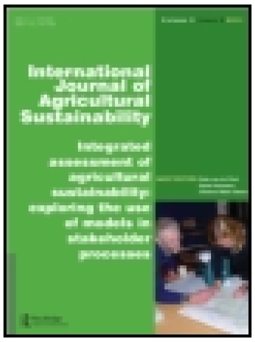

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International Journal of Agricultural Sustainability

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/tags20

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INTERNATIONAL JOURNAL OF AGRICULTURAL SUSTAINABILITY
https://doi.org/10.1080/14735903.2020.1807893

Do voluntary certification standards improve yields and wellbeing? Evidence from oil palm and cocoa smallholders in Ghana

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ABSTRACT

Cocoa and oil palm production are major agricultural activities in Ghana, contributing substantially to the national economy and rural livelihoods. Even though smallholders produce practically all cocoa and a large fraction of oil palm in Ghana, their production is currently characterized by low yields and negative environmental and socioeconomic outcomes. Different certification standards have been promoted to enhance oil palm and cocoa sustainability in Ghana. This paper assesses the impact of certification standards on farm yields and the wellbeing of oil palm and cocoa smallholders. We focus on two sites of Ghana using a combination of monetary and non-monetary wellbeing indicators and Propensity Score Matching (PSM). Through certification, oil palm and cocoa smallholders adopt sustainable production practices (albeit to different extents), with certification having a mostly significant positive effect on farm yields, income and multidimensional poverty for both types of crop smallholders. However, certified cocoa smallholders have a relatively lower income diversification, which increases their vulnerability to price and yield fluctuations. It is important to build farmer capacity with income diversification strategies, possibly through the certification training received and the re-investment of the economic gains obtained through premiums and yield gains.

KEYWORDS

Income; household consumption; yield; multidimensional poverty; voluntary standards; Sub-Saharan Africa

1. Introduction

Cocoa (*Theobroma cacao* L.) and oil palm (*Elaeis guineensis,* Jacq.) are the main commodity crops produced in Ghana. They directly contribute to the livelihoods of about 700,000 and 600,000 cocoa and oil palm households respectively (Anaglo et al., 2014; Danso-Abbeam et al., 2014; MASDAR, 2011; Peprah, 2015). Their production also contributes substantially to the national economy through the generation of foreign exchange revenue (ISSER, 2012; MASDAR, 2011). Currently, smallholders undertake the bulk of cocoa production, while most oil palm is produced in hybrid systems consisting of large core plantations, surrounded by smallholders contractually linked to the plantations (outgrowers) and independent smallholders (Adjei-Nsiah et al., 2012; Aidoo & Fromm, 2015; Anaglo et al., 2014).

Both cocoa and oil palm production have been consistently increasing during the past decades through coordinated policy support, and mainly through the expansion of crop area rather than yield improvements (FAOSTAT, 2020). However, cocoa and oil palm productivity in Ghana are below the global average levels (Danso-Abbeam et al., 2012; FAOSTAT, 2020; Fold & Whitefield, 2012; MASDAR, 2011; Rhebergen et al., 2018). This is despite the strong policy support for both crops in Ghana, and is partly due to the (a) low adoption of agricultural innovations, (b) low access to extension services and credit and (c) high prevalence of old cocoa and oil palm trees (Gockowski et al., 2013; Ofosu-Budu & Sarpong, 2013).

Cocoa and oil palm expansion have had major environmental implications in Ghana in terms of land use change, deforestation and environmental

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Supplemental data for this article can be accessed at https://doi.org/10.1080/14735903.2020.1807893 pollution from excessive agrochemical use (Danyo, 2013; Mason & Asare, 2014: Ntiamoah & Afrane, 2008; Ntiamoah & Afrane, 2008; Ofori-Bah & Asafu-Adjaye, 2011; Wessel & Quist-Wessel, 2015). Poverty is still endemic within most cocoa and oil palm production areas (Asamoah et al., 2013; Gockowski et al., 2013). Studies have linked oil palm and cocoa production to low-income generation and food insecurity (Anderman et al., 2014; Asamoah et al., 2013; Kline et al., 2017), inequitable compensation (Fountain & Hütz-Adams, 2015), and poor labour practices, including child labour (Ingram et al., 2018; Myzabella et al., 2019).

It has been argued that the adoption of certification standards can mitigate the low yields, high poverty and the negative environmental and social outcomes of the current cocoa and oil palm production practices in Ghana (Fenger et al., 2017; MASDAR, 2011; Oosterveer et al., 2014; Waarts et al., 2015). Certification standards have proliferated rapidly across the world due to the considerable international interest in the sustainable production of food and non-food crop commodities, and the shifts from a 'system of state-centered governance toward a system in which governance has multiple (often private) sources' (UNCTAD, 2018, p. 1).

Certification standards are basically a structured compendium of environmentally and socially responsible production practices seeking to enhance the sustainability of commodity crop production (Dankers & Liu, 2003; Kleemann et al., 2014; Tran et al., 2013). In the context of cocoa and oil palm production some of the most common environmentally responsible practices include the use of recommended pesticides, and the avoidance bush burning and production in natural areas (RSPO, 2014; SAN, 2017; UTZ, 2015) (see Table S19 in the Supplementary Material for some of the main environmentally responsible practices integrated in certification standards). Socially responsible practices include fair compensation, use of personal protective equipment (PPE) and banning of child labour (Djokoto et al., 2016; RSPO, 2014; SAN, 2017; UTZ, 2015). Currently, many different certification standards operate in the Ghanaian cocoa and oil palm sectors, including the standards of the UTZ/Rainforest Alliance, Roundtable on Sustainable Palm Oil (RSPO) and Fairtrade (Ansah et al., 2020; Djokoto et al., 2016; Oya et al., 2018).

Considering the growing interest in the sustainable sourcing of commercial crops such as cocoa and oil palm, there are increasingly important intersections between smallholder-based certification, with food, agricultural and industrial policies in both producing and consuming countries (e.g. Oosterveer et al., 2014; UNCTAD, 2018). At the same time, there is growing interest in whether certification standards deliver the expected environmental and socioeconomic outcomes, especially in smallholder settings, considering that their adoption requires significant investment that may further drain farmer resources (Barham & Weber, 2012; Beuchelt & Zeller, 2011; Fenger et al., 2017; Jena & Grote, 2017; Kleemann & Abdulai, 2013; Krumbiegel et al., 2018; Ruben & Fort, 2012).

So far, some studies have pointed to the mixed environmental and socioeconomic outcomes of cocoa and oil palm certification in Ghana (Fenger et al., 2017; Gockowski et al., 2013; Waarts et al., 2015), with some of the underlying reasons being the inappropriate implementation of certification standards due to the high investment costs (Fenger et al., 2017; KPMG, 2012), the abandonment of good production practices soon after adoption (Ansah et al., 2020) and the delayed manifestation of impacts (Waarts et al., 2015). The inappropriate implementation of certification standards may also compromise yield gains and premium payments, further affecting income generation from oil palm and cocoa production (Ansah et al., 2020; Djokoto et al., 2016). However, the literature is inconclusive, with some studies finding that certification has positive income outcomes (Chiputwa et al., 2015; Tran & Goto, 2019), and other studies finding little-to-no impact (Mitiku et al., 2017). However, studies seeking to unravel the local sustainability outcomes of certification adoption are not always methodologically robust, often failing to control for the inherent selection biases that may jeopardize the generalization of results (Fenger et al., 2017; Kleemann & Abdulai, 2013; Krumbiegel et al., 2018). For example, some studies have relied on simple descriptive statistics to provide cursory insights into certification impacts, thereby being prone to selection biases (Fenger et al., 2017). In terms of variable selection, most impact studies have been limited to monetary measures of economic wellbeing, without considering non-monetary measures such as multidimensional poverty (Chiputwa et al., 2015; Mitiku et al., 2017). Furthermore, most studies have focused on cocoa (Fenger et al., 2017; Gockowski et al., 2013), with an evident lack of oil palm or multi-crop studies.

The aim of this paper is to bridge these gaps by assessing the impact of oil palm and cocoa smallholder certification in Ghana on yield, good production practices and human wellbeing. For human wellbeing we synthesize results from both monetary (i.e. income, consumption) and non-monetary measures (i.e. multidimensional poverty) to offer a comprehensive picture of certification impacts. Section 2 outlines the study sites, and data collection and analysis methods. Section 3 presents the main results regarding certification impacts and Section 4 an in-depth discussion and synthesis of the results, and key policy and practice recommendations to improve the adoption and performance of smallholder certification in Ghana and other developing contexts.

2. Methodology

2.1 Study sites

To assess the impacts of cocoa and oil palm certification on crop production yields and wellbeing of cocoa and oil palm smallholders, we focus on two different study sites (Figure 1). The cocoa site is located in the semi-deciduous forests of Assin North Municipal. The oil palm study sites were selected from the tropical rainforest zone of the Mpohor district. Table 1 contains the main characteristics of the two study sites.

In the cocoa study site, we selected in areas where UTZ and Rainforest Alliance certified farmers operate under the initiative Mars Partnership for African Cocoa Communities of Tomorrow (iMPACT). One of the major selection considerations was that Rainforest Alliance and UTZ certification are the most popular certification schemes in Ghana, with farmers certified since 2009 thus offering a high possibility of observing the impacts of certification. The Assin North Municipal is located in the semi-deciduous forest, which is conducive for the cultivation of both cocoa and oil palm (GSS, 2014a). Approximately, 75% of the population is involved in agricultural activities, with a substantial output of certified and non-certified cocoa coming from the area. The incidence of poverty is standing at 24%, which is relatively low compared to Ghanaian standards (GSS, 2015).

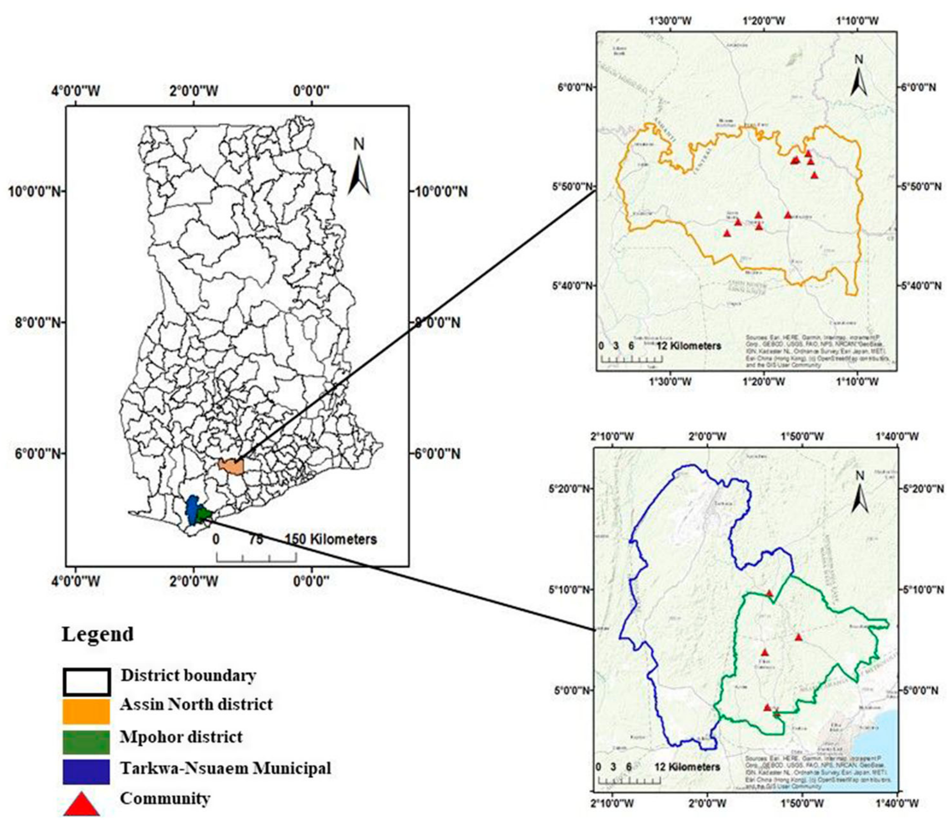

Figure 1. Location of study sites.

Table 1. Key characteristics of the study area.

	Oil palm	Cocoa
District	Mpohor	Assin north Municipal
Population	42,923	161,341
Rural population (%)	74.8	64.2
Vegetation	Tropical rainforest	Semi-deciduous forest
Certification start	2014	2009
Certification adopters	Scheme smallholders	Independent smallholders
Annual rainfall (mm)	1300–2000	1500–2000
Poverty incidence (%)	40.4	24.4

In the oil palm site, we selected certified scheme smallholders under the Benso Oil Palm Plantation (BOPP), a large oil palm plantation, which has been RSPO-certified since 2014. We selected this plantation, as it is one of the earliest certified plantations in the country. As oil palm certification is fairly new in Ghana, many large plantations and independent farmers have not adopted. BOPP is located in Mpohor district in the tropical rainforest belt, which supports oil palm production (GSS, 2014b). Oil palm production is the major farming activity in the district, which also contains other large oil palm mills like Norpalm Ghana Limited. Apart from these large plantations and their surrounding scheme smallholders, this region also contains many independent small- and medium-sized producers considering the large local demand for Fresh Fruit Bunches (FFB). However, the poverty head count is about 40%, which is relatively high compared to Ghanaian standards (GSS, 2015).

2.2. Data collection

In each area we conducted household surveys with three distinct groups: (a) certified cocoa/oil palm smallholders (treatment group), (b) uncertified cocoa/oil palm smallholders (control group 1) and (c) food crop farmers (control group 2). In total, we conducted approximately 100 surveys with each group, for a total of 608 surveys across the two sites (Table 2).

Household surveys were conducted between August-September, 2018 (cocoa site) and August-September, 2019 (oil palm site). The semi-structured questionnaires included both open- and close-ended questions to elicit the different indicators outlined in this study. The main set of questions included: (a) demographic and socioeconomic household characteristics, (b) agricultural practices, (c) income and expenses, (d) poverty indicators and (e) perceptions of the environmental impact of certification (only for certified farmers). The questionnaire was developed based on preliminary site visits and interviews with experts and farmers. Prior to the final survey, the questionnaires were piloted in Akonfudi (Assin North Municipal) and Ayiem (Mpohor district), and subsequently adjusted to adequately capture the required data. Local enumerators conducted face-to-face interviews using tablets. For the design of the overall protocol and the quality assurance mechanisms we followed the approach suggested for studies in industrial crop settings in Sub-Saharan Africa (Gasparatos et al., 2018).

Due to variability in information availability and production modalities in each site (which largely reflect the differences in cocoa and oil palm value chains), we followed different sampling approaches for the different study groups (Table 1). A major sampling consideration was the possible spillover of knowledge on recommended production technologies gained through certification, to uncertified farmers within the same community or surrounding communities. Possible spillover effects complicate the estimation of the actual impact of certification, and should be eliminated as much as possible (Fenger et al., 2017; Waarts et al., 2015).

To reduce the possibility of such spillover effects we selected uncertified cocoa/oil palm farmers (control 1) and food crop farmers (control 2) from communities that do not contain certified cocoa and oil palm farmers. For the cocoa study site, we set a minimum distance of 13 km between certified and uncertified cocoa communities in line with other studies that allowed a reasonable distance between communities (e.g. 7 km in Fenger et al., 2017). For the oil palm study site, a minimum distance of about 21 km was allowed between certified and uncertified farmers.

Respondents in the cocoa study site were classified into cocoa farmers certified by UTZ/Rainforest Alliance (treatment), uncertified cocoa farmers (control) and food crop farmers (control). The list of all certified cocoa farmer communities and farmers under the iMPACT project was obtained from Agro Eco- Louis Bolk Institute (AELBI). Five (5) communities were randomly selected using the random number generator in Stata 15, and subsequently 100 certified cocoa farmers were selected randomly from the actual certified farmer list, weighing for the number of

Table 2. Sampling groups and selection.

Study site	Group	Code	Community	Sample	Total sample	Sampling strategy
Assin North (Cocoa)	Certified	Cert_coc	Wawase	19	100	Random selection of five communities containing certified farmers. Random selection of certified farmers from farmer list, weighing for the number of certified farmers in each community to avoid oversampling. List was obtained from Agro Eco-Louis Bolk Institute.
			Sabena	25		
			Gold coast camp	20		
			Ghana camp	16		
			Kadadwen	20		
	Uncertified	Uncert_coc	Amoakrom	20	100	Random selection of five communities containing uncertified farmers. Random selection of uncertified farmers from farmer list, weighing for the number of uncertified farmers in each community to avoid oversampling. List was obtained from the Cocoa Health and Extension Division.
			Akodayemobor	17		
			Sekanbodua	19		
			Basofi Ningo	23		
			Aponsie	21		
	Food crop farmers	Food_crA	Amoakrom	20	100	Farmers were selected from the same communities as uncertified cocoa farmers. Due to lack of reliable data/ farmer list on food crop farmers, farmer selection was done through transect walks (see main text for more details),
			Akodayemobor	17		
			Sekanbodua	19		
			Basofi Ningo	23		
			Aponsie	21		
Mpohor (Oil palm)	Certified	Cert_op	Adum Banso	55	100	Random selection of certified farmers from farmer list. Farmer list was obtained from BOPP
			Benso	45		
	Uncertified	Uncert_op	Mpohor	35	100	Three communities were randomly selected from a list of uncertified farmer communities selling FFB to BOPP. Due to lack of reliable data/farmer list on uncertified oil palm farmers, farmer selection was done through transect walks (see main text for more details).
			Wassa Manso	30		
			Anwonakrom	35		
	Food crop farmers	Food_crM	Mpohor	38	108	Sampling was done in the same communities as for the uncertified oil palm farmers. Due to lack of reliable data/ farmer list on uncertified oil palm farmers, farmer selection was done through transect walks (see main text for more details).
			Wassa Manso	34		
			Anwonakrom	36		

certified farmers in each community to avoid oversampling (Table 2). For uncertified cocoa farmers, data on farmers and communities was obtained from the Cocoa Health and Extension Division of the Ghana Cocoa Board (Cocobod). In a similar manner we used the random number generator to select five communities within the same ecological zone (Section 2.1) and 100 uncertified cocoa farmers, weighing for the number of uncertified farmers in each community to avoid oversampling. However, food crop only farmers were selected using a different sampling approach due to the lack of reliable public data on food crop farmers and the difficulty in finding food crop farmers. In particular, we used transect approach using a prominent landmark within each community such as the chief's palace as the starting points. Enumerators started four transects from each landmark, and visited every second house to identify farmers that produced only food crops.

Respondents in the oil palm study site were selected trough a similar sampling approach. Certified scheme smallholders under the BOPP were randomly selected using the random number generator in Stata 15. The respondents were located in the two main communities (Adum Banso and Benso) that contain BOPP scheme smallholders (Table 2). It should be noted that BOPP scheme smallholders are contractually obliged to sell FFB only to the BOPP mill. To ensure comparability across certification impact and not across marketing dynamics we selected uncertified oil palm farmers that sold FFB to BOPP. First, we identified a list of uncertified farmer communities that sell FFB to BOPP. We then selected randomly three uncertified communities that sell to BOPP through the random number generator in Stata 15. These communities were further divided into two using the major roads and landmarks identified as starting points of the survey. We followed the transect-based systematic random sampling approach outlined above to identify uncertified oil palm farmers and food crop farmers (Table 2).

2.3. Data analysis

2.3.1. Yields and wellbeing variables

In estimating yields, data on farm output and size were collected for 2017–2018 and the 2018–2019 cropping season for cocoa and oil palm farmers respectively.

Food crop yields were not estimated, as food crop farmers normally engage in mixed cropping which complicates the allocation of cropping areas across the different crops. Yields are estimated by dividing output by farm size, and are presented using *t*-test to ascertain the statistical significance in the difference of mean yields (Abdul-Rahaman & Abdulai, 2018; Danso-Abbeam & Baiyegunhi, 2018).

Income is estimated by combining the different income streams of oil palm, cocoa farmers and food crop farmers. These income streams include income related to cocoa and oil palm production, own businesses, livestock sales, pensions, salaries and remittances (Ahmed et al., 2019). Comparisons between groups are made using the Ghana Statistical Studies cut-offs of poverty (poverty line of USD 1.90 per day per person). We conduct *t*-test to establish statistically significant difference in mean income among certified and uncertified farmers (Chiputwa et al., 2015).

Consumption is estimated by combining different expenditure items within the respective cropping seasons including expenditures related to farming, food, education, housing, clothing, communication, social activities, housing and support to relatives. Total household expenditure is estimated on a per adult equivalent basis following the Ghana Statistical Service estimates, which signifies consumption poverty as annual expenditure below GHC 1,314 per household member (Ahmed et al., 2019; GSS, 2015).

We used the Multidimensional Poverty Index (MPI) as a non-monetary measure of human wellbeing to complement income and consumption results (Alkire & Foster, 2011a, 2011b; Mudombi et al., 2018). This offers an additional layer about the human wellbeing outcomes of certification considering that the monetary measures of poverty often obscure some of the underlying characteristics of poverty (Bennett & Mitra, 2013; OPHI, 2015). The MPI estimates the number of people in each study group suffering deprivations across three dimensions, namely education, health and living standards, based on an established threshold (Table 3) (Alkire & Santos, 2011; Tran et al., 2015). These three dimensions are further divided into 10 indicators. Similar to other studies we replaced the conventional measure of nutrition (Body Mass Index), with a measure of household diet diversity (Food Consumption Score) (Table 3) (Ahmed et al., 2019; Mudombi et al., 2018).

Initially, deprivation scores are estimated for each indicator, which is summed to obtain the household deprivation score. Household deprivation is judged based on a cut-off of 33.3% of the weighted indicators. Households with deprivation scores of 0.33 (or above), are considered to be multi-dimensionally poor. The headcount ratio (H) denotes the proportion of the multi-dimensionally poor in the population;

Table 3. MPI dimensions, indicators, weights and cut-offs.

Dimension	Indicator	Cut-off deprivation	Weight
Education	Years of schooling	If no household members has completed 7 years of schooling	1/6
	Child school attendance	If any school-aged child is not attending school up to class 8 (Primary 6)	1/6
Health	Nutrition	Deprived if the FCS is below acceptable threshold (63 or below)	1/6
	Child mortality	Any under-5year old child died in the household during past 12 months preceding census	1/6
Living Standards	Electricity	Deprived if the household has no electricity.	1/18
	Drinking water	If the household does not have access to clean drinking water in more than 30 minutes round trip walk from homestead.	1/18
	Sanitation	Deprived if the household does not own a toilet facility or if their toilet is shared.	1/18
	Flooring	Deprived if a household has sand, dirt and or dung floor.	1/18
	Cooking fuel	If the household cooks with firewood, dung and charcoal.	1/18
	Assets ownership	If the household does not own more than one radio, TV, telephone, bike, motorbike or refrigerator, car or truck or tractor.	1/18

Source: (Alkire & Santos, 2014)

$$H = \frac{q}{n} \tag{1}$$

where q is the number of multidimensional poor people and n is the population.

$$A = \frac{\Sigma_j^q C_i}{q} \tag{2}$$

where c_i is the deprivation score the ith individual experiences. The deprivation score, ci of the ith poor person is estimated as the sum of deprivations in each dimension j ($j = 1, 2, 3$). The Multidimensional

Poverty is calculated by multiplying the incidence of poverty and the intensity of poverty.

$$MPI = H*A \quad (3)$$

The multidimensional poverty results obtained for each group in each site are presented in bar charts and compared with both regional and national MPI estimates (Ahmed et al., 2019; Mudombi et al., 2018).

Finally, the perceptions about the environmental impact of certification are captured through Likert-scale questions. In particular, for a given environmental impact or related production practice, certified farmers rate the observed/experienced change since certification adoption (1 = Decreased substantially to 5 = Increased substantially). These questions were only posed to certified cocoa and oil palm farmers as they have experienced/observed these changes. We opted for qualitative questions as the long-term recollection (5–10 years in this case, Table 1) can increase the uncertainty of responses. For each impact/practice the results are expressed as the mean score across certified farmers.

2.3.2. Propensity score matching

Establishing the impact of treatments such as certification differences between treatment and control groups using *t*-test and charts, is inadequate in establishing causality of certification adoption. This is because of major problems related to selection bias, endogeneity and systematic errors from researcher judgments (Caliendo & Kopeinig, 2008; Dehejia & Wahba, 2002; Mitiku et al., 2017).

In establishing causality amidst these estimation problems, the Propensity Score Matching (PSM) is adopted in this study to compare yield and economic outcomes of certified farmers and uncertified farmers (Abate et al., 2016; Chiputwa et al., 2015; Kemeze et al., 2018; Mitiku et al., 2017). The fundamental idea behind PSM is to compare non-participants with participants under similar pre-treatment observable characteristics, *x*. Differences in the outcomes are taken and attributed to involvement in a programme or treatment (Caliendo & Kopeinig, 2008; Hirano & Imbens, 2001; Rosenbaum & Rubin, 1985). PSM estimation involves two stages. The first stage involves a probit or logistic regression (binary or multinomial depending on the treatment investigated) which results in the estimation of propensity scores (Abate et al., 2016). Matching is done using the propensity scores obtained in the first stage of the estimation to measure the impact being investigated (Caliendo & Kopeinig, 2008; Dehejia & Wahba, 2002).

In estimating the treatment effects, two parameters; Average Treatment Effect (ATE) and the Average Treatment Effect on the Treated (ATT) are normally estimated (Hirano & Imbens, 2001; Hoque et al., 2015). The ATE refers to the impact of the programme/treatment on all the observation (Treatment and control) whiles ATT refers to the impact of the programme on only the treated group (Stuart, 2010). The ATE is connoted as the difference between expected outcome after participation and non-participation within a population. It is expressed as

$$\tau ATE = E(\tau) = E[Y(1) - Y(0)] \quad (4)$$

This equation in (4) can however not be estimated because $Y(1)$ and $Y(0)$ cannot be observed at the same time. Only one of them can be observed. The observed is expressed as

$$Y_i = Y_i(K_i = 1) + (1 - K_i)Y_i(0) \quad (5)$$

where $K = 1$ represents when the ith household adopts certification and $K = 0$ represents when the ith household has not adopted certification. It is re-specified as;

$$ATE = P[E(Y_i\ (1) /\ K_i = 1) + E(Y_i(0)\ /\ K_i = 1)]$$

$$+(1 - P)[E(Y_i(0)\ /\ K_i = 0) - E(Y_i(0)\ /\ K_i = 0)] \quad (6)$$

where P is the probability to adopt certification. This equation is estimated based on the assumption that the unobserved counterfactual of adopters if they had not adopted can be estimated from that of non-adopters.

ATE is an important estimate however, it may not be relevant in policy decisions. This is because it lumps all individuals in the population including those stakeholders for whom the programme is not targeted. Because of this challenge, the ATT is normally preferred by researchers (Apiors & Suzuki, 2018; Kemeze et al., 2018) for better targeting of policy recommendations. It is estimated as;

$$ATT = E\{Y_i(1) - Y_i(0)/k = 1)\}$$
$$= E[E\{Y_i(1) - Y_i(0)/k = 1), p(X)\}]$$
$$= E[E\{Y_i(1) - Y_i(0)/k = 1), p(X)\} - E\{Y_i(0)/$$
$$= K = 0,\ p(X)\}/K = 1] \quad (7)$$

where X is a set of matching variables (see Supplementary material, Table S1).

In estimating Treatment Effects, matching is done using one of several algorithms such as Nearness

Neighbor, Radius Caliper and Kernel matching. The difference lies with how the neighbours of the treated individual are defined and how a researcher handles the common support assumption (Caliendo & Kopeinig, 2008).

We conducted three levels of comparison for each impact category (Section 2.3.1), namely 'certified vs. uncertified', 'certified vs. food crops' and 'uncertified vs. food crops'. The first comparison essentially elicits the impacts of certification adoption, and the latter two the impact of cash crop adoption using improved (i.e. certified) and standard (i.e. non-certified) production practices, respectively.

3. Results

3.1. Household and farm characteristics

The main household and farm characteristics are shown for the different groups in the cocoa (Table 4) and oil palm (Table 5) study sites. Table 4 shows the significant differences in the age and education of the household heads among certified and uncertified cocoa farmers, as well as between certified cocoa farmers and food crop farmers. In terms of gender, comparatively more female-headed households participate in food crop farming (control 2) followed by certified and uncertified cocoa farmers with the differences, however, not being statistically significant. Furthermore, even though certified cocoa farmers tend to have higher levels of engagement in formal employment, these differences are not significant. Certified cocoa farmers have the highest frequency of extension visit compared to other groups, but this is not statistically significant (Table 4). Certified cocoa farmers have a significantly higher access to credit and farm sizes compared to other groups. Even though cocoa producers dedicate most of their plots to cocoa production, they tend to set aside some parts for food crop production. Certified farmers tend to cultivate improved varieties compared to other groups.

Table 5 suggests that significantly more males are involved in oil palm production. Certified oil palm farmers have the highest level of education (7 years) and are engaged in formal employment activities compared to the other groups (Table 5). Certified oil palm farmers have the highest frequency of extension visit and access to credit. All certified oil palm farmers cultivate the improved *Tenera* variety, while uncertified farmers grow a mix of *Tenera* and dura varieties. However, certified growers have significantly older trees on average, which may affect yields (Section 3.2). Certified oil palm farmers have significantly higher farm sizes compared to the rest of the groups, but relatively smaller portions of these plots are used for food crop farming.

3.2. Yields and good production practices

Table 6 contains the yields of certified and uncertified farmers. The average total output (770 kg) and yield (276 kg/ha) of certified cocoa farmers are significantly higher to those of uncertified cocoa farmers. Similarly, the average total farm output (16.90 ton) and average yields (4.18 tons/ha) are higher for certified oil palm grower, but only the former has statistically significant difference with uncertified farmers. Table 7 contains the self-reported adoption of good production practices linked to certification standards, with the results suggesting differences between the two systems.

Since adopting certification, cocoa farmers increased agrochemical use, even though this includes those prescribed by certification standards such as recommended pesticides and organic fertilizers (e.g. 59% of certified farmers used organic fertilizer compared to 47% of uncertified farmers). These patterns possibly reflect the fact that many cocoa farmers tend to adopt certification as a means of obtaining better access to credit that can assist access to agricultural resources. However, certified farmers seem to have adopted and maintained good production practices related to land use change.

On the other hand, oil palm farmers report a large decrease in fertilizer and agrochemical use since the adoption of certification, which might point to the strong compliance efforts made by BOPP to certify its overall operation, with which the certified smallholders are contractually linked (and receive their agricultural inputs). At the same time, slightly more certified farmers report using organic fertilizer (21%) compared to uncertified farmers (15%). However, there seems to be little change in land use change-related impacts, possibly suggesting the long-term existence of the plantation (since the mid-1970s).

3.3. Income, consumption and multidimensional poverty

Certified cocoa farmers have significantly higher total household income and total household income per

Table 4. Household characteristics for study groups in the cocoa site.

Group	Age (Years)	Gender	Education (Years)	Formal employment	Household size (persons)	Household size (Adult equivalent)	Area of birth	Extension visits (number)	Credit access	Variety grown	Tree age (years)	Total farm size (ha)	Area under cocoa (ha)	Area under food crop (ha)	Farm distance (km)
Cert_coc	51.11	0.66	4.58	0.44	4.03	2.84	0.46	2.49	0.13	0.36	17.44	3.24	3.03	0.21	2.61
	(1.318)	(0.048)	(0.437)	(0.049)	(0.175)	(0.105)	(0.0501)	(0.341)	(0.034)	(0 .048)	(0.852)	(0.221)	(0.212)	(0.038)	(0.262)
Uncert_coc	45.63	0.72	5.82	0.34	4.36	2.87	0.58	2.21	0.05	0.33	16.77	3.09	2.64	.45	4.11
	(1.402)	(0.045)	(0.478)	(0.048)	(0.225)	(0.132)	(0.0496)	(0.331)	(0.022)	(0.047)	(1.065)	(0.201)	(0.186)	(0.083)	(2.144)
Pooled	48.37	0.69	5.2	0.39	4.19	2.86	0.52	2.35	0.09	0.35	17.11	3.17	2.84	0.33	3.36
	(.979)	(0.033)	(0.326)	(.035)	(0.143)	(0.084)	(0.0354)	(0.237)	(0.0203)	(0.034)	(0.681)	(0.149)	(0.141)	(0.046)	(1.079)
difference	−5.48***	0.06	1.24*	−0.1	0.33	0.031	0.12*	−0.28	−0.08**	−0.03	−0.67	−0.15	−0.39	0.24***	1.50
	(1.924)	(0.066)	(0.648)	(0.069)	(0.285)	(0.169)	(0.0705)	(0.475)	(0.040)	(0.068)	(1.364)	(0.299)	(0.282)	(0.091)	(2.160)
Cert_coc	51.11	0.66	4.58	0.44	4.03	2.84	0.46	2.49	0.13	–	–	3.24	–	0.21	2.61
	(1.318)	(0.048)	(0.437)	(0.049)	(0.175)	(0.105)	(0.0501)	(0.341)	(0.034)			(0.221)		(0.038)	(0.262)
Food_crA	45.99	0.61	6.28	0.36	3.69	2.58	0.68	2.09	0.05	–	–	1.56	–	1.56	2.076
	(1.742)	(0.049)	(0.442)	(0.048)	(0.191)	(0.109)	(0.0469)	(0.339)	(0.022)			(0.098)		(.0098)	(0.318)
Pooled	48.55	0.635	5.43	0.4	3.86	2.71	0.57	2.29	0.09	–	–	2.40	–	0.89	2.34
	(1.104)	(0.0341)	(0.316)	(0.035)	(0.129)	(0.0759)	(0.0351)	(0.240)	(0.0203)			(0.134)		(0.071)	(0.207)
difference	−5.12**	−0.05	1.7***	−0.08	−0.34	−0.26*	0.22***	−0.40	−0.08**	–	–	−1.68***	–	1.35***	−0.53
	(2.184)	(0.0683)	(0.622)	(0.069)	(0.259)	(0.151)	(0.0686)	(0.481)	(0.040)			(0.242)		(0.105)	(0.413)
Uncert_coc	45.63	0.72	5.82	0.34	4.36	2.87	0.58	2.21	0.05	–	–	3.09	–	.45	4.11
	(1.402)	(0.045)	(0.478)	(0.048)	(0.225)	(0.132)	(0.0496)	(0.331)	(0.022)			(0.201)		(0.083)	(2.144)
Food_crA	45.99	0.61	6.28	0.36	3.69	2.58	0.68	2.09	0.05	–	–	1.56	–	1.56	2.076
	(1.742)	(0.049)	(0.442)	(0.048)	(0.191)	(0.109)	(0.0469)	(0.339)	(0.0219)			(0.098)		(0.098)	(0.318)
Pooled	45.81	0.665	6.05	0.35	4.03	2.73	0.63	2.15	0.05	–	–	2.33	–	1.00	3.09
	(1.115)	(0.033)	(0.325)	(0.034)	(0.149)	(0.086)	(0.0342)	(0.236)	(0.0154)			(0.123)		(0.075)	(1.084)
difference	.36	−0.11	0.46	0.02	−0.67	−.293	.1	−0.12	0	–	–	−1.51	–	1.13***	−2.035
	(2.236)	(0.067)	(0.651)	(0.068)	(0.295)	(0.171)	(0.0683)	(0.474)	(0.031)			(0.223)		(0.128)	(2.168)

Note: Refer to Table S1 in Supplementary Electronic Material for a description of the variables. *$p < 0.10$; **$p < 0.05$; *** $p < 0.01$.

Table 5. Household characteristics for study groups in the oil palm site.

Group	Age	Gender	Education (Years)	Formal employment	Household size (Adult equivalent)	Household size (persons)	Area of birth	Extension visit	Credit access	Variety grown	Age of trees	Total farm size	Farm size (oil palm)	Farm size (food crop)	Farm distance (km)	Farm experience
Cert_op	58.06	0.61	6.74	0.11	2.36	3.17	.84	1.7	0.081	1	19.58	4.35	4.045	0.31	4.39	28.17
	(1.133)	(.049)	(0.476)	(0.031)	(0.105)	(0.17)	(0.037)	(0.160)	(0.028)	(0)	(0.653)	(0.127)	(0.082)	(.061)	(0.260)	(0.994)
Uncert_op	53.48	0.63	5.82	0.11	2.45	4.47	0.82	0.53	0.02	0.58	16.26	2.77	2.42	0.35	4.18	26.66
	(1.271)	(0.049)	(0.396)	(0.0314)	(0.115)	(0.279)	(0.039)	(0.134)	(0.014)	(0.049)	(0.609)	(0.264)	(0.235)	(0.108)	(0.937)	(1.314)
Pooled	55.77	0.62	6.28	0.11	2.41	3.82	0.83	1.12	0.050	0.79	17.92	3.56	3.23	0.33	4.29	27.42
	(.865)	(0.034)	(0.311)	(0.0221)	(0.078)	(0.169)	(0.027)	(0.112)	(0.0155)	(0.0289)	(0.461)	(0.156)	(0.137)	(0.0617)	(0.485)	(0.823)
difference	−4.58***	0.02	−0.92	0	. 0.089	1.3***	−0.02	−1.17***	−0.061*	−0.42***	−3.32***	−1.58***	−1.63	0.042	−0.22	−1.51
	(1.703)	(0.069)	(0.619)	(0.0444)	(0.156)	(0.327)	(0.053)	(0.209)	(0.031)	(0.050)	(0.893)	(0.293)	(0.249)	(0.124)	(0.972)	(1.647)
Cert_op	58.06	0.61	6.74	0.11	2.36	3.17	0.84	1.7	0.081	–	–	4.35	–	0.31	4.39	28.17
	(1.133)	(0.049)	(0.476)	(0.0314)	(0.105)	(0.17)	(0.037)	(0.160)	(0.0275)			(0.127)		(0.0605)	(0.260)	(0.994)
Food_crM	49.33	0.31	4.33	0.17	2.33	3.13	0.73	0.21	0.0093	–	–	1.21	–	1.21	21.12	20.19
	(1.354)	(0.045)	(0.399)	(0.036)	(0.0727)	(0.125)	(0.043)	(0.0811)	(0.0092)			(0.152)		(0.152)	(10.476)	(1.374)
Pooled	53.53	0.45	5.49	0.14	2.34	3.15	0.78	0.93	0.043	–	–	2.72	–	0.78	13.08	24.02
	(0.938)	(0.035)	(0.319)	(0.0241)	(0.063)	(0.104)	(0.029)	(0.102)	(0.0142)			(0.148)		(0.090)	(5.459)	(0.900)
difference	−8.73***	−0.30***	−2.41***	0.057	−0.035	−0.04	−0.11*	−1.487	−0.072**	–	–	−3.14***	–	0.91***	16.72	−7.98***
	(1.766)	(0.066)	(0.622)	(0.0478)	(0.128)	(0.211)	(0.057)	(0.179)	(0.029)			(0.198)		(0.164)	(10.470)	(1.696)
Uncert_op	53.48	0.63	5.82	0.11	2.45	4.47	0.82	0.53	0.02	–	–	2.77	–	0.35	4.18	26.66
	(1.271)	(0.0485)	(0.396)	(0.0314)	(0.115)	(0.279)	(0.039)	(0.134)	(0.014)1			(0.264)		(0.108)	(0.936)	(1.314)
Food_crM	49.33	0.31	4.33	0.17	2.33	3.13	0.73	0.21	0.0093	–	–	1.21	–	1.21	21.12	20.19
	(1.354)	(0.045)	(0.399)	(0.036)	(0.0727)	(0.125)	(0.043)	(0.0812)	(0.0092)			(0.152)		(0.152)	(10.476)	(1.374)
Pooled	51.33	0.46	5.04	0.14	2.39	3.77	0.77	0.37	0.014	–	–	1.96	–	0.80	12.97	23.29
	(0.940)	(0.035)	(0.286)	(0.0241)	(0.0668)	(0.156)	(0.029)	(0.0777)	(0.00829)			(0.159)		(0.0991)	(5.478)	(0.977)
difference	−4.15**	−0.32***	−1.487***	0.057	−0.12	−1.34***	−0.089	−0.32**	−0.011	–	–	−1.55***	–	0.86***	16.94*	−6.47***
	(1.857)	(0.066)	(0.563)	(0.0478)	(0.136)	(0.306)	(0.058)	(0.157)	(0.017)			(0.305)		(0.187)	(10.518)	(1.901)

Note: Refer to Table S1 in Supplementary Electronic Material for a description of the variables. *$p < 0.10$; **$p < 0.05$; *** $p < 0.01$.

Table 6. Cocoa and oil palm total farm output and yields.

Group	Total farm output (kg/farm or ton/farm)	Yield (kg/ha or ton/ha)
Cert_coc	769.60 (72.485)	276.06 (19.188)
Uncert_coc	527.69 (50.319)	205.5665 (14.958)
Pooled	648.64 (44.836)	240.82 (12.389)
difference	−241.91*** (88.239)	−70.50*** (24.329)
Cert_op	16.90 (0.834)	4.18 (0.166)
Uncert_op	6.87 (0.542)	3.98 (0.416)
Pooled	11.88578 (0.611)	4.08 (0.224)
difference	−10.03*** (0.995)	−0.19 (0.448)

Note: $^{*}p < 0.10$; $^{**}p < 0.05$; $^{***}p < 0.01$.

capita compared to uncertified cocoa and food crop farmers. Uncertified cocoa farmers have in turn significantly higher incomes compared to food crop farmers. These patterns are observed also (and are mostly statistically significant) for farm and off-farm income (see Table 8). In terms of cocoa income, certified farmers have a significantly higher income (GHC 5836.93) compared to uncertified farmers (see Table 8). Similarly, in terms of total consumption and per capita consumption, the levels in decreasing order are certified cocoa farmers, uncertified cocoa farmers and food crop farmers, with the differences, however, not being statistically significant.

In the oil palm study site, the income levels are relatively different (see Table 9). Even though certified oil palm farmers still have higher total incomes and income per capita than the other groups, these differences are not always statistically significant. Interestingly food crop farmers have higher, but not statistically significant, income levels from uncertified oil palm producers. In addition, certified oil palm farmers have significantly higher mean oil palm income than uncertified oil palm farmers. In terms of total consumption and per capita consumption, certified farmers report the higher levels than uncertified oil palm farmers and food crop farmers, but the difference is not always statistically significant (see Table 9).

When comparing income levels with the national poverty thresholds (see Table 10) it seems that fewer certified cocoa farmers are extremely poor compared to uncertified cocoa and food crop farmers. Certified oil palm farmers have consistently the lowest levels of poverty and extreme poverty, followed by uncertified oil palm and food crop farmers (Table 10).

Figure 2 contains the multidimensional poverty estimations, with lower MPI levels denoting households that are less multi-dimensionally poor. Certified oil palm farmers (0.015) have the lowest MPI, compared to uncertified oil palm farmers (0.065) and food crop farmers (0.074), with 8%, 25% and 27%, respectively, being multi-dimensionally poor (see Figure 3). All farmer groups in the oil palm study site register lower MPI compared to those of the Western region (0.164) and entire country (0.179) (GSS, 2013). Similarly, certified cocoa farmers (0.131) have the least multidimensional poverty, followed by uncertified cocoa farmers (0.216) and food crop farmers (0.248) (see Figure 2). With the exception of certified cocoa farmers, all other groups in the cocoa study site have register higher MPI levels compared to those of the Central region (0.155) and the entire country (0.179) (GSS, 2013). Overall, 35% of certified cocoa farmers, 56% of uncertified cocoa farmers and 63% of food crop farmers are multi-dimensionally poor (see Figure 3).

When it comes to the elements of the MPI, the worst deprivation is observed for sanitation and cooking fuels (Table 11). It is noteworthy that certified oil palm farmers have much lower (but still high) deprivation in terms of sanitation (78%) and cooking fuel (79%) compared to uncertified oil palm

Table 7. Self-reported adoption of good production practices for certified cocoa and oil palm farmers.

Group	Impact/practice	Mean Score	Remarks
Certified cocoa farmers	Inorganic fertilizer use	3.60	Increased moderately
	Organic fertilizer use	3.46	Increased moderately
	Pesticide use	2.48	Remained the same
	Recommended pesticide use	3.52	Increased moderately
	Protection of water bodies	3.62	Increased moderately
	Protection of wild animals	3.55	Increased moderately
	Protection of forest	3.65	Increased moderately
Certified oil palm farmers	Inorganic fertilizer use	2.30	Decrease moderately
	Organic fertilizer use	3.44	Remained the same
	Pesticide use	1.42	Decrease substantially
	Recommended pesticide use	3.02	Remained the same
	Protection of water bodies	2.32	Decrease moderately
	Protection of wild animals	2.62	Remained the same
	Protection of forest	2.62	Remained the same

Note: Refer to Table S19 (Supplementary Electronic Material) for more details about these production practices.

Table 8. Economic wellbeing indicators for study groups in the cocoa site.

Group	Per capita income (GHC/person)	Total household income (GHC)	Total off-farm income (GHC)	Farm income (GHC)	Cocoa income (GHC)	Food crop income (GHC)	Total household consumption (GHC)	Per capita consumption (GHC)
Cert_coc	3015.63 (264.922)	7969.95 (717.581)	1934.99 (236.023)	6034.96 (591.251)	5836.93 (546.862)	198.03 (74.701)	5165.47 (388.951)	1906.59 (138.557)
Uncert_coc	1603.721 (140.267)	4027.17 (344.075)	1155.48 (149.874)	3897.58 (340.943)	3767.99 (341.883)	129.59 (37.329)	5084.36 (393.230)	1864.68 (121.879)
Pooled	2309.68 (157.658)	5998.56 (420.787)	1545.24 (142.153)	4966.27 (348.725)	4802.46 (329.910)	163.81 (41.720)	5124.92 (275.866)	1885.64 (92.046)
difference	−1411.91*** (299.764)	−3942.77*** (795.808)	−779.51*** (279.587)	−2137.37*** (682.509)	2068.93*** (644.936)	−68.44 (83.509)	−81.11 (553.094)	−41.92 (184.533)
Cert_coc	3015.63 (264.922)	7969.95 (717.581)	1934.99 (236.023)	6034.96 (591.251)	-	198.03 (74.701)	5165.47 (388.951)	1906.59 (138.557)
Food_crA	752.87 (94.231)	1835.64 (214.506)	1162.01 (166.746)	673.63 (118.586)	-	673.63 (118.586)	4418.64 (336.822)	1756.302 (120.807)
Pooled	1884.25 (161.551)	4902.79 (432.207)	1548.5 (146.709)	3354.29 (355.758)	-	435.83 (71.904)	4792.06 (257.975)	1831.45 (91.837)
difference	−2262.77*** (281.182)	−6134.31*** (748.957)	−772.98*** (288.983)	−5361.33*** (603.026)	-	475.6*** (140.154)	−746.83 (514.52)	−150.29 (183.827)
Uncert_coc	1603.721 (140.267)	4027.17 (344.075)	1155.48 (149.874)	3897.58 (340.943)	-	129.59 (37.329)	5084.36 (393.230)	1864.68 (121.879)
Food_crA	752.87 (94.231)	1835.64 (214.506)	1162.01 (166.746)	673.63 (118.586)	-	673.63 (118.586)	4418.64 (336.822)	1756.302 (120.807)
Pooled	1178.29 (89.511)	2931.406 (216.627)	1158.745 (111.819)	2285.61 (213.237)	-	401.61 (64.934)	4751.5 (259.306)	1810.49 (85.673)
difference	−850.86*** (168.981)	−2191.53*** 405.463	6.53 224.2014	−3223.95*** (360.978)	-	544.04*** (124.323)	−665.72 (517.763)	−108.38 (171.606)

Note: *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$

Table 9. Economic wellbeing indicators for study groups in the oil palm site.

Group	Per capita income (GHC)	Total household income (GHC)	Total nonfarm income (GHC)	Farm income (GHC)	Oil palm income (GHC)	Food crop income (GHC)	Total household expenditure (GHC)	Per capita expenditure (GHC)
Cert_op	6029.053 (410.273)	12861.67 (845.086)	7904 (813.746)	4957.67 (258.139)	4209.60 (209.769)	748.07 (172.955)	9798.53 (472.107)	4752.25 (294.805)
Uncert_op	3575.49 (413.716)	7189.13 (703.448)	4901.40 (660.563)	2287.729 (181.490)	1755.78 (115.690)	531.95 (138.802)	8720.22 (875.047)	3911.70 (365.759)
Pooled	4802.273 303.327	10025.4 (584.087)	6402.70 (533.458)	3622.7 (183.641)	2982.69 (147.781)	640.01 (110.868)	9255.375 (497.556)	4327.98 (236.178)
difference	−2453.559 (582.653)	−5672.54*** (1099.55)	−3002.6*** (1048.106)	−2669.94*** (315.554)	−2453.82*** (239.557)	−216.12 (221.764)	−1086.31 (994.631)	−848.55* (469.691)
Cert_op	6029.053 410.273	12861.67 (845.086)	7904 (813.746)	4957.67 (258.139)	–	748.07 (172.955)	9798.53 (472.107)	4752.25 (294.805)
Food_crM	3855.29 (386.895)	9139.82 (991.834)	7498.55 (929.623)	1641.28 (292.553)	–	1641.28 (292.553)	6611.36 (549.570)	2952.95 (256.334)
Pooled	4900.369 (290.822)	10929.17 (667.042)	7693.48 (620.002)	3235.70 (227.060)	–	1211.85 (175.532)	8143.65 (380.212)	3817.99 (203.772)
difference	−2173.76*** (563.926)	−3721.85*** (1303.037)	−405.45 (1235.468)	−3316.39*** (390.158)	–	893.21*** (339.854)	−3187.17*** (724.508)	−1799.31*** (390.662)
Uncert_op	3575.49 (413.716)	7189.13 (703.448)	4901.40 (660.563)	2287.729 (181.490)	–	531.95 (138.802)	8720.22 (875.047)	3911.70 (365.759)
Food_crM	3855.29 (386.895)	9139.82 (991.834)	7498.55 (929.623)	1641.28 (292.553)	–	1641.278 (292.553)	6611.36 (549.570)	2952.95 (256.334)
Pooled	3720.77 (282.180)	8201.99 (618.383)	6249.92 (583.447)	1952.07 (176.207)	–	1107.947 (169.956)	7625.24 (512.335)	3413.89 (222.496)
difference	279.80 (566.435)	1950.70 (1215.966)	2597.15** (1140.414)	−646.45* (344.276)	–	1109.33*** (323.810)	−2108.86*** (1033.312)	−958.75** (446.640)

Note: *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

Table 10. Poverty incidence for the study groups.

Case study	Group	Incidence (%) Total	Extreme poverty (<GHC 792.05)	Poverty (GHC 792.05-GHC 1314.00)
Assin North (Cocoa)	Cert_coc	39	16	23
	Uncert_coc	42	22	20
	Food_crA	41	22	19
	Pooled	41	20	21
Mpohor (Oil palm)	Cert_op	4	1	3
	Uncert_op	24	17	7
	Food_crM	32	22	10
	Pooled	21	14	7

and food crop farmers. When looking at the major differences between sites, the respondents in the oil palm site consistently report lower deprivation in terms of electricity, flooring material and child mortality, and respondents in the cocoa site report lower deprivation for access to improved sources of drinking water.

3.4. Propensity score matching analysis

Tables 12 and 13 report the outcomes of the PSM approach that elicits possible causality for the adoption of certification and cash crop adoption using different production practices (Section 2.3.2) (see further details in Supplementary Material, Tables S2-S18; Figures S1-S2).

The comparison between 'certified vs. uncertified cocoa farmers' uses the radius caliper algorithm (see Supplementary Electronic Material: Table S5 for balancing test; Figures S1 for histogram of propensity scores; Tables S8 for sensitivity analysis). The PSM analysis suggests that certification adoption leads to significantly higher total household incomes (by GHC 3638.71, $p < 0.01$), per capita income (by GHC 1259.56, $p < 0.01$), cocoa income (by GHC 1572.48, $p < 0.01$), farm income (GHC 1721.12), yield (by 81.74 kg/ha, $p < 0.01$) and lower poverty (by −0.069, $p < 0.01$). There is however no difference in total consumption and per capita consumption between certified and uncertified cocoa farmers.

The comparison between 'certified cocoa vs. food crop farmers' uses kernel common trim algorithm (see Supplementary Electronic Material: Table S6 for balancing tests; Figure S1 for histogram of propensity scores; Table S9 for sensitivity analysis). suggests that improved cocoa production leads to significantly higher total household income (by GHC 3747.52, $p < 0.01$), per capita income (GHC 1453.12, $p < 0.01$), farm income (GHC 3498.48, $p < 0.01$) and reduced poverty (−0.082, $p < 0.01$). However, it may also lead to increased consumption (by GHC 586.18) and per capita consumption (GHC 213.74), with the difference not being statistically significant.

The comparison between 'uncertified cocoa vs. food crop farmers' uses the nearness neighbour algorithm (see Supplementary Electronic Material: Table S7 for balancing tests; Figure S1 for histogram of propensity scores; Table S10 for sensitivity analysis). The results suggest that conventional cocoa cultivation leads to significantly higher income (GHC 1305.47, $p < 0.05$), per capita income (GHC 483.16, $p < 0.1$) and farm income (GHC 2429.87, $p < 0.01$). Also, conventional cocoa production leads to reduced poverty and lower consumption, though the differences are not statistically significant.

The comparison between 'certified vs. uncertified oil palm farmers' uses the radius caliper algorithm (see Supplementary Electronic Material: Table S13 for balancing tests; Figure S2 for histogram of propensity scores; Table S16 for sensitivity analysis). The PSM analysis suggests that adoption of RSPO certification leads to significantly higher total household income (by GHC 5741.80, $p < 0.01$), per capita income (by GHC 2400.71, $p < 0.01$), oil palm income (by GHC 2430.97, $p < 0.01$), farm income (by GHC 2631.90, $p < 0.01$) and reduced poverty (by −0.028, $p < 0.1$). Certification adoption also leads to increased yield, consumption and per capita consumption, with however, the differences not being statistically significant.

The comparison of 'certified oil palm vs. food crop framers' uses the kernel common trim algorithm (see Supplementary Electronic Material: Table S14 for balancing tests; Figure S2 for histogram of propensity scores; Table S17 for sensitivity analysis). The results show that the adoption of improved oil palm production leads to increased, but not statistically significant, total household income, per capita income and reduced poverty. Conversely the adoption results in significantly higher farm income (by GHC 4045.02, $p < 0.01$), total household consumption (by GHC 2103.64, $p < 0.1$) and per capita consumption (by GHC 1455.72, $p < 0.05$).

The comparison of 'uncertified oil palm vs. food crop' uses the Kernel common trim (see Supplementary Electronic Material: Table S15 for balancing tests; Figure S2 for histogram of propensity scores; Table S18 for sensitivity analysis). The result shows

Table 11. Deprivation across poverty dimensions in the two study sites.

		Education		Health		Living standards					
Case study	Groups/ dimensions	Years of schooling (%)	Child school attendance (%)	Nutrition (%)	Child mortality (%)	Electricity (%)	Improved drinking water (%)	Sanitation (%)	Cooking fuel (%)	Flooring material (%)	Assets ownership (%)
Mpohor (Oil palm)	Certified oil palm farmers	4	0	36	1	1	10	78	79	1	21
	Uncertified oil palm farmers	3	2	34	6	1	21	91	93	1	38
	Food crop only farmers	13	3	30	1	7	0	93	90	4	56
Assin North (Cocoa)	Certified cocoa farmers	8	3	22	5	16	0	91	95	32	14
	Uncertified cocoa farmers	12	6	21	12	34	5	95	98	54	34
	Food crop only farmers	11	6	27	11	22	0	97	98	40	45

Table 12. Propensity Score Matching analysis for the cocoa study site.

Variable	Groups (Observations after common support)	Treatment effect (ATT)	Balancing Test: Pseudo R^2	Balancing Test: *p*-value LR*	Balancing Test: Mean Bias	Balancing Test: Comment	Rosenbaum bounds gamma
Total household income	Cert_coc (89) & Uncert_coc (99)	3638.71*** (802.19)	0.005	1.000	3.7	Good matching	2.7
	Cert-coc (79) & Food_crA (85)	3747.52*** (677.96)	0.008	0.975	5.4	Good matching	**7.7**
	Uncert_coc (90) & Food_crA (74)	1305.47** (537.19)	0.011	0.941	6.8	Somewhat good matching	1.9
Cocoa income	Cert_coc (89) & Uncert_coc (99)	1572.48*** (602.18)	0.005	1.000	3.7	Good matching	–
Per capita income	Cert_coc (89) & Uncert_coc (99)	1259.56*** (287.28)	0.005	1.000	3.7	Good matching	2.1
	Cert-coc (79) & Food_crA (85)	1453.12*** (232.40)	0.008	0.975	5.4	Good matching	6.8
	Uncert_coc (90) & Food_crA (74)	483.16* (252.38)	0.011	0.941	6.8	Somewhat good matching	2.0
Farm income	Cert_coc (89) & Uncert_coc (99)	1721.12*** (651.32)	0.005	1.000	3.7	Good matching	–
	Cert-coc (79) & Food_crA (85)	3498.48*** (450.89)	0.008	0.975	5.4	Good matching	19.5
	Uncert_coc (90) & Food_crA (74)	2429.87*** (370.50)	0.011	0.941	6.8	Somewhat good matching	6.2
Total household consumption	Cert_coc (89) & Uncert_coc (99)	−149.85 (509.13)	0.005	1.000	3.7	Good matching	–
	Cert-coc (79) & Food_crA (85)	586.18 (696.41)	0.008	0.975	5.4	Good matching	–
	Uncert_coc (90) & Food_crA (74)	−374.9865 (789.16)	0.011	0.941	6.8	Somewhat good matching	–
Per capita consumption	Cert_coc (89) & Uncert_coc (99)	−31.26 (157.15)	0.005	1.000	3.7	Good matching	1.1
	Cert-coc (79) & Food_crA (85)	213.74 (277.38)	0.008	0.975	5.4	Good matching	–
	Uncert_coc (90) & Food_crA (74)	−280.14 (363.40)	0.011	0.941	6.8	Somewhat good matching	–
Yield	Cert_coc (89) & Uncert_coc (99)	81.74*** (28.61)	0.005	1.000	3.7	Good matching	1.3
Poverty (Deprivation scores)	Cert_coc (89) & Uncert_coc (99)	−0.069*** (0.023)	0.005	1.000	3.7	Good matching	3.6
	Cert-coc (79) & Food_crA (85)	−0.082*** (0.023)	0.008	0.975	5.4	Good matching	2.9
	Uncert_coc (90) & Food_crA (74)	−0.011 (0.033)	0.011	0.941	6.8	Somewhat good matching	–

Note: $^*p < 0.10$; $^{**}p < 0.05$; $^{***}p < 0.01$.

reduced income, per capita income, farm income and increased poverty and per capita consumption, without any of these results being statistically significant. Conventional oil palm production, however, leads to statistically significant higher total household consumption (by GHC 2722.36, $p < 0.05$).

4. Discussion

Both cocoa and oil palm production in the study sites are dominated by male-headed households, with higher proportions of female-headed households involved in food crop production and small-scale processing (Section 3.1). This reflects the common trend in Ghana (and much of Sub-Saharan Africa) that cash crops are mainly a male activity ((Danso-Abbeam & Baiyegunhi, 2018; Laven & Boomsma, 2012; MASDAR, 2011; World Bank, 2014). However, farmers in all groups have consistently low levels of education, similar to other agrarian contexts of Ghana (Ahmed et al., 2019; Aidoo & Fromm, 2015; Antwi et al., 2018). This can pose a major challenge for the effective training of farmers on certification standards and filling in the relevant documentation, as studies have identified the time constraints and complicated/extensive paperwork as major disincentives for certification adoption in the country (Hobbs, 2007).

Table 13. Propensity Score Matching analysis for the oil palm study site.

Variable	Groups (Observations (after common support)	Treatment effect (ATT)	Balancing test				Rosenbaum bounds gamma
			Pseudo R^2	*p*-value LR*	Mean bias	Comment	
Total household income	Cert_op (97) & Uncert_op (92)	5741.80***(1479.16)	0.005	0.998	4.2	Good matching	2.5
	Cert_op (63) & Food_crM (85)	1905.35(2102.18)	0.014	0.935	9.6	Somewhat Good matching	1.0
	Uncert_op (89) & Food_crM (83)	−2873.98 (2424.74)	0.005	0.999	4.0	Good matching	1.2
Oil palm income	Cert_op (97) & Uncert_op (92)	2430.97*** (330.11)	0.005	0.998	4.2	Good matching	8
Per capita income	Cert_op (97) & Uncert_op (92)	2400.71*** (728.42)	0.005	0.998	4.2	Good matching	3.1
	Cert_op (63) & Food_crM (85)	1777.10** (866.40)	0.014	0.935	9.6	Somewhat Good matching	1.4
	Uncert_op (89) & Food_crM (83)	−277.11 (991.43)	0.005	0.999	4.0	Good matching	1.1
Farm income	Cert_op (97) & Uncert_op (92)	2631.901 *** (397.23)	0.005	0.998	4.2	Good matching	19.0
	Cert_op (63) & Food_crM (85)	4045.71*** (373.90)	0.014	0.935	9.6	Somewhat Good matching	28.0
	Uncert_op (89) & Food_crM (83)	−665.36 (795.94)	0.005	0.999	4.0	Good matching	–
Total household consumption	Cert_op (97) & Uncert_op (92)	1040.78 (1249.32)	0.005	0.998	4.2	Good matching	1.0
	Cert_op (63) & Food_crM (85)	2103.64* (1195.52)	0.014	0.935	9.6	Somewhat Good matching	1.6
	Uncert_op (89) & Food_crM (83)	2722.36 (1144.49)**	0.005	0.999	4.0	Good matching	1.3
Per capita consumption	Cert_op (97) & Uncert_op (92)	696.13 (507.84)	0.005	0.998	4.2	Good matching	–
	Cert_op (63) & Food_crM (85)	1455.72** (635.85)	0.014	0.935	9.6	Somewhat Good matching	1.7
	Uncert_op (89) & Food_crM (83)	1014.78 (652.43)	0.005	0.999	4.0	Good matching	1.1
Yield	Cert_op (97) & Uncert_op (92)	0.778 (.50)	0.005	0.998	4.2	Good matching	1.5
Poverty (Deprivation scores)	Cert_op (97) & Uncert_op (92)	−0.028* (0.017)	0.005	0.998	4.2	Good matching	1.5
	Cert_op (63) & Food_crM (85)	−0.014 (0.023)	0.014	0.935	9.6	Somewhat Good matching	–
	Uncert_op (89) & Food_crM (83)	0.0024 (0.018)	0.005	0.999	4.0	Good matching	–

Note: *$p < 0.10$; **$p < 0.05$; *** $p < 0.01$.

Certified farmers generally have higher access to extension services and credit compared to their respective comparison groups (Table 5 and 7), which is consistent with the literature in Ghana and other parts of the world (Adjei-Nsiah et al., 2012; Ansah et al., 2020; Chiputwa et al., 2015; Djokoto et al., 2016). Furthermore, certified farmers have a better access to the improved *Tenera* oil palm variety (whose fruits have higher oil content and are preferable by oil palm mills), which is facilitated by BOPP with which the certified oil palm farmers are contractually linked (Manley & Van Leynseele, 2019; MASDAR, 2011). This reflects the support that certified farmers receive from Licensed Buying Companies (LBCs), Group Administrators (GAs) and large companies to enhance yields (see below), and is a major element that certification processes and associated food and agricultural policies should seek to

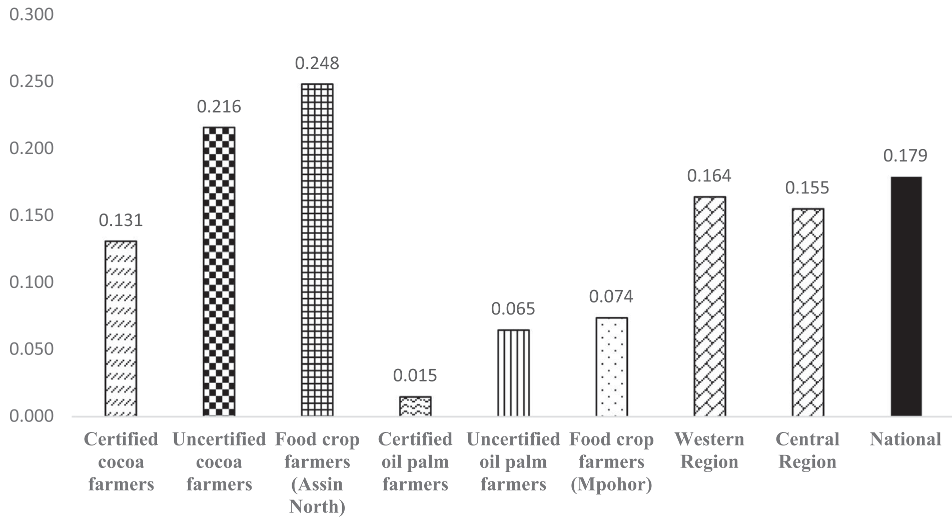

Figure 2. Multidimensional poverty levels in the two study sites.

reinforce. Conversely, uncertified farmers have lower access to credit and extension services, partly also due to their lower ability and capacity to organize into farmer groups (which another benefit derived from engagement in certification) (Danso-Abbeam et al., 2018; Lamontagne-Godwin et al., 2017).

Benefits such as the ones outlined above translate to the significantly higher yields of certified cocoa farmers in our study areas compared to uncertified cocoa farmers. Interestingly, despite the fact that the average cocoa farm sizes in the area are higher than the national average (2.84 ha vs. <2 ha) (Wessel & Quist-Wessel, 2015), cocoa yields are below the national average (240 kg/ha vs. 400 kg/ha) (Danso-Abbeam et al., 2012).

In any case, the certified cocoa farmers have both a higher cocoa income and farm income than uncertified farmers, which reflects similar findings on certification impacts across multiple crops and geographical contexts (Djokoto et al., 2016; Kleemann et al., 2014; Mitiku et al., 2017; Oosterveer et al., 2014; Tran & Goto, 2019). Apart from the adoption of improved production practices, these income gains are partly attributed to improved market linkages and premium payments (Fenger et al., 2017; Oya et al., 2018). However, when looking deeper in the results, we

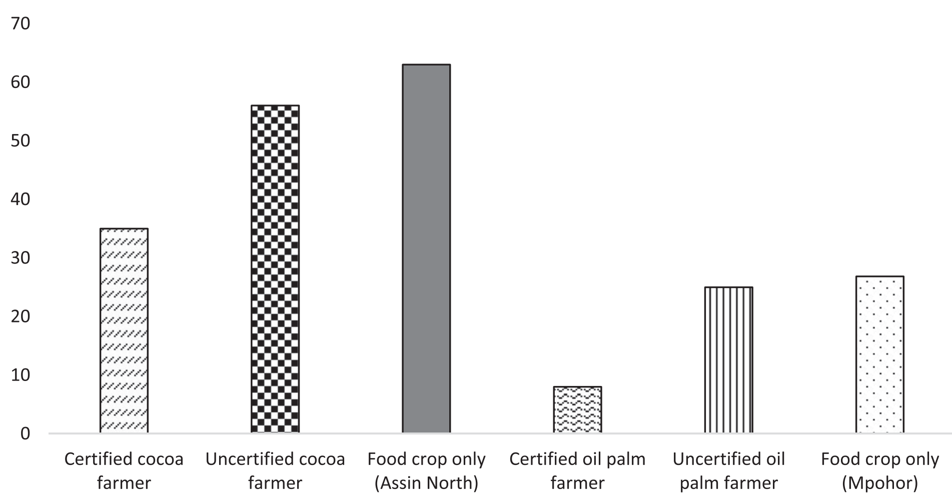

Figure 3. Proportion of farmers in each group that are multi-dimensionally poor.

find that in our study site income gains are mainly due to yield improvements rather than premiums (92.1% vs. 7.9% of contribution to income gains on average, respectively). It should also be noted that food crop income accounts for a rather low proportion of farm income for cocoa farmers (both certified and uncertified). This suggests the specialization of the farmers as has happened in other certification contexts (Vellema et al., 2015) and indicates the indispensability of cocoa production for their livelihoods. However, at the same time there is high exposure to possible livelihood shocks posed by fluctuating international cocoa prices due to fluctuating demand (KPMG, 2012; Lernoud et al., 2017). This constitutes a major trade-off that emanates from the engagement of smallholders in certified cocoa production that needs to be considered carefully in certification processes and broader related agricultural policies.

Similarly, certified oil palm farmers report higher yields, though not significantly, possibly due to the higher age of oil palm trees (Ofosu-Budu & Sarpong, 2013). It seems that similar to the cocoa study site, the observed yield gains are due to the extension and input support provided to scheme smallholders by BOPP, under which they are contractually linked (MASDAR, 2011). However, despite the significant difference in oil palm income between certified and uncertified farmers, the overall contribution to total household income is lower compared to off-farm income. This indicates their lower specialization and at the same time dependence on oil palm production, compared to the certified cocoa farmers (see above). This possibly reflects the higher overall development of the broader area considering that BOPP was established in 1976 and other similar firms (e.g. Norpalm Ghana Ltd) have been operating in the wider area for many decades (MASDAR, 2011). These large agro-industries have directly developed accessible roads and schools, which have in turn opened up opportunities for the further diversification of income and employment opportunities in the area (Agyeman et al., 2014; Senadza, 2012). In addition, the BOPP smallholder scheme was established about two decades ago and has since offered a stable market for the involved smallholders. In this sense, the long-term generation of stable income may have been reinvested to diversify household incomes over time, as has been observed around plantations in other parts of Sub-Saharan Africa (Mudombi et al., 2018).

The generally higher development of the broader oil palm site is also reflected in the consistently lower MPIs and deprivation scores for most dimensions for the study groups in the oil palm site compared to the cocoa study site. As discussed above this is due to positive spillover effects related to electrification attracted by the BOPP and the direct development of hospitals and schools from the company, which may be accessible also to non-certified farmers. Such positive spillover effects of plantations for some multidimensional poverty categories have been also identified in other parts of Ghana (Ahmed et al., 2019) and Sub-Saharan Africa (Mudombi et al., 2018). On the contrary, the cocoa communities are characterized by lower availability of social amenities, which can be further inaccessible to many uncertified cocoa and food crop farmers due to their comparatively lower income.

Certified farmers have higher yields and income compared to uncertified farmers in both study sites. This is mostly linked to the yield improvements, rather than actual premium payments. Yield improvements seem to be mediated by better access of certified farmers to training, agricultural inputs and credit, which are in turn facilitated by organization in groups (cocoa farmers) or strong linkages with large companies (oil palm farmers). On the one hand, certification processes and broader agricultural policies should seek to facilitate the provision of such services, as they are strongly linked to yield gains and positive socioeconomic outcomes. On the other hand, they should point to farmers that most of the expected benefits would likely manifest improved yields rather than the actual premium payments. This might enhance the proper implementation of certification practices (and thus the sustainability of oil palm and cocoa production), as a means of ensuring good yields. However, we believe that premiums still play a very important role through their direct visibility. In this sense well-designed and implemented premiums can become a very visible incentive to adopt certification, especially for independent oil palm smallholders as such premiums are not currently implemented in the oil palm sector.

However, despite the consistent income benefits of certification we observe very different levels of income diversification between cocoa and oil palm smallholders. In particular, income diversification is particularly low among cocoa farmers, which show high degree of specialization in cocoa farming. The lack of income diversification might increase household vulnerability to livelihood shocks from price fluctuations. In order to reduce such vulnerabilities, it is suggested that certification agencies, GAs and LBCs should raise the importance and build the capacity of their smallholders in other income-generating activities. This can be part of the certification training, offering for example suggestions on how to re-invest the extra income received through certification to other livelihood options.

Finally, certified farmers adopted sustainable production practices in both sites, but with some marked differences. For example, certified oil palm farmers decreased fertilizer and agrochemical use, while certified cocoa farmers experienced exactly the opposite. Conversely, cocoa certification seems to have boosted the successful adoption of production practices that mitigate land use related impacts, compared to oil palm certification that does not seem to have had any effect, possibly due to the already consolidated agricultural practices in the area. This suggests that crop and group dynamics can possibly have an effect on the adoption of certain sustainable production practices, and the manifestation of positive environmental outcomes (Abdulai et al., 2018; Nkegbe et al., 2012). This makes a strong case for the robust and consistent implementation and monitoring of certification standards, which sometimes is lacking (Tayleur et al., 2017). It also implies that differentiated environmental outcomes might manifest in production sites. Such differentiated outcomes must be weighted alongside the economic benefits of certification to ascertain its actual contribution to the sustainable production of oil palm and cocoa.

5. Conclusion

This study focused on how certification adoption among cocoa and oil palm smallholders in Ghana affected yields, human wellbeing and the adoption of sustainable production practices. Certified farmers adopted sustainable production practices in both sites, but with some marked differences. Oil palm smallholders tended to decrease agrochemical use, while cocoa farmers mostly practice to reduce negative effects on land use change. The adoption of certification has a positive effect on yields, incomes and multidimensional poverty for both oil palm and cocoa smallholders. However, income diversification is relatively lower among cocoa smallholders suggesting their higher vulnerability to price fluctuations. It is important to build capacity to diversify the extra income received by certification in order to ensure the long-term economic benefits to households. The environmental outcomes of certification must be weighted alongside the manifested economic benefits to ascertain its actual contribution to the sustainable production of oil palm and cocoa.

Acknowledgements

We acknowledge the support of all interviewed smallholders, with special appreciation to Kwame Kumi Kwakye (BOPP) and Isaac Duah (AELBI). We are also grateful to Samuel Avaala Awonnea (BOPP) and Vincent Akomea (Ghana Cocoa Board) for their assistance during data collection. The research forms part of the CGIAR programmes on Climate Change, Agriculture and Food Security (CCAFS). The research was funded through an Asahi Glass Foundation Continuation Grant for Young Researchers and the Japan Science and Technology Agency (JST) for the Belmont Forum project FICESSA. EDB is supported by a Monbukagakusho scholarship provided by the Japanese Ministry of Education, Culture, Sports, Science, and Technology (MEXT).

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by an Asahi Glass Foundation Continuation Grant for your Young Researchers and funding from the Japan Science and Technology Agency (JST) for the Belmont Forum project FICESSA.

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