	405.1 **kg**			421.2 **kg**			375.6 **kg**			400.6 **kg**	
$NFI = TRc +$	189795.9 ±4216.5	238581.6 ±4257.9	48786.6	198100 ±4156.3	257892.8 ±4656.9	59792.8	175203.5 ±3508.4	218284.4 ±3513.0	43,080.9	187699.8	238252.9
ROI= $\frac{NFI}{TC}$	1.10	1.29	0.19	1.14	1.38	0.24	1.06	1.23	0.17	1.10	1.30
BCR = $\frac{TR}{TC}$	2.11	2.29	0.18	2.21	2.47	0.26	2.07	2.23	0.16	2.13	2.33
NPM = $\frac{NFI}{TR}$	0.52	0.56	0.04	0.52	0.56	0.04	0.44	0.51	0.07	0.49	0.54

A = cocoa only, B= cocoa + diversified crops, diff. = difference (B-A), NFI =Net farm income, ROI=Return on investment, BCR=Benefit cost ratio, NPM = Net Profit Margin

The average weight of dried cocoa beans per hectare was 400.6 kg and the average sales price per kilogram was 902 FCFA. The profitability in a cocoa agroforestry was access by comparing the Net Farm income NFI, benefit cot ratio BCR, return on investment (ROI) and Net Profit Margin (NPM) for cocoa only and cocoa and diversified products. From the table 7 above, it was observed that the NFI, BCR and ROI of were higher for cocoa + diversified crops compared to analysis for cocoa alone throughout the 2019, 2020 and 2021. The average NFI was 187699.8, BCR was 1.10, ROI was 2.13 and NPM was 0.49for cocoa only compare to NFI =238252.9, BCR =1.30, ROI =2.33 and NPM = 0.54 for cocoa plus diversified crop (Table, 7).

5. DISCUSSION

5.1 Socio-demographic characteristics of farmers

From the results, it has been shown that majority of the farmers and land owners are males (72.8 %) as compared to women (27.2 %). This is as result of the labour intensive activities involve in the cultivation of cocoa and customs put in place that limit women from inheriting properties from their parents especially land. The finding is in line with that [16] who revealed that, in the cocoa producing regions in the South West Region of Cameroon, cocoa production is male-dominated activity. [17] also hold the same view in Lekie Division of Cameroon, who found out that 86.3% of the cocoa producers were men, confirming the statement of [18] that African women are considered to be producers of food crops while their male counterparts concentrate on cash crop and livestock production.

Majority of the respondents (77.3 %) are aged between 18 to 49 years meaning most of the farmers are at the active stage capable of providing a workforce to improve productivity of

cocoa, food crops, NTFPs and fruit trees. 55.1 % of farmers had farm sizes of 2-5 hectares with 77.3 % of respondents having farming experience of 6-15 years indicating the farmers were experienced and their information could be reliable.

Most of the farmers had attained some level of formal education 95 (80.5 %) though 58 (49.2 %) of the respondent had primary education and 17 (14.4 %) having junior secondary education. The low production could be linked to the low productivity of an average of 400.2 kg per hectare per year in a cocoa agroforestry this signified that new techniques and management were slowly practiced.

5.2 Diversified crop

From the results it was shown that 118 (100 %) of the respondents had cocoa as a cash crop with different crops diversified in their farms. Cocoa is one of the cash crops that can tolerate other crops in an agroforest system as oppose to other plantation crops. It does best under shade.91.4 % of the respondents diversified plantains in their farms along other crops. The primary reasons from majority of the respondents for planting food crops are for household consumption with excess harvest sent to the market. Majority of the respondents are involved in diversifying plantain in their farm because it a stable among the oroko ethnic group and the ease with which it can be managed in a cocoa agroforestry. Majority of the plantain are planted by men who are owners of the farms. The average price of a bunch of plantain in Bole Bakundu is valued at 1500 frs while in Matoh and NjombeMbonge is 1000frs. Cocoyam, cassava and maize are mostly planted by females since they require regular weeding with hoes and use of hand. A 15 Littre bucket of cocoyam sells at 3000 frs and a kilogram of maize sells averagely at 200frs. The cassava is usually processed and sold as garri and “cassava fufu” Quote other authors

Most of the NTFPs gathered were planted or protected by parents many years ago due to their long cropping cycle. The species available were local varieties that usually do not produce every year. Most of these NTFPs serve for income, household consumption of the seeds as well as fuel wood. These NTFPs also served as shade tree. A fully mature stem of Njangsang, Bitter cola and Bush mango can produce fruits which when ready, the processed seeds could sell between 20,000frs to 40,00frs per year. According to [19], market demand of Bush Mango, Bitter cola and Njangsang found in cocoa agroforests exceeds availability in Central Africa. [20] also, pointed out that some NTFPs are more easily stored and traded over long distances. These products have a greater chance to be developed as it is appreciated by consumers. Domestication could improve their contribution both to food security and income generation for poor cocoa farmers.

Cocoa trees need shade of between 30 to 70 % depending on the age of the cocoa trees, diversifying with crops of economic importance to provide shade like plantain, NTFPs (bush mango, njangsang and bitter cola),fruit trees and timber products will make the cocoa business more profitable and sustainable as also reported by [21, 22], that preserving domestic fruit trees could protect cocoa from sunshine because the cocoa trees grown in direct sunlight without the protection of shade can suffer from heat stress. The high temperature and the intense sun can thereby affect the health of the plant and ultimately decrease yields and the quality of the harvest.

5.3 Profitability analysis

From the results ~~in table7~~, the average weight of 400.6 kg per hectare was obtained, far less than the expected 1000kg/hectare in modern farms as reported by [23]. This low cocoa production could be attributed to education levels of the farmers. It was noticed that majority had only primary education and do not apply good management practices like the application of fertilizer, rightful application of pesticides With majority of the farmers (57.62 %) not having at least secondary education, make its very difficult for proper management of resources available and the adoption of new agricultural technologies.

The annual net income for one hectare of land for cocoa was 187699.8 FCFA. With majority of the farmers having farm sizes between 2-5 implies the yearly net income of majority of the family households were 375,399 - 938,495 FCFA. The monthly income of between 31283,25 – 78207.9 FCFA. This implies that majority of the farmers lived below the poverty line of 1 dollar per day. In the case where farmers diversified in their cocoa agroforestry, an annual net income of 238252.9 was obtained per hectare of cocoa farm. This implies majority of the family households were between 476505 -1191262.5 FCFA as annual income and monthly incomes between (39,708- -99,271) yearly with deference between 101,106 – 252,770 and monthly difference of between 8425 to 21064 FCFA between cocoa only and diversified cocoa agroforestry. This low income was as a result of the very low and fluctuating cocoa prices which on average stands at 902 FCFA per kilogram of cocoa dried beans. No authors quoted

~~From table 6,~~ the Returns on investment (ROI) of a diversified cocoa agroforest with other crops were 1.30 compared with 1.10 for cocoa only.

A benefit cost ratio, BCR greater than 1 indicated that cocoa production was profitable. The cocoa agroforestry with cocoa only gives a BCR of 2.13 and the cocoa agroforestry with diversified crops gives 2.33. The BCR for cocoa agroforestry with diversified products was

higher than that of cocoa only. This is in line with [23] who did eight different combinations in a cocoa agroforestry: Cocoa alone (C), Cocoa plus Safout(C+S), Cocoa plus Mango (C+M), Cocoa plus Ndjansang (C+N), Cocoa plus Safout plus Mango (C+S+M), Cocoa plus Safout plus Ndjansang (C+S+N), Cocoa plus Mango plus Ndjansang (C+M+N), Cocoa plus Safout plus Mango plus Ndjansang (C+S+M+N) and concluded that (C+S+M+N) yield the highest profit while Cocoa Only (C) is least profitable.

Net profit margin, NPM value of 0.49 for cocoa only and 0.54 for cocoa and diversified product. This indicates that for every 1 FCFA earn, 0.49 FCFA is retained as net profit for cocoa only and 0.54 FCFA for cocoa agroforestry with diversified crops.

6. CONCLUSION

~~It was discovered~~Results showed ~~-~~that majority of the people in meme division rely on cocoa cultivation for their livelihood. Improving the living standard of the people by bringing in a new pattern of cultivation to improve on the profitability in a cocoa agroforestry is the main reason for this study. ~~The result of~~ this study has shown that cocoa cultivation is profitable at 49 % profit margin but most rural farmers still live below the poverty line of 1 dollar per day. Diversification into other crops of economic value in the cocoa agroforestry can greatly increase the profitability and livelihood in the rural communities in a cocoa agroforestry.

Diversification of food crops with short cropping cycle like plantain, cocoyam, cassava, maize will greatly increase food production for income and also for household consumption. Prices of food crops have always been on an increase both in the rural and urban areas, increasing its cultivation coupled with its short life cycle makes the business more profitable.

Domestication of Non Timber forest products (bush mango, bitter cola njansang), fruit trees (oranges plum, pear and mangoes) and timber product like camwood, iroko, small leaves will provide extra income while serving as a shade tree in ~~a~~ cocoa farms.~~while providing shade to the cocoa trees.~~

REFERENCES

1. Schroth, G., Gustavo A.B. da Fonseca, C. A. Harvey, C. Gascon, H.L. Vasconcelos, and A-M. N. Izac. (eds.). 2004. Agroforestry and Biodiversity Conservation in Tropical Landscapes. Island Press, Washington DC. 523 pp
2. Leakey RRB (2001). Win landuse strategies for Africa: 1. Building on experience elsewhere and capitalizing on the value of indigenous tree products, *International Forestry Review*, 3, 1-10.
3. Sonwa, D.J., Weise, S.F., Schroth, G. (2014) Plant diversity management in cocoa agroforestry systems in West and Central Africa—effects of markets and household needs. *Agroforest Syst 88, 1021–1034*
4. Sulaiman, B. Boachie-Danquah (2017) Investing in Ghana's Cocoa Processing Industry: Opportunities, Risks & the Competitive Advantage. Goodman. *Accra: AMC*
5. Food and Agricultural Organization of the United Nations (FAOSTAT), (2017), Data Base. Food and Agriculture Data, Rome, Italy.
6. Schroth, P. Laderach, A.I. Martinez-Valle, C. Bunn, L. Jassogne (2016), Vulnerability to climate change of cocoa in West Africa: patterns, opportunities and limits to adaptation, Sci. Total Environ. 556 231–241.

7. Sommeregger C, M. Wildenberg (2016). Bitter sweet chocolate: the truth behind the international chocolate industry, Sudwind, Laudongasse 40 1080.
8. Suh N.N and Molua. E L.(2022). Cocoa production under climate change variability and farm management challenges : some farmers perspectives. Journal of Agriculture and food Research 8:2666-1543
9. Ngong, J.T. Akume, D.A. . Njimanted, G.F. Vukenkeng A.W. (2019). An empirical investigation of the determinants of cocoa production in the South West region of Cameroon, Int. J. Econ. Commerce Manag. 7 (5) 411–430.
10. Varlet, F. 1991. Dynamique de Plantation et Stratégies des Planteursdans les Zones Cacaoyères et Caféières de Makénéné et Ndikiniméki (Centre-Cameroun). Rapport de Stage Effectué à laSODECAO. Yaoundé, Cameroun.
11. Aneani F,Anchirah,VM, Owusu-Anah F and Asamoah M. (2011). An analysis of the extent and determinant of crop diversification by cocoa (*Theobroma cacao*) farmers in Ghana. African Journal of Agricultural research 6:4277-4287
12. **Ndah RN,** Egbe E. A. and Bechem E **(2013).** Species composition, diversity and distribution in the disturbed Takamanda Rainforest, south west, Cameroon. ***African Journal of Plant Science*** 4: 223-232)
13. National Community Driven Development Program (PNDP) (2012) Communal Development Plan OfKonye Council
14. National Community Driven Development Program (PNDP) (2011) Communal Development Plan of Mbonge Council
15. Krejcie, R.V and Morgan, D.W.(1970).Determining sample size for research activities. Educational and Psychological measurement,30(3):607-610

16. Ngwang N.N. and Miliko O.M. (2021). Profitability analysis of smallholder cocoa production in south west region Cameroon African Journal of Agricultural Research 17(7):991-997
17. Tchokote J. Nguezet D.P. and Onyebuchi. K.I. (2015). An economic Appraisal of cocoa production in Cameroon :The case study of Lekie Division Journal of Economics and sustainable Development 6(9):168-181
18. Rwelamira JK (1999). Effecr of socio-economic and gender issues on sustainable resource management .Land and Agricultural policy centre, Johannesburg, South Africa
19. Wilkie D (2000) CARPE and non-wood forest products. In: Sunderland TCH, Clark LE, Vantome P (eds) Non-wood forest products of Central Africa*:* current research issues and prospects for conservation and development. *Food and Agriculture Organization, Rome, Italy*, pp 3–18.
20. Van Noordwijk, M., Bizard, V., Wangpakapattanawong,P., Tata, H.L., Villamor, G.B. AndLeimona, B. 2014. Trees cover transitions and food security in Southeast Asia. *Global Food Security.*
21. Degrande, A., H. Essomba, C.A. BikouéMekongo and A. Kamga. (2007). Domestication, Genre et Vulnérabilité. Participation des Femmes, des Jeunes, et des Catégories les plus Pauvres à la Domestication des Arbres Agroforestiers au Cameroun. Working Paper N°48. ICRAF/WAC, Yaoundé, Cameroon.
22. Jagoret, P., N.H. Todem, E. Bouambi, J.L. Battini and S. Nyassé. 2006. Caractérisation des Systèmes de Cacaoculture du Centre-Cameroun. IRAD/CIRAD. Yaoundé, Cameroun.

23. Jaza FA, Eboutou L.Y, DegrandeA, MoulendeFT,Kamajou F and Bauer S (2015). Benefit from tree species diversification in cocoa agroforests in the centre region of Cameroon. Russian Journal of Agriculture and socio-economic sciences 11(45):1-13

More references are needed especially under discussion