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Agronomic characteristics and economic performance of cocoa farms in Haiti

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Abstract. This study aimed to describe the agronomic characteristics of the cocoa based farms, estimate their agronomic and economic performance and carry out a gender analysis. Data relating to crops economic value or food security importance, household size, farmers' age, farm size, crop yield and farm family income were collected by focus groups or individual surveys. The results showed that, in average, the households' size was 4.37 people and the producers' age, 52 years. The female headed farm size was 1.56 ha against 2.20 ha for the male headed ones. Cocoa farm yield was 562.98 kg/ha and average farm income, 622.3 USD for female headed farms against 1138.0 USD for male headed ones. Compared to male, female farmers possessed less land and earned lower farm income.

Keywords: crops' yield, farm income, farm size, gender analysis, rural households

INTRODUCTION

Cocoa (*Theobroma cacao* L.) is an important tropical perennial crop whose seeds called beans are consumed across the globe (Aremu-Dele et al., 2022). It is currently cultivated in Latin America (its area of origin), Africa, Asia and Oceania (MacLeod, 2000; Rusconi, Conti, 2010) and the worldwide production exceeds 5 million tons (Aremu-Dele et al., 2022). Around 90% of the global production is made by 10 countries, namely: Ivory Coast, Ghana, Indonesia, Nigeria, Ecuador, Cameroon, Brazil, Peru, Columbia, and Dominican Republic (Bermudez et al., 2022). About 67% of the global cocoa production comes from West Africa (Poelmans, Swinnen, 2019), particularly from Ivory Coast and Ghana sharing 37.4 and 18.0%, respectively (Vanhove, 2020). Asia, Latin America and Oceania come far behind with respectively 15, 14, and 2%.

Cocoa is cultivated on a total land area of around 10 million ha of which over 5 million ha in Africa (Vanhove, 2020). In the seven major producing countries (Ivory Coast, Ghana, Indonesia, Nigeria, Cameroon, Brazil and Ecuador), the yield varies from 282 to 530 kg/ha, with the average being 421 kg/ha (Vanhove, 2020). Wessel and Quist-Wessel (2015) reported yields of 600 kg/ha in Ivory Coast (the world's largest producer) and 300 kg/ha in Cameroon. Apart in Brazil, Ecuador and Malaysia where large plantations are found, 90% of global production is made by around 5 million rural families farming 1 to 5 ha, particularly in Africa and Asia (Gavrilova, 2021).

The global cocoa-chocolate sector market generates around 100 billion USD annually (Gavrilova, 2021; Bermudez et al., 2022). However, out of this amount, only 6 billion go to 5 million small farmers (Poelmans, Swinnen, 2019; Gavrilova, 2021). That represents an income of 1200 USD/year/farm or 3.29 USD/day/farm. The per capita income of most cocoa-producing families is below the United Nations official poverty line of 2 USD/day (Cappelle, 2009; Norton, 2013). Cases of child labor, child

slavery and deforestation have been reported (Merem et al., 2020). Danso-Abbeam et al. (2020) reports significant differences between men and women in terms of technical efficiency on farms in Ecuador, with women less efficient.

In producing countries, cocoa is an important source of revenue for the state (Wilcox, Abbott, 2004). According to Bunn et al. (2018), in Ghana and Ivory Coast, cocoa accounts for 3 and 7% of the GDP, respectively. Government regulations on production, domestic marketing and export were very severe in the 1970s and 1980s (Fold, 2001; Gilbert, 2009). From 1986, the market began to liberalize, partly under pressure from the World Bank and the International Monetary Fund relative to structural adjustment programs and producers generally obtain better prices (Gilbert, 2009). Producing countries also face agronomic problems including parasitic pressure, aging plantations and soil degradation.

Haiti produces around 7500 tons of cocoa yearly as estimated by United Nations Program for Environment (PNUE, 2016). Ministry of Agriculture, Natural Resources and Rural Development (MARNDR, 2012a) estimated that the plantings cover 20,000 ha in agroforestry located at 95% in the departments of Grand'Anse (55%) and Nord (40%). According to Agronomists and Veterinarians without Borders (AVSF, 2015), about 20,000 rural families are involved in cocoa production in Haiti. Schwartz (2020) reported that 15000 to 25000 rural households farming about 1.5 ha each one produce cocoa in Haiti.

Haiti occupies the western part of the Hispaniola Island that it shares with Dominican Republic in the Greater Antilles Archipelago in the Caribbean Sea. It is located at the south of Bahamas, Turks and Caicos Islands and at the east of Cuba and Jamaica. With a total land area of 27750 km^2, Haiti is the largest country of the Caribbean. However, according to World Bank (2024a) and United Nations International Children's Emergency Fund (UNICEF, 2023), it is the poorest nation of the Latin American region with a Gross Domestic Product (GDP) of 19.85 billion USD, a 1693.07 USD GDP per capita and a 59% poverty ratio. The Haitian population is about 11.90 million people of which 40.34% live in rural area, as estimated by the United Nations Population Fund (UNFPA, 2024). Agriculture shares 21.40% of the GDP and provides 49.91% of the total employments (World Bank, 2024b). The country is characterized by little public investment, 17.31% of the GDP, which is low compared to the global average of 24.55%. Moreover, Haiti faces with recurrent natural disasters (floodings, earthquakes, and cyclones), political instability, public insecurity, and depreciation of the national currency, which affects negatively the national economy, the agricultural sector in general and the cacao farmers in particular and increases the gender inequalities (Llorente-Marrón et al., 2020).

However, in spite of all those difficulties, Haitian farmers produce a premium cocoa sold under organic label. This study aimed to describe the agronomic characteristics of cocoa-farms in Haiti; estimate the crop yield and the farm income; and carry out a gender analysis of the involved farmers.

METHODOLOGY

Study area

The study was conducted in departments of Grand'Anse and Nord where cocoa production is concentrated in Haiti (Figure 1). Surveys were carried out in August and September 2022. Cocoa trees are grown in Haiti in semi-humid plains and valleys and in mountains at altitude lower than 500 m above the sea level (MARNDR, 2009), similar to what is found in most production regions in the world (Vanhove, 2020; Aremu-Dele et al., 2022). The average rainfall is 1000 to 2600 mm in Grand'Anse and 800 to 1900 mm in Nord, and the average monthly temperature varies between 24 and 29 ^{o}C in both departments, with an average daily fluctuation of 3.20 ^{o}C (NASA, 2023). In plains and valleys, the soil is alluvial, gray or brown in color and 150 cm depth or more. In mountains, the dominant substrate is limestone, although basalt is observed in some places; the soil depth is shallow with rock outcrops observed in some cases, indicating soil loss by water erosion. Cocoa concentration in the study area is higher in valleys and plains compared to mountains (MARNDR, 2009).

Exploratory visits

For a global view of the study areas, exploratory visits were conducted. Observations were made on soil color, bedrock type, presence of line water erosion, cropping systems and dominant trees. Discussions took place with 15 privileged informants (13 men and two women) from MARNDR and the Canadian Center for International Cooperation (CECI), an NGO operating in the study areas). Information was provided on the general agricultural situation.

Focus groups

Eleven focus groups of 15 to 20 farmers (73% men and 27% women) were organized in five municipalities in Grand'Anse (Abricots, 1; Anse-d'Hainault, 2; Chambellan, 2; Dame-Marie, 2 and Moron, 1) and three in Nord (Borgne 1, Grande-Rivière, 1 and Port-Margot, 1). Those farmers were invited with the help of the privileged informants.

Individual surveys

Following the focus groups, direct individual surveys were carried out with farm managers to widen the data col-

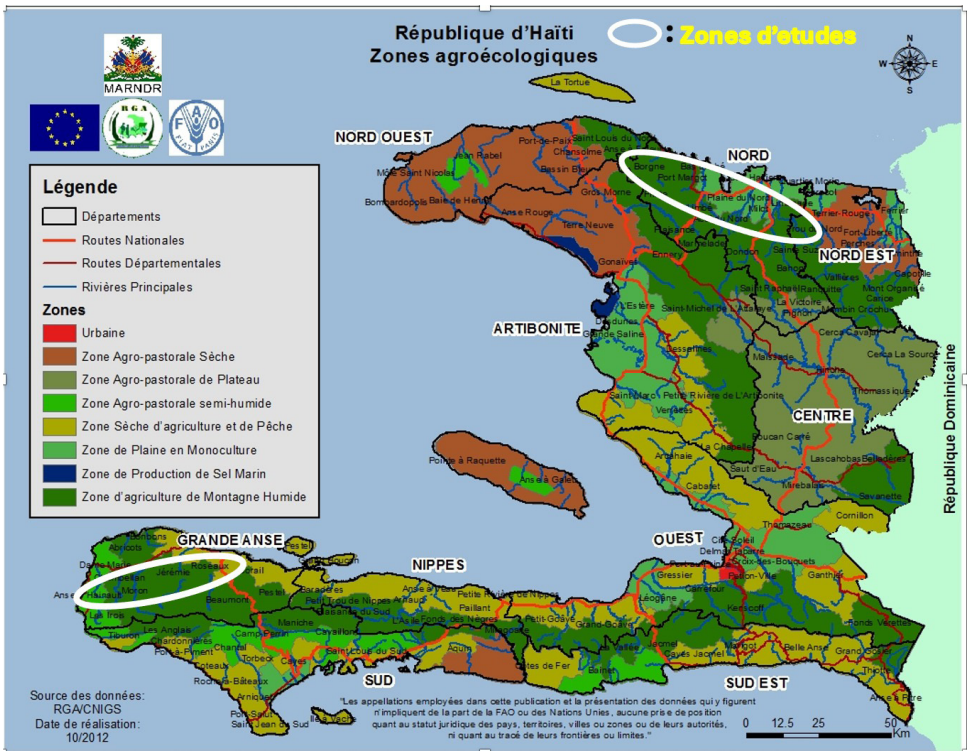

Figure 1. Haiti map showing location of the departments of Grand'Anse and Nord (MARNDR, 2012b).

lection. These surveys were conducted by eight students from the College of Agriculture and Veterinary Medicine (FAMV) of the State University of Haiti (UEH) under guidance of three professors who also implemented surveys for verification purposes.

Sampling

The above mentioned municipalities were purposely selected to cover places where cocoa production is concentrated. Surveyed people were drawn from a sampling base of 400 farmers (50 per municipality) provided by CECI executives. After classification by gender, 40 women and 120 men were randomly selected to constitute a subsample of 160 people. A total of 124 farmers including 30 women (24%) and 94 men (76%) agreed to participate to the survey, which represented a response rate of 78%. These proportions of 24% women and 76% men are similar to what is found nationally, because 22% of Haitian farms are managed by women (Plantin, 2021). The sample size of 124 respondents made it possible to make the planned estimates at an error margin of 8.8% and a confidence level of 95%.

Data collection

We developed and administrated a questionnaire to the 124 participants to gather comprehensive information about them, their households and their farms. Our questionnaire covered a range of socio-demographic characteristics, including age, gender, number of persons per household, and farm income (FI). Farm characteristics were assessed and related data included farm size (FS), crops grown, animals raised, areas allocated to different crops, species associated with cocoa, planting density of cocoa trees, farming practices, problems encountered, and tools ownership. Data to estimate FI included quantities and selling prices of harvested crops, values of sold animals and animal-products, costs of purchased animals and inputs, purchase prices of owned tools, ages in year and current values of owned tools, and amount spent for labor. Other collected data included extra-agricultural activities and off-farm income (OFI). Examples of OFI include received donations, land rents, livestock's rents, interest on loans, and agricultural services sold by a farmer out of his/her own farm.

Crop yield and household income calculation

Crop yields and household income were calculated for a financial year corresponding to the last 12 months preceding the surveys. Yield was obtained by dividing the harvested quantity by the corresponding surface area. FI calculation took into account gross plant production (GPP), gross animal production (GAP), total gross production (TGP), intermediate consumption (IC), gross added value (GAV), depreciation (DE), net added value (NAV) and labor cost (LC).

GPP is the value of all plant products harvested on the farm. For a given commodity, this value is obtained by

multiplying the harvested quantity (Q) by the average unit sale price during the financial year (P). Gross plant production for n commodities was obtained by the following formula: GPP=ΣQi * Pi, with i=1 to n. GAP represents the variation in the livestock value during the financial year (A) + value of animals sold (B) - value of animals purchased (C) + value of animal products sold (D). Variation in the livestock value (A) = value at end of year – value at beginning of year. TGP is the sum of GPP and GAP (TGP=GPP+GAP). IC represents the value of all inputs consumed on the farm during the financial year. Examples of inputs include livestock feed, animal rope and veterinary products. GAV represents the difference between TGP and IC (GAV=TGP-IC). DE was calculated for all tools, materials or structures which were used on the farm during the financial year covered by the study and whose lifespan is longer than one year. The depreciation of a given tool, material or structure during the year covered by the study was estimated using this formula: DEi=(Vn-Vr)/t, with t representing its age in years; Vn, its value when new; and Vr, its current residual value. The total value of depreciation for k tools, materials or structures during the financial year was computed as DE=ΣDEi, with i=1 to k.

NAV represents the difference between gross value added and depreciation (NAV=GAV-DE). LC represents the value of all wages paid for agricultural services received by the farm during the financial year. Let S be the salary paid for a given service, the amount for n services is LC= ΣSi, with i= 1 to n.

Farm income (FI) was calculated by subtracting the labor cost from the net added value (FI=NAV-LC). Total income (TI) was determined by summing farm income and off-farm income (TI=FI+OFI) and farm income to total income ratio in % was obtained by dividing farm income by total income and multiplying the result by 100 (FI/TI ratio in %= [FI/TI]*100).

Data analysis

Data of farmers age, number of persons per household, FS, and crop yield were subjected to descriptive statistical analyses. Based on FS, farmers were grouped into three types using the first and third quartiles (Q1 and Q3, respectively) as borders. Type I farms corresponded to the lower 25% having FS < Q1. Type II comprised the middle 50% whose Q1≤FS<Q3. Type III represented the top 25% of which FS≥Q3. Income data were submitted to analysis of variance (ANOVA) to determine its relationship with FS. Multiple means comparison were carried out by LSD test at $\alpha = 0.05$. Relationships of FS and income with farmer sex were also investigated. Significant difference was set at p-value < 0.05, observed difference > LSD or 95% confidence interval (CI) not including zero. Excel and R software were used. Results were presented as mean ± standard deviation (SD), mean ± standard error (SE), and mean (95% CI) unless otherwise stated.

RESULTS

Age of the farm managers

The farm managers' age varied from 23 to 86 years (Table 1). The youngest 25% were 23 to 41 years old and the middle 50%, 41 to 62. The oldest 25% were aged 62 to 86 years. The overall median age was 52 years. The farmers were much older than the national population age whose median is 23.5 years (United Nation, 2022). Women farmers were on average 46 years old (95% CI: 41.52; 50.80) and men 53 (95% CI: 50.59; 55.83). Women were on average 7.05 years younger than men (95% CI: 1.47; 12.63 on the difference).

Household size

The number of people per household varied from 2.00 to 5.20 with mean ± standard deviation (SD) = 4.07±1.81 in female headed farms and from 3.57 to 4.89 with mean ± SD = 4.47 ± 2.00 in male headed ones. The difference of 0.4 people observed in favor of male headed farms was not significant (p=0.37).

Farm size

Farm size varied from 0.16 to 12.25 ha, with mean being 1.97 ha (Table 2). It was 0.97 ha or less for the lower 25% households (Q1=0.97 ha), 1.52 ha or less for the lower 50% (median=1.52 ha) and 2.26 ha less for the lower 75% (Q3=2.26 ha). The top 25% of the farmers possessed more than 2.26 ha of surface area. Female farmers owned 1.56 ha on average (95% CI: 0.93; 2.20) and male farmers, 2.20 ha (95% CI: 1.74; 2.46). A non significant difference of 0.64 ha (95% CI: - 0.19; 1.26) was observed in favor of male farmers (p=0.14). The average surface area of 1.97 ha per farm was not in one piece, with female headed farms possessing 2.35 ± 0.47 plots of 0.61 ± 0.24 ha and male headed ones having 2.96 ± 0.61 plots of 0.77 ± 0.19 ha. In average, the overall number of plots per farm was 2.65 ± 0.63 and the overall plot size, 0.69 ± 0.24 ha. The three types of farmers defined on FS were: type I (FS < 0.97 ha), type II (0.97 ha ≤FS <2.26 ha), and type III (FS ≥ 2.26 ha).

General characteristics of cocoa-culture and other cropping systems

Cocoa is grown in agroforestry under shade of taller trees in association with yam (*Dioscorea* sp.) although other food crops such as taro (*Xanthosoma sagittifolium* L.) and pineapple (*Ananas sativus* L.) are often present in the same space. During the survey, it occupied 56.6% of the farmers plots (Table 3). It is estimated that 21% of agroforestry land in Haiti is cocoa-based (Chery, 2015). Tree cover was dense in cocoa plantings and sparse in areas reserved to annual crops. A great diversity of cover trees was

Table 1. Age [year] of the farm managers in different municipalities.

Municipality	Mean	Standard deviation SD	Minimum	1st quartile Q1	Median	3rd quartile Q3	Maximum
Abricots	50	11	33	41	50	59	68
Anse-d'Hainault	43	16	23	28	39	59	71
Chambellan	51	15	27	40	51	56	86
Dame-Marie	52	14	27	44	52	59	77
Moron	50	15	31	38	50	56	73
Borgne	50	13	25	41	46	61	74
Grande-Rivière du Nord	59	9	46	52	58	68	72
Port-Margot	61	11	40	57	64	66	80
Overall	52	14	23	41	52	62	86

Table 2. Variation of the farm size [ha] in different municipalities.

Municipality	Mean	Standard deviation SD	Minimum	1st quartile Q1	Median	3rd quartile Q3	Maximum
Abricots	1.90	1.73	0.32	0.97	1.37	2.02	7.42
Anse-d'Hainault	2.03	1.02	0.97	1.29	1.76	2.66	4.52
Chambellan	2.00	1.24	0.32	0.97	1.93	2.56	5.15
Dame-Marie	1.91	1.05	0.32	1.13	1.76	2.74	3.87
Moron	1.69	1.10	0.32	0.97	1.45	2.18	3.87
Borgne	1.81	2.44	0.16	0.85	1.13	2.08	12.25
Grande-Rivière du Nord	2.42	2.28	0.97	0.97	1.60	2.10	6.96
Port-Margot	2.12	2.57	0.21	0.48	0.97	3.23	9.35
Overall	1.97	1.76	0.16	0.97	1.52	2.26	12.25

observed in all production sites during the exploratory visits. The most common species are breadfruit (*Artocarpus altilis* L.), mango (*Mangifera indica* L.), avocado (*Persea americana* Mill), cedar (*Cedrela odorata* L.), mahogany (*Swietenia mahogani* L.), saman (*Albizia saman* L.), coconut palm (*Cocos nucifera* L.) and oak (*Catalpa longissima* L.). Other species approximately as tall as cocoa trees such as citrus and bananas (*Musa* sp.) were also grown in same space. Cocoa plant materials were dominated by phenotypes resulting from crosses involving Trinitario, Criollo types and others. Boccara et al. (2017) reported different genetic origins of cocoa trees in Grand' Anse. These include Amelonado, Criollo, Matina 2/8, Iquitos, Namay, Marañon, Contamana, Trinitario and Refractario. In most plots, cocoa trees were over 40 years old.

The most common planting distances were 5 m × 6 m to 5 m × 7 m, giving planting densities of 285 to 330 trees/ha, unlike what is found in the main West African producing countries (3 m × 3 m, 2.5 m × 2.5 m, even 1.5 m × 1.5 m) as reported by Olufemi et al. (2020). Cocoa plantings are subjected to few cultural practices. Soil fertility was ensured only by decomposition of organic matter from fallen leaves. Chemicals are not used since Haitian cocoa is sold under organic label. 11 local cooperatives were involved in marketing organic cocoa and offering farmers better prices than traditional traders. Cocoa and cover trees' pruning for light control and pest management were sometimes carried out at initiative of some cocoa field rehabilitation projects, but is not systematic. Farmers did soil work only when preparing the fields to plant crops such as yam, banana and taro they grow in association with cocoa trees.

In plots where tree cover is sparse or absent, farmers practiced other cropping systems. The survey results show that the most common was roots and tubers includ-

Table 3. Percentages of areas allocated by the farm managers surveyed to different cropping systems in eight municipalities.

Municipality	Agroforestry cocoa	Roots and tubers	Cereals and legumes	Others
Abricots	44.3	35.4	13.4	6.9
Anse-d'Hainault	44.2	37.2	10.5	8.0
Chambellan	63.1	29.3	2.3	5.3
Dame-Marie	55.7	30.4	8.6	5.2
Moron	66.1	29.0	2.1	2.8
Borgne	74.4	18.6	3.3	3.5
Grande-Rivière du Nord	40.5	23.7	25.5	10.4
Port-Margot	56.0	19.6	5.3	19.2
Average	55.5	27.9	8.9	7.7

Table 4. Relative position attributed by the farmers to six main crops on basis of their economic and food importance during focus groups.

Crop	Position as cash crop								Position as food crop							
	A	B	C	D	E	F	G	H	A	B	C	D	E	F	G	H
Cocoa	2	4	1	5	2	1	1	1	-	-	-	-	-	-	-	-
Yam	1	3	2	-	1	2	3	2	-	1	2	6	-	2	2	1
Banana	5	2	3	-	5	3	2	3	2	2	3	3	2	1	1	2
Maize	-	-	-	-	-	-	-	-	1	4	5	2	1	5	5	-
Common bean	3	-	5	-	3	5	6	5	3	5	4	4	3	-	4	3
Ginger	-	1	-	2	-	-	-	-	-	-	-	-	-	-	-	-
Taro	-	-	6	1	-	-	-	-	-	-	-	-	-	3	-	6
Pineapple	-	5	-	3	-	-	4	-	-	-	-	-	-	-	-	-
Sugar cane	-	6	4	6	-	-	-	-	-	-	-	-	-	-	-	-
Sesame	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-
Pigeon pea	4	-	-	-	4	-	-	-	4	-	-	-	4	6	-	-
Cassava	6	-	-	-	6	4	5	4	5	6	6	-	5	-	3	4
Peanut	-	-	-	-	-	6	-	6	-	-	-	-	-	-	6	-
Breadfruit	-	-	-	-	-	-	-	-	-	3	1	1	-	-	-	-
Sweet potato	-	-	-	-	-	-	-	-	6	-	6	5	6	4	-	5

ing mainly cassava (*Manihot esculenta* Crantz.) and sweet potato (*Ipomoea batatas* Lam.), occupying 27.2% of the plots. 8.2% of the available plots were allocated to corn (*Zea mays* L.) and legumes, namely common bean (*Phaseolus vulgaris* L.) and pigeon peas (*Cajanus cajan* L.). The remaining 8% was reserved to other crops such as sugar cane (*Saccharum officinarum* L.), ginger (*Zingiber officinale* Mill.), roroli (*Sesamum indicum* L.), and peanut (*Arachis hypogaea* L.). Cocoa farmers also raised livestock animals.

Ranking of the crops by farmers in terms of importance for food security and income generation

In each municipality, the first six main crops were ranked by the famers in terms of importance for food security or income generation (Table 4). Upon the criteria of economic value from the farmers' point of view, the first three more important crops in the study area were cocoa, banana and yam. In fact, cocoa was considered as the first cash crop in four municipalities and as second in two. It was followed by yam ranked as first cash crop in two municipalities, and second in three. Then, banana came with good consideration as cash crop. For food security contribution, the first three food crops were banana, yam and maize. Banana was ranked first food crop in two municipalities and second in four. It was followed by yam ranked first in two municipalities and second in three. Then, maize came with good consideration as food crop. The other listed crops had limited economic relative importance in the overall area both for revenue generation and food security contribution.

Main crops yield

The yield of marketable cocoa ranged from 191.59 kg/ha in Moron to 1522.61 kg/ha in Borgne, with the average for all eight municipalities being 536.59 kg/ha (Table 5). For yam, it varied from 447.29 kg/ha in Grande-Rivière-du-Nord to 2150.82 kg/ha in Borgne (average for the eight municipalities: 1445.58 kg/ha). Banana yield varied from 710.20 kg/ha in Grande-Rivière-du-Nord to 2766.88 kg/ha in Moron (average for the seven communes: 1463.49 kg/ha). For corn, they varied from 133.69 kg/ha in Anse-d'Hainault to 531.76 kg/ha in Port-Margot (average for five municipalities: 382.53 kg/ha).

Table 5. Variation of crops' yields [kg/ha] among the municipalities.

Municipality	Cocoa	Yam	Banana	Corn
Abricots	405.81	2060.74	1268.74	-
Anse-d'Hainault	260.24	986.52	716.70	133.69
Chambellan	325.54	1636.29	728.16	-
Dame-Marie	214.96	1336.13	1327.28	369.74
Moron	191.59	1145.72	2766.88	435.00
Borgne	1522.61	2150.82	2534.37	-
Grande-Rivière du Nord	305.89	447.29	710.20	442.45
Port-Margot	1066.11	1801.09	1655.58	531.76
Average	536.59	1445.58	1 463.49	382.53

Table 6. Farmers' income (mean ± SE) in USD.

Variable	Type I farm	Type II farm	Type III farm
Farm-income (FI)	532.6 ±200.3 b	1031.6 ±121.1 a	1273.8 ±155.9 a
Farm-income/ha	974.9 ±134.1 a	778.2 ±81.0 a	376.1 ±104.3 b
Off-farm income	274.2 ±148.4 a	547.0 ±89.7 a	270.6 ±115.5 a
Total income (TI)	806.8 ±239.2 b	1578.6 ±144.5 a	1544.4 ±186.1 a
FI to TI ratio (%)	75.1 ±5.3 a	72.4 ±3.2 a	81.7 ±4.1 a

Annotation: SE = standard error; Means with the same letter in a line are not significantly different at α=0.05.
Type I farm: FS< 0.97 ha (mean = 0.53 ha), Type II farm: 0.97 ha ≤FS<2.26 ha (mean = 1.38 ha), Type III farm: ≥ 2.26 ha (mean = 3.82 ha). 1 USD = 134 HTG.

Table 7. Difference in income [USD] between female and male headed farms.

Variable	Female headed farm	Male headed farm	Difference
Farm-income (FI)	622.3 (273.6; 971.0)	1138.0 (941.0; 1335.0)	515.8 (115.3; 916.3)
Farm-income/ha	543.7 (311.3; 776.4)	738.5 (607.2; 869.9)	194.7 (-83.8; 476.1)
Off-farm income	330.9 (71.0; 590.8)	437.5 (290.7; 584.3)	106.6 (-192.7; 405.8)
Total income (TI)	953.2 (538.4;1367.9)	1575.5 (1341.2; 1809.8)	622.4 (140.7; 1103.7)
FI to TI ratio (%)	72.1 (62.9; 81.3)	76.9 (71.7; 82.1)	4.8 (-5.8; 15.4)

Annotation: Results are mean (95% CI). Difference is not significant if 95% CI includes 0.

Income

The average farm income varied from 532.58 USD for type I farms to 1273.81 for type III farms (Table 6). Type I farms, owning less land, have significantly lower income than both types II and III. This result means that access to land is a limiting factor for farm income. Farm income per ha also varied significantly among the three farm types, with types I and II performing better than type III. Agriculture was by far the dominant activity in the study areas. However, two thirds of farmers declared that they practiced a secondary activity which could be small business, livestock breeding, fishing, masonry, teaching, carpentry, cabinetmaking, motorcycle taxi or sewing. Therefore, they had an off-farm income. The off-farm income was 274.2 USD for type I farms, 547.0 for type II farms and 270.6 USD for type III farms. Like farm income, total income increased significantly with farm size from 806.8 USD for type I to 1544.4 USD for type III. It was 1578.6 USD for type II.

With 622.3 USD (95% CI: 273.6; 971.0), female headed farms earned lower farm income than male headed ones (mean: 1138.0; 95% CI: 941.0; 1335.0). A significant difference of 515.8 USD (95% CI: 115.3; 916.3) was observed (Table 7). Female and male headed farms were not different for farm income per ha. The off-farm income of female headed farms was not significantly different from that of male headed ones either. These results suggest that the lower farm income of the female headed households was partly explained by their smaller farm size. As a consequence of their lower farm income, female headed farms had a significantly lower total income than male headed ones, the difference being USD 622.4 (95% CI: 140.7; 1103.7). Agriculture contributed 76.9% (95% CI: 71.7; 82.1) to total income for male headed farms and 72.1% (95% CI: 62.9; 81.3) for female headed ones.

DISCUSSION

Age of the farm managers

The median age of 52 years of cocoa producers in Haiti was much higher than the national median age of 23.5 years as estimated by United Nations (2022), which means that young people were poorly involved in the subsector and succession was not ensured. Decision-makers must find a way to attract young people and keep them in the subsector, of which the future in the country will be in danger otherwise.

Crop importance

Cocoa was the first economic crop for the farmers, followed by yam and banana, which were also the first two food crops. Banana and yam were considered as mixed performance crops in all the area. Famers will give priority to agroforestry cocoa as long as they find it more beneficial than other crops such as banana and yam. If another cropping system turns to be more beneficial, they will shift. Efforts are necessary to keep cocoa agroforestry system because beyond its production function, it protect the environment on about 20 000 ha.

Farm size

As reported by Gavrilova (2021), 90% of global cocoa production is ensured by around 5 million small farms with an average surface area of 1 to 5 ha, particularly in Africa

(Ivory Coast, Ghana, Cameroon and Nigeria) and Asia. In Haiti, the farm average surface area is 1.97 ha. Our findings added concordantly to the existing literature and supported the idea that the small size of cocoa farms is a global situation.

Cocoa yield

The global cocoa farm yield ranges from 300 kg/ha in agroforestry to 600 kg/ha in full sun production (Merem et al., 2020; Wessel, Quist-Wessel, 2015), from 282 to 530 kg/ha with the average being 421 kg/ha according to Vanhove (2020). From 2000 to 2020, cocoa yield in Ivory Coast declined from 701 to 461 kg/ha, while it increased in Ghana from 291 to 552 kg/ha in the same period (Aremu-Dele et al., 2022), which corresponded to a change from 496 to 506 kg/ha for the two countries considered together. The average yield of 537 kg/ha of cocoa bean in Haiti should be improved, but was similar to what is found globally. Improving factors could include pest and light control, rejuvenation of cocoa plantations, planting density and soil fertility management.

Income and gender gap

Global cocoa-chocolate sector is flourishing, generating an approximate annual amount of 100 billion USD (Gavrilova, 2021). However, famers are struggling with poverty and gender inequities. In 2018, the worldwide cocoa production exceeded 5 million tons (Aremu-Dele et al. (2022) of which 67% came from West Africa (Poelmans, Swinnen, 2019). Ivory Coast and Ghana share 37.4 and 18% of the global production, but 77% of Ivorian cocoa farmers live in poverty and 58% live in extreme poverty as defined by World Bank (Vanhove, 2020). Globally, only six billions USD go yearly to 5 million small farmers, yielding a 1200 USD income per farm. In Haiti, farm income of cocoa farmers was even lower (622.3 USD for female headed farms; 1138.0 USD for male headed farms; mean = 1013.23 USD). After adding off-farm income, farmers' total income was 1424.94 USD (953.2 USD for female headed farms; 1575.5 USD for male headed farms). Norton (2013) estimated that, for most cocoa-producing families, the daily per capita income is below the official poverty line of 2 USD established by the United Nations. Considering the household size of 4.37 people in cocoa areas in Haiti, the total income per capita per day was 0.89 USD, far lower the World Bank updated poverty line of 2.15 USD (World Bank, 2024b).

Our findings in farm size and income also add to an international body of literature on gender inequalities in access to agricultural resources and incomes (Özçatalbaş, Sogué, 2020). Danso-Abbeam et al. (2020) reported significantly lower technical efficiency in female-headed cocoa farms in Ecuador compared to male-headed ones. Ahrin (2022) reported significant gender inequalities in the cocoa sector in Ghana with women facing major challenges including access to land for cocoa production, access to producer groups or cooperatives and access to training and extension education.

Environment concerns

Full sun cocoa production raises environment concerns in Asia and Africa, as new plantings establishments are often associated with primary forest clearance (Merem et al., 2020). Conversely in Haiti, cocoa is exclusively produced in agroforestry and constitutes a protection guarantee for keeping the tree cover. Measures to improve farm yields and farmers income will contribute at the same time to protect the environment. In the beginning of the 21st century, increase of cocoa production relied mainly on expansion of the planting area in the main producing countries, particularly Ivory Coast and Ghana (Wessel, Quist-Wessel, 2015). The planting area expansion resulted in regression of forest land and became an environment concern. Nowadays, to satisfy the increasing demand, producing countries need to obtain higher yields per ha.

Further research works

Further works are needed on how to design and implement interventions to successfully overcome poverty in the subsector and barriers female farmers face in Haiti and other parts of the world. Further research works should also successfully address the common constraints to higher yields such as pests and diseases, aging plantings and soil fertility in producing countries, including the largest ones, namely Ivory Coast, Ghana, Indonesia and Nigeria.

CONCLUSION

In Haiti, cocoa is produced in agroforestry in association with annual crops, mainly yam and banana, by families of 4.37 people farming 1.97 ha split into 2.65 plots of 0.69 ha in average. The median age of the farmers at the survey time was 52 years, far over that of the national population (23.5 years). The farmers considered cocoa as their first cash crop, followed by yam and banana that were their first two food crops. Most cocoa plantings were over 40 years old with few cultural practices. The yield varied from 192 to 1522 kg/ha, with the mean being 536.59 kg/ha. Farm income was low, influenced by FS and varied significantly between female and male headed farms (622.3 against 1138.0 USD). Besides agriculture, farmers had other activities and earned off-farm income (330.9 USD for female against 437.5 USD for male). Total income was also low and gender gap significant between female and male headed farms (953.2 against 1575.5 USD). In average, family members involved in cocoa farming in Haiti

earned a 0.89 USD total income per capita per day, far below the World Bank updated poverty line of 2.15 USD per day.

Crop yield needs to be increased, farmers' income improved, and gender gap reduced. Yield improvement factors should include pest and light control, planting density and soil fertility management. Income improvement needs good policies regulating the subsector and better prices to farmers. Cocoa production in West Africa, including the main producing countries (Ivory Coast and Ghana), faces some similar challenges, in particular low yields, farmers' poverty and gender inequalities. This situation in the main producing countries may be considered as an opportunity for Haiti to join the global effort needed to increase cocoa production and improve the income of cocoa farmers.

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REFERENCES

Ahrin A., 2022. Tackling Gender Inequality in the Cocoa Supply Chain: Are big chocolate companies delivering on their global commitments in Ghana? doi:10.21201/2022.8625.

Aremu-Dele O., Sobowale I. O., Nduka B. A., Adesanya K. A., and Solomon O., 2022. Cocoa production improvement in some major producing countries of the world. In: Presentation at the Conference Natural Ecosystem Sustainability in the 21st Century, Ibadan, Nigeria. scholar.google.com (accessed September 13, 2024).

AVSF., 2015. Un cacao paysan de qualité et certifié en Haïti. incah-haiti.gouv.ht (accessed April 7, 2024).

Bermudez S., Voora V., Larrea C., Luna E., 2022. Cocoa prices and sustainability sustainable commodities marketplace series market overview. pp. 1-42. scholar.google.com (accessed April 7, 2024).

Boccara M., Motilal L.A., Umaharan P., Cernio P., Jean Simon L., Jeanniton R., 2017. Caractérisation morphologique et moléculaire de variétés de Cacaoyer cultivées dans le département de la Grand'Anse à Haïti. pp. 1-18. International Symposium on Cocoa Research (ISCR), 13-17 November 2017, Lima, Peru, scholar.google.com (accessed April 7, 2024).

Bunn C., Schreyer F., Castro F., 2018. The economic case for climate action in West-African cocoa production report Cali, Colombia: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). scholar.google.com (accessed September 13, 2024).

Cappelle J., 2009. Towards a sustainable cocoa chain: power and possibilities within the cocoa and chocolate sector. IPIS vzw Research Centre. scholar.google.com (accessed April 7, 2024).

Chery W., 2015. Factors influencing sustainable cocoa production in Northern Haiti". MS thesis, Louisiana State University and Agricultural & Mechanical College. repository.lsu.edu/gradschool_theses (accessed April 7, 2024).

Danso-Abbeam G., Baiyegunhi L.J., Ojo T.O., 2020. Gender differentials in technical efficiency of Ghanaian cocoa farms. Heliyon, 6 (5): e04012, doi:10.1016/j.heliyon.2020.e04012.

Fold N., 2001. Restructuring of the European chocolate industry and its impact on cocoa production in West Africa. Journal of Economic Geography, 1(4): 405-420, doi:10.1093/jeg/1.4.405.

Gavrilova N.G., 2021. Contemporary global production and consumption of cocoa: An assessment. In: IOP Conference Series. Earth and Environmental Science, 839(2): 022-095, doi:10.1088/1755-1315/839/2/022095.

Gilbert C.L., 2009. Cocoa market liberalization in retrospect. Review of Business and Economics, 54(3): 294-312, scholar.google.com (accessed April 30, 2024).

Llorente-Marrón M., Diaz-Fernandez M., Moreno S.D., Méndez-Rodríguez P., 2020. Socioeconomic consequences of natural disasters on gender relations: The case of Haiti. International Journal of Disaster Risk Reduction, 50, 101693, scholar.google.com (accessed September 13, 2024).

MacLeod M., 2000. Cacao. pp. 635-640. In: The Cambridge World History of Food (volume 2); eds. Kiple K.F. and K.C. Ornelas; Cambridge: Cambridge University.

MARNDR, 2009. Atlas agricole d'Haïti. agriculture.gouv.ht (accessed August 1, 2023).

MARNDR, 2012a. Stratégie de filière du cacao au niveau des régions du Nord et de la Grand 'Anse d'Haïti. agriculture.gouv.ht (accessed April 30, 2024).

MARNDR, 2012b. République d'Haïti, zones agro écologiques. https://www.google.fr/ search?q= map+ rga+cnigs+ marndr+haiti&sca (accessed April 30, 2024).

Merem C.E, Twumasi Y.A., Wesley J., Olagbegi D., Crisler M., Romorno C., Alsarari M., Isokpehi P., Hines A., Ochai G. S., Nwagboso E., Fageir S., Leggett S., 2020. Exploring cocoa farmland use in the West African region. International Journal of Agriculture and Forestry, 10(1): 19-39, doi:10.5923/j.ijaf.20201001.03.

National Aeronautics and Space Administration (NASA), 2023. Prediction of Worldwide Energy Resource (POWER). power.larc.nasa.gov/data-access-viewer/. (accessed April 7, 2024).

Norton M., 2013. Cost-benefit analysis of farmer training in Ghanaian cocoa farming". Inquiry. The University of Arkansas Undergraduate Research Journal, 15(1): 1-25. scholarworks.uark.edu/inquiry/vol15/iss1/6 (accessed April 30, 2024).

Olufemi A.K., Olatunde F.A., Adewale A.S., Mohammed I., Osasogie U., Efe A.F., Adeyemi O.F., 2020. Effect of high-density planting on the vigour and yield of *Theobroma cacao* L. in the Southwest of Nigeria. World Journal of Advanced Research and Reviews, 8(1): 217-223, doi.org/10.30574/wjarr.2020.8.1.0203.

Özçatalbaş O., Sogué B., 2020. Improving women's role in agricultural production and food security promotion. pp. 816-829. In: Gender Equality. Encyclopedia of the UN Sustainable Development Goals; Springer, Cham, doi:10.1007/978-3-319-70060-1_77-1.

Plantin J., 2021. Gender and resilience. How inclusive participation in cattle management strengthens women's resilience in Northern Haiti. USAID & Chemonics International Inc., chemonisc.com/wp-content/uploads/2021/04 (accessed April 7, 2024).

PNUE., 2016. Économie verte. Etude sur les filières agricoles et le verdissement dans le Département du Sud -Haïti. unep.org/greeneconomy (accessed April 7, 2024).

Poelmans E., Swinnen J., 2019. A brief economic history of chocolate. pp. 11-42. In: The economics of chocolate, hdl.handle.net/10419/200496 (accessed April 7, 2024).

Rusconi M., Conti A., 2010. Theobroma cacao L., the Food of the Gods: A scientific approach beyond myths and claims. Pharmacological Research, 61(1): 5-13, doi:10.1016/j.phrs.2009.08.008..

Schwartz T., 2020. Étude de la chaîne de valeur cacao, noix de cajou, huile de ricin et fruit à pain dans les Départements de la Grand Anse et du Sud, Haïti. scholar.google.com (accessed April 30, 2024).

UNFPA, 2024. World Population Dashboard. Haiti. World Population Dashboard -Haiti | United Nations Population Fund (unfpa.org).

UNICEF, 2023. Humanitarian Action for Children Haiti. https://www.unicef.org/media/ 132191/file/2023-HAC-Haiti.pdf.

United Nations, Department of Economic and Social Affairs, Population Division, 2022. World Population Prospects 2022: Summary of Results. undesa/pop/2022/tr/no. 3. population.un.org/dataportal/data/indicators (accessed April 7, 2024).

Vanhove W., 2020. Cocoa Cultivation: New Challenges for the 21st Century. Bulletin des Séances. Académie Royale des Sciences d'Outre-Mer, 64(2): 261-293, doi: 10.5281/zenodo.4066547.

Wessel M., Quist-Wessel P.F., 2015. Cocoa production in West Africa, a review and analysis of recent developments. Wageningen Journal of Life Sciences, 74(1): 1-7, doi: 10.1016/j.njas.2015.09.001.

Wilcox M.D., Abbott P.C., 2004. Market power and structural adjustment: the case of West African cocoa market liberalization. pp. 1-31, scholar.google.com (accessed April 30, 2024).

World Bank, 2024a. Global poverty update from the World Bank: first estimates of global poverty until 2022 from survey data. World Bank blog, Leuven, worldbank.org (accessed April 7, 2024).

World Bank, 2024b. Haiti: GDP share of agriculture. Haiti GDP share of agriculture - data, chart; TheGlobalEconomy.com.

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