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Assessing the trade and welfare effects of certification schemes: The case of GlobalGAP in Ghana's mango sector

Rexford Akrong[a,*], Angela Dziedzom Akorsu[a], Praveen Jha[b], Joseph Boateng Agyenim[a]

[a] School for Development Studies, University of Cape Coast, Cape Coast, Ghana
[b] Center for Economics Studies and Planning, Jawaharlal Nehru University, New Delhi, India.

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ABSTRACT

The study analyzes the trade and welfare effects of GlobalGAP certification using primary data collected from 224 mango farmers in Southern Ghana. The multivariate probit model and an endogenous switching regression (ESR) model were used to estimate the effects of certification on the choice of marketing channels, quantity sold and income, respectively. The results show that certified farmers are less likely to supply to local traders and more likely to sell to industrial processors and the export market. The study found that certification increased quantity sold to high-value markets by 12% for certified farmers. GlobalGAP certification also has the potential to increase income by 20% more for farmers who opt to be certified. It is, therefore recommended that government and development partners shouldcontribute to the development of the technical and financial capacities of farmers in order to enhance farmers' participation in certification schemes.

Introduction

In light of globalization, an agenda pushed by proponents of the neoliberal theory, developing countries have increasingly integrated farmers into global value chains (GVCs) [2,17]. Participation in these chains is governed by sustainability standards that certify the social and environmental sustainability of agricultural production [10]. Ideally, these standards are expected to threaten or eliminate smallholders who are unable to negotiate the high costs of inputs or 'entry barriers' from participation in GVCs [2] since these farmers have to make significant adjustments to their farms and production practices amidst the financial and technical constraints they face [5,16].

Following the theory of change of certification schemes, adoption of certification can increase productivity, improve the quality of crops, market access, household income, environmental quality and wellbeing [31]. Accordingly, as suggested by the rational choice and neoliberal theories, rational individuals will adopt certification schemes to maximize their welfare [15]. Hence, enhancing smallholder farmers' participation in certification programmes to achieve the Sustainable Development Goals (SDGs) of no poverty, zero hunger, and decent jobs and employment for all. The best-known certification initiative in the horticultural sector is the GlobalGAP certification which has been more popular in Ghana's pineapple sub-sector

* Corresponding author at: School for Development Studies, University of Cape Coast, Cape Coast, Central Region, Ghana.
E-mail address: akrongrexford@yahoo.com (R. Akrong).

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compared with the mango sub-sector (Annor, [3]). This could be attributed to the fact that the pineapple sub-sector has been Ghana's major fruit sector whereas the mango sub-sector is an emerging one [30] with a growing demand on both local and international markets.

Ghana's mango is marketed in both low-value and high-value market chains including the local traders, industrial processors and the export markets, which offer low and high prices, respectively. The high-value mango market chain has stringent requirements and standards such as GlobalGAP certification and Organic certification [9,33]. Zakari [33] and Annor [3] note that compliance with certification standards remains a challenge to smallholder mango farmers in Ghana. In fact, as of 2017, only 105 out of 8,000 registered mango farmers in Ghana had a valid GlobalGAP certificate [12,14]. Although this certification standard is based on a framework of Good Agricultural Practices (GAP) (such as pesticide and fertilizer use) that ensure compliance with public food safety requirements, it also encompasses other factors such as traceability, worker safety, and farm management practices (Subervie and Vagneron [34]). Smallholder mango farmers' ability to meet the GlobalGAP certification standards implies an increase in productivity, quality of farm produce and upgrading market acceptability of farm produce ([22]; Annor [3]).

To improve certification among small-scale farmers in Ghana, the Government of Ghana has forged public-private partnerships with key non-state actors including multinational agribusiness firms. Examples include training and capacity development programmes organized in the 'Southern Belt' of mango production by multinational corporations such as HPW, Blue Skies Limited, and Bomarts that form the main mango processors; USAID/TIPCEE (now replaced by ADVANCE) and the Ministry of Food and Agriculture's (MOFA) direct extension services West Africa Competitiveness Programme (WACOMP), [32].

Despite these measures to improve certification, participation in the GlobalGAP certification scheme remains minimal among mango farmers in Ghana. Meanwhile, the GlobalGAP certification scheme is a necessary condition for access to export markets [10,11]. Indeed, a low level of certification is considered the main factor hampering the integration of small-scale farmers into GVCs [14], thereby limiting their access to remunerative market and as a consequence, the loss of opportunity to maximize gains from mango production.

There are still controversies about the effect of certification on the economic upgrading of smallholder farmers. Some pieces of evidence suggest that certification has positive effects on trade and other socioeconomic outcomes including farm income and return on investments [10,11,20]. Other studies suggest that certification does not lead to the economic upgrading of smallholder farmers in developing countries (Cramer et al. [6]). These heterogeneities in the effects of certification are attributed to differences in certification schemes and products [10,25]. This study aims at identifying the determinants of GlobalGAP certification among mango farmers in Ghana and examining the impact of certification on economic upgrading in terms of market performance (quantity of mangoes sold) and household income of mango farmers in Ghana.

The study will contribute to the relevant literature on certification and market access as follows. First, by analyzing the drivers of participation in GlobalGAP certification and its effects on participation in markets and household income. Previous studies have focused on the determinants of certification and its effects on return on investments by pineapple farmers in Ghana (Annor, [3,20,28]). Second, studies that have used rigorous statistical and econometric techniques to assess the impacts of certification are limited (e.g., [20]). This study fills this methodological gap by using an endogenous switching regression (ESR) to determine the impacts of certification on the intensity of market participation and household income of mango farmers.

The rest of the paper is organized as follows. Section 2 describes the methods of data collection and the theoretical and empirical strategy the study used. Section 3 presents empirical results whiles Section 4 presents the discussions of the results in line with previous studies. Section 5 highlights the main conclusions and recommendations. From Section 2 onwards, "GlobalGAP certification" and "certification" are used interchangeably.

Materials and methods

Study area

The study was conducted in the Southern Cluster of mango production in Ghana. This cluster covers the Greater Accra Region and the Eastern Region. The major mango production zones in this cluster include the Shai Osudoku District, and the Yilo Krobo and Manya Krobo Districts. This cluster accounts for about 50% of annual mango exports and supplies significant volumes of mango to processors [32,33]. The cluster hosts strong mango producer associations (9) and is well recognized in Ghana due to the strength of the producer cooperatives as well as the volumes of mango produced.

Sampling

The study used a three-stage sampling procedure to select participants. First, the study used the purposive sampling technique to select the Eastern Region and the Greater Accra Region due to their relatively high level of mango production and trade. Next, the study identified the main mango production zones in these regions. From these zones, the purposive sampling technique was again used to select the Shai Osudoku District, Yilo Krobo and Manya Krobo Districts, where mango is intensively produced for both domestic and export markets. In the third stage, we identified villages where mangoes were predominantly produced and generated a list of mango farmers from these villages. The list of the farmers was compiled

from lists obtained from three farmer groups (The Dangme West Mango Farmers' Association, The Yilo Krobo Mango Farmers' Association and the Manya Krobo Mango Farmers' Association) and mango producing households that were identified with the help of extension officers who were employed as field officers. We assigned random numbers to the farmers on the list using Microsoft Excel 2016 and 224 mango farmers were selected. The sample size is representative for all mango farmers in Southern Ghana and sufficient for regression analyses since according to Israel (1992), a sample size of between 200 and 500 is mostly desirable when the intention is to conduct multiple regression analyses. However, we deeply acknowledge that using this method impedes replication of random selection.

Interview schedules were used by enumerators who were trained to collect information from the farmers. The data collected from the farmers were on the sociodemographic and socioeconomic characteristics, farm characteristics, marketing characteristics and farmers' access to institutional and support services. The data set includes 224 mango farmers of which almost half of them (49.55%) were GlobalGAP certified farmers whereas the rest had no certification.

GlobalGAP certified farmers sold to the export markets as their first preference, the industrial processors as their second preference, and the local traders as their last preference, without any reference to certification. Non-certified farmers could sell to the export markets and industrial processors as their first preference owing to the high prices offered at these markets, and the local traders as their last preference with no reference to certification.

Empirical approach

Mango farmers adopt certification based on some expected satisfaction. Given that GlobalGAP is the certification scheme available to the mango farmers in the study area, certification is a binary choice of which the farmer weighs up the expected net utility of "being certified" against not "being certified". This decision to certify mainly depends on the decision to participate in high-value markets. The question is whether a farmer will make conscious efforts to meet the stringent requirements of remunerative markets or not. Thus, the certification decision is a binary choice problem that is based on the maximization of an underlying utility (increased intensity of participation in high-value markets and household income).

If the expected utility derived from adopting certification is represented by I_{1i}^{*}, and I_{0i}^{*}, the expected utility derived from not adopting certification of farmer $i(i = 1, \ldots, N)$ of an observed population size N, then the difference between the decision to "certify" and "not certify" $I_i^{*} = I_{1i}^{*} - I_{0i}^{*}$ represents the choice of the farmer. The utility of each mango farmer is unobservable but can be inferred from the choice made by the farmer which can be represented by I_i, where $I_i(I_i \in \{0, 1\})$ is a dichotomous variable, with $I_i = 1$, for the treatment, i.e., the decision to certify, and $I_i = 0$ for non-certification:

$$I_i^{*} = Z_i'\alpha + \varepsilon_i$$

$$I_i = 1 \; if \; I_i^{*} > 0$$

$$I_i = 0 \; if \; I_i^{*} \leq 0 \tag{1}$$

Where, I_i^{*} is a dichotomous variable that depends on a vector of observable characteristics of the farmer Z and an error term ε_i, with mean = 0 and variance = δ^2.

The probability of "being certified" is given by:

$$\Pr(I_i = 1|Z_i) = \Pr\left(I_{1i}^{*} > I_{0i}^{*}\right) = \Pr\left(I_i^{*} > 0\right) = F\left(Z_i'\alpha\right) \tag{2}$$

F is the cumulative distribution function for ε_i. The assumption on the functional form for F guides the estimation models. Following Maddala [24] and Greene [13], the probit model is used if the cumulative distribution function follows the standard normal distribution. However, if the cumulative distribution function is the logistic, we have the logit model.

In addition to the probability of adopting the certification, the study was interested in estimating the effect of certification on the choice of marketing channels and the impacts of certification on smallholder farmers the quantity sold to high-value markets as well as the farmers' household income. The choice of marketing channel was estimated using the multivariate probit model since the choice of marketing channels is not mutually exclusive (i.e., a farmer can simultaneously choose multiple marketing channels). Following Arinloye et al. [4], the selection of market i by a farmer j is defined as y_{ij}. The choice of farmer j to transact in market i ($y_{ij} = 1$) or not ($y_{ij} = 0$) is given by:

$$y_{ij} = \begin{cases} 1 \; if \; y_{ij} = x_{ij}'\beta + \varepsilon_{ij} \geq 0, \; x_{ij}'\beta \geq -\varepsilon_{ij} \\ 0 \; if \; y_{ij} = x_{ij}'\beta + \varepsilon_{ij} < 0, x_{ij}'\beta < -\varepsilon_{ij} \end{cases} \tag{3}$$

where β is a vector of estimators and ε_{ij} is a vector of error terms which is normally distributed, y_{ij} is the dependent variable representing $localtraders_j$, $processors_j$ and $export_j$, which are dichotomous variables that assume a value of 1 when farmer j chooses the local traders, industrial processors or the export market respectively. x_{ij}' is the linear combination of the of the explanatory variables.

The quantity sold to high-value markets was measured in terms of the quantity of mangoes in tonnes sold to these markets and household income was measured in terms of the total income generated by all members of the household. The relationship between certification and quantity sold or household income is given by:

$$Y_i = f(X_i; I_i) \tag{4}$$

where Y is the outcome variable (quantity sold or household income), X represents the explanatory variables, and I represents a dichotomous variable for the decision to certify. If Y_i is the outcome variable (quantity sold and household income) of individual i as a function of the certification status I, Y can take two forms; Y_{1i} and Y_{0i}.

Selection bias remains a crucial issue in impact assessment studies. Thus, with a non-random treatment, untreated individuals may differ systematically due to self-selection into treatment and at best the average treatment on the treated (ATT) can be estimated. FollowingLokshin and Sajaia [23], the ATT is given by:

$$\tau_{ATT} = E(Y_1|I=1) - E(Y_0|I=1) \tag{5}$$

where τ represents treatment effect (ATT), and E[.] denotes an expected value operator. The change in the outcome due to certification can be specified as the difference between certification and non-certification. Thus, the expected outcomes are employed to obtain unbiased estimates of the effects of certification. These estimates are termed the ATT in the impact assessment literature [23].

Since randomization is impossible in the case of this study, a quasi-experimental technique, the endogenous switching regression model (ESR) [23], as employed by studies (such as [20,27]; Senou et al. [29]) was used for correction of selection bias in estimating treatment effects. Selection bias arises when decision-makers make a choice due to some comparative advantage [13]. Also, the bias occurs because farmers who would obtain lower than average net benefits from certification choose not to certify and as such truncate the observed certification income distribution. In cases where selection bias stems from observable variables, such as income, regression techniques are used [20]. However, when selection bias is due to unobservable factors that both affect the certification decision and the outcome (quantity sold) (e.g., risk aversion, innate technical or managerial abilities), it results in the problem of omitted variables.

The ESR model uses two different estimation equations for certified and non-certified farmers where the selection process is controlled by adding the inverse mills ratio (IMR) that is calculated through a selection equation in the first step. This equation requires an instrument to avoid collinearity, because the covariates included in the selection equation enter the second stage estimation twice, non-linear through the inverse Mills ratio and linear as a coefficient for the quantity sold and income. In this study, we use the variable Region as the instrument since the region where a farmer is based can influence their decision to certify and not the quantity sold nor income. This is because, capacity development programmes that aim at increasing certification are mainly organized in the Eastern Region [32]. Further, the Eastern Region hosts the strongest mango farmers' associations that can facilitate these capacity development programmes as well as group certification in the study area. Thus, being in the Eastern Region increases a farmer's propensity of being certified. On the other hand, region does not matter for quantity sold given that mango buyers purchase from the farmgate. Consequently, region can only affect the quantity supplied to high-value markets as well as income only through certification. In this study, we follow Davidson and MacKinnon [7] to test for endogeneity using the Durbin-Wu-Hausman test (augmented regression test). The results are presented in Appendix 1.

Two different regimes are associated with the outcome variable, conditional on the certification decision which is estimated by a probit model.

From Eqs. (1) and (4), the two regimes for certification and non-certification are given by:

$$Y_{0i} = X_i'\beta_0 + \varepsilon_{0i} \; if \; I_i = 0 \tag{6}$$

$$Y_{1i} = X_i'\beta_1 + \varepsilon_{1i} \; if \; I_i = 1 \tag{7}$$

where Y_0 and Y_1 represent the separate outcomes for the two regimes of certification and non-certification, and ε_0 and ε_1 are the error terms. Self-selection caused by unobservable factors could lead to a correlation between ε_i, and ε_0, ε_1. In such cases, the use of standard regression techniques such as the ordinary least squares (OLS) would yield biased estimates. A solution to this problem is the derivation of the IMRs $\lambda_0$and λ_1 leading to a transformation of Eqs. (6) and (7) into the following:

$$Y_{0i} = X_i'\beta_0 + \sigma_{0i}\lambda_{0i} + u_{0i} \; if \; I_i = 0 \tag{8}$$

$$Y_{1i} = X_i'\beta_1 + \sigma_{1i}\lambda_{1i} + u_{1i} \; if \; I_i = 1 \tag{9}$$

where $\sigma_0 = cov(\varepsilon_0, \varepsilon_i)$ and $\sigma_1 = cov(\varepsilon_1, \varepsilon_i)$, and u_{0i} and u_{1i} are the error terms which are normally distributed with zero means. This study uses the full information maximum likelihood (FIML) method [23] to estimate the selection and the outcome equations simultaneously. There is an endogenous switch if either the correlation coefficient of ε_0 and ε_i, or ε_1 and ε_i is statistically significant. As noted by Kleeman et al. [20], alternate signs of the correlation coefficients ρ_{0i} and ρ_{1i} show that individuals are certified due to their comparative advantages. On the other hand, the same signs depict an above-average quantity sold for certified individuals compared to non-certified individuals independent of the certification decision.

In such instance, the ATT τ_{ATT}^{ESR} is given by:

$$\tau_{ATT}^{ESR} = E(Y_1|I=1) - E(Y_0|I=1) = X'(\beta_1 - \beta_0) + (\sigma_{1i} - \sigma_{0i})\lambda_1 \tag{10}$$

Table 1
Description of variables of the ESR model and their expected signs.

Variable	Description	Expected sign		
		Channels	Quantity sold	Household Income
Dependent variables:				
Certification	GlobalGAP certification (dummy: 1= Yes; 0= otherwise)			
Quantity sold	Quantity of mangoes in tonnes sold			
Household income	Total income in the household in Cedis			
Independent variables:				
Age	Age of the mango farmer in years	+	+	+
Household size	Number of members in the household	+	+/-	+/-
Education	Number of years of formal education in years	+	+	+
Off-farm income	Non-agricultural income (dummy: 1= Yes; 0= otherwise)	**-c**	+	
Farming experience	Number of years engaged in mango farming	+	+	+
Farm size	Total number of acres under mango production	+	+	+
Transport (Tricycle)	Ownership of transport (tricycle) (dummy; 1= Yes, 0= otherwise)	+	+	+
Extension access	Access to extension services (dummy: 1 = Yes; 0 = otherwise)	+	+	+
Credit access	Access to financial agricultural credit (dummy: 1 = Yes; 0 = otherwise)	+	+	+
Market information	Access to mango market information (dummy: 1 = Yes; 0 = otherwise)	+	+	+
Distance to road	Distance from farm to tarmacked roads in kilometers	+	+	+
Group membership	Membership of mango farmers' association (dummy: 1 = Yes; 0 = otherwise)	+	+	+
Region	Location of farmer (dummy: 1 = Eastern; 0 = otherwise)	+		
Storage	Access to storage (dummy: 1 = Yes; 0 = otherwise)	+		
Price	Price per kg of mangoes sold in Ghanaian Cedis	+		
Record	Keeps record of farm activities (dummy: 1 = Yes; 0 = otherwise)	+		
Trust	If farmer trusts high-value market (dummy: 1 = Yes; 0 = otherwise)	+		
Tree density	Number of mango trees per acre of mango farm	+		

Note: we use a conversion factor of 1 Ghanaian cedi = 0.2 US Dollars (calculated based on the May 2019 exchange rate).

Description of variables

Table 1 presents the description of the variables used in the ESR model and their expected signs.

Results

Descriptive statistics

Table 2 presents the differences in means of characteristics of certified and non-certified smallholder mango farmers in Southern Ghana. The descriptive statistics show that on average, certified mango farmers sold 1.98 tonnes more than non-certified farmers. It was also found that non-certified farmers had a significantly larger household than certified farmers. We hypothesize a negative relationship between household size and certification given that larger households imply channeling more resources for household use and less for farm use. As expected, the sample certified farmers had more years of formal education than non-certified farmers. Education enhances the farmers' ability to understand certification standards (Karalliyadda and Kazunari [18]). Therefore, we hypothesize a positive relationship between education and certification. Further, the average income was significantly higher for certified farmers than non-certified farmers. The results also revealed that more non-certified farmers engaged in non-agricultural activities to generate additional income. According Quartey et al. [28], off-farm activities in which smallholders are involved are not often remunerative enough to enable them cover costs necessary to enable their participation in certification. We hypothesize an inverse relationship between certification and off-farm income.

More of the certified farmers owned a motorized transport (tricycle) and had access to storage facilities as compared with non-certified farmers. It was also revealed that compared with the non-certified farmers, access to storage facilities and record-keeping were more popular among certified farmers. The certified farmers had a higher trust level and received higher prices compared with non-certified farmers.

Regarding institutional support services and transaction costs, this study observed that the sample certified farmers had more extension contacts and access to financial credit than the non-certified farmers. Access to credit increases the resource endowment of farmers, thereby enabling them to afford certification costs and approved inputs required to certify [20]. We hypothesize a positive relationship between access to credit and certification. The certified farmers had more access to

Table 2
Differences in means of characteristics of certified and non-certified smallholder mango farmers.

Variable	Certified n = 111	Non-certified n = 113	Mean difference	t value
Dependent variables				
Quantity sold (tons)	7.24	5.26	1.98	1.9940**
Independent variables				
Age	48.43	46.78	1.64	0.9816
Household size	4.82	5.57	-0.75	-2.5326***
Education	9.31	8.36	0.95	1.4580
Total annual income	14117.48	9282.973	4834.504	2.8478***
Off_farm income	0.50	0.52	0.02	0.2626
Group membership	0.83	0.09	0.74	16.5541***
Transport (Tricycle)	0.24	0.07	0.17	3.6423***
Extension visit	1.20	1.11	0.09	0.3434
Credit access	0.60	0.12	0.48	8.8292***
Market information	0.93	0.65	0.28	5.4497***
Distance to road	7.79	11.73	-3.94	-2.2728***
Farm size	5.30	4.71	0.59	0.8894
Region	0.98	0.67	0.31	6.6578***
Farming experience	9.32	9.11	0.21	0.3148
Storage	0.45	0.09	0.36	6.6713***
Radio	0.79	0.58	0.21	3.5827***
Price	1.91	1.30	0.61	6.9409***
Record	0.90	0.70	0.20	3.8767***
Trust level	0.82	0.42	0.4	6.6395***
Tree density	38.24	39.67	-1.43	-0.9836

Notes: we use a conversion factor of 1 Ghanaian cedi = 0.2 US Dollars (calculated based on the May 2019 exchange rate). ** and *** represent statistical significance at 5% and 1% levels, respectively.

agricultural production and marketing information since they used their radio device to listen to agricultural programmes compared with the non-certified farmers. Also, more certified farmers were members of farmer-based organizations compared with non-certified farmers. According to Kleeman et al. [20] certification is organized in groups. Thus, we hypothesize a positive relationship between certification and group membership. The results show that the non-certified farmers were farther away from the tarmacked roads compared with certified farmers. Regarding location, more of the certified farmers were in the Eastern region whereas more of the non-certified farmers were in the Greater Accra Region.

Influence of certification on the choice of different mango marketing channels by smallholder farmers in Ghana

The study used the multivariate probit model to assess the effect of certification on the choice of marketing channels by mango farmers in Southern Ghana. The results are presented in Table 3. Wald chi-square statistics that were used to test for the overall significance of the variables included in the model is statistically significant at the 1% level. This indicates that the subsets of coefficients are jointly significant and the explanatory power of the factors included in the model is satisfactory [4]. Also, we test for multicollinearity between the explanatory variables using the variance inflation factor (VIF). We detect no multicollinearity since none of the VIFs exceeds 5 or 10 (Appendix 1). However, the interpretation results of the multivariate probit model should be taken with caution as we did not account for possible endogeneity that may cause biases in the estimates of the relationship between certification and the choice of different mango marketing channels.

The test of independence between the choice of a marketing channel which is given by the likelihood ratio test ($\rho_{21} = \rho_{31} = \rho_{32}$) is statistically significant at 1% level, indicating the goodness of fit of the model. Hence, there exist differences in market selection behavior among mango farmers, which is given by the likelihood ratio statistics. The results show correlations between dependent variables (marketing channels) which are given by ρ_{ij}. The study found a (statistically) significant negative relationship between the choice of the local traders and the export market which is given by the negative correlation coefficient of ρ_{31} (correlation between the choice for local traders and the export market). This leads to the conclusion that farmers who sell to the export market are less likely to sell to the local traders. Although the statistical significance was weak (10% level), the correlation coefficient of ρ_{32} (correlation between the choice for the export market and industrial processors) was negative. This indicates that farmers who sell to the industrial processors are less likely to supply to the export market. However, the correlation coefficient of ρ_{21} (correlation between the choice for industrial processors and local traders) was positive indicating that farmers who sold to the industrial processors were more likely to sell to the local traders. This shows that the processors market and the local traders serve as complements to the farmers. This is because the farmers sell the mangoes that were rejected by the processors to the local traders since the latter do not have stringent quality requirements.

Access to and participation in high-value markets, especially the export markets, require that farmers meet some certification standards. The results reveal that certified farmers were more likely to supply to the export market and the industrial processors and less likely to sell to the local traders.

Table 3
Multivariate probit estimates of factors influencing the choice of marketing channels.

	Marketing channels		
Factors	Local traders	Industrial processors	Export market
Household characteristics			
Household size	0.010(0.072)	0.017(0.055)	0.117(0.054)**
Schooling years	0.111(0.032)***	-0.086(0.026)***	0.141(0.037)***
Household income	0.543(0.174)***	0.218(0.164)	0.154(0.143)
Production characteristics			
Farming experience	-0.054(0.027)**	-0.049(0.027)*	-0.039(0.028)
Tree density	-0.007(0.012)	-0.016(0.010)	-0.002(0.012)
Institutional and market factors			
Certification	-1.286(0.415)***	1.804(0.312)***	0.742(0.284)***
Trust level	0.770(0.457)*	-0.752(0.286)***	0.531(0.260)**
Price	-0.656(0.212)***	1.394(0.263)***	0.473(0.189)***
Tricycle	1.428(1.250)	0.635(0.411)	-0.108(0.012)
Access to extension	-0.032(0.096)	0.121(0.069)*	-0.387(0.088)***
Radio	0.585(0.418)	0.085(0.282)	0.384(0.283)
Distance to market	0.001(0.012)	0.026(0.007)***	0.008(0.008)
Constant	-2.025(1.359)	-3.801(1.416)***	-4.972(1.261)***
ρ_{21}	0.028(0.156)		
ρ_{31}	-0.474(0.161)***		
ρ_{32}	-0.279(0.168)*		
Number of observations	224		
Wald chi^2 (degree of freedom)	269.72(36)***		
Likelihood ratio test Ho: $\rho_{21} = \rho_{31} = \rho_{32} = 0$; chi$^2(3) = 10.542$***			

Notes: *, ** and *** indicate 10%, 5% and 1% significance levels.
Numbers in parentheses indicate robust standard errors (STATA controls for the model's robustness using the "robust option").

The results show that household characteristics play a role in the choice of high-value marketing channels. Households with a large family size are more likely to choose the export market as their marketing channel.. Another household characteristic that influences the choice of mango marketing channels is the educational attainment of the farmer. Farmers who have acquired more years of formal education were more likely to choose the local traders and export market but were less likely to supply to the industrial processors. However, given that the two high-value markets are substitutes and that the export market offers the highest prices, more educated farmers who have access to the export market are less likely to sell to the industrial processors.

The results of the study show a negative relationship between farming experience and the probability of supplying to the local traders and the industrial processors. This implies that young farmers have a preference for supplying to industrial processors as well as local traders. This could be because young farmers may have a longer planning horizon or are more risk-averse (Senou et al., 2022).

The results of the study show that farmers who had contact with extension officers were more likely to supply to the industrial processors but less likely to sell to the export markets. Farmers who had a high level of trust in the local traders and the export market were more likely to supply to these markets but less likely to supply to the industrial processors. Farmers who owned a tricycle were more likely to sell to the industrial processors. This is because ownership of means of transport reduces variable transaction costs and encourages market participation [19]. The results reveal that farmers who were farther from the mango markets were more likely to supply to the industrial processors. This could be due to a low level of infrastructural development which reduces the ability of the farmers to access rural markets.

The price received by the farmers influenced their marketing selection decisions. Farmers who received higher prices were more likely to supply to the industrial processors and the export market and less likely to sell to the local traders. This finding is intuitive because farmers are profit maximizers, hence, they will choose a market channel that yields them the highest profit.

ESR estimates of quantity sold and household income impacts of certification

ESR estimates of determinants of certification

The full information maximum likelihood estimates of the determinants of certification (selection equations) in the ESR model are presented in Columns (1) and (4) in Table 4. The results from the selection equations show that the drivers of certification include age of farmer, total household income, farm size, availability of off-farm income, group membership, access to credit, location of the farmer and distance to nearest tarmacked road. The results show that older farmers were more likely to adopt certification. The results also show a positive relationship between household income of certification, an indication that farmers with more household income were more likely to adopt certification. The results further show that availability of off-farm income was negatively related to certification. This implies that farmers who had access to other

Table 4
Estimation results of ESR for the adoption of certification, the quantity sold to high-value markets, and household income.

	Level of participation in GVCs			Household income		
Variables	Selection model	Certified	Non-certified	Selection model	Certified	Non-certified
	(1)	(2)	(3)	(4)	(5)	(6)
Age	-0.184** (0.088)	-0.048 (0.030)	0.004 (0.033)	-0.092 (0.076)	0.051* (0.029)	0.078** (0.037)
Agesq	0.002** (0.001)	0.001** (0.0002)	0.0001 (0.0003)	0.001 (0.001)	-0.0005* (0.0003)	-0.001** (0.0004)
Loghhsize	0.040 (0.286)	-0.055 (0.114)	-0.038 (0.122)	-0.155 (0.250)	0.088 (0.113)	-0.025 (0.153)
Schooling years	-0.046 (0.032)	0.039** (0.017)	0.005 (0.015)	0.043 (0.033)	0.016 (0.017)	0.048*** (0.004)
Logincome	0.524*** (0.211)	0.130 (0.103)	0.432*** (0.085)			
Off-farm income (Yes = 1)	-0.839** (0.368)	-0.185 (0.130)	0.509*** (0.169)			
Farming experience (years)	0..040 (0.038)	-0.017 (0.019)	0.022 (0.015)	0.020 (0.032)	0.023 (0.019)	0.020 (0.018)
Logfarmsize	0.427** (0.227)	0.517*** (0.129)	0.262*** (0.092)	0.239 (0.032)	0.537*** (0.119)	0.220** (0.106)
Tricycle (Yes = 1)	0.418 (0.401)	0.161 (0.155)	0.634*** (0.239)	0.530 (0.430)	0.068 (0.156)	0.012 (0.280)
Distance to road	-0.010 (0.013)	0.003 (0.008)	-0.008 (0.005)	-0.031*** (0.011)	-0.010 (0.008)	-0.002 (0.007)
Group membership (Yes = 1)	2.636*** (0.361)	-0.496*** (0.202)	-0.249 (0.259)	2.482*** (0.335)	-0.500** (0.237)	-0.695 (0.386)
Access to extension services (Yes = 1)	0.524 (0.343)	0.224 (0.180)	-0.028 (0.154)	0.072 (0.322)	0.014 (0.185)	0.079 (0.180)
Access to credit	0.874** (0.389)	-0.204 (0.195)	0.350 (0.233)	1.147*** (0.389)	0.046 (0.213)	-0.631 (0.294)
Access to market information (Yes = 1)	0.093 (0.559)	0.493* (0.260)	-0.582*** (0.203)			
Region (Eastern Region = 1)	3.608*** (0.856)			2.066*** (0.699)		
Constant	-4.513* (2.623)	0.804 (1.084)	-3.363*** (0.852)	-0.415 (1.981)	7.251*** (0.863)	6.017*** (0.833)
Model diagnosis						
ρ_0			0.036 (0.309)			-0.899 (0.660)
ρ_1		-1.386** (0.609)			-0.681* (0.394)	
Likelihood ratio test of independent equations χ^2 (1)		4.88* (0.087)			5.38* (0.067)	
Observations		224	224		224	224

Notes: *, ** and *** represent statistical significance at 10%, 5% and 1% levels, respectively.
S.E represents standard errors.
Movestaty, the STATA command for endogenous switching regression model does not allow post-estimation for marginal effects or odds ratio.

Table 5
Impacts of adopting certification on income and the level of participation in high-value markets in terms of quantity sold to high-value markets.

Outcome variable	n	Sub-sample	Decision stage		Treatment effects	
			To certify	Not to certify		
Quantity sold (tonnes)	224	Certified	(a) 1.72 (0.05)	(c) 1.54 (0.07)	ATT	0.12**
		Non-certified	(d) 2.03 (0.06)	(b) 1.20 (0.06)	ATU	0.69***
Income	224	Certified	(a) 9.30(0.04)	(c) 7.76(0.04)	ATT	0.20***
		Non-certified	(d) 9.61(0.05)	(b) 8.71(0.04)	ATU	0.10***

Notes: ** and *** represent statistical significance at 5% and 1% levels, respectively.
n represents the sample size. ATT ((a-c)*100/c) and ATU ((d-b)*100/b) represent the average treatment effect on the treated and average treatment effect on the untreated, respectively. ATT and ATU are the row-wise differences between "to certify" and "not to certify" decisions for respective sub-samples. Numbers in parentheses represent standard errors.

sources of income were less likely to pursue market innovations that would improve their access to remunerative markets. Farm size, group membership and access to credit positively influenced farmers' adoption of certification. This is intuitive since farmers with a larger farm size, are more likely to invest in market innovations that would improve their access to remunerative markets. Also, farmers who were members of mango farmer associations were more likely to certify. This could be because these farmers get access to information and training that could influence their economic upgrading activities. Farmers who had access to credit were more likely to certify since access to credit increases their resource endowments and capacitates farmers to cover certification costs. Farmers who were in the Eastern Region were more likely to certify whereas farmers who were further away from tarmacked roads were less likely to certify. These results are consistent with previous studies on farmers' decision to certify ([20,28].

ESR estimates of determinants of quantity sold to high-value markets and household income

Results of the outcome equations are presented in Columns (2) and (3) and (5) and (6) in Table 4. The estimated coefficients of the independent variables for the certified and non-certified regimes have different signs and magnitudes for some of the variables. This indicates that the switching regression approach is preferred over simple treatment effects model, as it captures heterogeneity between the two certification categories. In this study, the differences are noticeable for farm size and access to market information. Among certified farmers, the results show that those who had access to market information sold more to high-value markets than those who did not have access. On the contrary, non-certified farmers who had access to market information sold less to high-value markets compared with those who had access. The effect of increases in farm size on the level of participation and income differed among certified and non-certified farmers. The increase in the quantity sold and household income was higher for certified farmers than for non-certified farmers.

Certified farmers who had more years of schooling and larger farm sizes sold more to high-value markets. In the case of non-certified farmers, a higher household income, access to off-farm income, larger mango farm sizes and ownership of motorized transport increased their quantity sold to high-value markets. In terms of income, certified farmers who were older and had larger farm sizes had a higher income; whereas for non-certified farmers, income increased with increases in years of schooling and mango farm size.

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Table 4 presents the results of the main impact assessment and indicates the expected quantity sold under actual and counterfactual scenarios. From the table, the main diagonal elements ((a) and (b)) and the off-diagonal elements ((c) and (d)) in the decision stage columns represent actual and counterfactual outcomes, respectively. The row-wise differences between actual and counterfactual outcomes give the true causal impacts. The average treatment effect on the treated (ATT) is the difference between how much certified farmers sold (a) and how much non-certified farmers would have sold had they adopted certification (c). On the other hand, the average treatment effect on the untreated (ATU) is given by the difference between how much certified farmers would have sold had they not adopted certification (d) and how much non-certified farmers sold without adopting certification (b). Table 5 shows the results of the ATT and ATU in the treatment effects column.

Overall, after controlling for confounding variables and counterfactual outcomes, the results show that certification influences household income and the level of participation in high-value markets. The results reflect that certification increased the quantity sold to high-value markets by 12% for mango farmers who were certified. Similarly, non-certified farmers would have increased their quantity sold to high-value markets by 69% if they had been certified. This indicates the importance of certification to the mango trade, especially for non-certified mango farmers.

On income, the results show that certification increased the income of certified farmers by 20%. Similarly, the income of non-certified farmers would have increased by 10% if they had been certified.

Discussion

The study analyzed the role of certification in farmers' choice of different marketing channels. It was revealed that certification reduces farmers' propensity to sell to low-value mango markets including the local traders and increases farmers propensity to sell to high-value markets including the industrial processors and the export markets. This finding is consistent with the findings of Ngenoh et al. [26] and Akrong et al. [1] who concluded that certification is a tool for economic upgrading which enhances farmers' participation in high-value market chains in Kenya and Ghana, respectively. Certified farmers can meet the quality requirements of high-value markets since they enforce good agricultural practices [1]. The results revealed that older farmers are more likely to participate in certification schemes. According to Martey et al. [8] older farmers ae more experienced and understand market dynamics. These attributes can capacitate them to adopt certification schemes. Farmers with a higher household income were more likely to certify. High income farmers are more likely to be able to afford costs of approved inputs as well as certification costs which can increase their propensity to be certified [1]. Regarding off-farm income, the study found that farmers who had access to off-farm income were less likely to participate in certification schemes. According to Quartey et al. [28], the type of off-farm activities in which farmers engage could have lower returns which might not be enough to supplement farm income in order to enhance farmers' ability to cover certification costs. Kleeman et al. [20] highlights that certification requires farmers to have a larger farm size and high incomes, consequently, farmers with large farm size or wealthy farmers are more likely to adopt certification. Since certification is mostly organized in groups [3], farmers who are members of farmer-based organizations are more likely to adopt certification [20]. Also, the high rate of information-sharing between farmers in groups enhances access to information and problem-solving in the context of group certification and group marketing [21]. Access to credit facilities increases resource endowment of farmers and capacitate farmers to adopt certification.

Both certified farmers and non-certified farmers sold to high-value market chains. The results show that certified farmers who were older, more educated and had larger farm sizes were more likely to sell more to high-value markets. On the other hand, non-certified farmers who were wealthier (high incomes, larger farms and access to off-farm income) sold more to high-value markets. Further, non-certified farmers who had motorized transports were more likely to sell to high-value markets. According to Akrong et al. [1], motorized transports enhances farmers access to bulking points and factory location of industrial processors.

Age and farm size increased household incomes of both certified and non-certified farmers. This could be because older farmers have the capacity to engage in activities that can generate larger incomes. Farmers larger farm sizes have the capacity to increase production and output which can translate to high incomes. Kleeman et al. [20] found that large farm size reduced incomes of organic certified farmers. However, this study considered conventional farmers who can easily manage large farm sizes compared with organic farmers who require additional skills to manage their farms.

The study found positive impacts of certification on quantity sold to high-value markets and income of smallholder mango farmers. Categorically, certified farmers would sell 12% more to high-value markets. Also, certification increases income of certified farmers by 20%. These results are consistent with the findings of Kleeman et al. [20] who found that certification increases return on investment for farmers. The impact of certification on incomes and access to market implies the ability of certification programmes to achieve the sustainable development goals (SDG) numbers 1 of No Poverty and 2 of Zero Hunger.

Conclusion and policy recommendations

This study assessed the impacts of adopting GlobalGAP certification on farmers' household income and the quantity of mangoes sold by smallholder mango farmers in high-value mango markets in Southern Ghana.

The study concludes that certification increases the likelihood of selling to high-value markets (industrial processors and the export market). We further, conclude that certification increases quantity sold to high-value markets as well as household incomes of farmers.

Given that certification increases the likelihood of participation in high-value markets, quantity sold to these markets and household income of farmers, it is recommended that government and development partners alike enhance the factors that promote certification in order to enhance certification. An enhanced participation can be achieved through an intensified focus on the enablers of certification including membership to farmer-based organization, access to credit and large farm size. Farmers who belong to farmer groups benefit from capacity development programmes which increases their likelihood of participation in certification schemes. Accordingly, governments and development partners should intensify capacity development programmes among farmers to intensify their adoption of certification. Further, since access to credit enhances the adoption of certification, governments and development partners should increase their budget allocation to agriculture which will enhance farmers' access to credit. This will accelerate their access to approved inputs and also enable them to cover certification costs. Finally, governments and development partners can regulate the land tenure system in rural areas of developing countries to promote access to land by farmers. This can ensure that farmers would increase the farm sizes and be eligible for certification.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Rexford Akrong: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Writing – original draft, Writing – review & editing. **Angela Dziedzom Akorsu:** Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing – review & editing. **Praveen Jha:** Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing – review & editing. **Joseph Boateng Agyenim:** Conceptualization, Investigation, Methodology, Supervision, Validation, Writing – review & editing.

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Appendix

Appendix 1 and Appendix 2

Appendix 1
Test of multicollinearity.

Variable	VIF	1/VIF
Certification	1.52	0.66
Distance to market	1.44	0.69
Access to extension	1.43	0.70
Price	1.4	0.71
Trust	1.39	0.72
Farming experience	1.36	0.74
Household income	1.32	0.76
Schooling years	1.2	0.83
Radio	1.12	0.89
Tricycle	1.1	0.91
Tree density	1.09	0.92
Mean VIF	1.31	

Appendix 2
Test of endogeneity.

Test of endogeneity	
Robust regression F(1, 201)	37.58
Prob > F	0.000***

Note: *** represent statistical significance at 1% level.

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