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Gender Inequality in the Cocoa Supply Chain: Evidence from Smallholder Production in Ecuador and Uganda

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ABSTRACT

Most cocoa is grown by smallholder farmers whose livelihoods depend largely on the income from cocoa. Today, cocoa production must increasingly comply with social and environmental requirements as the worldwide demand for sustainably produced cocoa is growing steadily. There is, however, insufficient information available on whether the sourced cocoa is produced under gender-equitable conditions. We address this by examining two cocoa supply chains using our own sex-disaggregated survey data from producing communities in Ecuador and Uganda that supply the Swiss market, using descriptive and inferential statistics. Our results show that women in Uganda were highly involved in cocoa production on both male and female managed farms, but their decision-making power was limited to female managed farms. In Ecuador, women were moderately engaged in decision-making yet participated less in cocoa production. Our log-linear regression analyses for both cases showed substantial differences in annual cocoa revenues of farms managed by women compared to those managed by men. Several socio-economic and agronomic factors for which women face structural inequalities largely explain the revenue gap, such as poorer access to productive resources. Indeed, our findings suggest that cocoa production is characterised by high levels of gender inequality, suggesting that private and public sustainability efforts do not sufficiently address gender discrimination. These findings can help design interventions for more gender-equitable rural development that address the complexity of disadvantages in the local context. Offering gender-specific trainings within private programs and promoting women's access to credit by the public sector represent first steps towards gender equality.

1. Introduction

Women in developing countries, women in agriculture, and women in general, face numerous obstacles and limitations that their male counterparts do not. For female farmers and female household members in smallholder production systems, these include limited access to education [74], agricultural training [32,58], productive resources such as land, inputs, and labour [14,45,58], and formal financial services [80]. However, achieving gender equality can result in better food and nutrition security and more resilient and just food systems [53], which is crucial for sustainable development and therefore included in the Sustainable Development Goals as Goal 5 "Achieve gender equality and empower all women and girls" [77].

The unjust distribution of resources due to diverse structural inequalities for women in agriculture also applies to cocoa production systems. Cocoa (*Theobroma cacao*) is typically grown in smallholder production systems in tropical zones along the equator for high-value markets in the Global North [78]. In recent years, consumer awareness of poor living conditions and unsustainable farming practices has risen, in part due to increased media coverage. As a result, consumers and NGOs in Western countries are increasingly demanding higher levels of social and environmental sustainability, and members of the cocoa-chocolate supply chain, such as chocolate companies and traders, are following suit and requiring this from their producers and supply chains [9,25,71]. This is also reflected in the strong increase in certified cocoa area, which grew by 53% between 2015 and 2019 [41], and in the case of Switzerland, where 97% of imported cocoa beans in 2021 came from sustainable production [69]. In addition to voluntary sustainability standards and certifications, many chocolate companies have their own sustainability programs in place, which also include commitments to reduce gender inequalities across their supply chains [9,71]. Yet, due to low levels of mechanisation, high physical labour demand, and its cash crop nature, cocoa continues to be deemed a "male" crop in many countries [13,44], with cocoa sourcing influenced by complex gender roles in cocoa pro-

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ducing communities while influencing or reinforcing gender differences at the same time [13]. Accordingly, the implications of cocoa sourcing for local social contexts in producing communities are poorly understood and rarely taken into consideration by downstream supply chain operators [13].

Previous research has investigated gender constraints in cocoa production systems with mixed results. Abdulai et al. [1], for example, assessed cocoa yield gaps in Ghana and did not find farmers' gender to have a significant influence. Looking at technical efficiency (a measure of input use efficiency), Danso-Abbeam et al. [23] identified a gap between male and female cocoa plot managers, which they explained by women's lower education levels, off-farm income, and farm size. In contrast, Effendy et al. [30] found that female managers in Indonesia were more efficient than their male counterparts, and female participation on farms positively influenced technical and economic farm efficiency as they were highly engaged in cocoa cultivation and thus reduced costs for labour and post-harvest management to increase value added on farms. Women's high involvement in cocoa production activities and their considerable contribution to the quality of cocoa beans were also a result in Barrientos' [13] study of producer communities in Ghana and India. Yet, the study also found that the women involved were poorly remunerated for their work contribution [13]. Kiewisch [44] similarly concluded that women have a lower earning potential and decision-making influence within cocoa producing households in Côte d'Ivoire and Abukari et al. [2] identified that women in Ghana were less likely to be involved in cocoa production, causing them to become more engaged in non-cocoa enterprises.

The empirical evidence confirms significant gendered discrimination in farming activities, decision-making, and economic efficiency between male and female managed cocoa farms. However, very little is known about the differences in cocoa revenue generation on the individual farm level and the resulting benefits from cocoa supply chains between male and female managed farms. This is especially the case for countries outside West Africa, where most of the available literature is focused on. The only other study using revenue as the outcome variable of interest is Gibbon et al. [37], who, however, did not collect sex-disaggregated data. We address this research gap in revenue generation and decision-making in the present study, which aims to shed light on gender dynamics on small-scale cocoa farms in geographical areas that are underrepresented in the current literature. We hypothesised that (i) male household members have more decision-making power than female household members on both male and female managed farms, and (ii) cocoa revenues are lower on female managed farms than on male managed farms due to systemic discrimination against women.

In particular, we used primary cross-sectional data from our own survey of farmers in Central Province, Uganda and four provinces of north-western Ecuador, collected between 2019 and 2020. We analysed the differences between male and female managed farms in terms of decision-making power and roles to cocoa-growing and related activities using descriptive statistics. The impact of farm manager gender on the farm's annual cocoa revenue was examined using linear regression models.

This manuscript is structured as follows. Section 2 provides a brief description of the study context and analytical approach; Section 3 presents the findings, which are then discussed in Section 4; and Section 5 concludes the paper and provides concrete recommendations.

2. Material and methods

2.1. Case studies

We addressed our research questions using two case study supply chains of cocoa produced in Uganda and Ecuador that is supplied to downstream Swiss chocolate producers with ambitions to source sustainably produced cocoa. We selected two Swiss chocolate companies as industry partners with two very different supply chains to get comprehensive insights into the cocoa sector. The following provides a short overview of the case study supply chains (for more information, see Tennhardt et al. [70]).

2.1.1. Uganda

The first Swiss chocolate company is relatively young and small, and sources sustainably produced and certified cocoa through a small export company from novel cocoa production regions in Uganda. Farmers have been converting to organic certification since 2017, organised by a national export company, which also organises group trainings for farmers and buys certified cocoa with a price premium. The certification process does not specifically address gender topics, but a gender balance was observed among farmer trainers in the sample region.

With almost 35,000 tonnes in 2019 [31], Uganda's global share in cocoa production is relatively small but the suitability for cocoa production in Central and East Africa is expected to increase due to climate change [19]. Major cocoa producing areas in Uganda are Bundibugyo in the Western and Mukono in the Central Region. In 2019, over 72% of the Ugandan national workforce and over 76% of the female workforce was officially employed in agriculture [82]. Uganda had an agricultural gender gap of 13% in 2015 [73,76], indicating lower productivity by female farmers than by male farmers.

2.1.2. Ecuador

The second Swiss chocolate company is one of the five largest chocolate companies in Switzerland and sources – among other origins – raw cocoa through a multinational trader and its own in-house sustainability program from traditional cocoa production regions in Ecuador. Farmers, purchasing intermediaries, and the export company within this supply chain form part of the Swiss chocolate company's corporate sustainability program. This program provides in-kind premiums and training events for farmers as well as development projects for farming communities. Gender aspects were not specifically addressed in the program.

Ecuador produced over 283,000 tonnes of cocoa in 2019 and was thus the world's fifth largest cocoa producer [31] and the largest producer of fine flavour cocoa [6]. Most of the country's cocoa cultivation takes place in the coastal area [40]. Almost 30% of the Ecuadorian workforce and 27% of the female workforce was officially employed in agriculture in 2019 [82] with 12% of the economically active population employed in the cocoa sector [16]. While Ecuador has made legal advances in terms of gender equality in recent years, large discrepancies exist between men and women [16].

2.2. Farmer sampling and data collection

We followed a randomised farmer sampling approach within both case studies, targeting sample sizes of around 200 farmers that were feasible within the project framework. The sustainability program in Ecuador counted a very high number of farmers (>6,000) with a wide geographical distribution. To reduce regional differences in our sample, we concentrated on north-western Ecuador, where we selected eight supplier groups in four provinces. Based on lists of participating farmers provided to us by the export company implementing the sustainability program, we randomly selected 25 farmers per group and a total of 190 farmers (Fig. 1). In Uganda, all 450 farmers within the group converting to organic certification were located in Mukono district in Central province. We randomly selected 204 for this study, based on a list of registered farmers provided by the export company organising the certification.

Trained enumerators and one co-author visited the selected farms between July and September 2019 in Ecuador and February and March 2020 in Uganda to undertake face-to-face semi-structured interviews with farm managers (more detailed description in Tennhardt et al. [70]). We collected all information for one reference year: 2018 in Ecuador and 2019 in Uganda. All relevant institutional and national ethical guidelines were respected during data collection and the approval by an ethics

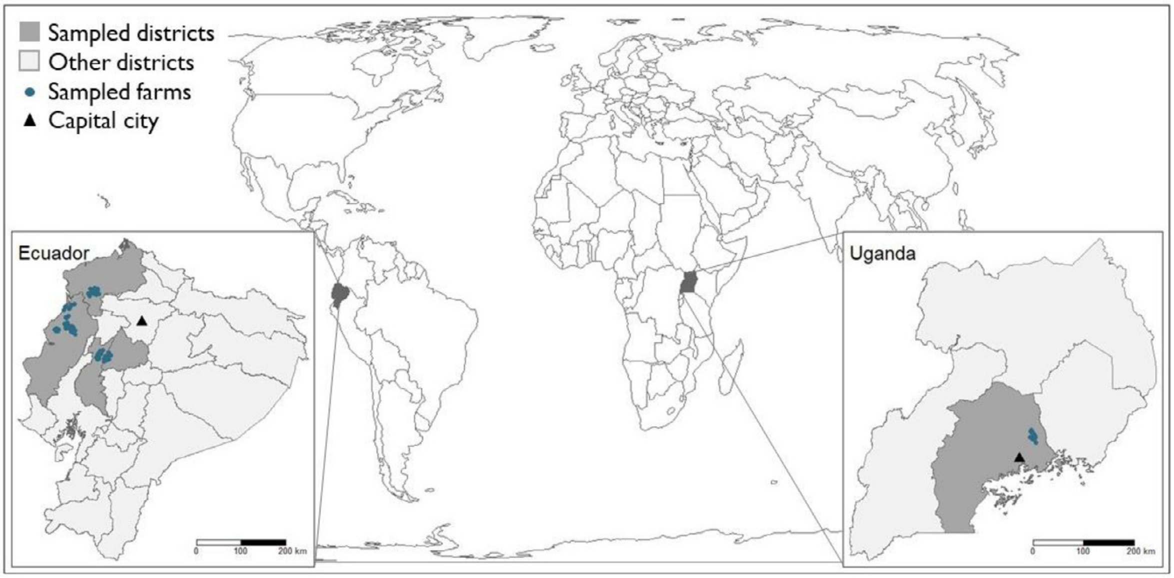

Fig. 1. Map of study sites in Ecuador (Manabí, Esmeraldas, Los Ríos, and Cotopaxi Provinces; Ecuador shown here without Galapagos) (farm sample N = 190) and Uganda (Central Province) (N = 204). Illustration based on Open Street Map data, developed using Tmap package in RStudio. Source: Tennhardt et al. [70].

committee was not required under Swiss, Belgian, Ecuadorian, and Ugandan law. Prior to the interview, we informed farmers that their participation was voluntary and their data would be treated confidentially and farmers confirmed their consent by signing a participation sheet.

2.3. Data description

To identify the economic benefits derived by female farmers' from cocoa supply chains, we looked into two aspects in this study (see Fig. 2). First, we used data on male and female participation in farm decision-making and cocoa production activities to evaluate gender roles on farms. Second, we used data on cocoa revenue to assess differences between male and female managed farms. An additional set of socio-demographic, farm characteristics, and management indicators that might explain cocoa revenue as well as potential gender discrimination was selected from the available data. We defined a male/female managed farm based on the sex of the interviewed person, i.e. the self-proclaimed farm manager, irrespectively of the official land ownership.

Gendered roles in farm decisions and cocoa production activities: Gendered roles in the key decisions on farm finances and input use as well as key production steps of cocoa crop management, cocoa harvest, and fermentation and drying of cocoa beans were used to evaluate female participation.

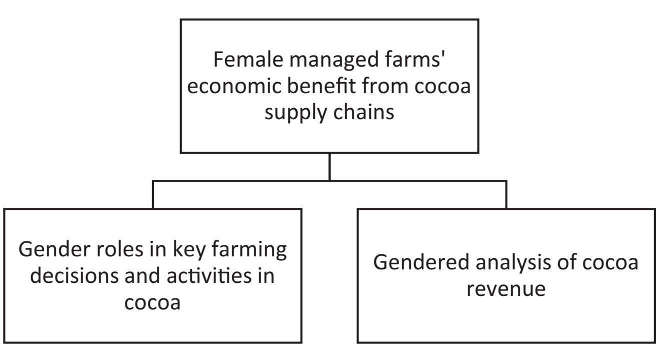

Fig. 2. Analytical framework to evaluate female farmers' economic benefits from cocoa-chocolate supply chains.

Cocoa revenue: Cocoa is a cash crop of high importance for farmers, as they derive a large portion of their annual revenue from it [33]. Multiple factors influence cocoa revenue, such as cocoa output, which is related to the size and/or input intensities of the farm, as well as farm gate prices received, depending on the bargaining power of the individual and the condition of the local market. Hence, we chose revenue as the output variable based on its ability to account for various characteristics of the cocoa farmer and its ability to act as an indicator for agronomic success.

Several *socio-demographic* farmer factors and *farm characteristics* influence cocoa revenue and might at the same time show structural disadvantages of female farmers. The range of variables included in the analysis, along with how they are described, their expected effect on cocoa revenue, and the literature sources leading to the expectation are provided in Table 1.

2.4. Analytical approach and calculation

2.4.1. Descriptive statistics

Descriptive statistics were carried out to analyse the determining sociodemographic, farm, and contextual characteristics of the sampled farmers in Ecuador and Uganda. We used a Wilcoxon sum rank test to compare nonparametric data and a chi-square test to compare categorical data between male and female managed farms within each case study. Furthermore, to account for differences at the farm-level, gendered responsibilities and roles in cocoa cultivation and related activities were examined for the surveyed cocoa farmers based on the answers from the semi-structured interviews. We used a 3-point response scale with increasing level of female participation (mainly men, both, mainly women) as used by Hillesand et al. [39]. To assess the level of women's involvement in cocoa growing activities and their participation in farm decision-making, we calculated two scores. The "Female Decision Score" shows the gendered decision-making power regarding finances and inputs, and the "Female Activity Score" considers the responsibilities for on-farm activities in cocoa production, fermentation, and crop management by gender. Based on the survey responses, we assigned a value to each task based on the gender that was primarily responsible as follows: mainly men (=0), both (=0.5), and mainly women (=1). Both scores represent the mean value for each farm. The numerical value obtained represents the degree of female participation in farm decision-making

Table 1
Explanatory variables for cocoa revenue.

Variables	Description	Expected Effect on Cocoa Revenue	Expected Effect based on Empirical Evidence
Socio-Demographic Variables of Farm Managers			
Female	Female (=1) vs. male (=0) farmer	-	[76]
Marital Status	married (=1) vs. unmarried (=0)	+	[76]
Age	Age in years of farmer	-	[4,20,26]
Education	Number of years of schooling	+	[8,26,55,57]
Formal Savings Account[1]	formal savings account was used (=1) vs. no formal savings account was used (=0)	+	[38,80,81]
Informal Savings Account[1]	informal savings account was used (=1) vs. no informal savings account was used (=0)	+	[38,80,81]
Farm Characteristics			
Farm Size	Farm size in hectares	+	[36,54,55]
Weed Management	Frequency of weed management in 2019/2020	+	[36,66]
Group Membership	member (=1) vs. not a member (=0)	+	[17,47,68]
Production Diversity	Number of crops cultivated on farm	-	[29,36,64,65]
Workforce	Number of workers employed on farm	+	[18,56,62]
Training	Number of training days received in 2019/2020	+	[58]
Cash Crops Sold	Number of cash crops sold in local markets	+	[32,54]
Cocoa-Specific Variables			
Cocoa Area	Cocoa area in hectares	+	[20]
Sold Dried Cocoa	Cocoa sold fermented and dried (=1) vs. fresh (=0)	+	[50]
Share Agroforestry	Agroforestry in hectares rel. to the farm size	-	[52,83]
Hybrid Cocoa[2]	1 if cultivation of CCN-51 Hybrid	+	[27]
Degree of Involvement			
Female Decision Score	Mean female involvement across farm decisions (financial, inputs): mainly men (=0), both (=0.5), mainly women (=1)	+	[9,12,60]
Female Activity Score	Mean female involvement across cocoa production activities (harvest, crop management, fermentation): mainly men (=0), both (=0.5), mainly women (=1)	+	[9,28,67]

Notes: Farmer refers to the respondent, that was either the farm owner or farm manager; if a positive influence of the variable on revenue was expected, the chosen sign is + and, vice versa, - if a negative influence was expected.
[1] Data only available for the Ugandan case study.
[2] Data only relevant for the Ecuadorian case study.

as well as in cocoa production activities, with a higher value in a score indicating a greater involvement of women in the respective farm.

From the original farmer samples in Ecuador and Uganda, we excluded those farms that had 0 USD/year cocoa revenue as their cocoa plantations were still young and no cocoa was sold at the time of data collection. Additionally, we excluded cocoa revenue outliers based on the visual interpretation of the histogram. Based on these criteria, we excluded 25 farms in Uganda and 15 farms in Ecuador. Stata 17 was used for the statistical analysis.

2.4.2. Empirical model

We first employed a linear regression model and a log-linear regression model, as shown in Eqs. (1) and (2) below, and tested the models for each case study independently:

$$Y_i = \alpha + \beta \cdot X_i + \varepsilon_i \quad (1)$$

$$\ln(Y)_i = \alpha + \beta \cdot X_i + \varepsilon_i \quad (2)$$

Y_i is the dependent variable and stands for the total annual revenue of cocoa production at the individual farm level. $\ln(Y_i)$ is the dependent variable and stands for the natural log transformed total annual revenue of cocoa production at the individual farm level. X_i is a dummy that takes the value 1 if the farm was female managed and 0 if it was male managed. i refers to the ith individual farm and ε_i is a random error term. We used the model as follows: We first carried out a simple regression that solely included X_i as the explanatory variable. Here, β was expected to be negative, based on the assumption that a female farmer is disadvantaged in cocoa revenue generation.

We then employed a log-linear model, as shown in Eq. (3) below, and tested the models for each case study independently:

$$\ln\left(Y_i\right) = \alpha + \beta \cdot F_i + y \cdot X_i + \varepsilon_i \quad (3)$$

$\ln(Y_i)$ is the dependent variable and stands for the total annual revenue of cocoa production at the individual farm level. F_i is a dummy that takes the value 1 if the farm was female managed and 0 if it was male managed. X_i is a vector of various agronomic and sociodemographic control variables. i refers to the ith individual farm and ε_i is a random error term.

Dependent variable description. The dependent variable refers to the total annual revenue from cocoa production at the farm level in 2019 (Ecuador) and 2020 (Uganda) and was calculated by multiplying the average farm-gate unit price in USD for one kg of cocoa per farm and the units sold in the same year as reported by each interviewee (Eq. (4)). Thereby, i corresponds to the ith individual based on individual statements made by the farmers interviewed in the survey.

$$Cocoa\ Revenue\ (2019/20)_i = Unit\ Price\ Cocoa\ (USD)_i\ x\ Cocoa\ Units\ Sold\ (kg)_i \quad (4)$$

Independent variables description. We assumed that gendered disadvantages in key areas of agricultural production, such as productivity, input access, and bargaining power affect female farmers' ability to generate cocoa revenue adversely. Accordingly, we used the 19 potential explanatory variables for cocoa revenue that are listed in Table 1.

3. Results

3.1. Descriptive statistics

3.1.1. Socio-demographic and farm characteristics

Descriptive statistics of the individual characteristics by gender and the results of a Wilcoxon sum rank test and chi-square test on potential gender differences of both case studies are shown in Table 2.

Table 2
Mean (standard deviation) and percentages of socio-demographic and farm characteristics by gender in Uganda and Ecuador.

	Uganda					Ecuador				
	Female (n = 58)	Male (n = 122)	Total (N = 180)	*p*-value		Female (n = 44)	Male (n = 131)	Total (N = 175)	*p*-value	
Average Fresh Cocoa Price (USD / kg)	0.62 (0.03)	0.61 (0.03)	0.62 (0.03)	0.476		0.87 (0.39)	0.76 (0.20)	0.79 (0.27)	0.498	
Average Dry Cocoa Price (USD / kg)	1.63 (0.27)	1.70 (0.28)	1.68 (0.28)	0.207		1.49 (0.31)	1.60 (0.37)	1.57 (0.35)	0.277	
Fresh Cocoa Sold (kg / year)	92 (167)	215 (787)	174 (651)	0.524		1511 (2434)	1862 (1373)	1767 (1709)	0.045	*
Dry Cocoa Sold (kg / year)	27 (47)	64 (107)	52 (93)	0.033	*	1506 (1345)	2455 (2046)	2181 (1908)	0.163	
Cocoa Revenue (USD / year)	345 (350)	868 (1096)	699 (955)	0.004	**	1861 (2092)	2673 (2961)	2469 (2785)	0.029	*
Marital Status = Married (dummy)	13 (22.4%)					18 (40.9%)				
Marital Status = Widowed (dummy)	20 (34.5%)					2 (4.5%)				
Age (years)	56.8 (12.0)	50.6 (13.1)	52.6 (13.0)	0.003	***	48.2 (15.6)	51.8 (13.3)	50.9 (13.9)	0.171	
Education (years of schooling)	5.64 (2.75)	8.06 (3.55)	7.32 (3.50)	< 0.001	***	8.77 (4.60)	7.40 (3.68)	7.75 (3.96)	0.086	
Training (number of days)	1.57 (1.61)	3.37 (4.85)	2.79 (4.18)	0.021	*	3.37 (5.56)	2.91 (5.58)	3.03 (5.56)	0.504	
Workforce (number of workers)	2.97 (1.01)	3.42 (1.23)	3.27 (1.18)	0.008	*	3.64 (1.60)	3.82 (2.87)	3.78 (2.61)	0.919	
Farm Size (hectares)	4.44 (3.96)	8.55 (8.79)	7.22 (7.81)	< 0.001	***	8.04 (7.50)	13.03 (18.03)	11.78 (16.17)	0.195	
Cocoa Area (hectares)	0.43 (0.40)	0.75 (0.85)	0.65 (0.75)	0.001	***	2.72 (3.32)	2.16 (1.74)	2.30 (2.25)	0.656	
Sold Dried Cocoa (dummy)	14 (24.1%)	29 (23.8%)	43 (23.9%)	0.957		15 (34.1%)	37 (28.2%)	52 (29.7%)	0.463	
Share Agroforestry (% of farm size)	0.60 (0.26)	0.61 (0.23)	0.61 (0.24)	0.979		0.33 (0.40)	0.28 (0.34)	0.29 (0.36)	0.676	
Production Diversity (number of crops)	6.64 (1.82)	6.92 (1.92)	6.83 (1.89)	0.384		2.55 (1.98)	3.18 (1.93)	3.02 (1.96)	0.061	*
Cash Crops Sold (number of crops)	3.43 (1.58)	4.40 (2.01)	4.09 (1.93)	< 0.001	***	2.34 (1.38)	2.64 (1.22)	2.57 (1.27)	0.08	
Weed Management (number per year)	3.69 (1.67)	4.68 (3.99)	4.37 (3.46)	0.142		3.88 (2.06)	3.86 (2.36)	3.86 (2.29)	0.638	
Formal Savings Account (dummy)[1]	3 (5.2%)	29 (23.8%)	32 (17.8%)	0.002	**					
Informal Savings Account (dummy)[1]	37 (63.8%)	44 (36.1%)	81 (45.0%)	< 0.001	***					
Hybrid Cocoa (dummy)[2]						24 (54.5%)	78 (59.5%)	102 (58.3%)	0.561	
Group Membership (dummy)	42 (72.4%)	83 (68.0%)	125 (69.4%)	0.551		26 (59.1%)	86 (65.6%)	112 (64.0%)	0.433	
Female Decision Score (value between 0-1)[3]	0.25 (0.45)	1.79 (0.46)	0.74 (0.85)	< 0.001	***	0.99 (0.75)	0.43 (0.46)	0.57 (0.60)	< 0.001	***
Female Activity Score (value between 0-1)[4]	0.67 (0.46)	1.53 (0.45)	0.95 (0.61)	< 0.001	***	0.62 (0.54)	0.27 (0.40)	0.36 (0.46)	< 0.001	***

Notes:
[1] Data only available for the Ugandan case study.
[2] Data only relevant for the Ecuadorian case study; hybrid variety CCN-51.
[3] Mean female involvement in farm decisions (financial, inputs): mainly men = 0, both = 0.5, mainly women = 1.
[4] Mean female involvement in cocoa production (harvest, crop management, fermentation): mainly men = 0, both = 0.5, mainly women = 1.
Numeric variables are compared using a Wilcoxon test, categorical variables using a chi-square test.

In total, 32% of the Ugandan interviewees were female, of which 22% were married and 35% were widowed. Fourteen variables showed significant differences between male and female farmers in the Ugandan data set. Female farmers sold significantly less cocoa per year (μ=500 kg) than male farmers (μ=1111 kg) and the mean quantity of dried cocoa also differed significantly between female and male managed farms (μ=27 kg and 64 kg, respectively). Cocoa revenue was significantly lower on female managed farms compared to male managed farms (μ=345 USD and 868 USD, respectively). Since this variable was of particular interest, the distribution is shown on a boxplot (Fig. 3). Female farmers were significantly older than male farmers (μ=57 years and 51 years, respectively), completed significantly less years of school (μ=5.6 and 8.1 years, respectively), received less training (μ=1.6 and 3.4 days, respectively), had smaller farms (μ=4.4 and 8.6 hectares, respectively) and cocoa plots (μ=0.4 hectares and 0.8 hectares, respectively), grew fewer cash crops (μ=3.4 and 4.4, respectively), had a smaller workforce (μ=3.0 and 3.4, respectively), and owned more informal savings accounts (μ=64 and 36 percent, respectively) than formal savings accounts (μ=5 and 24 percent, respectively). Furthermore, there was a significant difference between the farms managed by men and women in the assessment of scores concerning female decision-making (μ=0.25 and 1.79, respectively) and activities (μ=0.67 and 1.53, respectively), which suggests that women were less involved in male managed farms.

In Ecuador, 25% of interviewed farmers were female with 41% married and 5% widowed. Female managed farms had significantly lower cocoa revenues than male managed farms (μ=1861 USD and 2673 USD, respectively). Fig. 3 gives an indication of how cocoa revenue was distributed in this data set. The additional significantly different variables between female and male farmers within this data set included the amount of fresh cocoa sold (μ=1511 kg and 1862 kg, respectively) and product diversity (μ=2.6 and 3.2 crops grown, respectively). Finally, on a scale from 0 to 1 indicating no to full female participation, women's decision-making (μ=0.99 and 0.43, respectively) and activity (μ=0.62 and 0.27, respectively) scores showed a significant difference in women's participation in between female and male managed farms.

3.1.2. Decision-making and role distribution at farm-level

The involvement of men and women in farming decisions and cocoa productive activities varied strongly between male and female managed farms as well as case studies (see Fig. 4 and Annex 1). As mentioned above, we defined a male or female managed farm based on the gender of the self-proclaimed farm manager.

In the Ugandan case study, women mainly took the decisions and carried out activities on female managed farms. Similarly, we found that men were the main decision-makers and executors of activities on male managed farms. Men were rarely involved in crop management or harvesting on farms managed by women. In the year prior to data collection, 21% of sampled Ugandan farms fermented and dried their cocoa beans, which was carried out jointly on 34% of the male managed farms and by women on 34% of the female managed farms.

On male managed farms in both Ecuador and Uganda, women were involved in financial decision-making on 52% and 20% of the farms, respectively. Similar results were found for input decisions on farms managed by men, with women involved in such decisions on 32% of Ecuadorian and 22% of Ugandan farms. However, female participation in financial decisions on female managed farms was lower in Ecuador (75%) than in Uganda (97%). Women in Ecuador were also much less

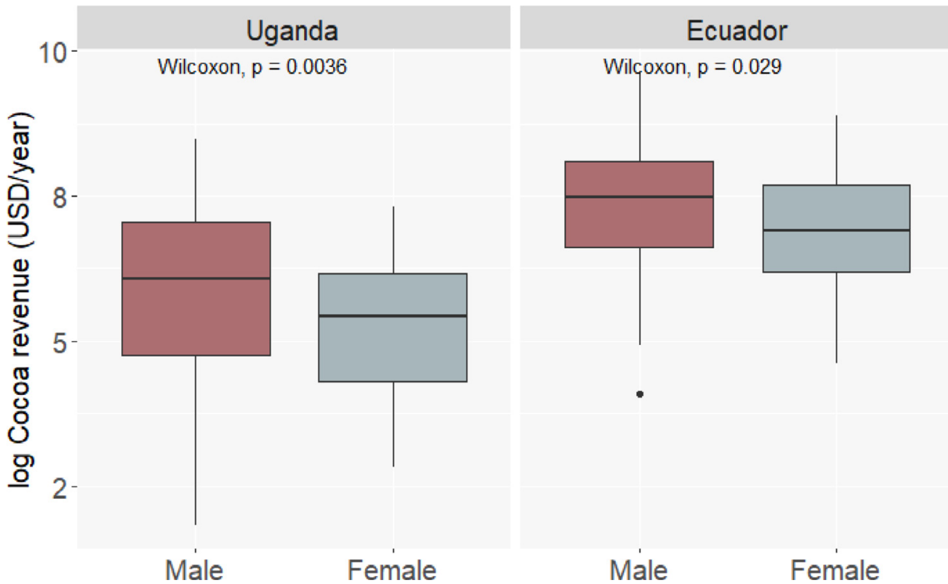

Fig. 3. *log*-transformed cocoa revenue of male and female managed farms in Uganda and Ecuador.

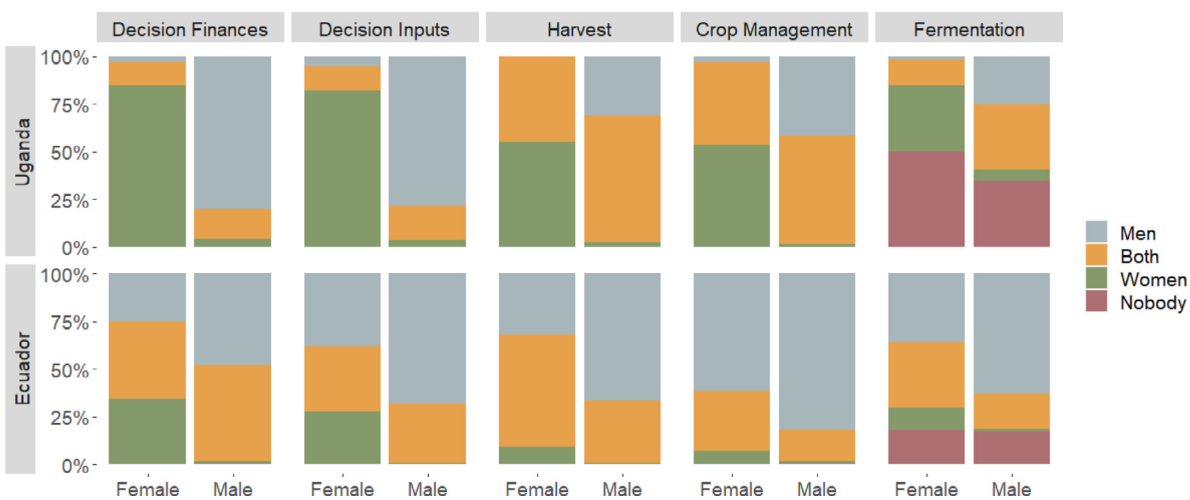

Fig. 4. Differences in roles and responsibilities among male and female household members for different decisions and activities on farm between the sample of female and male managed farms in both case study countries. Uganda: n (female) = 58, n (male) = 122. Ecuador: n (female) = 44, n (male) = 131.

involved in crop management and harvesting activities on both male and female managed farms (18% and 39%, respectively, for crop management; 33% and 68%, respectively, for harvesting). In the year prior to data collection, 30% of the Ecuadorian sample fermented and dried their own cocoa beans, which was carried out by men on 63% of male managed farms on 36% of female managed farms.

3.2. Regression analysis

Female farmers in Uganda generate significantly less revenues from cocoa, resulting in earnings of about 523 USD/year less than male farmers (Table 3). When controlling this difference for other factors that are known to explain cocoa revenue generation, this difference amounts to a (non-significant) disadvantage of 15.3% (Table 4). Additionally, the number of workers on the farm (=Workforce), the size of the farms' cocoa plots (=Cocoa Area), and the share of agroforestry relative to the farm size (=Share Agroforestry) show a significant and positive relationship with cocoa revenue, while the number of training days shows a significant and negative relationship with cocoa revenue (Table 4).

With an 812 USD/year difference, female farmers within our Ecuadorian sample had significantly lower cocoa revenues than male farmers (Table 3). The significant difference remained at 35% also when controlling for other factors that are known to explain cocoa revenue (Table 4). Additionally, farmers' years of schooling, the frequency of weed management, and selling fermented and dried cocoa showed a significant and positive relationship with cocoa revenue, while the share of agroforestry was significantly and negatively related to cocoa revenue (Table 4).

4. Discussion

We have analysed women's roles and abilities to benefit from the cocoa supply chain based on two case studies in Uganda and Ecuador. The results show that women were involved in most cocoa production and processing steps in both countries. While the concrete results are specific to the sample groups of our case studies, we argue that female cocoa farmers in other national contexts face similar disadvantages based on extrinsic factors that hinder them to fully participate in and benefit from the global cocoa supply chain. As conditions are similar in other cocoa-producing communities in Latin America and Africa, we believe that some broader lessons can be drawn. We will first elaborate on the individual results from Uganda and Ecuador and then place and compare both case studies in a common context.

Table 3
Regression analyses of cocoa revenue and female dummy (USD) (2019/20).

	Uganda		Ecuador	
	(1) Cocoa Revenue (USD)	(2) Cocoa (*log*)Revenue (USD)	(1) Cocoa Revenue (USD)	(2) Cocoa (*log*)Revenue (USD)
Female (dummy)	-523.1***	-0.611***	-811.9*	-0.446**
	(147.6)	(0.229)	(482.7)	(0.191)
Constant	868.0***	5.885***	2,673***	7.371***
	(83.76)	(0.130)	(242.0)	(0.096)
Observations	180	180	175	175
R-squared	0.066	0.038	0.016	0.031

Standard error in parentheses.
* $p < 0.05$,
** $p < 0.01$,
*** $p < 0.001$.
Notes: USD = United States Dollar. UGX = Ugandan Schilling. USD/UGX exchange rate of 10.08.2921. 1 USD: 0,00028 UGX.

4.1. Uganda

The finding that women in the Ugandan case study were at a significant disadvantage to male farmers in several key aspects of agricultural production, such as farm size, education, and training in good agricultural practices as well as access to formal banking accounts is consistent with the evidence from Doss et al. [29], Fischer and Qaim [32], and Meinzen-Dick [48]. Our data further show that Ugandan male managed farms had a higher production diversity and sold more cash crops, which is in line with the results of Ogutu and Qaim [54] and Carr [21], who found that male farmers are almost exclusively engaged in cash crop cultivation due to more intensified farming processes and higher input and machinery use. This suggests that there are forces in place that hinder women from taking up intensified farming processes, despite being involved in every step of cocoa cultivation, which is in agreement with Fountain & Hütz-Adams [34] finding that women make up a large portion of cocoa labour but are not remunerated accordingly.

The evaluation of roles and decisions in cocoa production showed that women were primarily responsible for decision-making regarding finances and inputs on female managed farms, which is in contrast to the results by Fischer and Qaim [32]. It became clear that female managed farms rely to a substantial extent on a female workforce in which women take most decisions and carry out most activities. Our results show that women also play an important role on male managed farms by participating in joint crop management activities and harvesting. The discrepancy between the respective roles and responsibilities of male and female managed farms could be explained by the different structures of the agricultural household. One possible explanation is that the female farmers of the sample are responsible for cocoa 'by default' because they are either single, widowed, or because the men work elsewhere, which is why they are engaged in agriculture. This assumption is also supported by our data, which shows that the majority of female farmers are either single or widowed and may not be able to receive support from a man outside of the household. This is congruent with the findings of Hillesland et al. [39], who found that decision-making on female-owned farms is primarily conducted by women, and Kang et al. [43], who found that the likelihood that a plot is solely managed by a female is statistically larger in female owned plots. Hence, we can show that social and cultural norms exclude female farmers from accessing or including male labour on their farms. In contrast, male farmers have a different household structure and have easier access to family labour through a wife or daughters, which is confirmed in our data.

Moreover, revenue from cocoa differed significantly and considerably by gender, with female farmers generating only about one third of the revenue of male farmers in absolute terms (μ= 345 USD and 868 USD, respectively). Controlling for numerous aspects of cocoa-growing as well as on mechanisms that are identified to discriminate against women, the estimation results showed that the coefficients for the number of workers, cocoa area, and the share of agroforestry had a significant positive association with cocoa revenue. This is plausible because there is a systemic gender and knowledge gap in these characteristics, based on the findings of this study and the available literature. The designated cocoa area is smaller, since farms managed by women are generally smaller than those managed by men. This is in line with other findings from Uganda, i.e. UN Women [76], which found that agricultural land cultivated by women is 0.23 ha smaller than that cultivated by men, and Reynolds et al. [63], who found that female-headed households have less landholdings and cultivated land. This is mainly caused by tenure systems in Uganda that prevent women from inheriting land, as men are preferred in these due to cultural norms [42]. A larger cocoa production area, however, most certainly leads to higher output quantities. Also, female managed farms are resource constrained, lacking the necessary pecuniary means to employ additional workers, as also noted by Pierotti et al. [59]. This limits their options to respond to time and labour shortages in their farming activities. Surprisingly, the variable 'training days' had a significant negative association with cocoa revenue, which we cannot explain using the available data and contradict past studies that showed a positive relationship between training participation and cocoa yields [3]. Yet, the study's findings make it clear that female managed farms are at a disadvantage in critical attributes of cocoa farming, resulting in a comparative disadvantage in revenue generation compared to male managed farms as constraints disproportionately affect farms managed by a woman.

4.2. Ecuador

In general, comparing farmers' socio-demographic and farms' characteristics did not indicate significant differences between male and female managed farms in our Ecuadorian sample. Only 'production diversity' was significantly lower on female managed farms. This result was surprising, given that the conclusion would be that no structural disadvantages exist for female farmers within our sample. However, female managed farms had significantly lower cocoa revenues, recording a difference of 35% to male managed farms, even after adding additional control variables that generally influence revenue generation. Despite the substantial difference, female disadvantages in cocoa revenue generation cannot be fully explained by our set of predictors and potentially lie beyond the farm level. While Ecuador has a solid legal framework of gender equality and has made advances in terms of political representation of women [75], this has not yet translated into widespread gender equality within rural households and among cocoa producers [16]. For example, property rights violations are high among Ecuadorian women [24] and women are more likely to be asset poor due to inheritance laws that favour men, for example in land titling [7]. Our observations in the field and our results on the involvement of women in cocoa farm-

Table 4
Log-linear regression analyses of cocoa revenue for the Ugandan and Ecuadorian sample (USD) (2019/20).

	Uganda		Ecuador	
	Cocoa (*log*)Revenue (USD)	Percentage effects	Cocoa (*log*)Revenue (USD)	Percentage effects
Socio-Demographic Variables				
Female (dummy)	-0.166	-15.3	-0.433**	-35.1
	(0.483)		(0.194)	
Marital Status (dummy)	0.053	5.4		
	(0.420)			
Age (years)	-0.010	-1.0	0.004	0.4
	(0.008)		(0.006)	
Education (years of schooling)	-0.031	-3.1	0.052**	5.3
	(0.031)		(0.021)	
Formal Savings Account (dummy)	0.436	54.7		
	(0.306)			
Informal Savings Account (dummy)	0.093	9.7		
	(0.263)			
Farm Characteristics				
Farm Size (hectares)	-0.015	-1.5	0.003	0.3
	(0.031)		(0.005)	
Weed Management (number per year)	0.008	0.8	0.120***	12.7
	(0.030)		(0.034)	
Group Membership (dummy)	0.243	27.5	-0.108	-10.2
	(0.235)		(0.170)	
Production Diversity (number of crops)	0.012	1.2	0.002	0.2
	(0.066)		(0.055)	
Workforce (number of workers)	0.227**	25.5	0.011	1.1
	(0.096)		(0.030)	
Training (number of days)	-0.055**	-5.4	-0.015	-1.5
	(0.025)		(0.014)	
Cash Crops Sold (number of crops)	0.027	2.7	0.061	6.3
	(0.064)		(0.078)	
Cocoa-Specific Variables				
Cocoa Area (hectares)	0.746***	110.9	0.032	3.3
	(0.252)		(0.034)	
Sold Dried Cocoa (dummy)	-0.203	-18.4	0.345*	41.2
	(0.235)		(0.201)	
Share Agroforestry (% of farm size)	1.814***	513.5	-0.460*	-36.9
	(0.466)		(0.270)	
Hybrid Cocoa (dummy)			0.302	35.3
			(0.206)	
Female Decision Score (value between 0-1)[1]	-0.094	-9.0	-0.030	-3.0
	(0.267)		(0.154)	
Female Activity Score (value between 0-1)[2]	-0.070	-6.8	-0.084	-8.1
	(0.239)		(0.190)	
Constant	4.155***		6.032***	
	(0.763)		(0.503)	
Observations	156		170	
R-squared	0.399		0.318	

Standard error in parentheses.
* $p < 0.05$,
** $p < 0.01$,
*** $p < 0.001$.
Notes: USD = United States Dollar.
[1] Mean female involvement in farm decisions (financial, inputs): mainly men = 0, both = 0.5, mainly women = 1.
[2] Mean female involvement in cocoa production (harvest, crop management, fermentation): mainly men = 0, both = 0.5, mainly women = 1.

ing and farm decision-making mirror these results, especially their low involvement on male managed farms. Similar observations were made in Peru [15]. Our sample included few households subject to male out-migration that leave women in charge of family farms, a common phenomenon that can increase women's decision-making power on farms [22,79]. Additionally, our results might be specific for "mestizo" communities in the Ecuadorian coastal area and do not represent the diverse gendered and racial issues on access to land that are more pronounced in the Ecuadorian highlands and Amazon basin [61]. We hypothesise that inheritance laws and the registration in the sustainability program might create the distortion between data and observations: Many farms are legally owned by women yet managed by their male family members (as shown by the low female participation in farm activities and decisions). In order to have the largest benefits from the sustainability program (mainly in-kind premiums), these female landowners are registered in the program, despite not being the person managing cocoa.

The results of the regression model showed that farmers' education, frequency of weed management, and selling fermented and dried cocoa had a significant positive association with cocoa revenue. Past studies have shown the importance of farmers' education for the adoption of new technologies that increase productivity (e.g. [11]). Education might furthermore relate to access to market information and farmers' ability to identify buyers willing to pay higher prices. We understand the frequency of weed management as a proxy for good agricultural practices in cocoa that indicates time investment in the crop, which is essential for productivity [3]. Prices for fermented and dried cocoa in Ecuador were up to three times higher in our sample than for fresh cocoa, which might explain the positive relationship with cocoa revenue. However, to ferment cocoa beans, farmers need a minimum quantity to generate the required heat [51], which means that small farms or farms with low yields are less likely to add value to their beans on farm. Finally, the proportion of a farm's agroforestry systems showed a significant negative relationship with cocoa revenues, potentially due to lower cocoa density in mixed production systems and thus yields. This is in line with Armengot et al. [10] and Middendorp et al. [49], who found lower cocoa yields in agroforests compared to monoculture.

4.3. Cross case study comparison

Our results show a general lack of gender equality in cocoa production and revenue generation, however with substantial differences between the two producing countries. These differences highlight the risk of generalisation in the debate about, and efforts to achieve, gender equality in cocoa supply chains, as stressed by Friedman et al. [35]. Our results also highlight that gender inequalities persists even within the allegedly 'sustainable' cocoa sector, as already highlighted for sustainability certification by Meemken and Qaim [46] for Uganda. This highlights the need for cocoa buyers and processors to find specific responses to local issues in their supply chains and go beyond standardised approaches, as in voluntary sustainability certification.

We also noticed a strong difference between the two case studies regarding gender roles in decision-making and activities around the farm. Ugandan female farm managers were clearly responsible for the decisions made on their farms and involved men only in labour-intensive activities, such as harvesting, but predominantly through joint labour. On the contrary, women had little say or involvement on male managed farms in pecuniary areas, such as input or financial decisions, but contributed in labour-intensive work by providing joint labour. In Ecuador, a larger part of the farm activities was shared and decisions were made jointly. The share of labour and decision-making power of men on male-managed farms was proportionally larger than in Uganda. As the results show, role allocation in both countries as well as between male and female managed farms is complex and context specific. Nonetheless, we highlight that Ugandan women are disadvantaged by social norms, which prevent them from participating in decisions on male managed farms, while women in Ecuador experience higher levels of equality in most measures. This could be related to, among other things, the lower education level of Ugandan women, while Ecuadorian women in our sample had a higher education than men. Another reason for the differences in decision-making may be that a larger proportion of Ugandan producers are single women and may therefore be responsible for cocoa production by default, for example, because they are widowed.

4.4. Limitations of the study

Despite the meaningful results obtained, the small sample sizes and the share of female managed farms suggest that the results should be generalized with caution. With regard to the specific effects of female managed farms in cocoa, the results may differ depending on the geographic context and the structure of the local supply chain. We acknowledge that the use of cross-sectional data may not be able to control certain effects in such a way that statistical inference was possible.

Another limitation is that no clear distinction was made between the farm manager and the farm owner in the survey, which offered room for biases, especially with regard to gender dynamics. A farm manager may be more involved in the day-to-day business while the farm owner may not be involved in the farming business at all. Hence, differences in perceptions and attitude can arise, which indicates that information asymmetries could be present. Another weakness that could not be considered with the available data is the scenario that the farm-manager is a woman, but the owner is a man, which means we cannot draw conclusions as to how this could potentially influence the economic situation of a farm and the respective roles and decision-making. Similarly, distinguishing between male and female managed farms included one major difficulty - namely the ignorance of contributions that women made to farms in households headed by men, and vice versa, as challenged by Doss [28]. The present study therefore did not capture the gender dynamics of smallholder farm households and how different roles and decisions are distributed to an extent that would be satisfactory for external validity. Regarding the analysis of roles and decision-making on cocoa farms, the survey questions either referred to which gender made the decision or who carried out the farming activities. Therefore, no clear statement can be made about the structure of the decision-making authority at all stages of cocoa processing, since for some activities the only information available concerned the execution of a task, not the execution of the decision.

Given these limitations, we recommend future research to examine the structures, roles, and synergies of farm households and measure economic and social outcomes that build on our analysis while covering additional aspects. This can lead to an improved understanding of women's differential access to land, credit, human capital, and other productive resources, and contribute to strategies that address the systemic gender gap. This can guide potentially effective interventions that can expand the evidence base on what is successful in reaching, benefiting, and empowering female farmers and women in agriculture.

5. Conclusions

This study examined the participation of women in cocoa production and explored gender roles and decision-making using our primary data set from smallholder farms in the Central Province of Uganda and four north-western provinces in Ecuador. Our analyses revealed large country-specific differences, but female managed farms achieved significantly lower cocoa revenues compared to male managed farms when not controlling for other confounders. When controlling for factors known to influence revenue generation, the results revealed that this gender gap is caused by several interrelated systemic inequalities in landownership, access to productive resources and finances that hinder women from participating in the cocoa-chocolate supply chain with the same benefits as men. While women's contribution to agricultural production was of high importance with diverse and complex roles, the case studies show major differences in the division of roles and decision-making power. This affects women's ability to manage a successful agricultural business and puts them at a comparative disadvantage to men.

Some broader lessons and cautious policy implications can be derived from our work. First, both case studies revealed gender disparities in the cocoa supply chain, although to different degrees, despite belonging to the so-called 'sustainable cocoa' segment. This indicates that sustainability frameworks and downstream chocolate manufacturers do not yet sufficiently address gender issues within their supply chains, mirroring past findings from Amuzu et al. [5] and Traldi [72]. Second, past studies have shown that farmer training can positively influence cocoa management and yields [1,30]. In our study, female training participation was significantly lower in the Ugandan case study. Gender-targeted interventions need to take women's realities into account. This includes adapting training schedules to meet women's schedules and employing female extension officers, which may have positive outcomes on women's training participation, farming skills, and economic and financial decision-making power [23]. Third, our results revealed disadvantages for women cocoa farmers regarding access to official land titles and formal saving accounts as well as access to education and training opportunities. This points to an urgent need for policy frameworks that address these existing institutional disparities.

The demand for sustainably produced cocoa beans is unlikely to decrease in the coming decades, yet challenges in cocoa producing communities prevail. The cocoa sector has made great advances towards increasing sustainability, however, is not reaping its full potential and still has a long way to go in reaching gender equality. Supporting female cocoa farmers is a critical step for the global cocoa sector to create a future where the communities that produce the raw material prosper. The shift towards a 'gender-transformative' cocoa sector offers an opportunity to combat existing and future challenges, also in consideration of climate change, by removing existing bottlenecks for women and female cocoa farmers. This, in turn, may increase resilience to shocks, improve food security, alleviate rural poverty, and contribute to the economic development in cocoa producing countries.

Supporting information: Overview of analyses carried out

Wilcoxon signed-rank test
Independent sample t-test
Variance inflation factor
Logarithmic functions
Parsimonious models
Ordinary Least Squares Regression models
Cooks Distance/Robust Regression models
Scatter, Q-Q Plots (not an analysis)
Log-Linear Regression
Linear OLS Regression

Declaration of Competing Interest

None.

Appendix 1

Table A1

References

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Table A1
Share of involvement by gender in farm decision and cocoa production activities in Uganda and Ecuador.

	Sample	Response	Crop Management	Decision Finances	Decision Inputs	Fermentation	Harvest
Uganda	Female	Men	-	0.02	-	0.02	-
		Women	0.26	0.72	0.70	0.22	0.26
		Both	0.43	0.12	0.13	0.14	0.45
		Mostly Men	0.03	0.02	0.05	-	-
		Mostly Women	0.28	0.12	0.13	0.12	0.29
		Nobody				0.50	
	Male	Men	0.21	0.59	0.56	0.17	0.18
		Women	-	0.02	0.02	0.02	0.02
		Both	0.57	0.16	0.18	0.34	0.66
		Mostly Men	0.20	0.21	0.23	0.08	0.13
		Mostly Women	0.02	0.02	0.02	0.03	0.01
		Nobody				0.34	
	Full	Men	0.14	0.41	0.38	0.12	0.12
		Women	0.08	0.25	0.23	0.09	0.09
		Both	0.52	0.14	0.16	0.28	0.59
		Mostly Men	0.15	0.15	0.17	0.06	0.09
		Mostly Women	0.10	0.05	0.05	0.06	0.10
		Nobody				0.39	
Ecuador	Female	Women	0.07	0.25	0.23	0.09	0.09
		Men	0.41	0.16	0.25	0.23	0.18
		Both	0.32	0.41	0.34	0.34	0.59
		Mostly Women	-	0.09	0.05	0.02	-
		Mostly Men	0.20	0.09	0.14	0.14	0.14
		Nobody				0.18	
	Male	Women	0.01	0.01	0.01	0.01	0.01
		Men	0.72	0.44	0.63	0.55	0.56
		Both	0.16	0.50	0.31	0.18	0.32
		Mostly Women	0.01	0.01	-	0.01	-
		Mostly Men	0.11	0.05	0.05	0.08	0.11
		Nobody				0.17	
	Full	Women	0.02	0.07	0.06	0.03	0.03
		Men	0.64	0.37	0.53	0.47	0.47
		Both	0.20	0.48	0.32	0.22	0.39
		Mostly Women	0.01	0.03	0.01	0.01	-
		Mostly Men	0.13	0.06	0.08	0.09	0.11
		Nobody				0.18	

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