Doctoral Thesis (Abridged)

博士論文（要約）

Adoption and impacts of certification standards for oil palm and cocoa smallholders in Ghana

(ガーナのパーム油とカカオの小規模農家における認証基準の採用とその影響)

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ABSTRACT

Cocoa and oil palm are the major industrial crops produced in Ghana. Their production and export has played a significant role in the Ghanaian economy, with pre- and post-independence governments enacting multiple policies and interventions to promote their cultivation. This has in turn stimulated their expansion both in terms of area and output. Currently, Ghana ranks as the 2nd largest producer of cocoa and the 8th largest producer of oil palm in the world. Cocoa is almost completely produced by smallholders that either specialize in cocoa production or produce it jointly with other crops. Conversely, oil palm is mostly produced in hybrid systems consisting of large core plantations surrounded by hundreds or even thousands of smallholders that are either contractually linked to the core plantation (i.e. scheme/outgrowers) or cultivate and sell it independently (i.e. independent growers). Due to the large smallholder involvement in both cocoa and oil palm production, these crops are major sources of rural livelihoods and have been associated with positive socioeconomic outcomes related to income generation, poverty alleviation and food security.

However, the production of both cocoa and oil palm has been linked to many negative environmental and socioeconomic impacts such as land use change/deforestation, pollution due to the extensive use of fertilizers and agrochemicals, unfair compensation practices, and land tenure conflicts, among others. In response to these negative sustainability impacts, oil palm and cocoa certification has gained traction as a means of ensuring their sustainable production and guaranteeing mutual benefits across their value chains in Ghana. Certification standards are largely voluntary, and entail the strict adoption of socially and environmentally responsible production practices. Currently, various sustainability standards have targeted the two sectors, including UTZ, Fairtrade, Rainforest Alliance, Organic and Roundtable on Sustainable Palm Oil (RSPO). This reflects global certification trends that have been largely driven by changing consumer preferences and behavior, partly due to rising living standards and concerns about food safety and the environmental/social consequences of agricultural production.

There is a growing interest regarding the extent of the possible economic, social and environmental impact of certification, especially for smallholders. Certification is expected to improve the farmer incomes through increased yields and premium payments, while ensuring environmental sustainability. However, evidence about the impact of certification is mixed, with some studies reporting positive impacts and others reporting low-to-no impacts. However, many of these studies are limited or not robust in terms of methodology, and the selection of variables, crops and geographical contexts.

This thesis therefore aims at assessing the adoption and impacts of certification standards for oil palm and cocoa smallholders in Ghana. The specific objectives include:

1) To understand the perceptions of the main stakeholders involved in oil palm and cocoa value chains towards certification, as well as the existing connections in the context of certification
2) To analyse the promotion and adoption dynamics of farmer participation in certification programmes
3) To establish the impact of certification adoption on farm productivity, multidimensional poverty, income, and food security
4) To provide policy recommendation to enhance the adoption and impacts of certification for smallholders in Ghana

A mixed method approach was employed using data obtained through an institutional analysis, expert interviews (33 respondents) and household surveys (608 respondents) in two areas of cocoa and oil palm production. The expert interview respondents were identified through an institutional analysis and represent organisations with different engagement in cocoa and oil palm certification such as government ministries, civil society, research and the private sector. Their interviews were analyzed through content analysis to identify the major themes regarding the drivers, impacts and future options of oil palm and cocoa certification in Ghana. For the household surveys the identified cocoa study site is located in the Assin North Municipal of Ghana and the oil palm site in the Mpohor district. Respondents in each site included certified cocoa/oil palm farmers (treatment group), uncertified cocoa/oil palm farmers (control group 1), and food crop farmers (control group 2). The household surveys were analyzed through descriptive statistics, mixed effect probit regressions, and propensity score matching estimation.

For (1), the expert interviews suggest that premiums are the major drivers of certification adoption among smallholders, especially in the cocoa sector. Consumer demand also drives certification adoption among smallholders and large companies in both sectors. Farm productivity, income generation and reduced environmental impacts are the major impact associated with certification adoption. However, the high cost of certification due to direct and opportunity costs are the major barriers to certification adoption, followed by heavy documentation, bureaucracy and lack of farmer capacity.

For (2), certification is promoted using varied targeting approaches including buyer-led, farmer-led and intervention-based targeting (for cocoa) and mill-led and intervention-based targeting approach (for oil palm). Apart from the intervention-based approach, profit motives are a dominant feature of promotion activities. The mixed effect probit regression analysis indicates that the age of the household head, livestock ownership and ownership of information access devices positively influences cocoa smallholders' decision to adopt certification schemes on their farms. Surprisingly, education of household head has a negative relationship with adoption. Livestock ownership, which is an indication of wealth, positively influences the decision to adopt certification, suggesting that wealthier and better-endowed households tend to be more likely to adopt certification. Ownership of information devises (e.g. phone) positively affects farmers' decision to adopt certification, as this also implies better access to information which is a critical aspect of the successful implementation of certification standards. In addition, farmers also experience the challenge of high input cost and low premiums, which is a major disincentive for sustained adoption.

For (3), the propensity score matching estimations suggest that certified cocoa farmers are better-off than uncertified cocoa farmers in terms of household income (by GHC 3,638.71, $p<0.01$), cocoa income (by GHC1572.48, $p<0.01$), per capita income (by GHC1259.56, $p<0.01$), yield (by 81.74 kg/ha, $p<0.01$), food security (Food Consumption Score) (by 2.12 points) and multi-dimensional poverty. However, certified farmers have lower consumption as compared to uncertified cocoa farmers. Estimations between "certified cocoa farmers vs. food crop farmers", as well as "uncertified cocoa farmers vs. food crop farmers" also show similar impact trends. Similarly, certified oil palm farmers are better-off compared to uncertified oil palm farmers in terms of household income (by GHC5,741.80, $p<0.01$), oil palm income (by GHC2,430.97, $p<0.01$), per capita income (by GHC2400.71, $p<0.01$) and multi-dimensional poverty compared to uncertified oil palm farmers. However, there is no significant difference between certified oil palm farmers and uncertified oil palm farmers in terms of consumption expenditure and food security.

For (4), considering the results obtained, certification can be a promising avenue to enhance social, environmental and economic livelihoods of farmers. However, efforts should be taken to a) improve smallholder targeting approaches, b) improve premium design, c) Improve yield gains, d) Enhance income diversification for smallholders, e) Include crop diversification in certification guidance and principles, f) Explore the feasibility of a nationally mandated approach to certification to harness the potential of certification to catalyse progress across multiple SDGs.

(1152 words)

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DEDICATION

I dedicate this PhD thesis to my parents, Mr. Maxwell Dompreh and Madam Esther Ampomaah

You never had the best of education but you have given me the world

I pray for you to see more of what you have achieved with my life

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ABBREVIATIONS

RSPO	Roundtable on Sustainable Palm Oil
RA	Rainforest Alliance
LBC	Licensed Buying Company
GA	Group Administrator
CAADP	Comprehensive African Agriculture Development Programme
NEPAD	New Partnership for Africa's Development arrangement
FAO	Food and Agriculture Organization
MoFA	Ministry of Food and Agriculture
UNCTAD	United Nations Conference on Trade and Development
Cocobod	Ghana Cocoa Board
RSSF	RSPO Smallholder Support Fund
BMP	Best Management Practices
GAPs	Good Agricultural Practices
PSM	Propensity Score Matching
BOPP	Benso Oil Palm Plantation

CHAPTER ONE

INTRODUCTION

1.1 Commercial crops and certification in Sub-Saharan Africa

1.1.1 Commercial crop production in Sub-Saharan Africa

Agricultural production in Sub-Saharan Africa is a very important economic activity due to its enormous contribution to employment creation and Gross Domestic Product (Tomsik et al., 2015; Chauvin & Porto, 2011). The increased importance of agriculture also reflects in the low diversification of the economies of majority of African countries (OECD/FAO, 2016). As such, it has gained attention at the continental level as a priority for increasing economic growth, improving livelihoods and resilience of people within the framework of the Comprehensive African Agriculture Development Programme (CAADP) developed through the New Partnership for Africa's Development arrangement (OECD/FAO, 2016; NEPAD, 2003).

Apart from food crops that are produced for subsistence, commercial crops (both food and non-food) have played significant roles in the economies of Sub-Saharan African countries which has influenced their increased production (Figure 1-1) (FAOSTAT, 2020; Ahmed *et al*., 2019; Gasparatos *et al*., 2018). For example, tobacco and sugarcane contribute significantly to export earnings in Malawi (Chinangwa et al. 2017), while cocoa is a major commodity crop in Ghana and the Ivory Coast, in terms of foreign exchange revenue and livelihood dependence (Breisinger *et al*. 2008; Danso-Abbeam *et al*., 2012). Sugarcane, tea and coffee are also major agricultural commodities contributing to the livelihoods of smallholder farmers as well as foreign exchange to the Kenyan economy (D'Alessandro *et al*., 2015; FAOSTAT, 2020). The increased importance of these agricultural commodities is also seen in increased acreage of production. This increased production has major impacts on the environment as well as availability of food for household consumption (Kline *et al*., 2017; Ahmed *et al*., 2019; Antwi *et al*., 2018).

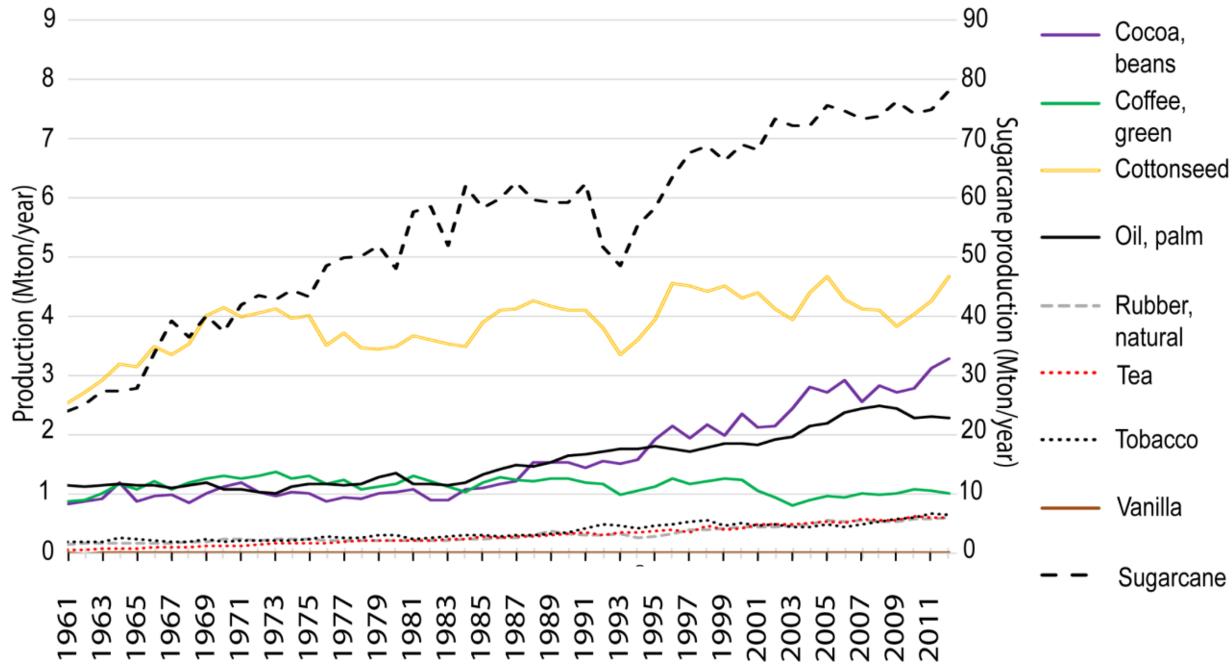


Figure 1-1: Output of major agricultural commodities in sub-Saharan Africa (FAOSTAT, 2020)

Pertinent to the production of these commodities are smallholder farmers constituting about 80% of all farms (Misaki *et al*., 2018). In-country production dynamics also show similar trends of production. For example, smallholder production represents 75% of agricultural production in Kenya (D'Alessandro *et al*., 2015) while more than 80% of agricultural production is attributed to smallholder production in Ghana (FAO, 2004). In spite of the indispensability of smallholder production to livelihoods as well as Sub-Saharan African economies, smallholders are characterized by lack of credit (Misaki *et al*., 2018; Mpandeli & Maponya, 2014), high levels of poverty (Asamoah *et al*., 2013), food insecurity (Kline *et al*., 2017; Biederlack & Rivers, 2009), low productivity (Shimeles *et al*., 2018), land tenure conflicts (Deininger *et al*., 2017), negative environmental impacts (MASDAR, 2011; Moreno-Penaranda *et al*., 2018) as well as inequitable compensation (Khatun *et al*., 2020). These challenges have influenced several interventions by development partners, civil society and private sector to help farmers scale-up production and drive economic development in African countries (Stewart *et al*., 2015; CGIAR, 2017).

1.1.2 Sustainability of commercial crop production in Sub-Saharan Africa

There has been a gradual transition from local and geographically bounded supply chains of agricultural commodities, to more unrestricted global markets (Askoy *et al*., 2005; Chiputwa *et al*., 2015). One of the major drivers of this transition has been the changing consumer demand in terms of the quality, safety and impact of agricultural commodity crops and their products (Ansah et al., 2020; Fenger et al., 2017; Mitiku et al., 2017). However, there has been major concerns over the environmental and socioeconomic impacts of many commodity crops (e.g. oil palm, cocoa, sugarcane, cotton) (Vijay *et al*., 2016; Fountain & Hutz, 2015; Hess *et al*., 2016), which is also partly driven by Non-Governmental Organizations' advocacy on the sustainability of agricultural production,

For instance, oil palm and cocoa production have been associated with negative forest degradation and exploitation of High Conservation Value areas (Mason & Asare, 2014; Izah *et al*., 2016). The culmination of environmental impacts across different commodity crops has resulted in the generally dire environmental status of production fields such that about 75% of arable land could be degraded by 2020 (Snapp *et al*., 2018). This has the potential of compromising production both for food and industrial purposes, leading to heightened food insecurity levels and low economic outcomes. One of the most probable approaches to dealing with the challenge of low productivity has been the use of nutrient fixing chemicals (fertilizers) (Danso-Abbeam et al., 2014). However, farmers are faced with low access to inputs (Fenger et al., 2017) which forces them to resort to expansionary farm measures, resulting in worsened increase in deforestation.

On the social perspective, about 2.1 million children are involved in forced and hazardous work in Ghana and Cote D'Ívoire, raising issues about the intergenerational sustainability of cocoa growing communities (International Cocoa Initiative, 2018). These concerns have garnered global attention in the sustainability debate and has been major intervention points for NGOs and other development partners. The International Cocoa Initiative has been one of the major continental organization helping to curb child labour on farms trough establishment of monitoring and remediation systems. These challenges associated with agricultural production do not only characterize SSA countries but also production systems in developing countries as such has found its way in the Sustainable Development Goals, to increase the share of land allocated for sustainable agriculture (target 2.4 in SDG2) (Akoyi *et al*., 2020). This has been necessitated as a result of the need to increase production to feed the ever-increasing global population as well as guaranteeing rural livelihoods and food security (Wang *et al*., 2020).

In the midst of the sustainability discussion, the attention on agricultural commodities particularly in Sub-Saharan African countries have been heightened (Schleifer & Sun, 2020; Tran & Goto, 2020), owing to the fact that agriculture is one of the central economy propelling activities largely dominated by smallholders characterized by a myriad of challenges including food insecurity, high poverty levels, limited access to land, inequitable compensation as well as low productivity levels (Dahri & Omri, 2020; Gockowski *et al*., 2013; FAO, 2002; Cervantes-Godoy & Dewbre, 2010).

Additionally, the prevalence of weak regulatory systems in agricultural production in Sub-Saharan African countries has contributed to the sustained attention on sourcing sustainable produce particularly from these countries (Tran & Goto, 2019), which is also related to export-based pattern of agricultural production in Sub-Saharan Africa. Hence, consumers in international markets have been key stakeholders in driving sustainable production[1] (Khatun *et al*., 2020; Chiputwa *et al*., 2015; Mitiku *et al.*, 2017) in Sub-Saharan African countries. Some of the approaches of ensuring sustainable production include traceability and certification schemes as well as establishing input credit schemes to support the critical production base: smallholder farmers, to deliver sustainable products (Waarts *et al*., 2015; Ingram *et al.*, 2018)

1.1.3 Certification of commercial crops in Sub-Saharan Africa

A number of market-oriented strategies aimed at ensuring sustainable production have been promoted in Sub-Saharan Africa (Fenger et al., 2017; Ansah et al., 2020; Mitiku et al., 2017; Khatun *et al*., 2020). Sustainability certification has emerged as one of the major tools to ensure the sustainable production of commodity crops, as a means of guaranteeing broader societal benefits across their value chains (Glasbergen, 2018; Ingram *et al*., 2018). The proliferation of these standards, has been shaped by increasing consumer demand partly through awareness creation and lobbying campaigns from the civil society concerning the environmental and socioeconomic impacts of current consumption and production patterns (Dankers & Liu, 2003; Kleeman et al., 2014; Oosterveer et al., 2014). As a result, certification standards have been promoted for most commodity crops, including coffee, cocoa, tea and oil palm, which are very important in Sub-Saharan African economies (Chiputwa et al., 2015; Fenger et al., 2017; Mitiku et al., 2017).

Current estimates of land allocated to certification standards adoption show promising trends which indicates stakeholder commitment to make sustainability the core of production. Aside coffee certification (25.8-45.3%) which is most adopted, followed by cocoa (22.8-37.6%), tea

[1] Sustainable production refers to production that does not compromise future production in current production by adopting environmentally, socially and economically responsible practices

(13.2-18.1%) and oil palm (11.7-12%) (Lernoud *et. al*., 2018), farmers have also adopted certification for crops such as pineapples, banana and papaya. For all commodity crops, the most widely adopted certification is Organic certification (57.82 Mha) followed by Global GAP (3.29Mha), Roundtable on Sustainable Palm Oil (3.24Mha), Rainforest Alliance (3.11Mha), UTZ (2.73Mha) and Fairtrade certification (2.48Mha) (Lernoud *et al*., 2018) (Figure 1-2). Other standards including Better Cotton Initiative and Bonsucro have been adopted among smallholder farmers in various countries either through single or multiple certification schemes as a way of guaranteeing markets and ensure consistent income (Fenger *et al*., 2017; Lernoud *et al*., 2018).

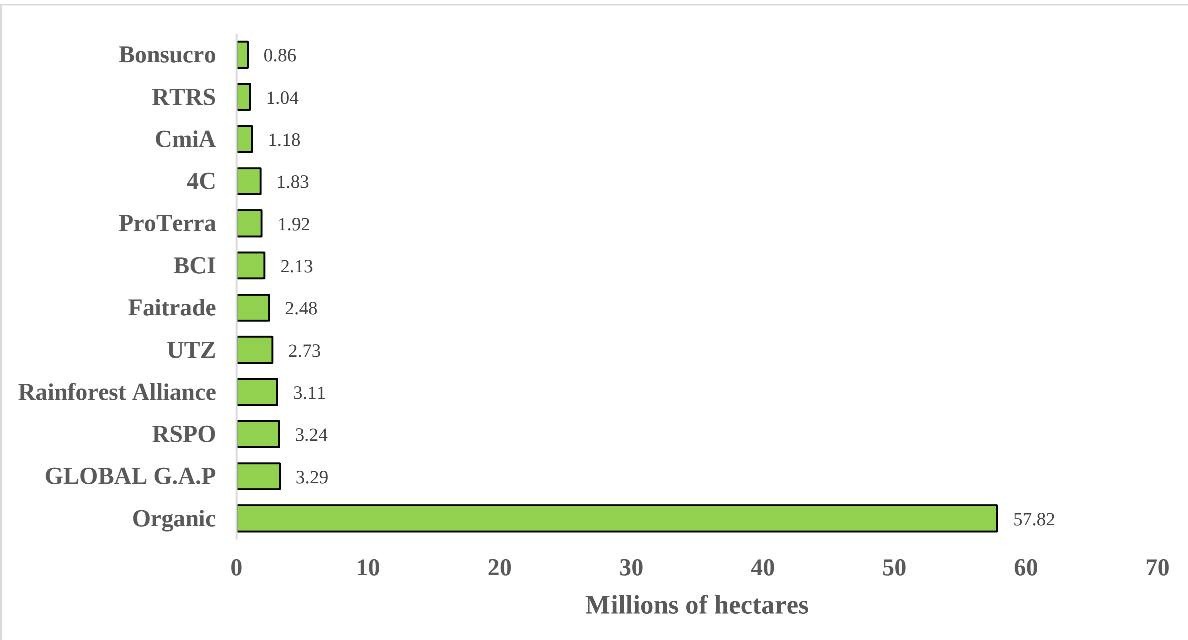


Figure 1-2: Global adoption of major certification standards (Lernoud et al., 2018)

At the global level, certification adoption by smallholders in Sub-Saharan Africa (SSA) is very notable. For instance, Africa accounts for about 47% of Fairtrade certification which is also dominated by SSA countries. Specifically, Ghana leads in terms of Fairtrade adoption globally (250,983ha). For UTZ certification, Africa accounts for 73% of certified area with Cote DÍvoire (more than 1.1Mha) and Ghana (401,487ha) being the leading adopters (Figure 1-3) (Lernoud et al., 2018). This increased adoption of certification relates to the importance of commodity crops in the wider national economies, the need to enhance the marketability of agricultural commodities as well as the heavy dependence of these crops by smallholder farmers (Mitiku et al., 2017; Chiputwa et al., 2015; Ingram et al., 2018). In addition, the adoption of certification relates with the type of certification, the requirements and the demands it exacts on smallholders (Djokoto et al., 2016). For instance, only 3% of land allocated to Organic certification is found in Africa (Lernoud et al., 2018). This may be related to the fact that Organic certification is much more stringent on environmental standards including the avoidance of synthetic chemical weed control (Djokoto et al., 2016) which may complicate the already high cost of certification or lead to lower yields, hence decreasing incomes.

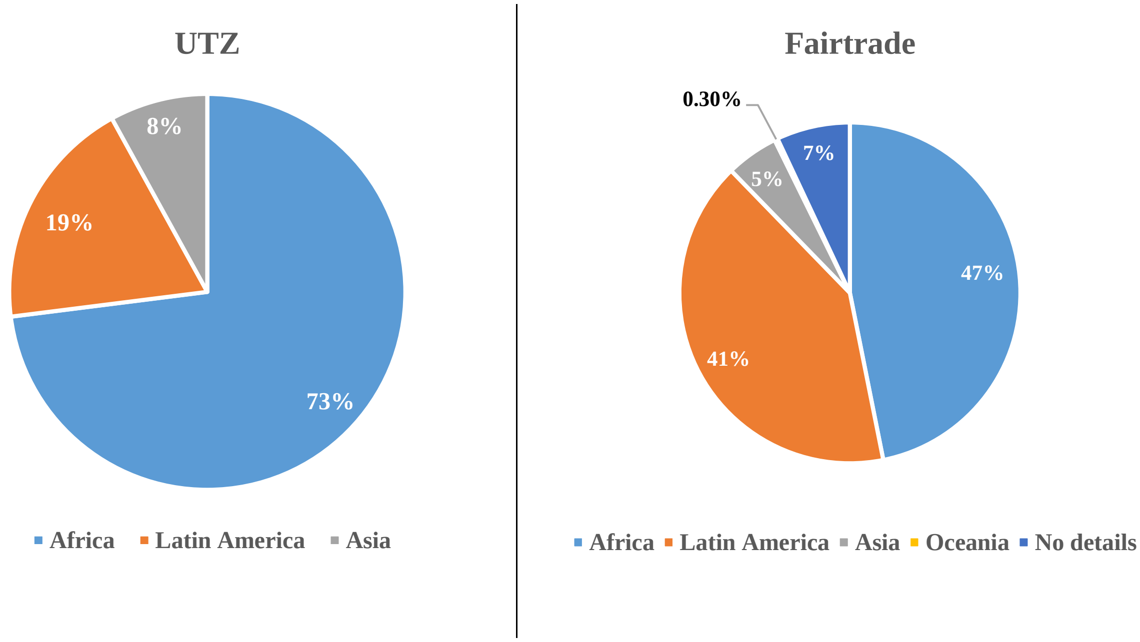


Figure 1-3: Global adoption of UTZ and Fairtrade certification

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 the mechanisms of certification adoption and 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 (Krumbiegel *et al.*, 2018; Kleemann & Abdulai, 2013; Jena & Grote, 2017; Ruben & Fort, 2012; Barham & Weber, 2012; Beuchelt & Zeller, 2011; Fenger *et al.*, 2017). However, the current literature on promotion mechanisms, adoption and impacts is limited and quite differentiated in terms of geographical context and crop type (Djokoto *et al*., 2016; Fenger *et al*., 2017; Khatun *et al*., 2020).

1.2 Commercial crop production in Ghana

1.2.1 History and commercial crop production patterns in Ghana

The main commercial crops produced in Ghana include cocoa, cotton, rubber, coffee, shea and oil palm (MoFA, 2011; MASDAR, 2011; Danso-Abbeam et al., 2014). As a result of their importance to Ghana's economy in terms of employment creation and foreign exchange revenue, they have received priority in the development of interventions and policies including Food and Agricultural Sector Development Policies (FASDEP), Medium Term Agricultural Sector Investment Plans (METASIPs) as well as specific political interventions eg. President's Special Initiative (PSI) and the current Investing for Food and Jobs plan (MASDAR, 2011; MoFA, 2007; MoFA, 2018). Among these crops that have contributed significantly to Ghana's development cocoa and oil palm are most important (Fenger *et al*., 2017; Khatun et al., 2020; Ansah et al., 2020). These crops have experienced different production dynamics which is related to colonial strategies of control, political support, potential for alleviating poverty as well as local and international demand for the crops (MASDAR, 2011; Carrere, 2013; Kolavalli & Vigneri, 2017)

Cocoa production began as one of the many crops grown in Ghana with no special importance. However, in 1893, the first export of two bags of cocoa out of the shores of Ghana began to hone an identity and relationship with the crop (Lowe, 2017). This was expedited by the activities of Christian Missionaries who before the commercial introduction had distributed seedlings to affiliate missions as an alternative to the livelihood challenges of locals, albeit with little success, (ECOWAS-SWAC/OECD, 2007). This effort coupled with the massive distribution drive by Tetteh Quarshie (introduced cocoa to Ghana) from his small nursery led to an increased allocation of farm land to cocoa production. Soon, national production figures began to soar until Ghana was recognized as the largest producer of cocoa in the world (Asuming-Brempong *et al*., 2007). Following the increase, there were widespread incidence of the black pod disease and the Cocoa Swollen Shoot Virus Disease which dipped production and wreaked untold hardship on Ghanaian farmers (Kolavalli & Vigneri, 2017) and led to Cote D'Ívoire overtaking Ghana in production. The Colonial government introduced a rehabilitation program which led to large hectares of cocoa farms been cut down. Because cocoa occupied a central part of the livelihood of farmers, the cutting down of cocoa trees spelled untold hardships and courted greater disaffection for the colonial government which eventually was exploited by the Ghanaian political system to gain independence (Kolavalli & Vigneri, 2017; Asuming-Brempong *et al*., 2007).

Throughout the history of cocoa production in Ghana, there has been generally four phases of development. These phases include: initial adoption and rapid cultivation (1988 to 1937); slow growth followed by a short but sharp increase in production after independence (1938 to 1964); near total failure of the sector (1965 to 1982); and the period of regaining its growth potential and current production increase (1983 to date) which was partly as a result of interventions in the Economic Recovery Program. All these phases have shaped the current structure of the cocoa sector: privatization of the produce buying company (PBC), liberalization of local purchase of cocoa beans from farmers as well as continuous control of the export of cocoa by the government through the Ghana Cocoa Board (Kolavalli & Vigneri, 2017).

Oil palm production also followed similar historical trends as smallholder production dominated production fields (MASDAR, 2011). This production system dominated because the British colonial administration in Ghana was somewhat opposed to plantation development, partly due to the fact that they thought plantations may marginalize peasants which may court disaffection for the colonial authority and also disrupt exports to Britain (Carrere, 2013). Also, they believed that small-scale production was more resilient compared to plantations (MASDAR, 2011).

The Dutch however had some interest in oil palm plantation and was widely promoted. Dickson (1969) mentions that at the beginning of the 18th century the Dutch established oil palm plantations along the coast. During the early part of the 20th century however, exports from Ghana significantly dwindled and farmers abandoned their plantations (MASDAR, 2011). Others also converted their farmlands into other more productive crops. This was primarily because world market prices at that time drastically reduced as a result of increased palm oil supply in the Dutch colonies within the Southeast Asia region as well as the discovery of new temperate zone substitutes (Folds, 2012). The end of British rule in 1957 marked a paradigm shift in the production of oil palm in Ghana. This was because the post-independence government of the day enacted a policy change that widely promoted oil palm plantations within the framework of food self-sufficiency. This policy favored the establishment of state-owned and state-operated plantations

(Carrere, 2013) which also stimulated local interest in oil palm cultivation around the zones of the plantations, which has characterized production systems till date.

Though production of cocoa and oil palm predates the colonial era, it was exploited by colonial governments as a way of exercising control as well as supply to companies in Europe (MASDAR, 2011; Kolavalli & Vigneri, 2017). In the post-colonial era, cocoa and oil palm have become major commercial crops for the Ghanaian economy contributing to employment creation and livelihoods of smallholder farmers (Danso-Abbeam et al., 2014; Anaglo et al., 2014). However, it has still maintained the colonial vestige of exporting large proportions of raw materials to Europe and other foreign countries partly due to the low level of industrialization and low domestic demand for cocoa products (Ackah et al., 2016; Asante-Poku & Angelucci, 2013).

1.2.2 Cocoa and oil palm production and impacts in Ghana

Cocoa (*Theobroma cacao* L.) and oil palm (*Elaeis guineensis*, Jacq.) are the main commodity crops produced in Ghana showing a consistent increase in production both in output and cultivated area (Figure 1-4) (FAOSTAT, 2020). They directly contribute to the livelihoods of about 800,000 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). Presently, Ghana is the 2nd largest producer of cocoa in the world and the 8th largest producer of oil palm contributing 3% and 1% to Ghana's GDP respectively (FAOSTAT, 2020; MASDAR, 2011; GSS, 2015). 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 (Aidoo & Fromm, 2015; Adjei-Nsiah *et al.*, 2012; Anaglo *et al.*, 2014).

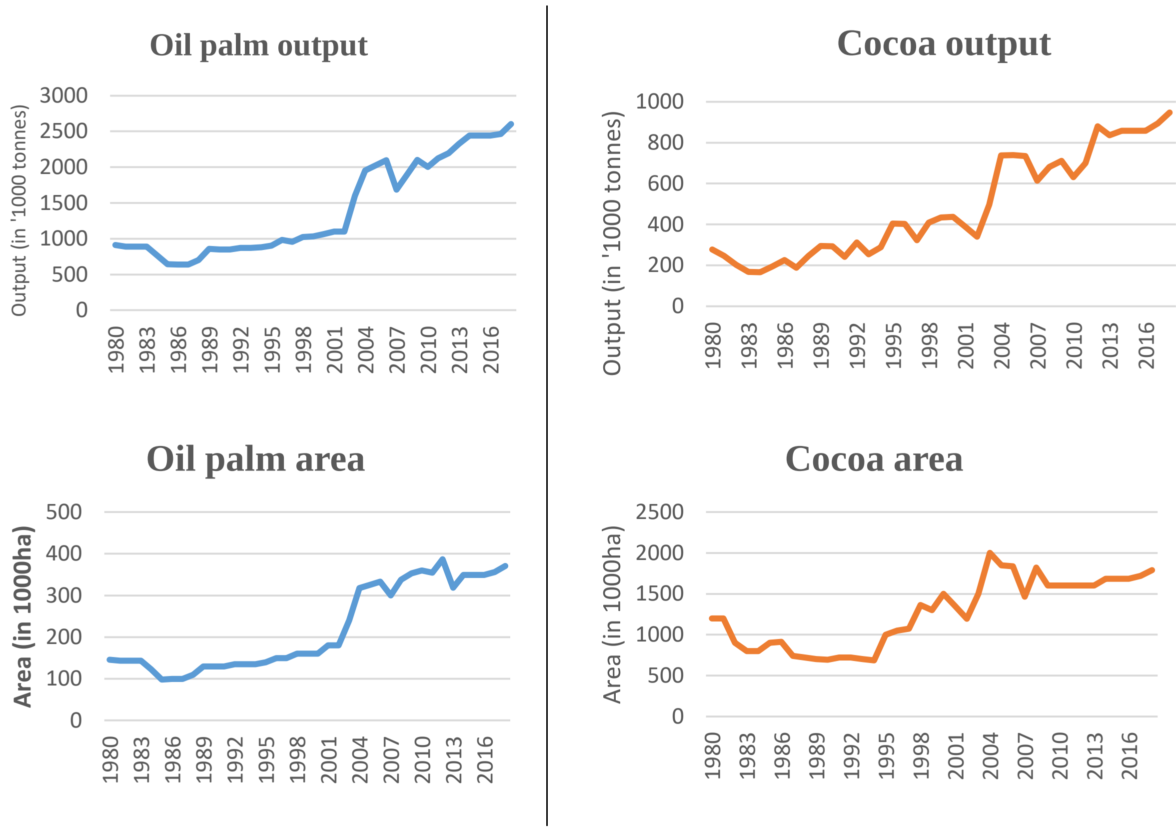


Figure 1-4: Output and cultivated area of cocoa and oil palm. Source (FAOSTAT, 2020)

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). Actually, both cocoa and oil palm productivity in Ghana are below global average levels (FAOSTAT, 2020; Danso-Abbeam *et al.*, 2012; MASDAR, 2011; Fold & Whitfield, 2012; 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).

However, cocoa and oil palm expansion have been associated with major environmental implications in Ghana in terms of land use change, deforestation and environmental pollution from excessive agrochemical use (Wessel & Quist-Wessel, 2015; Ofori-Bah & Asafu-Adjaye, 2011: Mason & Asare, 2014; Ntiamoah & Afrane, 2008; Danyo, 2013). Additionally, poverty is still endemic within most cocoa and oil palm production areas (Gockowski *et al.*, 2013; Asamoah *et al.*, 2013). Studies have also linked oil palm and cocoa production to low income generation (Kline *et al.*, 2017; Asamoah *et al.*, 2013; Anderman *et al.*, 2014), inequitable compensation (Fountain & Hütz-Adams, 2015), and poor labor practices, including child labour (Ingram *et al.*, 2018; Myzabella, 2019).

Furthermore, one of the major intersecting issues arising from the production of agricultural commodities has been the competition between the production of food crops and non-food cash crops such as cocoa, coffee, sugarcane, oil palm and jatropha (Hermann *et al*., 2018; Achterbosch et al., 2014; Anderman *et al*., 2014; Solidaridad, 2016). Reviews of the academic literature have suggested that engagement in the production of such non-food crops can have radically different food security outcomes, which are mediated through different mechanisms depending on the crop, mode of production and the socioeconomic and environmental context (Jarzebski *et al*., 2020; Wiggins *et al*., 2015). About 67 percent of cocoa farmers have thus been linked with high levels of food insecurity (Antwi *et al*., 2018) whiles oil palm farmers may also suffer food insecurity (Anderman *et al*., 2014).

In response to these negative environmental and socioeconomic impacts and characteristics, certification standards have been widely promoted in the cocoa and oil palm sectors to ensure sustainable production (Fenger *et al*., 2017; Khatun *et al*., 2020). Even though certification offers opportunities for product differentiation and new markets for Ghanaian cocoa and oil palm, there is no comprehensive policy in Ghana directly promoting certification. Furthermore, many producers are reluctant to adopt certification standards due to the high direct and opportunity cost, lack of capacity, and the fact that proliferation of certification standards sometimes confuses farmers and/or causes implementation errors (Ingram *et al*., 2018; Oya *et al*., 2018; Djokoto *et al*., 2016).

1.2.3 Process of oil palm and cocoa certification in Ghana

Certification standards are voluntary schemes promoted to achieve sustainable production and entails the strict internalization of socially and environmentally responsible production practices (Djokoto *et al*., 2016; Ansah *et al*., 2020). However, the standards differ depending on the focus and standard modalities. For instance, some standards are much more stringent in terms of environmental requirements while others have an increased focus on enhancing farm yields in a more sustainable way (UTZ, 2015; Djokoto *et al*., 2016)

Currently, various sustainability standards[2] target the two sectors, including Fairtrade, UTZ, Rainforest Alliance (RA) (UTZ and RA were separate entities), Organic and Roundtable on Sustainable Palm Oil (RSPO) (Oya *et al*., 2018). Some of the most common socially and environmentally responsible practices include the use of recommended pesticides, the avoidance of bush burning, protection of High Conservation Value areas and avoidance of child labour on farms (RSPO, 2014; SAN, 2017; UTZ, 2015). Certification principles and criteria are largely set at the international level and therefore certain local factors may not favour the adoption of the standards. As such, national interpretations involving civil society organizations, private sector, farmer representatives and certification agencies collaborate to give a national definition of the standards to ease operationalization at the local level (RSPO, 2014).

[2] Sustainability standards refer to voluntary schemes consisting of environmentally, socially and economically responsible production practices ensuring that production does not negatively affect people, the planet and profits (Mitiku et al., 2017; Fenger et al., 2017).

Certification processes involve multiple different actors in diverse ways across the entire value chains of agricultural commodities (Fenger *et al*., 2017; Oya *et al*., 2018). This includes, among others, producers (e.g. private companies, individual farmers), as well as government agencies that regulate the agricultural sector, Non-Governmental Organizations (NGOs) that promote certification standards or support farmers, and companies that oversee the proper adoption and implementation of standards (Fenger, *et al*., 2017; Djokoto *et al*., 2016; Khatun et al., 2020).

Certification involves three main continuous stages including a) Training on certification principles and criteria, b) auditing and verification against principles and c) periodic auditing (Fenger *et al*., 2020; Ansah *et al*., 2020; RSPO, 2015, SAN, 2017). The first process involves training of farmers and company staff on using nationally interpreted certification principles and criteria for certification schemes. As such, farmers and large plantations make changes to production activities based on the recommended principles and criteria (Mitiku *et al*., 2017; Khatun *et al*., 2020; Djokoto *et al*., 2016). This often involves high costs related to input change, labour and setting up internal management systems (Kuits & Waarts, 2014).

Secondly, audits and verification are conducted by certification agencies such as Control Union and SGS to ascertain the strict compliance of principles and criteria. Audit findings are presented to the overarching body for the specific certification standards, for certificates to be granted or denied to farmers or companies (rspo.org; utz.org). Improvements are also recommended to farmers where necessary (RSPO, 2015, SAN, 2017). From this stage, farmers can produce and supply products using the subscribed certification labels.

The next aspect of the certification process involves periodic audits of farms and production settings to ensure continuous compliance with established criteria which may result in revocation of certificates as a result of non-compliance (RSPO, 2019; RSPO, 2015, SAN, 2017).

This is because some farmers abandon the use of the principles after obtaining certificates for standards (Ansah et al., 2020), which emphasizes the role of intermediaries (Buyers and Group administrators) as well as provision of support systems such as input credit for maximum compliance.

Even though certification offers opportunities for product differentiation and new markets for Ghanaian cocoa and oil palm, there is no comprehensive policy in Ghana directly defining or promoting oil palm and cocoa certification. Furthermore, many producers are reluctant to adopt certification standards due to the high direct and opportunity cost, lack of capacity, as well as the low/lack of premiums for (Ingram *et al*., 2018; Oya *et al*., 2018; Djokoto *et al*., 2016; Oya *et al*., 2018)

1.2.4 Cocoa certification in Ghana

Ghana is one of the developing countries whose economy relies to a large extent on cocoa production, and that has experienced a recent surge in the promotion of certification standards as highlighted above (Danso-Abbeam *et al*., 2014; Waarts *et al*., 2015). Currently, certification standards have become an integral part of the cocoa value chain, with different certification schemes promoted by NGOs and private sector stakeholders in most production areas. The certification standards that dominate the two sectors include Fairtrade, Organic, UTZ and Rainforest Alliance (RA) (UTZ and RA used to be separate entities). Certified cocoa production accounts for approximately 46% of total cultivated area, but there is a high possibility of over-estimation (30-50%) due to double and triple certification (Fenger *et al*., 2017; Lernoud *et al*., 2018). The main certification schemes for cocoa smallholders are UTZ/Rainforest Alliance which accounts for 529,891 ha and Fairtrade (245,746 ha), with minor adoption of Organic certification (Lernoud *et al*., 2018; FAO, 2020; Djokoto *et al*. 2016).

The structure of the cocoa sector in terms of policy, value chain actors and local demand for cocoa has influenced the adoption of cocoa certification in Ghana as well as the varied motivation and interests of the stakeholders (Ansah et al., 2017; Moreno-Penaranda et al., 2015). These motivations and vested interests depend largely on stakeholder position and functionality within the respective crop's value chain (Fenger et al., 2017; Djokoto et al., 2016). For smallholders, one of the most important motivations is income gains through yield improvements and premium payments (Mitiku et al., 2017; Ssebunya et al., 2019). Yield improvements usually manifest through the adoption of good agricultural practices, and improved access to credit and extension services, which are facilitated during the process of standard adoption (Djokoto et al., 2016; Rijsbergen et al., 2016).

For buyers and processing companies, the certification standards are mainly promoted or adopted as a means of meeting consumer demand for sustainable products, stabilizing/diversifying market access and essentially enhancing their bottom line (Ansah et al., 2017; Ansah et al., 2020). The above suggest that it is economic factors mostly influencing the engagement of producers and middlemen with certification. Conversely, the civil society organisations advocating certification standards or training local communities in their implementation, are mostly driven by their commitment to promote sustainability (e.g. Solidaridad, 2019), though the main sustainability issue (e.g. biodiversity conservation, fair compensation, poverty alleviation) varies to some degree between organisations.

The profit motives particularly for Licensed Buying Companies and Group Administrators (GAs) who are mandated to purchase cocoa and mobilize farmers, has stimulated a strong competition for independent smallholder farmers to adopt certification using their certification labels in order to mobilize more cocoa for onward sale to the Ghana Cocoa Board (the mandated institution to trade cocoa on the world market) (Waarts *et al*., 2015; Fenger *et al*., 2017; Ansah *et al*., 2017). For whichever method of promotion of certification, independent smallholder cocoa farmers however have the choice to adopt certification standards depending on their expectations and other household factors (Fenger *et al*., 2017). This is because certification is voluntary and farmers are not mandated to adopt certification, except that certified farmers receive price premium for adopting certification (Djokoto *et al*., 2016)

1.2.5 Oil palm certification in Ghana

Oil palm certification adoption is much lower (approximately 5% of total cultivated area) (FAOSTAT, 2020; Lernoud *et al*., 2018), with the dominant certification scheme being the Roundtable on Sustainable Palm Oil (25,478 ha). Other schemes such as Organic and Fairtrade certification are adopted by farmers (Lernoud *et al*., 2018). This trend of oil palm certification is largely shaped by the structure of the oil palm market, local demand and availability of support systems for adoption (Khatun *et al*., 2020; MASDAR, 2011). Oil palm is produced in hybrid systems consisting of large core plantations, surrounded by smallholders contractually linked to the plantations (scheme/outgrowers) and independent smallholders (Aidoo & Fromm, 2015; Adjei-Nsiah *et al.*, 2012; Anaglo *et al.*, 2014). In addition, palm oil is an important ingredient in local diets which has influenced the local demand for oil palm fresh fruit bunches (FFB) (Oosterveer et al., 2014; MASDAR, 2011). Moreover, support systems for the adoption of certification is quite low compared to cocoa certification which also partly influenced by the lack of contractual agreements between buyers and independent farmers (MASDAR, 2011).

Based on the above characteristics, oil palm certification, particularly, RSPO has been a new concept in the Ghanaian context with large oil palm plantations/mills dominating the adoption (MASDAR, 2011, Khatun et al., 2020). As a company, plantations/mills are motivated to adopt certification as a means of meeting consumer demands and increase markets, enhance public perception as well as guarantee the sustainability of company profits (MASDAR, 2011; MoFA, 2012). Upon adoption, certified large oil palm plantations support scheme smallholders to adopt certification standards because they are contractually linked to the large plantations and are mandated to sell certified FFB to the plantations. This is important because of the huge cost associated with certification, low resource capacity of smallholders and the lack of premiums. (Khatun et al., 2020; MASDAR, 2011; Rietberg et al., 2016).

Independent farmers, who self-organize, self-manage, self-finance their farms and have the freedom to sell FFB to any mill have been excluded from the certification system (RSPO, 2014). This is because of the low resource capacity, the high local demand for FFB and the lack of contracts between independent farmers and larger plantations (MASDAR, 2011; RSPO, 2015) which does not appeal to larger plantations to support independent farmers to adopt. In addition, the lack of premiums in oil palm certification is a major factor that has stalled RSPO adoption by farmers (Rietberg et al., 2016). This has influenced the implementation of RSPO Smallholder Support Fund (RSSF) at the international level to promote certification (Rietberg et al., 2016; Oosterveer et al., 2014).

1.3 Drivers and impacts of certification in Sub-Saharan Africa and Ghana

1.3.1 Drivers of certification adoption

1.3.1.1 Demographic factors

1.3.1.1.1 Age of household head

Age of household heads have been cited as a determinant of technology adoption (Chiputwa et al., 2015; Ruben & Fort, 2012). Age comes with experience, which implies that the older an individual is the higher the level of experience (Awuni et al., 2018). Within households in Ghana, household heads play a key role in decision making on household members as well as on household assets like land. They influence greatly which crops should be planted on farmlands as well as adoption of technologies like certification standards. Age of household is therefore modelled as a factor that could possibly influence the adoption of technologies (Awuni et al., 2018; Arslan et al., 2014).

1.3.1.1.2 Gender of household head

Gender of a household head influences adoption of technologies including certification (Djoko et al., 2016). Cocoa and oil palm production are cash/industrial crops in the Ghanaian context (Gockowski et al., 2013; Waarts et al., 2015). Production of these crops is largely dominated by males as compared to female farmers. This is because male household members are driven towards cash crops to enable them have access to cash for household expenditure (Hill & Vigneri, 2009). Women however are normally driven towards cultivation of food crops for household consumption. In cases, where food crops yield significant income, males may take over marketing activities (Hill & Vigneri, 2009). Therefore, certification adoption in cocoa production may be more tilted towards male smallholders as compared to female counterparts.

1.3.1.1.3 Education of household head

Education may affect a farmer's decision to adoption certification standards (Asante et al., 2013; Etwire et al., 2016). Education opens individuals to be able to access information from various avenues. Educated farmers are more likely to adopt certification because they can better understand the principles, criteria and guidelines, as well as the impact (Yigezu et al., 2018; Darkwah et al., 2019). It may take a lot of education and persuasion for a complete understanding for an adoption decision for farmers with low level of education. Also, educated farmers are more open to learn new methods as compared to less educated farmers. In addition, documentation is not a challenge to educated smallholders compared to less educated farmers. This because they adopt technologies that they can easily understand and practice (Martey et al., 2014; Chandio & Jiang, 2018). In this way, more educated farmers are likely to adopt certification standards. However, education of household heads can have a negative effect on certification adoption because farmers may be able to access sustainable practices on their own without necessarily adopting certification standards (Djokoto et al., 2016)

1.3.1.1.4 Household size

The size of a household indicates the labour available to households for production purposes (Anang, 2018). It influences a household's decision to adopt new technologies including certification (Ghimire et al, 2015; Chiputwa et al., 2015). Thus, technologies that are labour intensive may be appealing to large-sized households. In the case of certification, it is difficult to state whether certification increases labour requirements (Waarts et al., 2015; Chiputwa et al., 2015). It is envisaged that the initial labour requirements are high compared to later years of adoption because farmers have to make structural changes in their production practices (Waarts et al, 2015; Fenger et al., 2017).

1.3.1.2 Institutional factors

1.3.1.2.1 Access to extension

Extension leads to the communication of good agricultural practices and recommended technologies to farmers (Omondi et al., 2014; Anang, 2018). Hence, extension access has been modelled as a factor that affects the adoption of recommended production practices including certification (Awuni et al., 2018; Omondi *et al*., 2014; Anang, 2018). Extension agents from government, NGOs and Licensed Buying companies are assigned to production areas to provide capacity building and technical support to farmers. In doing so, farmers learn new methods of production which farmers' awareness of certification standards. It is expected that farmers exposed to extension agents have a greater probability of adopting technologies such as certification as compared to farmers who are less exposed to extension support (Awuni et al., 2018; Arslan et al., 2014).

1.3.1.2.2 Membership of Farmer Based Organizations

Farmer organizations are important institutions for knowledge sharing and points of contact for technology transfer. Extension agents and NGOs interested in sustainable production may contact farmer groups to educate them on recommended production methods. It is expected that farmers with membership in farmer groups may have a greater probability of adopting new methods of production including certification as compared to non-members (Nkegbe and Shankar, 2014; Mitiku et al., 2017; Awuni et al., 2018). This is because they are more exposed to new sustainable technologies and may exhibit better appreciation of technologies than non-members of farmer groups.

1.3.1.2.3 Credit access

Farmers' access to credit is quite limited. This may be partly due to the lack of collateral to secure loans from formal financial institutions. In addition, there are few tailor-made financing schemes that meets the production needs of farmers. Since certification is capital intensive in terms of the cost of audits, inputs as well as continuous changes to production practices (Fenger et al., 2017; Ansah et al., 2020), it is expected that farmers with access to credit have higher probability of adopting certification compared to farmers with lower access to credit (Awuni et al., 2018; Chandio & Jiang, 2018). Djokoto et al (2016) report that access to credit has significant positive relationship with farmers' willingness to adopt organic certification.

1.3.1.2.4 Ownership of information access devices (Radio, television and mobile phone)

Radio and television are important information access equipment. Various programmes are aired on radio and television where farmers may be informed about sustainable practices. In this way, farmers owning radio and television have increased awareness of sustainable production practices and may increase the probability of adopting certification as compared to households without such devices (Chiputwa *et al*., 2015; Awuni et al., 2018). Also, mobile phone usage is important in accessing information on new technologies from farmers in other areas or extension agents. Hence, farmers with access to mobile phones have a greater probability of adopting certification as compared to farmers without access to mobile phones (Chiputwa et al., 2015; Awuni et al., 2018).

1.3.1.3 Financial factors

1.3.1.3.1 Household income/Off-farm income

Certification adoption requires high initial investment (Ansah *et al*., 2020; Chiputwa *et al*., 2015). This may involve cost of certification and procurement of inputs such as protective equipment and agro-chemicals (MASDAR, 2011; Mitiku et al., 2017). Hence, the income generated in a household could influence the adoption of certification. In cases when farm incomes are not enough to support the process of adoption partly due to output fluctuations from disease and pest outbreaks, as well as price fluctuations, off-farm incomes may provide extra income to support the adoption process. Off-farm generating activities may provide livelihood support to farming households which gives farmers the opportunity to try new technologies (Asante *et al*., 2013; Darkwah *et al*., 2019). It is expected that farmers with non-farm income generating activities may have greater possibility of adopting certification as compared to farmers without off-farm income generating activity (Asante et al., 2013; Ghimire et al., 2015).

1.3.1.3.2 Livestock ownership

Livestock rearing in rural households serves as a store of value or security for households. It serves as a savings for rural households implying that in times of household need, livestock could be sold to offset expenditure. In the certification adoption, households owning livestock have a greater probability of adopting because they may easier access to funds to invest in the certification process as compared households who don't rear farm animals. In addition, they may afford to experiment new technologies with guaranteed security in case of failure of the technology (Arslan et al., 2014; Ghimire et al., 2015; Mitiku et al., 2017).

1.3.1.4 Farm characteristics

1.3.1.4.1 Total farm size

The size of farm lands influences farmers' decision to adopt technologies including certification (Anang, 2018; Bravo-Monroy et al., 2016). Farmers with larger cocoa and total land sizes have a greater possibility of adopting certification. Farm size tends to have a positive influence on farmer decision to adopt certification, as households with more land are usually associated with higher endowment, resource availability, and often willingness to "experiment" with new practices (Anang, 2018; Bravo-Monroy et al., 2016). In this way, they may adopt recommended practices with ease compared to households with limited land (Etwire et al., 2016; Martey et al., 2014).

1.3.1.4.2 Farm yield

The farm yields influence the adoption of certification standards (Djokoto et al., 2016). Smallholders depend heavily on the production of cocoa and oil palm for their livelihood (Danso-Abbeam et al., 2014; MASDAR, 2011; Anaglo et al., 2014). As such decreases in yield with its attendant decrease in income has dire consequences on farmers' livelihoods (Djokoto et al., 2016; Fenger et al., 2016). Farmers look for alternatives to improve their yields through certification and other yield enhancing schemes. From this, farmers with lower yields may be inclined to adopt certification compared to farmers with higher yields.

1.3.1.5 Market factors

1.3.1.5.1 Consumer demand

Consumer demand is a factor that influences the adoption of certification (Tran & Goto, 2019; Djokoto et al., 2016). Consumers represent a critical part of commodity value chains because their satisfaction affects the profitability of firms. NGO and Consumer advocacy on responsible production has increased consumer awareness about poor production practices on cultivation fields (Bray & Neilson, 2017; Mitiku et al., 2017; Mull *et al*., 2005; Berlan, 2013). For instance, widespread and intense advocacy on the prevalence of child labour on cocoa production fields encouraged consumers to demand for sustainable production (NEPCON, 2017; Mithofer et al., 2017; MASDAR, 2011). As such, the market for certified and traceable products has increased over the years (Lernoud et al., 2018). Hence, farmers, large mills and other relevant organizations adopt certification to assure consumers of sustainable production to guarantee consistent markets for their products (Fenger et al., 2017; MASDAR, 2011)

1.3.1.5.2 Associations with larger companies

Certification adoption is largely voluntary and is based on farmers' decision to adopt sustainable production practices (Chiputwa et al., 2015; Waarts et al., 2015; Mitiku et al., 2017). This is because in the current context of production in most Sub-Saharan countries, the local regulatory system for sustainable production is quite low (Tran & Goto, 2019). However, adoption may depend on farmer association with an entity (Khatun et al., 2020; MASDAR, 2011) which mandates them, whether willing or unwilling, to adopt. For instance, the current state of certification in the oil palm sector in Ghana is largely implemented by large plantations/mills which adopt certification. Scheme smallholders have been established by these large companies and are bounded by contracts (Khatun et al., 2020; MASDAR, 2011). As such, it is obligatory for scheme smallholders to adopt certification, with support from the large mills.

1.3.2 Impact of certification adoption on smallholders

1.3.2.1 Increased farm yield

Certification adoption involves the internalization of good agricultural practices (GAPs) (Mitiku *et al*., 2017; Ruben & Zuniga, 2011; Fenger *et al*., 2017; Djokoto *et al*., 2016). The correct implementation of these gaps requires access to inputs and extension. As such, farmers' access to inputs such as fertilizer and pesticides are enhanced to enable them adopt sustainable production practices (Chiputwa *et al*., 2015; Tran & Goto, 2019; Gockowski *et al*., 2013). The proper application of the GAPs enables farmers to increase yields thus reducing the deforestation of forests as a result of low yields recorded on farms. In addition, the microclimate created on farms as a result of implementing GAPs may influence tree nutrient uptake which affects the productivity of the farm (Waarts et al., 2015; RSPO, 2015).

Though the expectation is that adoption of certification may increase yield, literature shows mixed results based on a myriad of factors including type of standard, climatic conditions, tree age and lack of strong support by agencies. For instance, organic certification may reduce farm yields as a result of the strict avoidance of synthetic chemicals (Djokoto *et al*., 2016; Mitiku *et al*., 2017; Furumo *et al*., 2020). Farmers may however increase incomes as a result of increased premiums.

1.3.2.2 Increased income

Adoption of certification is expected to enhance the income of farmers and eventually improve the poverty status of farm households (RSPO, 2017; Khatun *et al*., 2020; Djokoto et al., 2016; Frondel *et al*., 2018). The increased income occurs through two main avenues: increased yields and premiums. First, certification enhances farmer access to productive assets which are applied on farms to increase farm yields and subsequently reflecting in increased incomes (Mitiku *et al*., 2017) and better livelihood outcomes. Second, certification enhances farmer access to markets that may guarantee premium prices for produce. This enhances the income of farmers (Waarts *et al*., 2016; Tey *et al*., 2020).

Literature abounds on the impact of certification on income of farmers. However, the impact is quite mixed. While certification is expected to increase farm incomes (Gockowski *et al*., 2013; Waarts *et al*., 2015; Mitiku *et al*., 2017) observe that organic certification reduces the incomes of farmers mainly due to reduced yields. In addition, the role of premiums in enhancing farm incomes have been questioned considering the dwindling premiums obtained by farmers (Tey *et al*., 2020; Mitiku *et al*., 2017). For instance, Waarts *et al* (2015) found that premiums only increased cocoa farm incomes by about 2 percent while oil palm premiums either very low (Furumo *et al*., 2020) or have not materialized in the context of Ghana (Khatun *et al*., 2020). Hence, increased incomes are mostly attributed to increased yields and diversified access to markets as a result of certification adoption (Waarts *et al*., 2015; Ssebunya *et al*., 2019; Khatun *et al*., 2020)

1.3.2.3 Increased food security

Cash crop agriculture directed towards industrial use rather than household food needs, is a common but debated strategy aimed at increasing farmer resilience to food insecurity (MASDAR, 2011; Anderman *et al*., 2014). This follows the logic that increased household incomes from crop sales may increase farmer's purchasing power to access food. Thus, the impact of agricultural commodities on household food security is dependent on whether incomes from cash crops are able to translate to food expenditures that cover the gaps as a result of reduced food crop production (Kline *et al*., 2017; Kuma *et al*., 2019; Achterbosch *et al*., 2014). This may occur as a result of resource competition such as land, between food and non-food crops thus reducing the availability of food for household consumption (Kline *et al*., 2017).

Though not always explicitly articulated in their theories of change, the adoption of certification standards, can affect directly and indirectly farmers' food security in a positive or negative manner (Oosterveer *et al*., 2014). Some of the positive impacts manifest through (a) enhanced farmer income (through yield improvements and premiums payment) that are used to buy food (Gockowski et al., 2011; Oosterveer *et al*., 2014; Chiputwa and Qaim, 2016), (b) access to knowledge on Good Agricultural Practices (GAPs) through better access to extension services (Ansah *et al*., 2020), (c) access to credit and agricultural inputs through closer connections with companies or ability to form farmer groups (Fenger *et al*., 2017; Ansah *et al*., 2020). This acquired knowledge and inputs from cash crops may be transferred to improve the productivity of other food crops within these farms, and further increase food crop yields and income (Oosterveer *et al*., 2014). Conversely, certification adoption might have negative food security outcomes through (a) increased production costs due to audit costs and changes in production practices, which may disrupt access to food (Bush et al., 2013; Dankers, 2003; Fenger *et al*., 2017), (b) displacement of food crops to specialize in cash crop production (Oosterveer *et al*., 2014; Kline *et al.*, 2017).

1.3.2.4 Enhanced gender equality and intergenerational sustainability

In agricultural commodities production, female farmers have been cited as been disadvantaged in terms of access to lands, inputs and credit (Ragsdale *et al*., 2018) which leads to decreased adoption of agricultural technologies (Awuni *et al*., 2018; Anang, 2018). This negatively influences farm level outcomes including yields and incomes. Moreover, a major issue associated with cocoa and oil palm production is child labour which has raised consumer concerns (Mull *et al*., 2005; Berlan, 2013; NEPCON, 2017; Mithofer et al., 2017). Almost all (92%) children engaged in the cocoa production are involved in activities detrimental to their health and wellbeing (Luckstead *et al*., 2015). This alarming observation may not just be emanating from poverty but also a contributor to intergenerational poverty.

As a result, certification standards capture principles and guidelines that aim to enhance gender equality and intergenerational sustainability including avoidance of child labour and other bad labour practices on farms (RSPO, 2014; SAN, 2017; UTZ, 2015). In the case of guaranteeing gender equality, certification stakeholders i.e. LBCs and GAs, ensure equal access to productive resources including agrochemicals and credits to bridge the gender gaps (Ansah *et al*., 2017; Djokoto *et al*., 2020; Fenger *et al*., 2017). In the case of child labour issues and intergenerational sustainability, a number of mechanisms have been suggested/implemented in literature including enhanced income through premiums, child labour monitoring in farming communities as well as provision of development projects such as schools, by certification agencies (Luckstead *et al*., 2015; Djokoto *et al*., 2020; Fenger *et al*., 2017). This ensures that farming communities have access to development projects for children to have normal courses of development to break the cycle of poverty in farming households. In spite of this, the realization of social sustainability is quite mixed, showing positive or zero effect (Ingram *et al*., 2018) of certification on social sustainability practices such as child labour.

1.3.2.5 Improved working conditions, health and safety

Agricultural commodity production including cocoa and oil palm are sometimes characterized by poor labour conditions including employing high number of casual labour as well as negligence of farm workers' health and safety (Waarts et al., 2015; Gottwald, 2018). In case of casual labourers, the continuous employment in such categories exposes farmers to high levels of vulnerability as a result of a lack of consistent working schedule which reflects in inconsistent income (Gottwald, 2018). Through collaborations between international labour rights organizations, trade unions and certification agencies, certification standards have emphasized in the principles and guidelines to address labour abuses in the production of cocoa and oil palm sectors (POIG, 2016).

Moreover, oil palm and cocoa farmers sometimes use banned chemicals and in large amounts as a result of the lack of education on appropriate chemical handling and storage or the low level of financial capacity (Fenger *et al*., 2017; Ansah *et al*., 2020). This may result in exposure to chemical residues that sometimes put the health of farm workers in jeopardy (NEPCON, 2017; RSPO, 2015). Certification standards exposes farmers to proper pesticide handling, storage as well as the use of appropriate protective equipment such as boots and overcoats to protect ensure the health and safety of farmers (Bray & Neilson, 2017; RSPO, 2014; SAN, 2017; UTZ, 2015). In spite of the positive impact of certification on farmer health and safety (Waarts *et al*., 2015; Furumo *et al*., 2020), some literature have reported zero effect of certification on the health and safety of smallholders and farm workers (Ingram *et al*., 2018). Moreover, research on the impact of certification on health and safety is still scarce (Furumo *et al*., 2020) in spite of the direct relationship.

1.3.2.6 Increased environmental sustainability

Cocoa and oil palm production has been associated with negative environmental practices such as deforestation and environmental pollution from excessive agrochemical use (Wessel & Quist-Wessel, 2015; Ntiamoah & Afrane, 2008; Khatun *et al*., 2020; MASDAR, 2011; Mason & Asare, 2014). These impacts may result from the lack of education on environmentally responsible production as well as farmers' quest to increase farm outputs through farm expansion (Djokoto *et al*., 2020; Fenger *et al*., 2017).

Concerns over such negative agro-ecological practices have resulted in the promotion of certification standards (Kleeman & Abdulai, 2013; Oya *et al*., 2018). Certification standards present a bundle of interventions that aim to build the capacity of farmers in the area of environmentally responsible production (Tayleur *et al*., 2018). As a result, farmers follow recommended environmental practices such as preserving High Conservation Value Areas as well as observing buffer zones for water courses (RSPO, 2014; SAN, 2017; UTZ, 2015). Despite the expected impact of certification on environmental sustainability, mixed results have been observed for smallholder farmers (Waarts *et al*., 2013). Low environmental practices implementation may be observed for smallholders as a result of the relaxed support of promoting agencies (Ansah *et al*., 2020). In addition, the increased access to inputs such as pesticides may complicate environmental sustainability agenda as a result of excessive usage, hence failing to ensure adequate balance between socio-economic and ecological outcomes (Vanderhaegen *et al*., 2018).

1.4 Research gaps

First, the major knowledge gap on certification adoption among cocoa and oil palm farmers revolve around the limited number of methodologically robust approaches to analyze adoption and impacts associated with certification adoption in Ghana (Djokoto *et al*., 2016; Fenger *et al*., 2017; Gockowski et al., 2013). Studies often fail to control for the inherent selection biases that may jeopardize the generalization of results (Krumbiegel *et al.*, 2018; Fenger *et al.*, 2017; Kleeman & Abdulai, 2013). For example, some studies have relied on simple descriptive statistics to provide cursory insights into certification impacts, being prone to selection biases (Fenger *et al.*, 2017). Certification impacts are analysed using the propensity score matching approach to address the selection biases as presented in Chapter five.

Secondly, a major gap in the literature is related to variable selection to measure impact. Most impact studies have been limited to monetary measures of economic wellbeing, without considering non-monetary measures such as multidimensional poverty (Mitiku *et al.*, 2017; Chiputwa *et al.*, 2015). Hence, failing to highlight the multidimensionality of poverty. This thesis combines monetary (income) and non-monetary measures of wellbeing to present a holistic view of the wellbeing impacts of certification adoption among farmers (Chapter five). 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, which has influenced the structure of this thesis in synthesizing findings from both oil palm and cocoa smallholders (Chapter 2).

In addition to the general scarcity of literature on cocoa and oil palm certification, there seem to be a lack of concentration on how certification can mitigate the negative food security impacts of industrial crop production (Chiputwa & Qaim, 2016; Kline et al., 2017; Schleifer & Sun, 2020). Existing impacts on food security are context-dependent (Schleifer & Sun, 2020) showing either positive (Chiputwa & Qaim, 2016) or negative impacts (Nesadurai, 2013).

Finally, for crops such as cocoa and oil palm that contribute significantly to livelihoods, there is evident lack of literature on how certification is adopted given the varied configurations of these sectors (Djokoto et al., 2016). Moreover, it is important to understand the existing connections among stakeholders as well as perceptions on drivers and barriers of certification adoption.

1.5 Research aims and objectives

Based on the existing gaps in the current literature on the adoption and impact of certification outlined in Section 1.4, this research assesses the adoption and impacts of certification standards for oil palm and cocoa smallholders in Ghana.

The specific objectives include:

5) To understand the perceptions of the main stakeholders involved in oil palm and cocoa value chains towards certification, as well as the existing connections in the context of certification
6) To analyse the promotion and adoption dynamics of farmer participation in certification programmes
7) To establish the impact of certification adoption on farm productivity, multidimensional poverty, income, and food security
8) To provide policy recommendation to enhance the adoption and impacts of certification for smallholders in Ghana

1.6 Focus on oil palm and cocoa

This thesis focuses on cocoa and oil palm smallholders in Ghana for two main reasons. First, cocoa and oil palm are the major industrial crops in Ghana contributing to the livelihoods of about 800,000 and 600, 000 households respectively (Anaglo *et al*., 2014; Danso-Abbeam *et al.*, 2014). In addition, Ghana is the 2nd largest producer of cocoa in the world and the 8th largest producer of oil palm in world (FAOSTAT, 2020) contributing 3% and 1% to Ghana's Gross Domestic Production (GSS, 2015; MASDAR, 2011). This makes the choice of cocoa and oil palm for this study very important because of the envisaged wider impact on the sustainability of production and livelihoods. Secondly, cocoa certification is dominated by independent smallholders (with adoption choice) while oil palm certification is dominated by large plantations and associated scheme smallholders (under obligation to adopt). Hence, focusing on oil palm and cocoa smallholders allows for unearthing patterns, certification processes, adoption and impacts from smallholders with radically different configurations.

1.7 Study significance

1.7.1 Academic significance

The originality of this research is shown in how this study draws insights from two crops i.e. cocoa and oil palm characterized by smallholder systems with radically different configurations. First, the cocoa sector is largely dominated by independent farmers (Waarts et al., 2015). These farmers have no contractual agreements with any individual or organization hence can decide on whether to join certification schemes or not. Oil palm smallholders may exist as independent, outgrowers or scheme smallholders with contractual agreements with large mills. Certification in the oil palm sector is fairly new in Ghana, as such certification has materialized with scheme smallholders as a result of certification of larger associated mills. This presents an important opportunity to gain insights on the adoption and impact variations relative to the different smallholder configurations to identify the convergence and divergence of findings to inform policy. In addition, in spite of the fact that there are a lot of studies capturing perspectives of stakeholders on certification, some of them focus on specific topics, stakeholder groups or specific crops. This presents some sort of narrow viewpoint on the operation of certification standards. In this study, perspectives of multiple stakeholders across different crops were gathered to provide a comprehensive view of the drivers, barriers and impact of certification.

Moreover, this study employs multiple approaches including household surveys and expert interviews to provide a form of triangulation of findings and also explore the sentiments behind quantitative data (Chapter 3). The use of such combined research methods could enhance the relevance, quality and applicability of the findings for different stakeholders in the cocoa and oil palm landscape. This contributes to the current knowledge on sustainable consumption and production especially in export-oriented commodities.

1.7.2 Policy and practice significance

Certification is gaining traction in Ghana as a way of ensuring sustainable adoption in the cocoa and oil palm sectors. Hence, this thesis will serve as an important literature that will contribute significantly to the sustainability debate on certification. The findings of this study serve as an important knowledge to inform policy development and interventions in the cocoa and oil palm sectors.

From a wider sustainability perspective, certification contributes significantly to multiple indicators in the Sustainable Development Goals. Specifically, the SDGs showing direct relationship with this study includes No poverty (SDG1), Zero hunger (SDG2), Decent work and economic growth (SDG8), Responsible consumption and production (SDG12) as well as Life on Land (SDG15). Thus the findings of this study may be important in helping Ghana develop policies to achieve the country's SDG commitments.

1.8. Structure of dissertation

This dissertation covers four main aspects (Figure 1-5). Objective 1 (Chapter 3) outlines the stakeholder perceptions of the drivers, barriers and impacts of certification adoption. Objective 2 (Chapter 4) provides insights into how certification is promoted and adopted in the Ghanaian cocoa and oil palm sectors. Objective 3 (Chapter 5) details the impacts of certification adoption among farmers while Objective 4 (Chapter 6) synthesizes the results obtained in Objective 1-3 and elicit policy and practice implications for certification uptake.

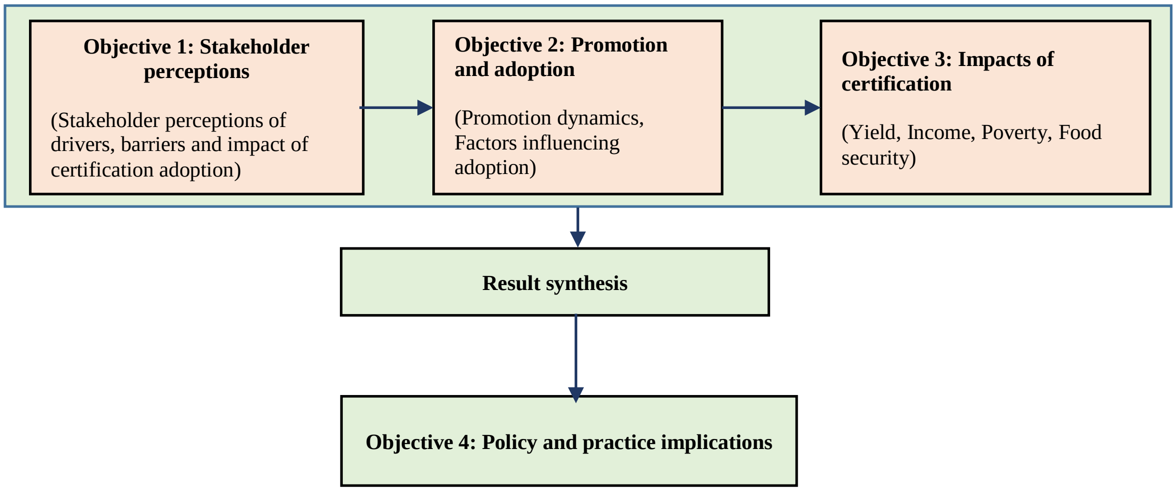


Figure 1-5: Research scope

Chapter 1 establishes from existing literature the importance of commercial crop production and the certification adoption in Sub-Saharan Africa. In addition, it also highlights the adoption of certification in Ghana, the processes as well as the drivers and impacts of cocoa and oil palm production. The research gaps on which this dissertation is hinged are also presented. These gaps follow with the aims and objectives of this research as well as how the subsequent chapters relate to specific gaps and objectives.

Chapter 2 presents the methodology of this research used to address the objectives in Chapter 1. In particular, the research approach, conceptual framework and data collection methods. In addition, the analytical approaches of this dissertation are also presented.

Chapter 3 highlights the perceptions of stakeholders on the drivers, barriers and impacts of certification adoption. Specifically, through expert interviews the perceptions related to smallholders and large companies are elicited.

Chapter 4 presents the promotion and adoption mechanisms of oil palm and cocoa certification among smallholders in Ghana. The different promotion mechanisms as well the determinants of adoption among cocoa farmers are presented.

Chapter 5 presents the impacts of certification adoption among cocoa and oil palm smallholders in Ghana. Specifically, results on yield, income, poverty and food security are presented.

Chapter 6 synthesizes the results obtained from chapter 3-5 utilizing literature from Chapter 1. Based on this, policy and practice options are recommended to support uptake and enhancement of the impact of certification adoption in the cocoa and oil palm sectors in Ghana.

CHAPTER TWO

METHODOLOGY

2. Introduction

This research is aimed at measuring how certification is adopted and whether it is achieving the theorized impacts (Fenger et al., 2017; Krumbiegel et al, 2018). Section 2.1 highlights the research approach adopted in this thesis. Section 2.2 presents the conceptual framework employed in this study. The theoretical and analytical framework is also captured in section 2.3 and 2.4 respectively. Section 2.5 highlights how the study was organized including the study sites selection, the sampling approaches and the variables used in the study. Section 2.6 follows with the analytical approaches adopted for this research.

2.1 Research Approach

Sustainability science is at the core of this research (Kates, 2001). The framework for evaluating this research aims at addressing issues from the point of economic, environment and social view. The concept of certification also takes into consideration accountability from the in production whiles safeguarding livelihoods, the environment and social ideals (Chiputwa et al., 2015; Fenger et al., 2017). It incorporates the following dimensions;

i. Goal setting
ii. Indicator setting
iii. Indicator measurement
iv. Causal analysis (Kajikawa, 2008)
v. Incorporation of interactions between social actions and ecological impacts
vi. Incorporation of multi-scale perspectives
vii. An attempt to include all dimensions of the problem under investigation

Initial point of consideration included setting a goal for this research. Cocoa and oil palm production are noted for environmental degradation and negative social impacts like child labour (Ingram *et al*., 2018; Myzabella, 2019). In response to this, certification has been introduced with the goal of ensuring sustainability in production. The goal of this research was thus aimed at measuring how certification is adopted (Djokoto *et al*., 2016) and whether certification is achieving the expected impact (Fenger *et al*., 2017).

Indicators were chosen to measure the impact of certification. These indicators included yields, poverty, food security and income. Indicators used are already existent and were only used to bring out perspectives on the impact of certification (Glasbergen, 2018; Mitiku *et al*., 2017; Chiputwa *et al*., 2015).

The study also includes a causal analysis of the impact of certification. In assessing the impact of certification, many factors influence how impacts manifest which may bias the results (Apiors & Suzuki, 2018). To measure the true impact of certification, matching approaches are used to isolate the impact of certification vis-à-vis observable characteristics.

Cocoa and oil palm production is engrained in the social life of people especially in Ghana's rural households. Considerations made by farmers is normally concentrated on economic and social improvement with little considerations on environmental implications (Mason & Asare, 2014; Ntiamoah & Asare, 2008). This research sheds light on environmental practices adopted by both certified and uncertified cocoa and oil palm farmers in Ghana. In effect, this research merges the social and ecological considerations related to agricultural production (Kajikawa, 2008).

In addition, this research adopts the approach of collecting stakeholder perspectives at different levels of the certification chain. First, perspectives from experts are gathered through interviews using semi-structured questionnaires. An in-depth data collection from farmers was done. These scales of perspectives are synthesized to give a holistic view of the process of certification adoption, impacts and barriers.

2.2 Approach to causality

Literature abounds with different approaches to measure the impact of interventions on targets including Randomized Control trials (Apiors & Suzuki, 2018; Glennerster & Takavarasha, 2013), comparing baseline and endline data (Waarts et al., 2015; Glennerster & Takavarasha, 2013), comparing past and present data from recollection (Fenger et al., 2017) as well as matching techniques using comparable groups (Chiputwa et al., 2015; Ahmed et al., 2019; Mitiku et al., 2017). However, the choice of a method is determined by various factors including the availability of data, market conditions as well as the robustness of generalizations.

2.2.1 Randomized Control Trials

Randomized Control Trials (RCTs) have been considered by many researchers as the gold-standard in causal effect estimations because it effectively helps to reduce the problems of selection as well as biases due to confounding variables by balancing the respondent characteristics, allowing for attribution of differences to treatment (Winship & Morgan, 1999; Apiors & Suzuki, 2018; Olofsgard, 2014). However, apart from the huge financial requirement involved, it is recommended for studies where interventions are randomized from the commencement of the study, and there is reasonable amount of time to observe and measure impacts (Olofsgard, 2014). As a result, it has often been used by development partners to help scale-up interventions. This approach has been adopted in several research in the context of African agriculture to measure the impact of interventions. For example, Nakano and Magezi (2020) adopted this method to measure the impact of credit on technology adoption and productivity and found that credit does not necessarily improve yield. Heckert et al. (2019) also utilized RCTs in measuring whether women empowerment is a pathway to improving child nutrition outcomes in a nutrition-sensitive agriculture program in Burkina Faso and found that the intervention reduced child wasting.

In spite of the robustness of this technique, it was not possible to implement the RCT in the context of certification as a result of structure of promotion modalities in cocoa and oil palm certification in Ghana. Certification is promoted in an open market where interested agencies are free to sign farmers to be certified. As a result, there is a scramble for farmers to be certified and therefore interventions could be polluted by the entry of competing agencies who may mobilize farmers to be certified. In the context of oil palm certification, the implementation of RCT was impossible because of the

2.2.2 Comparing baseline and end-line data

Comparisons of baseline and endline data without necessarily randomizing have been adopted in literature to establish causal effect (Glennerster & Takavarasha, 2013; Waarts et al., 2015). It is done by comparing the outcomes of participants in a programme or intervention before and after the programme. In this case, the intervention participants before the start of the program serve as the counterfactual. For instance, Waarts et al. (2015) utilized this approach in eliciting the impact of UTZ certification adoption by Ghanaian smallholder cocoa farmers on key variables including productivity and incomes, from 2011 to 2014. Ipsos Tanzania (2018) also used this technique in evaluating the impact of agricultural education media campaign by USAID in Tanzania. This approach is however subject to biases introduced by a) observed characteristics such as education and age that may originally be different between treatment and control groups and b) unobserved characteristics such as motivation to cultivate cocoa which may impose significant differences between groups (Caliendo & Kopeinig, 2008; Apiors & Suzuki, 2018). For effective estimation, there should be adequate data at baseline and at the end of the project.

For the purpose of this thesis on adoption and impacts of certification, this approach was not feasible under the circumstance since there was no accessible baseline data on certification adoption that wholly captures the impacts being studied, at the commencement of the household survey. As a result, there could not be a comparable data for the household survey conducted for this thesis.

2.2.3 Comparing past and present data from recollection

Deduction from memory recollection on past and present experience with an intervention or programme has been adopted to make causal inferences (Fenger et al., 2017). It provides a good approximation of the impact of certification, however there are high possibilities of biases that may not be removed by the mere comparison of past and present performance (Caliendo & Kopeinig, 2008; Rosenbaum & Rubin, 1986). In addition, there are uncertainties in recollection of past data, especially of highly quantitative data like incomes and food security. Implying that farmers may be unable to recollect correctly highly quantitative data.

Though in this study, past and present production performance are compared to gain insights into the impact of certification, it cannot be solely used for the purpose of generalizations because of its questionable attributions largely due to biases as stated above. For this reason, this approach was used to provide an additional confirmatory layer of information on the impact of certification standards on cocoa and oil palm smallholders.

2.2.3 Matching techniques using comparable groups

Impact estimations using comparisons between participants and counterfactuals is a well-used approach to establish causality (Chiputwa et al., 2015; Ahmed et al., 2019; Mitiku et al., 2017; Glennerster & Takavarasha, 2013). In this case, to ensure robust analysis, the set of factors on which people are matched must be sufficiently comprehensive that there are no remaining differences between groups that may affect the outcomes (Glennerster & Takavarasha, 2013). In addition, comparable groups must be close enough to reduce the differences in local economies that may impose some prior differences.

For the purpose of this studies, a widely adopted approach where a treatment is compared to a counterfactual using cross-sectional data is adopted (Ahmed et al., 2019; Mitiku et al., 2017; Ssebunya et al., 2019; Chiputwa et al., 2015) was used. This is because certification had been adopted for a long time before this study and therefore it couldn't lend itself for randomization. Specifically, certified cocoa farmers in the study area had adopted certification in 2009 and certified oil palm farmers had adopted certification since 2014. The propensity score matching approach was adopted to help in reducing the biases that may occur as a result of the problem of selection (Mitiku et al., 2017; Chiputwa et al., 2015). In addition, a comprehensive approach in selection of the comparable groups was adopted in reducing the impact of knowledge spill-over on the results as well as obtaining effective confounders.

2.3 Conceptual framework

Cocoa and oil palm production contribute significantly to deforestation, accelerates climate change, pollution and biodiversity loss (Ntiamoah & Afrane, 2008; Danyo, 2013). This impacts have been propelled by farmers' continuous expansion efforts, low use of recommended farm inputs and forest over-exploitation (Gockowski *et al.*, 2013; Ofosu-Budu & Sarpong, 2013). In addition, cocoa and oil palm production have been associated with increased violation of gender rights, child labour, poverty and high food insecurity levels ((Antwi *et al*., 2018; Anderman *et al.*, 2014).

Certification standards have been introduced in Ghana as one of the approaches to ensure sustainable production of cocoa and oil palm (Gockowski *et al*., 2013; Fenger *et al*., 2017; Jena & Grote, 2017). In spite of the similar objectives of different certification schemes (UTZ, RA, RSPO), the mechanisms of adoption are quite varied for both cocoa and oil palm.

For the cocoa sector, certification is mainly promoted to independent farmers by Licensed Buying Companies (LBCs) and Group Administrators (GAs). Farmers make a choice on adoption based on certain socio-economic factors including gender dynamics, credit access, extension access and access to recommended agro-chemicals (Djokoto *et al*., 2016). For oil palm sector, certification (RSPO being dominant) is largely promoted through larger plantations/mills such as Benso Oil Palm Plantation to scheme smallholders who are bounded by contractual arrangements with the larger mills. Particularly, some larger plantations have adopted certification standards and as such literally "force" scheme smallholders to adopt certification standards (Khatun *et al*., 2020; MASDAR, 2011).

The first step of adoption is the extension of information on good agricultural practices, technical assistance and modern technologies to farmers as enshrined in the principles and guidelines of certification standards. In addition, farm inputs and credit schemes are tailored to farmer needs to help implement the sustainable production practices (Figure 2-1).

After adoption, activities result in outputs such as knowledge transfer on Best Management Practices (BMPs), sensitization on social issues and capacity building in business management skills. Social skills on how to combat child labour, gender equality and business skills like record keeping and alternative livelihood support businesses are some specific outputs from activities undertaken in the process of certification (Fenger et al., 2017; Ansah et al., 2020).

These output results in environment, social and economic outcomes. These outcomes may not be mutually exclusive of each other. This means that some outcomes may result in other outcomes or the interaction between two or more outcomes may result in other outcomes. These outcomes are expected to further lead to impacts as captured in certification standards theories of change.

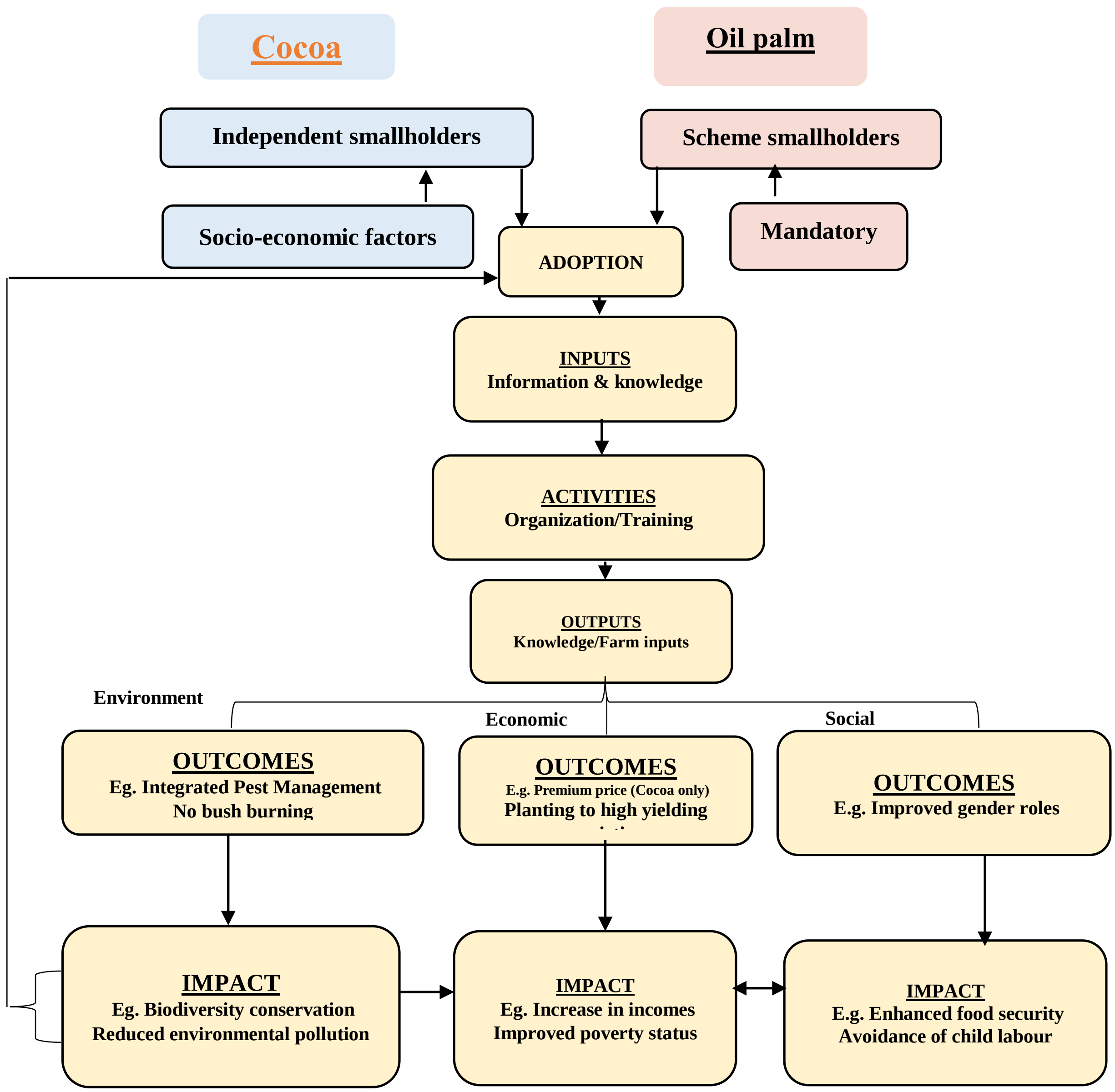


Figure 2-1: Conceptual framework for certification adoption (RA/Fairtrade/UTZ/RSPO/Fenger *et al*. (2017))

First, certification results in outcomes such as planting of shade trees on farms, timely and minimal application of agrochemicals, Integrated Pest management, no hunting for bush meat as well as decrease in logging and no burning of forests (UTZ, 2015; RSPO, 2014; SAN, 2017). These outcomes lead to impacts such as increased fertility, water and air quality, reduced deforestation, biodiversity conservation, increased yield and farm efficiency as well as reduced environmental pollution and climate change impact (Galati *et al*., 2017; Tran & Goto, 2019; Elder *et al*., 2013; Blackman & Naranjo, 2012).

Second, on the economic perspective, outcomes of the certification processes are replanting to higher yielding varieties, recording of farm activities, economic planning as well as benefits from premium price. This leads to economic impacts such as increased cocoa and farm income, household and farm investments and increased household income (Kleeman *et al*., 2014; Tran & Goto, 2019; Oya *et al*., 2018).

Also, social outcomes such as gender roles, investments in education and health infrastructure, compliance with labour regulations, child and adult literacy are expected to be enhanced upon adoption. These intermediate outcomes lead to improved food security, enhanced poverty status, enhanced labour conditions and improved education and health (Chiputwa *et al*., 2015; Mitiku *et al*., 2017).

The sustained adoption[3] of certification depends on the realization of the theorized impacts especially for cocoa farmers who have the prerogative of adoption. Oil palm scheme smallholders do not have a choice of dis-adoption because of the contractual agreement with large plantations. It should be noted that certification is largely hinged on social and environmental tenets such as

[3] Sustained adoption refers to continuous adoption of certification schemes (Kumar & Mehta, 2016)

no child labour, reduced deforestation and environmental pollution. However, economic aspects such as increased income, reduced poverty, food security, enhanced education of farm families and increased household investments may have major influence on the sustained adoption of certification (Fenger et al., 2017).

2.4 Theoretical framework

2.4.1 Theory of Farm Households

There is a plethora of literature on how farm households behave with respect to both consumption and production decisions (Mahama *et al*., 2020; Mendola, 2007). This is because the deciding entity is a producer, making input allocation such as labour and land for production, and at the same time, a consumer of goods and services, making the allocation of income from farm and non-farm activities to the consumption of farm and non-farm goods and services (Ahmed *et al*., 2019).

In the cocoa and oil palm sectors, farmers make simultaneous decisions on resource combinations such as land and inputs, and also consume resources like agrochemicals and improved technologies (Danso-Abbeam & Baiyegunhi, 2018). This puts farm households in a complex interrelation not only between varying production decisions but also on consumption decisions. The profit maximization model has been used to explain farm household behavior to indicate the production aspect of their livelihoods (McConnell, Brue, & Flynn, 2009). However, farm households do not only make decisions based on profit maximization motives but also based on how to maximize their utility as a result of a farm decision. In this way, farming households make production decisions on adoption of technology in a way that will maximize their utility (Ulimwengu & Sanyal, 2011). This behavior fits into the utility theory of farm households (Findeis, 2002). This theory is proffered under the assumption of full income, time constraints, labour supply and farm production technology. In making the simultaneous decision, it is important to note that such behavior is circular, with consumption influencing production, and production influencing consumption (Mendola, 2007).

With respect to certification, which is primarily an issue of technology adoption, cocoa and oil palm farmers make production decisions on whether to adopt certification or not if it maximizes their utility. Utility maximization is related to the expected impact on adoption of certification such as reduced poverty levels, increased income and increased food security. On adoption, farmers' maximization of utility based on impact points already introduced (Section 3.2) may lead to sustained adoption. However, if certification does not maximize their utility farmers may dis-adopt certification.

Though this theory, has been used by many researchers, it has some shortcomings. This includes the fact that this model ignores the subject of risk and uncertainty, and the social contexts in which smallholder productions occurs (Mendola, 2007). This means that the model assumes that outcomes or prospects are guaranteed, which is not exactly the case. Despite this criticism, the model still stands as an important model to explain technology adoption in literature (Lubungu *et al.,* 2012; Sadoulet et al., 1996; Kemeze *et al*., 2018).

2.5 Organization of study methodology

This study is organized into three (3) main stages as seen in Table 2-1. First, overview of cocoa and oil palm certification landscapes, drivers, barriers and impacts are presented. This was done through an extensive review of literature and policy documents to understand the how certification is represented within current policy and also identify the main stakeholders involved in certification. From this exercise, key stakeholders were interviewed to map out the drivers, barriers and impact of cocoa and oil palm certification (Objective 1). Third, data was collected using structured farmer household surveys. The household surveys and expert interviews were analyzed to elicit how certification is adopted and promoted in the cocoa and oil palm sectors (Objective 2). Also, analysis on the impacts of certification is done using data from the household surveys (Objective 3).

Table 2-1: Study methodology

Chapter	**Objective**	**Item**	**Data collection**	**Analysis**	**Output**
Stakeholder perceptions (Three)	1	Institutional analysis	Literature review Expert interviews	Content analysis Transcription and qualitative content analysis	Perceptions of drivers, barriers, impact and institutional linkages
Promotion and adoption dynamics of certification (Four)	2	Adoption and promotion of certification	Farmer household surveys/ Expert interviews	Statistical analysis (Mixed effect probit regression) Content analysis	Determinants of adoption Promotion dynamics
Impacts of certification adoption (Five)	3	Impact estimation of certification on yield, income, food security and multidimensional poverty	Farmer household surveys	Statistical analysis (Propensity Score matching)	Average Treatment Effect on Treated (ATT)
Policy/practice recommendations (Six)	4	Enhance adoption and impact of certification	Synthesis of 1,2 and 3	Co-integration of qualitative and quantitative analysis	Policy and practice options

2.6 Data collection

2.6.1 Expert interviews

A combination of institutional analysis and expert interviews to identify the main stakeholders (Table 2-2) in the Ghanaian oil palm and cocoa sector, is used to elicit perceptions about the drivers, impacts and challenges of certification.

Through the institutional analysis of the landscapes of certification stakeholders, especially focusing on the connections between actors, a stakeholder map was developed (Section 3.21 Section 3.2.2). This is achieved through the identification and critical reading of the main policies, regulations, guidelines, and other relevant official documents. The documents were collected through the portals of relevant organizations (e.g. Ministry of Food and Agriculture), and were supplemented from the academic literature.

Institutional analysis described above was used to identify the respondents for the expert interviews. Overall, stakeholders were categorized into seven groups reflecting their different interests and roles within certification processes (Table 2-2). Overall, thirty-three (33) respondents were interviewed: Government Agencies (n=7), Private Sector (n=5), Non-Government Organizations (NGOs) and Civil Society Organizations (CSOs) (n=11), Technical Institutions/Licensed Buying Companies (n=5), Research Institutions (n=2) and Certification Agencies (n=3) (Table 2-2). The individual respondents in each organization were either directly involved in certification or their mandates related strongly with the cocoa and oil palm sector. Each respondent was asked to reflect the position of their organization, rather than their personal opinion.

Table 2-2: Characteristics of expert interview respondents

Organization	Department	Position	Reference code
GOVERNMENT			PGI
Ghana Cocoa Board (Main)	Research, Monitoring and Evaluation	Principal Research Officer Senior Research Officer	RME
Ministry of Food and Agriculture	Directorate of Crops Services, Tree Crops Unit	Senior Agric. Officer	DCS
Environmental Protection Agency	Agriculture Unit	Chief Programme Officer	EPAAU
Ghana Standards Authority	Product Certification	Head	GSA
Forestry Commission Ghana	Climate Change	REDD+ Knowledge Management/ Stakeholder Consultation Specialist	FCG
Ministry of Food and Agriculture	Plant Protection and Regulatory Service Directorate	Director	PPRSD
Ghana cocoa Board	Quality Control	Manager	QC
LARGE COMPANIES			PCP
Ghana Oil Palm Development Company (GOPDC)	Health, Safety and Environment	Manager	GOPDC
Touton	Cocoa Sustainability Sourcing	Manager	TOUT
Serendipalm	Internal Control Systems	Manager	SER
Benso Oil Palm Plantation (BOPP)	Oil Palm Development Association (OPDA) Interpretation Taskforce for RSPO	Group Manager President Chairman	BOPP
Ghana Sumatra Limited	Marketing	Manager	GSL
TECHNICAL COMPANIES/LICENSED BUYING COMPANIES			
Cocoa Abrabopa	Extension	Technical Trainer	CAA
Agro Eco- Louis Bolk Institute	Cocoa	Project leader	ALB
Yayra Glover	Internal Control Systems	Manager	YG
Transroyal Ghana Limited	Project and Sustainability	Manager	TGL
Cocoa Merchants Ghana Limited	Sustainability	Manager	CMGL
RESEARCH INSTITUTIONS			RI
Oil Palm Research Institute	Commercialization and Information Division	Research Scientist	OPRI
Cocoa Research Institute	Cocoa Research Institute of Ghana (Social Science)	Agricultural Economist	SSU
CERTIFICATION AGENCIES			
Fairtrade	Fairtrade Africa	Business Development Advisor	FT
Rainforest Alliance	West Africa Landscapes and Livelihood	Senior Manager	RA
Control Union, Ghana	Control Union, Ghana	Managing Director	CU
CSOs/NGOs			
General Agriculture Workers' Union	Industrial Relations	Head	GAWU
International Cocoa Initiative	International Cocoa Initiative	Deputy National Coordinator/Programme Coordinator	ICI
Proforest	Africa Practitioner's Network	Programme Director	PF
Technoserve	Technoserve	Programme Manager	TECH
Friends of the Earth	EU-CiSoPFLEG Project	Project Facilitator	FoTE
Community Land and Development Foundation	Community Land and Development Foundation	Executive Director	COLANDEF
Ghana Wildlife Society	Ghana Wildlife Society	Executive Director	GWS
Nature and Development Foundation	Nature and Development Foundation	Operations Director	NDF
Conservation Alliance	Cocoa Certification	Project Coordinator	CA
Solidaridad	Oil Palm	Programme Manager	SWA
Nature Conservation research Centre	Programs and Research	Director	NCRC

Through these expert interviews the breadth of stakeholder perceptions regarding the drivers, impacts and challenges of certification was captured. As a result, mostly open-ended questions to allow respondents elaborate freely on their answers was used. Most questions were the same for all respondents to allow some level of consistent perception elicitation between stakeholder groups. Selectively follow-up probe questions to extract some of the specific knowledge that the different respondents have regarding certification and agricultural system in Ghana was used. Most interviews were conducted face-to-face (31), and two (2) interviews were conducted remotely through telephone and skype. All interviews were conducted between August 2017 and March 2018, and were audio-recorded after securing the consent of each respondent.

2.6.2 Household surveys

2.6.2.1 Selection of study sites

To assess adoption and impacts of cocoa and oil palm certification, the study focuses on two different study sites. The cocoa site is located in the semi-deciduous forests of Assin North Municipal (see Figure 2-2). The oil palm study sites are selected from the tropical rainforest zone of the Mpohor district (see Figure 2-2). Table 2-3 contains the main characteristics of the two study sites

Table 2-3: 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 cocoa study site, UTZ and Rainforest Alliance certified farmers operating under the initiative Mars Partnership for African Cocoa Communities of Tomorrow (iMPACT) were seclected. One of the major selection considerations were 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, 2014). 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).

In the oil palm site, certified scheme smallholders under the Benso Oil Palm Plantation (BOPP), a large oil palm plantation, which has been RSPO-certified since 2014, were selected. BOPP was selected because 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 (Section 1). BOPP is located in Mpohor district in the tropical rainforest belt, which supports oil palm production (GSS, 2014). 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).

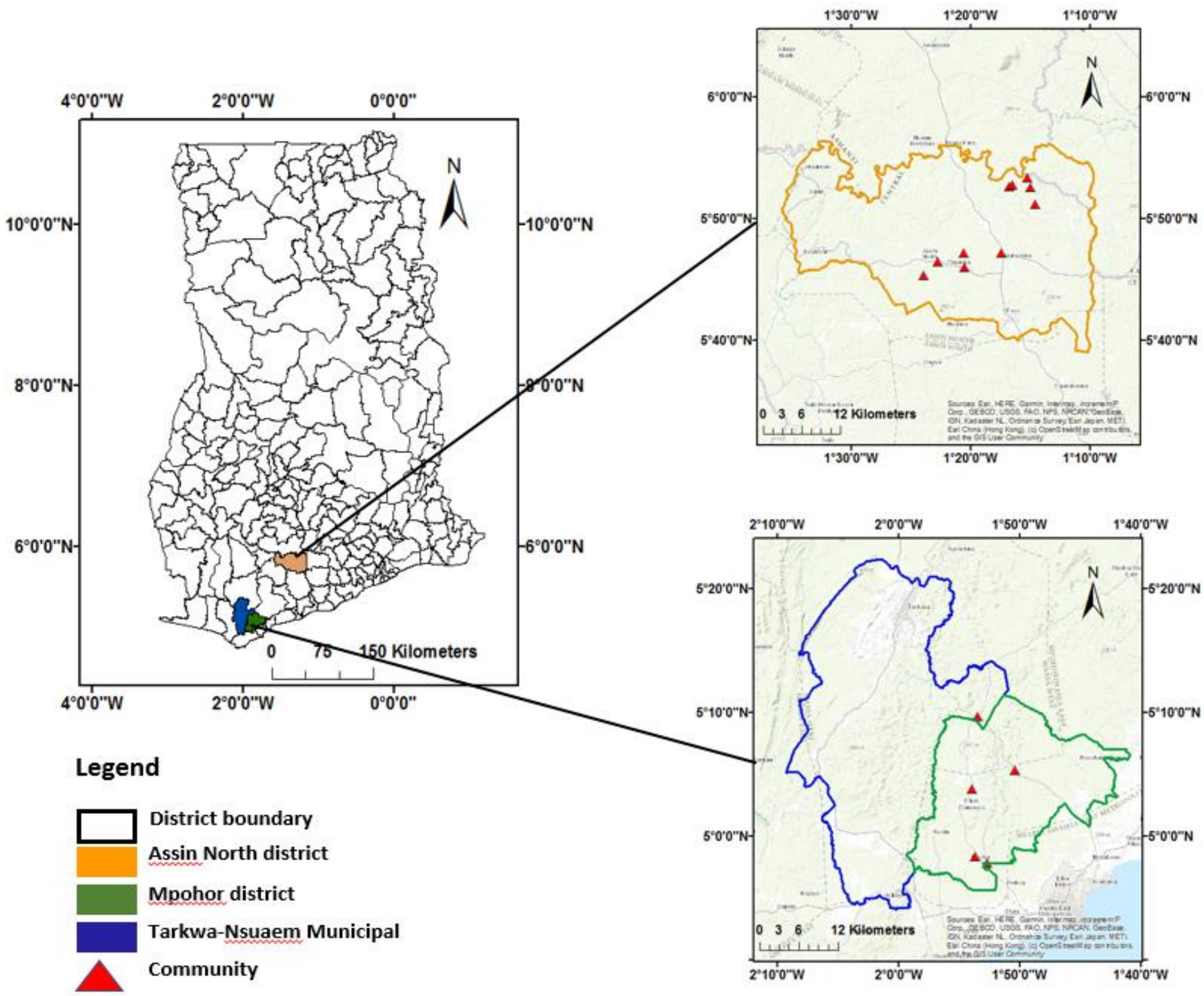


Figure 2-2: Location of study sites

2.6.2.2 Data Collection

To assess the determinants and impacts of certification structured household surveys with smallholders involved in cocoa/oil palm certification, were conducted. In particular, in each area household surveys were conducted 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, approximately 100 surveys with each group were conducted, for a total of 608 surveys across the two sites (Table 2-4).

Household surveys were conducted between August-September, 2018 (cocoa site) and August-September, 2019 (oil palm site). The 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, (e) food security indicators and (f) 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), different sampling approaches were followed for the different study groups (Table 2-4). Farmers throughout the Assin North Municipal and Mpohor district grow similar crops with the major crop being cocoa and oil palm respectively (GSS, 2014). Most cocoa/oil palm farmers are small-scale producers relying on cocoa/oil palm as important livelihood source (Fenger *et al*., 2017). Furthermore, the selected farmers are situated in the same agro-ecological zone (Fenger *et al.*, 2017), and experience similar rainfall patterns (1500-2000mm) (GSS, 2014). This identical situation in local economies and agro-ecological conditions between communities (see also Fenger et al., 2017), suggests the lack of major differences between communities in terms of livelihoods and agricultural production.

Certification is basically about knowledge transfer on sustainable production practices. The knowledge on sustainable practices can be shared between networks of friends or people within the same community, even though they may not be "certified"**.** As a result, 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, a minimum distance of 13km was allowed between certified and uncertified cocoa communities in line with other studies that allowed a reasonable distance between communities (e.g. 7km in Fenger *et al.,* 2017). For the oil palm study site, a minimum distance of about 21km was allowed between certified and uncertified farmers. In addition, uncertified cocoa/oil palm farmers (control 1) and food crop farmers (control 2) were selected from communities that do not contain certified cocoa and oil palm farmers. This is because both uncertified and food crop farmers have not adopted certification standards and therefore reasonable to select respondents from the same community.

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). First, 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 certified farmers in each community to avoid oversampling (Table 2-4). 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, the random number generator was used to select five communities within the same ecological zone 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, transect approach using a prominent landmark within each community such as the chief's palace as the starting points was used. 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. First, permission was obtained from Benso Oil Palm Plantation (BOPP) to interview farmers in their scheme smallholder system. Certified scheme smallholders under 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 2-4). 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 uncertified oil palm farmers that sold FFB to BOPP were selected. First, a list of uncertified farmer communities that sell FFB to BOPP were identified. This was followed by a random selection of 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. Transect-based systematic random sampling approach outlined above to identify uncertified oil palm farmers and food crop farmers was also used (Table 2-4).

Table 2-4: 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		

2.6.2.3 Household survey format

Household survey was conducted between August, 2018 and September, 2019. Prior to the survey, site visit was conducted to get adequate understanding of the landscapes, to establish the different smallholder and interest groups in the study areas. The study utilized household questionnaire to elicit results for the quantitative aspect of the research (objective 2-3). The questionnaire was categorized into ten (10) broad sections namely;

i. Respondent/Household characteristics
ii. Agronomic characteristics
iii. Institutional factors
iv. Membership in certification
v. Perception of certification
vi. Food Security
vii. Expenditure
viii. Assets
ix. Poverty Indicators

The questionnaire involved both open ended and close-ended questions. The data obtained from the household interviews were analyzed using statistical software packages including Stata 15 and Excel

2.6.2.4 Reducing non-sampling error

To reduce non-random errors, a number of efforts were adopted. This included the selection of enumerators living in the surveyed communities. This is because the enumerators speak the local language, may better understand the local context and dynamics to capture better the data. Enumerators were also trained and a pilot survey was conducted to correct errors in the questionnaire. During the main survey, data collected was cross-checked to ensure the right data is collected so that errors are clarified with the respondents before proceeding to the next community.

2.7 Data analysis

2.7.1 Qualitative analysis of expert interviews

The interviews were transcribed verbatim, and the transcripts were used to undertake content analysis using NVivo software. Inductive approach to draw out the themes and categories from the data was used. The themes and keywords used for the content analysis were informed by the reviewed literature on the drivers, barriers and impact of cocoa and oil palm certification in Ghana (Section 1) and the processes of cocoa and certification standards (RSPO, 2015; UTZ, 2014; SAN, 2017). The results are presented using descriptive statistics such as bar charts.

2.7.2 Adoption of certification standards

2.7.2.1 Analytical framework

To predict adoption decisions, the random utility model has been adopted widely in the literature (Kleeman *et al*., 2014; Hoque *et al*., 2015; Yigezu *et al*., 2018; Abdul-Rahaman & Abdulai, 2018). This model posits that decision of an individual to adopt a technology is based on the expected utility. However, utility cannot be measured but given a set of individual characteristics, a choice decision could be predicted.

For the purpose of this study, adoption of certification standards is modelled around a binary choice approach where the producer measures the level of utility as a result of adoption compared to non-adoption (conventional production) (Glenk *et al*. 2014; Abate *et al*., 2016). The choice of adoption or non-adoption is predicated on the attainment of certain outcomes such as increased productivity, increased farm income, food security, as well as reduced poverty. Hence, certification adoption is represented using a binary choice model based on the realization of maximum utility (Kleeman *et al*., 2014; Hoque *et al*., 2015).

Following Kleeman *et al*. (2014) and Hoque *et al*. (2015), $D_{1i}*$ is assumed to be the expected utility from adoption of certification (UTZ, Rainforest Alliance and RSPO) and $D_{0i}*$ is the expected utility for non-adoption of certification of farm household, i where i=1,..n of population of size, n. The choice of the individual household is expressed as the difference between the expected utilities for both adoption and non- adoption. This is expressed as follows;

$$D_i^* = D_{1i}^* - D_{0i}^* \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots (Eq. 1)$$

The utility of each farming household is unobserved but can be represented by the choice D_i, where D_i ($D_i \epsilon$ {0,1}) is a binary choice variable (Yigezu *et al*., 2018).

D_i= 1 if a farming household adopt certification

D_o=0 if a farming household does not adopt certification

$$D_i^* = Z_i^{\wr}\alpha - \epsilon_{Di} \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots (Eq. 2)$$

D_i=1 if D_i is greater than zero

D_i=0 if D_i is less than or equal to zero

The decision to adopt, D_i depends on a set of observable socio-demographic characteristics, Z and ϵ_{Di} is an error term of variance θ_D^2, in a latent variable model. Hence, this could be modelled using a probit or a logit estimation. The change in utility as a result of certification adoption is heterogeneous across the decision makers in a household. As a result, each household has differing expected benefits from the adoption of certification.

The probability of adoption is thus expressed as;

P (D_i=1|Z_i)=$P\ (D_{1i}^* > D_{0i}^*) = P(D_i^* > 0) = F(Z_i^{\wr}\alpha)$ … … … … … … … … … … … … … … … … $(Eq. 3)$

F is the cumulative distribution function of ϵ_{Di}

2.7.2.2 Promotion and adoption dynamics of certification adoption among smallholders

Studies have approached adoption decisions in agricultural innovations/technologies settings through various methods such as probit, logit, double hurdle and Poisson regression models (Asante et al., 2013; Etwire et al., 2016; Martey et al., 2014; Anang, 2018; Yigezu et al., 2018). When choosing a model, the dependent variable becomes an important consideration in determining. For example, studies have adopted the double hurdle model in estimating fertilizer adoption and use intensity among smallholders (Martey et al., 2014), as in their case the dependent variable was modelled as a two-step process where the first step was the adoption decision and the second step the use intensity. Poisson regression models have been used to assess the determinants of adopting soil and water conservation practices because their dependent variable was count data (Darkwah et al., 2019).

In this thesis, the mixed effect probit regression model is adopted to assess the factors that influence the adoption of certification by cocoa smallholders in Ghana (StataCorp, 2017) instead of a normal probit regression model (Mitiku et al., 2017; Anang, 2018). Mixed effect analysis provides better and more robust results in cases when data may be polarized or clustered between sampling units (Bonate, 2006). This is under the assumption that respondents nested in the same cluster are more likely to function in the same way, and in ways that are different to respondents nested in different clusters (Vermunt, 2005). Hence, using mixed-effect probit regression may help to satisfy the independence assumption (StataCorp, 2017). In this study, a random effect is fitted for communities (using distance to main market centres) to measure intra-community correlations between respondents. This is because distance to the main market centres has an effect on off-farm income activities, extension as well as access to credit, which are major determinants of certification adoption (Djokoto et al., 2016). For the purpose of this study, interaction term is created for off-farm income and community proximity to main market centre and was used to control for community differences (See section S1 for detail). The mixed-effect probit model is expressed as:

$$\Pr\left(y_{ij} = 1 \middle| x_{ij}, u_j\right) = H\left(x_{ij}\beta + z_{ij}u_j\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (Eq. 4)$$

…where y_{ij} is a binary response variable, x_{ij} is covariates for fixed effects, H is standard normal cumulative distribution, Z_{ij} is covariates corresponding to random effects, *j*=1…M clusters, with cluster j consisting of *i*=1…n (StataCorp, 2017)

The variables used in the mixed effect probit regression are shown in Table 2-5. The independent sample t-test to compare the means between certified and uncertified cocoa farmers for the main study variables. It should be noted that as the certification of the oil palm scheme smallholders is mandatory, the factors influencing certification adoption among oil palm farmers. However, a descriptive statistical analysis about their expectations and challenges associated with certification was estimated.

This dissertation also utilizes data from expert interviews to elicit the promotion mechanisms of certification adoption among cocoa and oil palm farmers. This is important because different crops have different arrangements which reflects in how certification is promoted.

Table 2-5: Meprobit regression variables

Variables	Description	Expected effect to certification adoption	Reference
Log(AgeHH)	Age of household head (Years)	+/-	Chiputwa et al., 2015; Ruben and Fort, 2012; Arslan et al., 2017
EduHH	Education (dummy)	+/-	Etwire et al., 2016; Yigezu et al., 2018; Awuni et al., 2018
HHsize	Household size (Adult Equivalent)	+/-	Djokoto et al., 2016; Awuni et al., 2018
Log(nonfarminc)	Off-farm income (Monetary value, GHC)	+	Asante et al., 2013; Darkwah et al., 2019
Log(Farmsizecocoa)	Cocoa farm size (Hectares)	+	Anang, 2018; Bravo-Monroy et al., 2016
Formempl	Formal employment (dummy)	+	Darkwah et al., 2019; Nguthi, 2008
livestoc	Livestock ownership (dummy)	+	Kuivanen et al., 2016
Accesstoinfodev.	Information access devices (dummy)	+	Chiputwa et al., 2015; Awuni et al., 2018
Distance to main market centre	1=9-14km, 2=14.1-19km, 3=above 19km		
Community	Distance to main market centre (dummy)*Log(off-farmincome)		

Note: + denotes an expected positive effect to certification adoption; - denotes an expected positive effect to certification adoption

The age and education of the household head can influence the adoption of certification because this is the household member usually making the decision about major investments and the use of productive resources. As such, their age and education relates to their experience and ability to access and process critically information and influences adoption decisions (Chiputwa et al., 2015; Etwire *et al*., 2016). In the contexts of rural Ghana labour for farming activities come mainly from within the household, and as such household size reflects overall labour availability. Considering that certification changes production practices, it also affects labour requirement, making thus labour availability an important deciding factor (Darkwah *et al*., 2019; Djokoto *et al*., 2016).

Farm size tends to have a positive influence on farmer decision to adopt certification, as households with more land are usually associated with higher endowment, resource availability, and often willingness to "experiment" with new practices (Awuni et al., 2018; Anang, 2018). Off-farm income and employment tend to influence positively farmer decisions to adopt certification, as they essentially represent sources of additional (and often stable) income to meet the financial requirements of certification (Asante *et al.*, 2013; Darkwah *et al.*, 2019). Livestock ownership tends to positively influence certification adoption, as livestock are a store of wealth in rural African contexts, indicating endowment and a possible source of extra income to facilitate certification adoption (Kuivanen et al., 2016). Ownership of information access devices implies access on information on sustainable production practices and opportunities, thus positively influences farmers' decision to adopt certification (Chiputwa et al., 2015; Awuni et al., 2018).

2.7.3 Causal estimation of impact of certification: Propensity score matching

Although this study tries to establish differences between treatment and control groups using t-test and charts, it 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 (Dehejia and Wahba, 2002; Caliendo & Kopeinig, 2008; Mitiku *et al.*, 2017). This is also related to the fact that adopters and non-adopters differ in their outcomes with and without treatment (Dehejia & Wahba, 2002; Caliendo & Kopeinig, 2008). In establishing causality amidst these estimation problems, the Propensity Score Matching (PSM) is adopted in this study to compare yield, income, poverty and food security outcomes of certified farmers and uncertified farmers (Chiputwa et al, 2015; Mitiku *et al.*, 2017; Kemeze *et al.*, 2018; Abate *et al.*, 2016). The fundamental idea behind propensity score matching is to compare non-participants with participants under similar pre-treatment observable characteristics, X.

In causal estimations using propensity score matching, some assumptions should be met. First, the unconfoundedness or conditional independence assumption should be met. This assumption denotes that given a set of characteristics, potential outcomes are independent of treatment assignment implying that the data has to be rich enough to contain the confounding variables (Abadie & Imbens, 2006; Heckman *et al*., 1997). Another assumption is common support or overlap assumption, which states that there is equal or similar likelihood of being participants or non-participants for subjects with similar/same covariates. These assumptions are referred to as assumption of "strong ignorability" (Rosenbaum & Rubin, 1983; Stuart, 2010). However, the assumption of "strong ignorability" may be relaxed in real situations. This is because matching on observed covariates directly controls for unobserved covariates as much as there is high correlation with the observed covariates (Stuart, 2010; Caliendo & Kopeinig, 2008). Hence, the remaining estimation problem lies with the unobserved covariates that are uncorrelated with the observed covariates. In this way, sensitivity analysis is conducted to measure at what level the unobserved covariates impose biases in the estimation (Stuart, 2010).

The Stable Unit Treatment Value assumption is also key (Caliendo & Kopeinig, 2008). This assumption states that outcomes of an observation should not be affected by the treatment of another observation. In this way, there should be an approach that eliminates or reduces spillover effects of treatment (Section 2.5.2.2). This ensures that data collected is pure and impact are solely attributable to participation or otherwise.

After these assumptions are met, differences in the outcomes are taken and attributed to involvement in a program or treatment (Hirano and Imbens, 2002; Caliendo and Kopeinig, 2008; Rosenbaum and 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 (Dehejia and Wahba, 2002; Caliendo and Kopeinig, 2008).

In estimating the treatment effects, two parameters; Average Treatment Effect (ATE) and the Average Treatment Effect on the Treated (ATT) are normally estimated (Hirano and Imbens, 2002; Hoque *et al.*, 2015). The Average Treatment effect refers to the impact of the program/treatment on all the observation (Treatment and control) whiles Average Treatment Effect on the Treated refers to the impact of the program 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

$$\tau ATE = E(\tau) = E[Y(1) - Y(0)] \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (Eq. 5)$$

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

$$Y_i = Y_i(K_i = 1) + (1 - K_i)Y_i(0) \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (Eq. 6)$$

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;

$$ATE = P[E(Y_i\,(1)/\,K_i = 1) + E(Y_i(0)\,/\,\,K_i = 1)] + (1 - P)[E(Y_i(0)\,/\,\,K_i = 0) - E(Y_i(0)\,/\,\,K_i = 0)] \ldots (Eq. 7)$$

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 program is not targeted. Because of this challenge, the Average Treatment Effect on the Treated (ATT) is normally preferred by researchers (Apiors & Suzuki, 2018; Kemeze *et al.*, 2018) for better targeting of policy recommendations. It is estimated as;

$$ATT = E\{Y_i(1) - Y_i(0)/k=1)\}$$

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

$$= E[E\{Y_i(1) - Y_i(0)/k=1), p(X)\} - E\{Y_i(0)/K = 0, p(X)\}/K = 1] \ldots\ldots\ldots\ldots\ldots\ldots\ldots (Eq. 8)$$

Where X is a set of matching variables that are used to compare certified farmers and uncertified farmers (see Table 2-6)

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 neighbors of the treated individual is defined and how a researcher handles the common support assumption (Caliendo & Kopeinig, 2008). The procedures for estimation of propensity scores are presented in Table 2.7.

Table 2-6: Description of matching variables and other household characteristics

Variables	**Measurement**
Matching variables	
Education	Years of schooling (Number)
Age	Number of years
Gender	Male=1 Female=0
Formal employment (dummy)	Yes=1 No=0
Formal employment (months)	Number of months
Area of birth	Born in the community=1, Not born in the community=0
Household size	Adult equivalent of household members
Age of trees	Number of years of the plants
Variety grown	Hybrid=1 Local=0
Farm distance (km)	Km
Farm size	Hectares (Ha)
Cocoa/Oil palm farm size	Hectares (Ha)
Other household characteristics	
Extension visit	Number of visits
Farm experience	Years of engaging in farming (Number)
Credit access	Dummy, Access=1, No access=0
Total cocoa output	Kilograms (kg)
Total oil palm output	Tons

Table 2-7: Data manipulation procedure for propensity score matching analysis

Steps	Activity
1	Data extraction from tablet
2	Data cleaning
3	Outcome variables estimation
4	Matching variables selection based on literature
5	Propensity score analysis using different matching algorithms
6	Selection of matching algorithms based on mean biases
7	Checking overlap/common support assumption using minima and maxima propensity score comparisons
8	Matching quality estimation (Biases, Pseudo-R^2, Significance levels, etc.)
9	Effect estimation (Using robust estimates)
10	Analysis of sensitivity of the effects

Finally, the perceptions about the environmental and socioeconomic impact of certification are captured through Likert-scale questions. In particular, for a given environmental and socioeconomic 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. Qualitative questions were used since the long-term recollection (5-10 years in this case) can increase the uncertainty of responses. For each impact/practice the results are expressed as the mean score across certified farmers.

2.7.4 Key outcome variables

The study assessed the impact of certification on key outcome variables including Food security (Food Consumption Score (FCS), Household Food Insecurity Access Scale (HFIAS), Coping Strategies Index (CSI)), Multidimensional Poverty Index (MPI), Income, Consumption and yield. The mechanisms of impacts for the different variables are presented in Table 2-7.

Table 2-8: Empirical description of outcome variables

Outcome variables	Measurement	A priori expectation
Total household consumption	Monetary value (Ghana cedis)	+
Per capita consumption	Monetary value (Ghana cedis)	+
Total household income	Monetary value (Ghana cedis)	+
Per capita income	Monetary value (Ghana cedis)	+
Farm income	Monetary value (Ghana cedis)	+
Cocoa income	Monetary value (Ghana cedis)	+
Oil palm income	Monetary value (Ghana cedis)	+
Food security (FCS)	Index	+
Food security (HFIAS)	Index	-
Coping Strategies Index (CSI)	Index	-
Poverty (MPI weighted)	Index	-
Oil palm yield	ton/ha	+
Cocoa yield	kg/ha	+

Table 2-9: Mechanisms of impact

Impacts	Mechanism
Total household consumption	-Increased incomes from cocoa and oil palm certification can positively impact on household consumption -Adoption of certification may reduce farm and total expenditure as a result of adoption of GAPs
Per capita consumption	- Increased incomes from cocoa and oil palm certification can positively impact on per capita consumption
Total household income	- Increased incomes from cocoa and oil palm certification increases household income
Per capita income	-Increased incomes from cocoa and oil palm certification increases per capita income
Farm income	-Increased income from cocoa and oil palm as a result of certification increase in farm income
Cocoa income	-Good agricultural practices (GAPs), credit access and extension enhances farmer yields which can increase cocoa income -Premium payment positively impacts cocoa income
Oil palm income	-Good agricultural practices, credit access and extension enhances farmer yields which can increase cocoa income
Food security	-Increased farm income from increased cocoa and oil palm incomes increases food purchasing power, hence enhancing food security -Extension knowledge on GAPs and credit from certification adoption can be applied on food crop farms to increase yields for food crops
Poverty (MPI)	-Increased incomes from cocoa and oil palm certification reduces the poverty status of farmers
Oil palm yield	-Certified farmers receive extension service on GAPs and also access credit (inputs, cash, etc) -GAPs, extension and credit access has the potential of increasing oil palm yields
Cocoa yield	-Certified farmers receive extension service on GAPs and also access credit (inputs, cash, etc) -GAPs, extension and credit access has the potential of increasing cocoa yields

Three levels of comparison for each impact category, namely "certified vs. uncertified", "certified vs. food crops" and "uncertified vs. food crops" was done. 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.

2.7.4.1 Food security

Standardized metrics of food security have recently gained attention for assessing food security at the household level (Carletto *et al*., 2013; Pérez-Escamilla *et al*., 2013). Such metrics include the Food Consumption Score (FCS) (WFP, 2008), Household Food Insecurity Access Scale (HFIAS) (Coates *et al*., 2007; Ngome *et al,* 2019) and the Coping Strategies Index (CSI) (Maxwell & Caldwell, 2008). These composite metrics offer certain advantages such as an ability to capture in a robust manner certain aspects of food security and at the same time reduce much of the complications associated with nutritional surveys (Carletto *et al*., 2013). Despite some shortcomings associated with their narrow viewpoint (Leroy *et al*., 2015), such standardized metrics can have large explanatory power and relevance for policy and practice (Pérez-Escamilla *et al*., 2013).

In this dissertation a combination of the FCS, the HFIAS, and the CSI is used. Such tools have been used for assessing the food security outcomes of involvement in non-food cash crop production in SSA (e.g. Balde *et al*., 2019; Bosch & Zeller, 2019; Anderman *et al*., 2014), however they have not been used in the context of certification. Between them these three metrics capture different aspects of food security (Anderman *et al*., 2014).

The *Household Food Insecurity Access Scale (HFIAS)* measures the severity of food insecurity based on household behaviours (Ballard *et al*., 2011). It is a continuous measure of access to food (Coates et al., 2007; Ngome et al, 2019) that is elicited using nine main sets of double questions of progressively more severe food insecurity within the four-week period (30 days) before the survey (Table 2-9). The two questions for each situation are an occurrence question (i.e. does the household experience the specific situation) and a frequency question (i.e. if the answer to the occurrence question is Yes, then how many times thus happened in the past 4 weeks). Responses in the frequency question are captured as: 1=Rarely (once or twice in the past four weeks), 2=Sometimes (three to ten times in the past four weeks) and 3=Often (more than ten times in the past four weeks). As such, scores range between 0-27 for every household. The average HFIAS score, as used in this study, is calculated by dividing the same of individual household scores by the number of scores (number of households) (Coates *et al.*, 2007).

Table 2-10: Questions for capturing HFIAS

No.	Occurrence Questions	Yes=1 No=0	If Yes, how often did this happen? 1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)
1.	In the past four weeks, did you worry that your household would not have enough food?		
2.	In the past four weeks, were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources?		
3.	In the past four weeks, did you or any household member have to eat a limited variety of foods due to a lack of resources?		
4.	In the past four weeks, did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources to obtain other types of food?		
5.	In the past four weeks, did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food?		
6.	In the past four weeks, did you or any household member have to eat fewer meals in a day because there was not enough food?		
7.	In the past four weeks, was there ever no food to eat of any kind in your household because of lack of resources to get food?		
8.	In the past four weeks, did you or any household member go to sleep at night hungry because there was not enough food?		
9.	In the past four weeks, did you or any household member go a whole day and night without eating anything because there was not enough food?		

Source: Coates et al. (2007)

The *Food Consumption Score (FCS*) captures dietary diversity, food frequency and relative nutritional frequency (WFP, 2008). Households report the consumption of nine food groups in the 7 days prior to the survey (Table 2-10). Consumption frequencies are summed for all types of food consumption within the same groups. The frequency values are multiplied by weights assigned to the food groups, and the weighted food group scores are summed and placed within determined modified thresholds according to the prevailing food commodities in the study areas (Poor, Borderline and Acceptable).

Table 2-11: Questions for capturing Food Consumption Score

	Food items	**Food groups (definitive)**	**Weight (definitive)**
1	Maize, maize porridge, rice, sorghum, millet pasta, bread and other cereals	Main staples	2
2	Cassava, potatoes and sweet potatoes, other tubers, plantains		
3	Beans. Peas, groundnuts and cashew nuts	Pulses	3
4	Vegetables, leaves	Vegetables	1
5	Fruits	Fruit	1
6	Beef, goat, poultry, pork, eggs and fish	Meat and fish	4
7	Milk yogurt and other diary	Milk	4
8	Sugar and sugar products, honey	Sugar	0.5
9	Oils, fats and butter	Oil	0.5
10	spices, tea, coffee, salt, fish power, small amounts of milk for tea.	Condiments	0

(WFP, 2008)

The threshold classification are as follows;

FCS	**Profiles**
0-49	Poor
49.5-63	Borderline
>63	Acceptable

The Coping Strategies Index (CSI) measures household adaptation strategies in case of a shortfall in food for consumption (Table 2-11). The coping strategies are weighted based on the severity of the strategy as follows: 1=least severe category; 4=most severe, with scores of 2 and 3 being intermediate categories. Changes in the index imply whether food security is improving or worsening, with high CSI denoting increased use of coping strategies and hence increased food insecurity (Maxwell & Caldwell, 2008).

Table 2-12: Coping Strategy Index (CSI) Questions

Behavior	Frequency: Number of days out of the past seven: (Use numbers 0 – 7 to answer number of days; Use NA for not applicable)
Rely on less preferred and less expensive food	
Borrow food or rely on help from relative/friend	
Buy food on credit	
Gather wild food, hunt	
Consume seed stock from next year	
Send household members to eat elsewhere	
Limit portion size	
Restrict consumption of adults for little children to eat	
Feed working members at the expense of non-working members	
Ration money saved and buy prepared food	
Reduce number of meals eaten in a day	
Skip entire days without eating	
Borrow money to buy food	
Casual labour for food (as payment)	
Total	

Source: (Maxwell & Caldwell, 2008)

Between them, these three metrics capture different aspects of food security. For example, the Coping Strategies Index measures household behavioral response to food shortage. As such, changes in quantities of food consumed (stability) as well as changing food preferences (likely effect on nutrition) in households elicit varied aspects of food security. Hence, combining CSI with other adopted indices: FCS (access, nutrition), HFIAS (access, stability) (Anderman *et al.*, 2014), coupled with income and crop diversification measurements offer a comprehensive approach to understand food security in the study sites.

2.7.4.2 Farm yields

In estimating oil palm and cocoa 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-Rahman & Abdulai, 2018; Danso-Abbeam & Baiyegunhi, 2018).

2.7.4.3 Household income

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). T-test is conducted to establish statistically significant difference in mean income among certified and uncertified farmers (Chiputwa *et al.*, 2015).

2.7.4.4 Household consumption

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 (GSS, 2015; Ahmed *et al.*, 2019).

2.7.4.5 Poverty: Multidimensional Poverty Index (MPI)

The Multidimensional Poverty Index (MPI) is a non-monetary measure of human wellbeing to complement income and consumption results (Mudombi *et al.*, 2018; Alkire & Foster, 2011a; Akire & Foster, 2011b) 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 (Bennet & 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 2-12) (Alkire and Santos, 2011; Tran *et al.*, 2015). These three dimensions are further divided into 10 indicators. Similar to other studies the conventional measure of nutrition (Body Mass Index) was replaced with a measure of household diet diversity (Food Consumption Score) (Table 2-12) (Mudombi *et al.*, 2018; Ahmed *et al*., 2019).

Each dimension is weighted equally on a maximum indicator value of 1 as seen in Table 2-12. In essence, this index helps to effectively direct policy towards the dimension that contributes the most to household poverty.

Table 2-13: 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-5 year 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 and Santos, 2014)

Estimation of the MPI begins with calculation of deprivation scores for each indicator which is summed to obtain the household deprivation score, c. Deprivation of a household is judged with a cutoff of 33.3 percent, 0.33 or 1/3 of the weighted indicators. Households with deprivation scores of .33 or more is multi-dimensionally poor.

The headcount ratio, H, which is the proportion of the multi-dimensionally poor in the population is estimated as;

$$H = \frac{q}{n} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (Eq. 9)$$

Where q is the number of multi-dimensional poor people and n is the population.

$$A = \frac{\Sigma_j^q c_i}{q} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (Eq.10)$$

Where c_i is the depreciation score the ith individual experiences. The deprivation score, c_i 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 headcount ratio and the intensity of poverty.

MPI=H*A……………………………………………………………………………(Eq.11)

2.8 Study Limitation

The study utilized cross-sectional data collection to elicit the impact of certification adoption. Cross-sectional data provides a point or snapshot analysis of the impact of certification whiles panel data allows subjects to be studied over time, which reveals the dynamics in a problem (Frees, 2004). Because of the advantage of the panel data in revealing dynamic relationships, it has been applied in several impact estimations where researchers collect data pre and post interventions to assess the impact of interventions (Apiors & Suzuki, 2018; Arslan *et al*., 2017). However, the use of panel data may encounter drawbacks such as high attrition rates and the high cost of collecting data from the subject within the research period (Frees, 2004). In addition, time constraints of the research may jeopardize the execution of the survey plan.

For this study on the impact of certification, an added challenge was the fact that since certification had been adopted prior to the commencement of this study, it was impossible to collect data before adoption. Based on these factors, this study adopted the use of cross-sectional data as used by other studies despite its shortcomings (Chiputwa *et al*., 2015; Mitiku *et al*, 2017).

Apart from the data limitations, the study was primarily based on assessing the socioeconomic impact of certification with partial concentration on environmental impact. The socioeconomic impact of certification was highlighted because it influences farmers' decision after adoption and how other uncertified farmers make decisions concerning certification. As such, the environmental impact was not included in the field surveys and analysis. This was primarily based on time and financial constraints. In eliciting the environmental impact however, expert interviews and farmer perceptions on environmental impact was used to provide some insights into the environmental dimension.

CHAPTER THREE

STAKEHOLDER ANALYSIS: DRIVERS, BARRIERS AND IMPACT OF COCOA AND OIL PALM CERTIFICATION

This chapter cannot be made public on the Internet for (5) years from the date of doctoral degree conferral because it is scheduled to be published as part of a journal.

CHAPTER FOUR

PROMOTION AND ADOPTION DYNAMICS IN THE CERTIFICATION OF COCOA AND OIL PALM SMALLHOLDERS IN GHANA

This chapter cannot be made public on the Internet for (5) years from the date of doctoral degree conferral because it is scheduled to be published as part of a journal.

CHAPTER FIVE

IMPACT OF CERTIFICATION ON YIELD, INCOME, POVERTY AND FOOD SECURITY

This chapter cannot be made public on the Internet for (5) years from the date of doctoral degree conferral because it is scheduled to be published as part of a journal.

CHAPTER SIX

RESEARCH SYNTHESIS AND POLICY IMPLICATIONS

6.1 Introduction

As outlined in Chapter 1, this study assesses the adoption and impacts of certification adoption among oil palm and cocoa smallholders in Ghana, and to proffer policy and practice options for increased adoption and possible impact. The focus of this study is on how UTZ/Rainforest Alliance smallholders and Roundtable on Sustainable Palm Oil certification possibly impacts smallholders. The specific objectives include:

1) To understand the perceptions of the main stakeholders involved in oil palm and cocoa value chains towards certification, as well as the existing connections in the context of certification
2) To analyse the promotion and adoption dynamics of farmer participation in certification programmes
3) To establish the possible impacts of certification adoption on farm productivity, multidimensional poverty, income, and food security
4) To provide policy recommendation to enhance the adoption and impacts of certification for smallholders in Ghana

This chapter presents a holistic synthesis of the main findings of this research (Section 6.2). Certification adoption is a key mechanism for sustainable production. This is important in achieving the Sustainable Development Goals as captured in Section 1.8.2. Section 6.3 presents policy and practice options for increased adoption and impact of certification adoption while 6.4 presents suggestions for further research.

6.2 Main findings

6.2.1 Stakeholder Analysis: Drivers, Barriers and Impact of Cocoa and Oil Palm Certification

The institutional analysis highlights the large diversity of stakeholders involved in oil palm and cocoa certification processes in Ghana, and their tight interconnections. In terms of policy, there is specific policy promoting certification adoption in Ghana (Section 3.2). Stakeholders at the local, national and international level are connected across policy, implementation, research and advocacy as well as funding lines. Smallholders, with inherently low capacity of resources and knowledge occupy a central part in certification processes in both cocoa and oil palm sectors (Figure 3-1,3-2) which requires collaborations to support farmers. Currently various LBCs, GAs, and NGOs organize, manage or provide support to smallholder cooperatives to engage in certification processes, especially in the cocoa sector (Fenger *et al.*, 2017).

When it comes to certification adoption, the results suggest that rather different factors drive certification adoption among smallholders and large companies. Most stakeholders indicate that market-related factors such as premiums and market demand are the most important in driving certification adoption among smallholders (Figure 3-3). Some respondents also indicated farm productivity gains (and associated impacts) as important drivers of adoption (Figure 3-3).

Conversely, most stakeholders perceive that large companies engage in certification processes mostly due to consumer demand for certified products, and that by catering to this demand can improve company competitiveness (Figure 3-4). Company image and core values are also strong drivers of certification among large producers in Ghana, albeit to a lesser extent (Figure 3-4). This is despite the fact that globally many large commercial producers of agricultural commodities steadily embrace a more sustainable image to guide their operations, viewing certification as a potential avenue to meet their CSR goals (Fenger *et al*., 2017).

Most stakeholders focused on the positive economic and environmental impacts of certification. Farm productivity increase, income gains and capacity-building opportunities are perceived to be the most important economic impacts (Figure 3-5). Some stakeholders also mentioned positive impacts in terms of access to extension, capacity-building and funding opportunities, all of which are scarce in many rural contexts of Ghana (Danso-Abbeam *et al*., 2018; Asiedu-Darko, 2013). In terms of environmental impacts, most stakeholders argue that the positive impact of certification is for reducing deforestation, pollution and biodiversity loss (Figure 3-5).

Stakeholders alluded to multiple financial, operational, marketing, capacity and institutional barriers to the adoption of certification in both sectors (Figure 3-6). Financing was perceived to be the major barrier to certification considering the high costs associated with training, altering operations, setting up internal control systems, and undertaking regular audit, which many farmers and companies cannot bear.

6.2.2 Promotion and Adoption Dynamics in the Certification of Cocoa and Oil Palm Smallholders in Ghana (Objective 2, Chapter 4)

The promotion of certification standards to smallholders (and their targeting) follows rather different approaches that reflect the distinct configurations of the two sectors. Specifically, the targeting of smallholders in the cocoa sector follows three approaches, namely the *buyer-led approach, intervention-based approach* and *farmer-led approach* (Section 4.2.1), Conversely smallholder targeting in the oil palm sector usually follows *mill-led* or *intervention-based* approaches (Section 4.2.2).

Conversely, the smallholder targeting approaches in the oil palm sector are rather discrete, with scheme smallholders targeted through *mill-led* approaches, and independent smallholders through *intervention-based* approaches (Section 4.2.2). Economic motives are very prevalent in *mill-led* approaches (Section 4.2.2), especially from the side of large plantations/mills that essentially oblige their scheme smallholders to adopt certification standards as a means of increasing their capacity to target different markets (Khatun *et al*., 2020) and essentially their long-term economic viability (MASDAR, 2011; Oosterveer *et al*., 2014; Tey *et al*., 2020). On the contrary the adoption of certification standards is voluntary among independent smallholders. However, economic issues such as lack of premiums and high certification costs preclude their adoption (Section 4.5). This leaves intervention-based approaches as the only feasible option to build capacity among independent oil palm smallholders, with a few civil society organizations such as Solidaridad West Africa promoting certification adoption among independent smallholders.

When it comes to the factors affecting the adoption of certification standards, the age of the household head, and the ownership of livestock and information access devices have a significant positive effect on adoption decisions (Section 4.4).

The high cost of inputs and concerns over profitability are major perceived challenges associated with certification adoption by both cocoa and oil palm smallholders (Ansah *et al*., 2020; Fenger *et al*., 2017; Rietberg & Slingerland, 2016). For oil palm smallholder the lack of profitability is linked to the lack of premiums (Section 4.2.2), which is in turn influenced by the high domestic oil palm demand considering palm oil's importance in local diets and other processing industries (Adjei-Nsiah *et al*., 2012). With domestic consumers not "demanding" sustainable palm oil to the same extent as international consumers, there is little incentive for independent smallholders to adopt certification standards considering the high costs of certification (Khatun *et al*., 2020; Oosterveer *et al*., 2014; Rietberg & Slingerland, 2016).

6.2.3 Possible impacts of Certification on Yield, Income, Poverty and Food Security (Objective 3, Chapter 5)

Certified farmers generally have higher access to extension services and credit compared to their respective comparison groups (Table 5-1 and 5-2), which is consistent with the literature in Ghana and other parts of the world (Ansah *et al.*, 2020; Chiputwa *et al.*, 2015; Djokoto *et al.*, 2016; Adjei-Nsiah *et al.*, 2012). 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). 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.

Certified cocoa farmers record significantly higher yields 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 addition, certified cocoa farmers have both a higher cocoa income and farm income than uncertified farmers (Section 5-5, Table 5.5), which is also reflected in increased household incomes of certified farmers. Apart from the adoption of improved production practices (Table 5.4), 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, income gains are mainly due to yield improvements rather than premiums (92.1% vs. 7.9% of contribution to income gains on average respectively).

Table 6-1: Percentage of cocoa income attributable to premium and increased yield

	Premium (GHC)	Premium (%)	Yield (%)
Minimum	10.00	.64	99.36
Maximum	495.00	31.49	68.52
Average	123.71	7.87	92.13

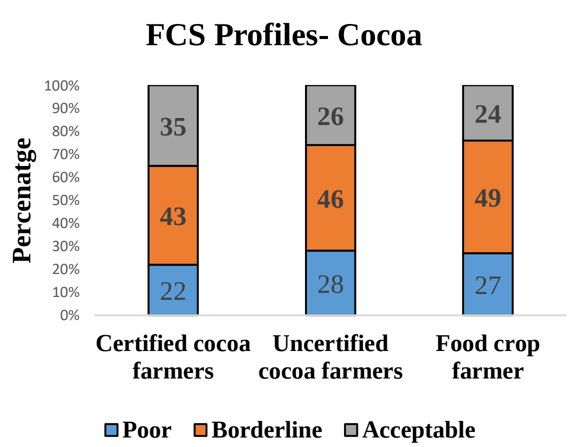
Certified oil palm farmers report higher yields (Section 5-3), though not significantly, possibly due to the higher age of oil palm trees (Ofosu-Budu & Sarpong, 2013). Overall oil palm contribution to total household income is lower compared to off-farm income. Additionally, study groups in the oil palm site show consistently lower MPIs and deprivation scores for most dimensions for the study groups compared to the cocoa study site (Figure 5-1). 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.

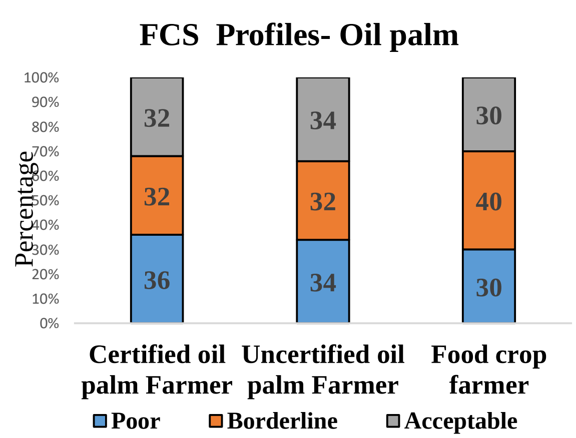
In addition, the results suggest that (a) certified cocoa and oil palm farmers have higher food security compared to uncertified farmers and food crop farmers, and (b) food crop farmers perform better than uncertified cocoa and oil palm farmers. These results are consistent among the three indicators used in this study, namely the FCS, HFIAS and the CSI (Section 5.6.1). These patterns might be mediated by three main underlying mechanisms (a) higher income and food expenditure associated with engagement in certification, (b) improved access to extension and credit access, (c) diversified food cropping.

In the cocoa study site, certified cocoa farmers have higher FCS compared to the controls (Section 5.7). In terms of HFIAS, which measures farmers' long-term behaviour of food insecurity in relation to availability and access, certified cocoa farmers are better off than the controls. This results obtained in the HFIAS estimation is also reflected in lower CSI (short term response to food security) of certified cocoa farmers.

In the oil palm study site, certified oil palm farmers have higher FCS compared to controls (Section 5.7). The low HFIAS of certified oil palm farmers is also reflected in lower CSI compared to uncertified oil palm farmers and food crop farmers. In addition, uncertified farmers show higher CSI compared to uncertified food crop farmers. This shows that uncertified cocoa farmers show higher long-term (HFIAS) and short term (CSI) behavioural food insecurity compared to food crop and certified oil palm farmers.

In spite of the positive effect of certification on food security, an important pattern is observed that may expose certified farmers to food insecurity shocks. It is observed that more than 60% of certified cocoa and oil palm farmers are classified in the poor and borderline profiles of the Food Consumption Score indicator (Figure 5-5) which gives an indication of farmers' exposure to food security.





Extracted from Figure 5-5

Generally, certification adoption enhances yields, incomes, poverty and food security among cocoa and oil palm farmers (Table 6-2). The extent of possible impacts are however varied for the different indicators mediated by a number of factors including input and extension access, access to credit, farmer capacity building, implementation of Good Agricultural Practices, crop age as well as local configurations of agricultural production.

Table 6-2: Synthesis of the possible impact of certification

Variables	Cocoa	Oil palm
Yield (kg/ha or ton/ha)	++	+
Farm income	++	+++
Oil palm /cocoa income	++	+++
Household income	+++	+++
Per capita income	+++	+++
Poverty (MPI)	+	++
Food security (FCS)	+	+
Food security (HFIAS)	++	++
Food security (CSI)	+	+++

Key:

+	++	+++
Low	medium	high

0-33%- low, **34-66%**=medium, 67-100%=high

6.3 Policy/practice implications and recommendations

As outlined in preceding chapters, the adoption of certification standards can have multiple impacts on the production and livelihood of oil palm and cocoa smallholders in Ghana. This is particularly important for Ghana as government and other relevant stakeholders are implementing interventions within the framework of its national investment plan: Investing for Food and Jobs and Tree Crops Policy which highlights the adoption of certification standards as a way of enhancing product quantity and quality, guaranteeing the marketability of Ghana's products as well as improving smallholder livelihoods (MoFA, 2018). In achieving this plan, the Ghana Cocoa Board for instance has a strategy of improving the yield of farmers to 1ton/ha, through the Productivity Enhancement Program. Interventions include farm rehabilitation, irrigation, improving extension, control of pest and diseases, as well as improving the demand for Ghana's cocoa. These interventions as well as certification standards can play an important role in achieving these targets as well as its commitment to the Sustainable Development Goals. Based on this, the following policy and practice options are recommended;

a. Improve smallholder targeting approaches (Section 6.2.1, Section 6.2.2)
b. Improve premium design (Section 6.2.1, Section 6.2.3)
c. Improve yield gains (Section 6.2.2, Section 6.2.3)
d. Enhance income diversification for smallholders (Section 6.2.3)
e. Include crop diversification in certification guidance and principles (Section 6.2.3)
f. Explore the feasibility of a nationally mandated approach to certification (Section 6.2.1, overarching alternative)

6.3.1 Improve smallholder targeting approaches

There is the need to improve smallholder targeting approaches from LBCs and GAs to avoid predatory practices or ineffective support to smallholders. This could go a long way to reduce the risk of smallholders dropping certification standards soon after adoption or not implementing them properly. This might require measures such as a stronger overseeing of LBCs/GAs from the Ghana

Cocoa Board or possibly capping the number of farmers/groups that LBCs/GAs can engage with based on available manpower. For the oil palm sector, there is the need to tailor contractual arrangements to garner support for independent smallholder oil palm certification adoption.

6.3.2 Improve premium design

Premium payments is perhaps the most important driver of certification adoption among smallholders (Section 4.2.1, Section 4.2.2). However premium payments are beset with many problems, which are major disincentives for cocoa farmers (pers. Comm, QC). In particular, cocoa premiums are very low (Table 6-1), while some LBCs delay premium payment or unilaterally change the amounts. The situation is even worse in the oil palm sector, as due to the certification modalities there is no premium payment to smallholders currently. It could be argued that both increasing premium payment levels and improving their design and payment modalities could catalyse the wider adoption of certification standards. This would most likely require (a) very different approaches between sectors, (b) further research to establish the most appropriate modalities, (c) coordination between stakeholders to reach mutually acceptable solutions, and exploring market demand to push for premiums for certification adopters.

However, it should be noted that most smallholders tend to concentrate on the modest direct payments offered by premiums (Fenger *et al*., 2017; Ansah *et al*., 2020), having little consideration or even understanding of the wider benefits of certification (Section 4.2.1). In a sense by "fixating" on the premium, no matter how important, smallholders run the risk of "seeing the tree rather than the forest". Hence, there should be significant efforts towards farmer education and training regarding the wider economic, environmental and social benefits of certification, conveying that premiums are just one of these benefits (and possibly one of the more modest ones).

In enhancing premiums and ensuring wider benefits, the major focal points for implementation of this policy includes Group Administrators, Licensed Buying Companies, Policy institutions and Non-Governmental organizations. This is because these stakeholders are at the core of implementation and regulation of certification landscape in Ghana.

6.3.3 Improve yield gains

Certified farmers have higher yields compared to uncertified farmers in both study sites. Yield improvements seem to be mediated by the better access of certified farmers to training, agricultural inputs and credit as well as the conducive microclimate on farms, which are in turn facilitated by organization in groups (cocoa farmers) or strong linkages with large companies (oil palm farmers) (Section 4.1). However, the increased yields are still lower compared to national yield levels. This implies that though certification has the advantage of enhancing farm yields, it has not been able to help farmers scale over the national average as seen in Figure 6-2.

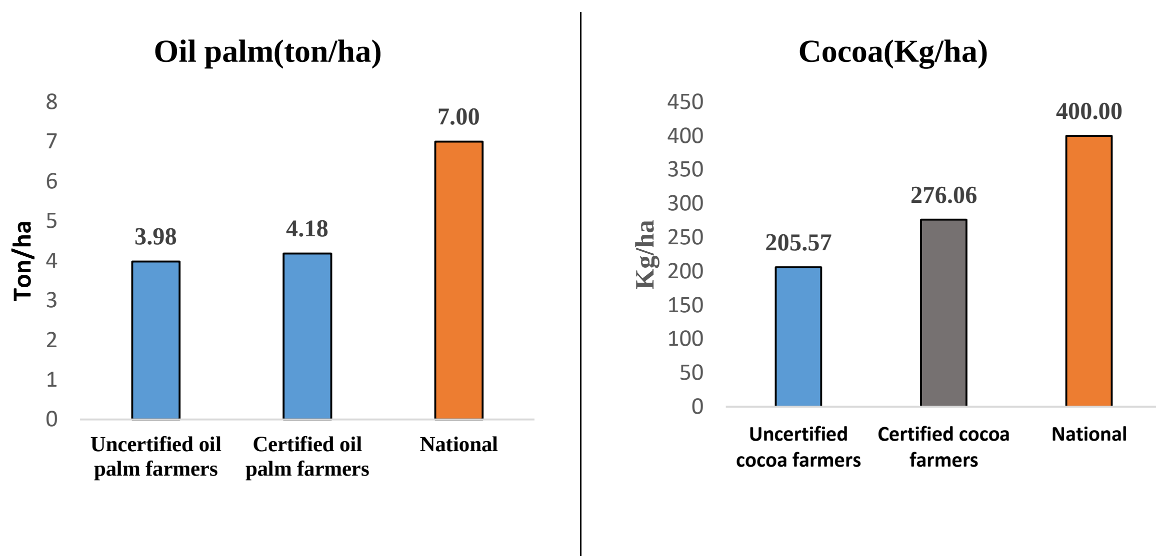


Figure 6-1: Yield of cocoa and oil palm farmers

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. In achieving yield gains, the target stakeholders to achieve impact are Group Administrators, Licensed Buying Companies, Oil palm mills, smallholders and Non-governmental organizations.

6.3.4 Enhance income diversification for smallholders

Though certification results in consistent income benefits for certified farmers in both the oil palm and cocoa study sites, very different levels of income diversification between cocoa and oil palm smallholders are observed. In particular, income diversification is low among cocoa farmers, which show high degree of specialization in cocoa farming (Table 5-5 and 5-6). The lack of income diversification might increase household vulnerability to livelihood shocks as result of pest and disease outbreak as well as climatic variations (Section 6.7.1).

In order to reduce such vulnerabilities, it is suggested that certification agencies, Group Administrators and Licensed Buying Companies 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. This also requires efforts by Non-Governmental organizations to building farmer capacity on other avenues for income generation.

6.3.5 Include crop diversification in certification guidance and principles

Certification adoption enhances the food security of certified cocoa and oil palm farmers (Section 6.2.3). However, certified cocoa and oil palm farmers may be vulnerable to food security shocks (Figure 22) in spite of the generally high food security levels of certified cocoa and oil palm farmers. This may be particularly related to the heavy dependence on cocoa incomes which may expose cocoa farmers to food insecurity as a result of weather variations, pest and disease outbreaks. Though certified oil palm farmers have much balanced dependence on oil palm income, the potential vulnerability to food insecurity may be resulting from other local mechanisms that favors oil palm production at the expense of food crops resulting in decreased food supply and high prices. This is manifested in the increased household expenditure on food for farmers in oil palm study site compared to the cocoa study site (Section 6.6).

From the foregoing, an enhanced strategy to encourage crop diversification in the programming of certification guidance and principles. This is because certification may be achieving some impacts in terms of enhancing farm incomes. Improved food crop diversification will further enhance farm availability, access and nutritional diversity of food for household consumption.

6.3.6 Explore the feasibility of a nationally mandated approach to certification

Certification in Ghana is currently performed at the farm level, i.e. at the individual producer level whether a company or a single farmer. This means that not all producers within a given landscape might opt to adopt certification standards. This can have important ramification for possible impact generation especially in the cocoa sector (possibly less so in the oil palm sector considering the block approach to certification), as the positive impact of good agricultural practices adopted by some producers may be negated by the business-as-usual approach of non-certified adjoining farmers, a case in point is pest and disease management. This may have contributed to the perceptions of some stakeholders that certification failed to produce substantial environmental benefits (personal comm.: NCRC). Thus, it might be beneficial to move certification from the farm level to landscape level through a well-designed policy, where entire landscapes are certified, possibly eliminating impact negation from uncertified producers and reducing the overall certification costs (Ghazoul *et al*., 2009). However, moving towards a landscape approach to certification would most likely require (a) substantial research to assess the potential and impacts of such approaches (Furumo *et al*., 2020), and (b) institutional reforms considering the highly fragmented nature of Ghanaian agrarian landscapes and the prevailing land tenure rules (Asaaga *et al*., 2020).

In addition, cocoa and oil palm certification are voluntary processes that are not regulated through a centralized policy framework (Section 1.3). Actually, despite the strong overseeing role of the Ghana Cocoa Board in the cocoa sector (and as an extension on cocoa certification) there is no dedicated policy mandating or regulating directly certification. In view of this policy gap, some stakeholders called for the development of a cohesive policy framework that could regulate centrally certification processes, for example, mandating the adoption of some minimum sustainable production practices for oil palm and cocoa (pers. Comm. RA; CAA; SSU). The underlying rationale is that such a framework could (a) show strong signals about the importance of certification, (b) coordinate fragmented actions between stakeholders, (c) rationalize the inconsistencies and confusion generated by the proliferation of certification schemes, (d) streamline the demanding (and often different) documentation requirements between schemes and the underlying bureaucracy. However, there would be a need for extensive prior deliberation between all relevant stakeholders about the scope and mandate of such a framework, coupled with robust research about its possible format and modalities, as stringent top down frameworks mandating and regulating certification have underperformed in some contexts (e.g. Buliga & Nichiforel, 2019).

The multiple possible sustainability impacts and distinct impact mechanisms related to certification suggest that the widespread adoption of certification can have a positive effect to progress for many Sustainable Development Goals (SDGs) if well ground in policy and implementation. In particular, although certification is inherently associated with the adoption of sustainable production practices, and is thus directly linked to SDG12 (Responsible consumption and production), certification can also contribute to multiple other SDGs. By boosting agricultural output, improving working conditions in plantations, and increasing the appeal of Ghanaian products to a sustainability-conscious international customer base (increasing in the process the competitiveness of domestic producers), cocoa and oil palm certification can have an appreciable effect to SDG 8 (Decent work and economic growth). At the same time the extra income to smallholders can contribute to rural poverty alleviation and SDG1 (No poverty). The widespread adoption of environmentally sound practices can reduce pressure on the climate and conserve ecosystems, contributing respectively to SDG13 (Climate action) and SDG15 (Life on land). Considering the multiple stakeholders involved in oil palm and cocoa certification, certification processes can become a point of convergence to foster more effective partnerships contributing thus to SDG17 (Partnership for the goals).

6.4 Suggestions for future research

A number of limitations are outlined in Section 2.8 which requires efforts to bridge as a way of enhancing the robustness of study results.

First, the study utilized cross-sectional data in eliciting adoption and possible impacts of certification standards on farmers. In causal estimations however, the gold methodology is the use of a randomized control trial to make causal inference. This is because it has the least potential bias that provides top level evidence for decision. It is therefore recommended to adopt such sampling approaches in subsequent impact estimations to adequately assess the impact of certification for independent farmers to inform interventions aimed wider uptake.

Secondly, it is recommended to undertake studies on the impact of certification on independent oil palm farmers. This is because independent oil palm farmers are the majority in oil palm production in Ghana. Thus, conducting such study will inform policy and practice on the true impact of certification adoption on independent oil palm farmers. This research was unable to assess impact on independent farmers because at the time of the study no independent smallholder had adopted certification (RSPO).

Finally, it is recommended for researchers to conduct in-depth studies into the environmental impact of certification. This is because this study as well as current reviewed literature mostly focus on socioeconomic impact of certification. Highlights on environmental aspects of certification is presented based on perceptions of adopted practices. This provides some insights but not comprehensive enough to assume causality. Hence, a comprehensive assessment of the environmental impact of certification may possibly be a good information source for policy decisions on possibilities of implementing landscape certification.

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APPENDICES

APPENDIX A: Supplementary material for mixed effect probit regression (Section 4.4)

Table S1: Correlation between explanatory variables for mixed effect probit regression (Section 4.4)

	Log(Age)	Education	Household size (Adult Equivalent)	Log (off-farm income)	logCocoa farm size	Formal employment	Livestock ownership	Access to information devices
Log(Age)	1							
Education	-0.2419	1						
Household size (Adult Equivalent)	-0.0305	0.1752	1					
Log (off-farm income)	0.0525	0.2303	0.0249	1				
Log Cocoa farm size	0.0547	0.0815	0.1463	0.0823	1			
Formal employment	0.0269	0.0733	-0.0575	0.2881	0.0507	1		
Livestock ownership	-0.0218	0.0944	0.1896	0.3110	0.0714	0.1638	1	
Access to information devices	-0.0391	0.2070	0.1191	0.0079	0.1031	-0.0580	0.1791	1

Table S2: Normal probit and mixed effect model.

Variables	Normal probit model		Mixed effect probit model	
	Coefficients	Standard errors	Coefficients	Standard errors
Log(Age of household head) (Years)	2.31***	0.79	2.67***	1.09
Education of household head (dummy)	-0.43*	0.23	-0.60*	0.33
Household size (Adult Equivalent)	-0.12	0.09	-0.10	0.12
Log(Cocoa farm size (ha))	0.39	0.35	0.44	0.50
Formal employment (dummy)	0.15	0.21	0.34	0.33
Livestock ownership (dummy)	1.09***	0.21	1.35***	0.32
Ownership of information access devices (dummy)	0.75***	0.22	0.94***	0.32
Community variable			1.78	1.29

Note: LR test vs. probit model: chibar2(01) = 9.86 Prob >= chibar2 = 0.0008

APPENDIX B: Supplementary material for impact estimation (Chapter 5)

Yield, income, consumption and Multidimensional Poverty (MPI)

Table S3: Balancing test for certified cocoa and uncertified cocoa farmers

	No. Of Significant. Variables	Pseudo R2	p-Value LR* Test	Mean Bias
Impact of involvement in certification				
Household Income				
Before matching	2	0.064	0.120	13.8
Radius Caliper (0.1)	0	0.005	1.000	3.7
Nearness neighbour	1	0.070	0.098	7.8
Kernel common trim (0.1)	1	0.004	1.000	4.0
Cocoa income				
Before matching	2	0.064	0.120	13.8
Radius Caliper (0.1)	0	0.005	1.000	3.7
Nearness neighbour	1	0.070	0.098	7.8
Kernel common trim	1	0.004	1.000	4.0
Per capita income				
Before matching	2	0.064	0.120	13.8
Radius Caliper (0.1)	0	0.005	1.000	3.7
Nearness neighbour	1	0.070	0.098	7.8
Kernel common trim	1	0.004	1.000	4.0
Farm income				
Before matching	2	0.064	0.120	13.8
Radius Caliper (0.1)	0	0.005	1.000	3.7
Nearness neighbour	1	0.070	0.098	7.8
Kernel common trim	1	0.004	1.000	4.0
Total household consumption				
Before matching	2	0.064	0.120	13.8

Radius Caliper (0.1)	0	0.005	1.000	3.7
Nearness neighbour	1	0.070	0.098	7.8
Kernel common trim (0.1)	1	0.004	1.000	4.0
Per capita consumption				
Before matching	2	0.064	0.120	13.8
Radius Caliper (0.1)	0	0.005	1.000	3.7
Nearness neighbour	1	0.070	0.098	7.8
Kernel common trim (0.1)	1	0.004	1.000	4.0
Yield				
Before matching	2	0.064	0.120	13.8
Radius Caliper (0.1)	0	0.005	1.000	3.7
Nearness neighbour	1	0.070	0.098	7.8
Kernel common trim (0.1)	1	0.004	1.000	4.0
Poverty (MPI weighted score)				
Before matching	2	0.064	0.120	13.8
Radius Caliper (0.1)	0	0.005	1.000	3.7
Nearness neighbour	1	0.070	0.098	7.8
Kernel common trim (0.1)	1	0.004	1.000	4.0

Table S3: Balancing test for certified cocoa farmers and food crop only farmers

	No. Of Significant. Variables	Pseudo R2	p-Value LR* Test	Mean Bias
Impact of involvement in certification				
Household Income				
Before matching	3	0.151	0.000	27.2
Radius Caliper (0.1)	0	0.005	0.993	6.2
Nearness neighbour	0	0.046	0.190	13.4

Kernel common trim (0.1)	0	0.008	0.975	5.4
Per capita income				
Before matching	3	0.151	0.000	27.2
Radius Caliper (0.1)	0	0.005	0.993	6.2
Nearness neighbour	0	0.046	0.190	13.4
Kernel common trim	0	0.008	0.975	5.4
Total household consumption				
Before matching	3	0.151	0.000	27.2
Radius Caliper (0.1)	0	0.005	0.993	6.2
Nearness neighbour	0	0.046	0.190	13.4
Kernel common trim (0.1)	0	0.008	0.975	5.4
Per capita consumption				
Before matching	3	0.151	0.000	27.2
Radius Caliper (0.1)	0	0.005	0.993	6.2
Nearness neighbour	0	0.046	0.190	13.4
Kernel common trim (0.1)	0	0.008	0.975	5.4
Farm income				
Before matching	3	0.151	0.000	27.2
Radius Caliper (0.1)	0	0.005	0.993	6.2
Nearness neighbour	0	0.046	0.190	13.4
Kernel common trim (0.1)	0	0.008	0.975	5.4
Poverty (Weighted score)				
Before matching	3	0.151	0.000	27.2
Radius Caliper (0.1)	0	0.005	0.993	6.2
Nearness neighbour	0	0.046	0.190	13.4
Kernel common trim (0.1)	0	0.008	0.975	5.4

Table S4: Balancing test for uncertified cocoa farmers and food crop farmers

	No. Of Significant. Variables	Pseudo R2	p-Value LR* Test	Mean Bias
Impact of involvement in certification				
Household Income				
Before matching	1	0.142	0.000	19.1
Radius Caliper (0.1)	0	0.017	0.834	9.9
Nearness neighbour	0	0.011	0.941	6.8
Kernel common trim (0.1)	0	0.020	0.776	10.5
Per capita income				
Before matching	1	0.142	0.000	19.1
Radius Caliper (0.1)	0	0.017	0.834	9.9
Nearness neighbour	0	0.011	0.941	6.8
Kernel common trim	0	0.020	0.776	10.5
Total household consumption				
Before matching	1	0.142	0.000	19.1
Radius Caliper (0.1)	0	0.017	0.834	9.9
Nearness neighbour	0	0.011	0.941	6.8
Kernel common trim (0.1)	0	0.020	0.776	10.5
Per capita consumption				
Before matching	1	0.142	0.000	19.1
Radius Caliper (0.1)	0	0.017	0.834	9.9
Nearness neighbour	0	0.011	0.941	6.8
Kernel common trim (0.1)	0	0.020	0.776	10.5
Poverty (MPI weighted deprivation)				
Before matching	1	0.142	0.000	19.1
Radius Caliper (0.1)	0	0.017	0.834	9.9

Nearness neighbour	0	0.011	0.941	6.8
Kernel common trim (0.1)	0	0.020	0.776	10.5

Table S5: Sensitivity analysis- Rosenbaum bounds results for certified cocoa and uncertified cocoa farmers

Total household income

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	4.4e-07	4.4e-07	3206.75	3206.75	2210	4280
1.1	2.9e-06	5.4e-08	2970.25	3462	1957.75	4535
1.2	.000014	6.5e-09	2771.75	3685	1713.75	4757.5
1.3	.000052	7.8e-10	2562.5	3902.5	1515.5	4975
1.4	.000157	9.3e-11	2390	4064.25	1365.5	5179
1.5	.000409	1.1e-11	2212.38	4272.5	1195	5391.75
1.6	.000932	1.3e-12	2035	4438.75	1048	5577.5
1.7	.00191	1.5e-13	1889.75	4586	897.5	5846.75
1.8	.003583	1.8e-14	1735	4730	733.5	6053.75
1.9	.006236	2.1e-15	1609	4862.5	609.75	6251
2	.010185	2.2e-16	1502.25	4993.5	474.5	6372.5
2.1	.015755	0	1412	5140	378.5	6537.5
2.2	.023256	0	1325.5	5257.5	258.25	6719.5
2.3	.032959	0	1212.5	5384.5	157.5	6860
2.4	.04508	0	1123.5	5511.75	40.0001	7014.5
2.5	.059765	0	1036.5	5590	-77.0001	7150.75
2.6	.077084	0	952.25	5749.5	-164.5	7315
2.7	.097029	0	857.75	5890	-247.5	7463.75
2.8	.119517	0	755	6027.5	-335	7618.75
2.9	.144398	0	671.5	6126.75	-410	7778
3	.171465	0	615	6247.5	-482	7865.5

* gamma - log odds of differential assignment due to unobserved factors

sig+ - upper bound significance level

sig- - lower bound significance level

t-hat - upper bound Hodges-Lehmann point estimate

t-hat - lower bound Hodges-Lehmann point estimate

CI+ - upper bound confidence interval (a= .9)

CI- - lower bound confidence interval (a= .9)

Cocoa income

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.200239	.200239	377.554	377.554	-336.367	1429.91
1.1	.325944	.108918	229.946	584.888	-456.269	1686.16
1.2	.461618	.055674	44.2351	791.288	-587.007	1941.35
1.3	.590889	.027061	-109.479	987.855	-713.62	2231.2
1.4	.702691	.012625	-232.734	1190.25	-802.391	2454.95
1.5	.792252	.005696	-335.792	1427.66	-876.528	2671.9
1.6	.859711	.002499	-413.611	1587.18	-947.043	2875.42
1.7	.908034	.001071	-487.306	1748.49	-1009.82	3075.57
1.8	.941244	.00045	-574.808	1912.56	-1060.01	3244.63
1.9	.963293	.000186	-642.975	2091.71	-1126.7	3403.7
2	.977511	.000076	-721.229	2260.91	-1168.96	3550.29

Per capita income

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.000019	.000019	758.539	758.539	420.953	1214.4
1.1	.000095	3.2e-06	674.362	851.5	352.725	1340
1.2	.000353	5.2e-07	599.186	945.978	293.866	1439.09
1.3	.001051	8.4e-08	539.803	1040.74	237	1539.32
1.4	.002623	1.3e-08	475.655	1125.72	193.338	1623.23
1.5	.005696	2.1e-09	421.734	1211.13	151.067	1720.73
1.6	.011039	3.3e-10	380.599	1291.95	101.856	1794.04
1.7	.019489	5.1e-11	336.231	1365.76	62.3616	1863.7
1.8	.031842	7.9e-12	299.902	1427.7	28.119	1925.41
1.9	.048748	1.2e-12	269.339	1491.14	2.73257	2011.22
2	.070634	1.9e-13	230.877	1553.78	-36.1184	2083.85
2.1	.097654	2.9e-14	203.223	1604.4	-53.835	2145.89

2.2	.129682	4.3e-15	180.183	1649.43	-74.7099	2231.94
2.3	.166333	6.7e-16	152.931	1711.48	-106.097	2289.05
2.4	.20701	1.1e-16	125.176	1763.61	-124.067	2365.07
2.5	.250959	0	98.0338	1797.83	-144.725	2422.3
2.6	.297336	0	77.2268	1832.9	-165.707	2486.86
2.7	.345266	0	53.7449	1886.76	-180.867	2542.73
2.8	.393889	0	33.4659	1917.06	-189.567	2596.52
2.9	.442407	0	15.8668	1963.03	-204.427	2664.28
3	.490106	0	4.44136	2009.05	-233.914	2708.65

Farm income

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.191196	.191196	422.108	422.108	-321.029	1477.78
1.1	.314225	.102923	242.458	656.135	-447.489	1798.58
1.2	.44859	.052078	46.4677	816.281	-562.232	2108.96
1.3	.578016	.025064	-58.7323	1037.79	-684.332	2367.92
1.4	.691096	.011581	-210.565	1248	-766.419	2574.85
1.5	.782556	.005176	-320.025	1470.08	-838.689	2774.03
1.6	.852077	.00225	-407.355	1652.72	-918.613	2966.47
1.7	.902315	.000956	-473.304	1886.29	-983.137	3149.19
1.8	.937134	.000398	-545.421	2072.42	-1035.68	3294.18
1.9	.96044	.000163	-621.45	2243.14	-1088.59	3485.44
2	.975589	.000066	-691.767	2391.06	-1131.93	3617.91

Total household Consumption

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.0653	.0653	-646.477	-646.477	-1278.43	61.6057
1.1	.028453	.130745	-814.783	-479.323	-1415.75	244.17
1.2	.011728	.220613	-933.439	-295.607	-1544.71	405.391
1.3	.004626	.327465	-1043.82	-167.165	-1667.96	519.572
1.4	.001761	.441038	-1168.13	-58.968	-1775.47	631.253

1.5	.000652	.551498	-1277.1	61.3409	-1881.54	772.829
1.6	.000235	.651521	-1362.34	179.762	-1994.84	888.06
1.7	.000083	.736963	-1443.78	273.676	-2069.26	1022.81
1.8	.000029	.806519	-1525.31	378.646	-2134.61	1122.97
1.9	1.0e-05	.860909	-1600.84	447.361	-2208.75	1209.57
2	3.4e-06	.902024	-1679.24	530.036	-2264.15	1306

Per capita consumption

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.048144	.048144	-213.479	-213.479	-407.254	-6.93723
1.1	.019911	.101256	-262.918	-165.498	-449.686	49.4818
1.2	.007804	.17823	-300.428	-121.043	-490.798	100.164
1.3	.002932	.274384	-337.515	-83.456	-528.532	150.487
1.4	.001065	.381377	-373.623	-43.2358	-556.355	188.685
1.5	.000376	.490006	-406.461	-7.13646	-583.297	234.016
1.6	.00013	.59245	-434.295	33.1241	-612.112	279.001
1.7	.000044	.683416	-462.373	61.9573	-636.85	318.353
1.8	.000015	.760271	-486.776	92.6563	-662.561	348.464
1.9	4.8e-06	.822562	-505.213	128.146	-684.179	385.425
2	1.6e-06	.871311	-530.984	152.797	-705.688	427.39

Yield (kg/ha)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.00483	.00483	48.8686	48.8686	17.797	84.2524
1.1	.013899	.001435	41.0208	56.5867	10.6138	93.5527
1.2	.032112	.000409	34.1485	64.0676	3.77825	103.365
1.3	.062734	.000113	28.7306	69.9034	-1.96842	115.527

1.4	.107558	.00003	22.5625	75.3001	-8.81288	123.46
1.5	.166332	8.0e-06	17.815	84.184	-13.7527	134.065
1.6	.236861	2.1e-06	13.5472	89.6784	-17.939	143.899
1.7	.315578	5.3e-07	8.59659	96.7271	-22.5735	154.646
1.8	.398326	1.4e-07	4.48868	102.381	-25.957	161.61
1.9	.481061	3.4e-08	.643369	108.371	-29.517	171.303
2	.56036	8.4e-09	-2.67754	116.708	-33.0889	178.7

Poverty (Weighted deprivation score)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	6.1e-09	6.1e-09	-.078728	-.078728	-.099199	-.054498
1.1	5.5e-10	5.4e-08	-.082642	-.075673	-.101774	-.050828
1.2	4.9e-11	3.3e-07	-.08823	-.072615	-.104582	-.048401
1.3	4.4e-12	1.5e-06	-.093185	-.069334	-.108149	-.046876
1.4	3.9e-13	5.6e-06	-.096982	-.062058	-.113055	-.045241
1.5	3.5e-14	.000017	-.099163	-.054787	-.117759	-.043645
1.6	3.1e-15	.000046	-.100938	-.051869	-.120863	-.041315
1.7	3.3e-16	.000108	-.102475	-.050309	-.123353	-.038579
1.8	0	.000231	-.104184	-.04858	-.124785	-.035272
1.9	0	.000453	-.105707	-.047713	-.126017	-.030221
2	0	.000827	-.108436	-.046805	-.127246	-.023551
2.1	0	.001421	-.111365	-.045811	-.128186	-.020959
2.2	0	.002316	-.115324	-.044747	-.128989	-.01963
2.3	0	.003605	-.11731	-.043759	-.129656	-.018434
2.4	0	.005388	-.119388	-.042551	-.130325	-.016868
2.5	0	.007773	-.121363	-.041173	-.131214	-.015645
2.6	0	.010865	-.122474	-.039522	-.132047	-.014169
2.7	0	.01477	-.123881	-.037611	-.132742	-.012412
2.8	0	.019584	-.124662	-.035296	-.133318	-.009834
2.9	0	.025394	-.125263	-.03381	-.133828	-.007086
3	0	.032273	-.125971	-.030854	-.134506	-.004292
3.1	0	.040279	-.126706	-.025035	-.135773	-.002085
3.2	0	.049453	-.127279	-.023328	-.136336	-.000515
3.3	0	.059819	-.127845	-.021777	-.137151	.001222

3.4	0	.071384	-.128312	-.020699	-.138	.002457
3.5	0	.084137	-.128736	-.020021	-.13925	.003537
3.6	0	.098052	-.129214	-.019521	-.141205	.005098
3.7	0	.113088	-.129559	-.018787	-.141981	.007055
3.8	0	.129191	-.129822	-.018116	-.144627	.008479
3.9	0	.146296	-.130248	-.017157	-.146191	.009931
4	0	.164329	-.130578	-.016308	-.148685	.011558

Table S6: Sensitivity analysis- Rosenbaum bounds results for certified cocoa farmers and food crop farmers

Total household income

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	6.3e-12	6.3e-12	2837.59	2837.59	2242.26	3645.81
1.1	7.1e-11	4.4e-13	2679.7	3036.73	2120.57	3840.03
1.2	5.4e-10	3.0e-14	2557.86	3182.61	2000.23	4065.55
1.3	3.0e-09	2.1e-15	2459.77	3322.48	1902.87	4267.54
1.4	1.3e-08	1.1e-16	2355.88	3454.23	1799.87	4453.67
1.5	4.7e-08	0	2281.72	3578.44	1704.85	4659.91
1.6	1.4e-07	0	2180.61	3704.54	1637.49	4855.95
1.7	3.9e-07	0	2121.78	3831.75	1564.93	5097.88
1.8	9.4e-07	0	2049.97	3955.69	1486.05	5262.68
1.9	2.1e-06	0	1978.21	4104.88	1432.06	5481.2
2	4.2e-06	0	1915.41	4230.85	1394.2	5665.38
2.1	8.0e-06	0	1846.32	4348.08	1327.23	5869.97
2.2	.000014	0	1803.1	4444.67	1275.84	6045.98
2.3	.000025	0	1745.06	4557.67	1226.3	6276.6
2.4	.00004	0	1696.14	4678.01	1180.85	6443.37
2.5	.000063	0	1652.38	4790.08	1145.08	6632.04
2.6	.000096	0	1615.77	4952.15	1108.38	6808.12
2.7	.000141	0	1580.57	5033.53	1068.8	7031.72
2.8	.000202	0	1526.99	5151.94	1027.34	7168.46
2.9	.000282	0	1493.43	5240.05	967.599	7330.81
3	.000385	0	1459.06	5363.02	924.646	7444.51

3.1	.000516	0	1432.72	5480.7	903.555	7544.61
3.2	.000679	0	1410.29	5556.84	874.076	7644.46
3.3	.000879	0	1388.03	5675.54	831.213	7714.02
3.4	.00112	0	1357.88	5769.84	787.588	7806.53
3.5	.001408	0	1324.18	5882.16	751.488	7915.72
3.6	.001748	0	1293.62	5976.29	710.401	7987.76
3.7	.002145	0	1270.25	6063.05	679.237	8088.07
3.8	.002605	0	1241.33	6223.6	647.463	8151.62
3.9	.003131	0	1219.72	6324.39	625.119	8221.82
4	.003729	0	1203.1	6411.08	599.501	8290.63
4.1	.004404	0	1174.71	6454.41	572.595	8323.23
4.2	.00516	0	1161.71	6564.87	544.107	8419.75
4.3	.006001	0	1143.46	6644.87	522.938	8487.79
4.4	.006932	0	1128.78	6729.6	494.282	8545.77
4.5	.007956	0	1103.29	6836.66	462.697	8592.56
4.6	.009077	0	1089.38	6904.17	425.651	8671.5
4.7	.010298	0	1067.81	7056.1	402.251	8732.54
4.8	.011621	0	1049.42	7122.53	388.824	8823.48
4.9	.013049	0	1027.34	7168.46	363.076	8887.28
5	.014585	0	1003.2	7264.38	327.511	8939.73
5.1	.01623	0	969.481	7319.88	315.253	9002.9
5.2	.017985	0	949.938	7379.72	299.266	9039.83
5.3	.019853	0	932.096	7436.64	255.26	9069.64
5.4	.021834	0	918.259	7484.85	226.394	9155.78
5.5	.023929	0	912.007	7510.94	190.075	9198.37
5.6	.026139	0	901.743	7569.97	171.846	9274.45
5.7	.028463	0	878.781	7610.3	147.505	9362.93
5.8	.030901	0	873.325	7645.38	135.822	9391.67
5.9	.033453	0	843.583	7676.39	109.45	9417.51
6	.036119	0	832.848	7705.05	87.2203	9458.19
6.1	.038897	0	815.984	7760.94	70.2697	9489.32
6.2	.041787	0	794.659	7799.21	53.6525	9519.35
6.3	.044788	0	777.101	7844.29	41.444	9592.88
6.4	.047898	0	762.37	7870.45	12.981	9669.79
6.5	.051116	0	749.657	7923.18	-5.07648	9711.69
6.6	.05444	0	733.259	7962.62	-24.424	9764.35

6.7	.057868	0	713.3	7981.05	-60.9013	9799.22
6.8	.061399	0	707.429	8006.86	-76.3183	9849.58
6.9	.06503	0	686.859	8053.61	-90.9825	9942.19
7	.068759	0	678.346	8099.85	-110.23	10036.2
7.1	.072584	0	667.294	8125.96	-129.013	10117.8
7.2	.076503	0	655.253	8150.79	-140.434	10148.5
7.3	.080513	0	641.401	8165.18	-152.523	10161
7.4	.084612	0	632.215	8194.97	-160.83	10170.1
7.5	.088798	0	624.934	8223.55	-187.603	10213.3
7.6	.093068	0	614.582	8247.4	-197.818	10273.9
7.7	.097418	0	599.937	8285.71	-211.141	10282.2
7.8	.101848	0	589.893	8299.64	-223.426	10321.9
7.9	.106354	0	579.492	8312.37	-232.072	10335.9
8	.110933	0	571.358	8343.82	-264.493	10411.5

```
* gamma  - log odds of differential assignment due to unobserved factors
  sig+   - upper bound significance level
  sig-   - lower bound significance level
  t-hat+ - upper bound Hodges-Lehmann point estimate
  t-hat- - lower bound Hodges-Lehmann point estimate
  CI+    - upper bound confidence interval (a=   .9)
  CI-    - lower bound confidence interval (a=   .9)
```

Per capita income

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	1.8e-11	1.8e-11	1112.5	1112.5	844.846	1449.39
1.1	2.0e-10	1.3e-12	1045.44	1197.29	788.74	1521.76
1.2	1.4e-09	9.9e-14	992.342	1265.91	742.478	1587.42
1.3	7.6e-09	7.3e-15	941.961	1325.61	709.314	1659.16
1.4	3.2e-08	5.6e-16	895.332	1380.94	668.59	1720.99

1.5	1.1e-07	0	855.619	1430.7	637.243	1784.99
1.6	3.4e-07	0	824.385	1478.77	603.192	1838.56
1.7	8.8e-07	0	790.067	1520.53	577.462	1898.76
1.8	2.1e-06	0	758.697	1560.42	551.34	1971.98
1.9	4.5e-06	0	736.22	1600.26	523.701	2062.36
2	9.0e-06	0	715.844	1645.42	498.166	2137.77
2.1	.000017	0	695.54	1678.71	481.603	2222.3
2.2	.00003	0	672.453	1715.01	463.451	2274.19
2.3	.00005	0	651.064	1755.08	441.7	2330.41
2.4	.000081	0	633.248	1792.24	420.356	2373.69
2.5	.000126	0	611.971	1818.89	404.798	2409.56
2.6	.000188	0	598.155	1847.81	388.491	2437.12
2.7	.000274	0	581.534	1883.95	369.485	2496.41
2.8	.000389	0	568.681	1927.65	352.483	2537.82
2.9	.000539	0	554.035	1963.13	336.865	2604.39
3	.00073	0	540.819	2013.02	323.952	2642.57
3.1	.000969	0	525.097	2059.34	309.902	2685.25
3.2	.001264	0	509.5	2096	297.687	2735.65
3.3	.001623	0	497.385	2141.33	278.256	2785.2
3.4	.002053	0	488.306	2181.36	257.996	2820.33
3.5	.002563	0	479.727	2228.23	248.607	2876.34
3.6	.003159	0	470.831	2251.62	235.218	2955.56
3.7	.003851	0	461.376	2277.9	223.96	3032.15
3.8	.004644	0	449.681	2301.93	212.2	3098.34
3.9	.005547	0	439.759	2338.18	202.716	3141.75
4	.006566	0	430.474	2355.44	189.376	3188.8
4.1	.007707	0	418.954	2381.41	179.298	3226.67
4.2	.008978	0	410.501	2393.13	162.606	3249.86
4.3	.010383	0	403.691	2410.45	149.394	3290.03
4.4	.011927	0	394.713	2431.02	138.365	3325.38
4.5	.013616	0	387.383	2442.2	126.679	3345.35
4.6	.015452	0	377.324	2472.79	115.186	3378.5
4.7	.01744	0	368.891	2498.67	109.94	3402.98
4.8	.019583	0	360.327	2520.11	97.3488	3432.13
4.9	.021882	0	352.483	2537.82	88.6784	3470.69
5	.02434	0	344.977	2567.7	74.8538	3500.99

5.1	.026959	0	337.736	2595.94	65.9131	3523.55
5.2	.029738	0	330.865	2615.13	56.7913	3560.34
5.3	.032678	0	325.307	2636.77	44.6721	3585.87
5.4	.03578	0	322.277	2651.83	38.7367	3600.5
5.5	.039043	0	315.172	2665.92	22.108	3623.26
5.6	.042466	0	307.398	2694.88	14.1126	3647.83
5.7	.046047	0	300.196	2718.67	7.13327	3689.84
5.8	.049786	0	297.083	2736.75	1.24468	3712.63
5.9	.053679	0	282.11	2755.77	-10.8644	3730.68
6	.057725	0	279.364	2778.87	-17.8395	3747.51
6.1	.061921	0	271.89	2795.4	-22.2606	3766.15
6.2	.066264	0	264.478	2810.42	-32.6534	3786.83
6.3	.070751	0	256.425	2839.64	-40.3152	3801.08
6.4	.075379	0	254.793	2862.09	-52.5761	3829.57
6.5	.080144	0	248.071	2887.75	-64.0121	3840.23
6.6	.085043	0	244.358	2931.7	-68.4901	3858.46
6.7	.090071	0	235.764	2946	-72.4342	3877.43
6.8	.095225	0	230.878	2985.19	-85.5486	3919.03
6.9	.100501	0	226.017	3009.08	-101.144	3970.2
7	.105894	0	222.135	3040.13	-104.619	4005.68

Farm income

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	2.7e-14	2.7e-14	2713.87	2713.87	2211.92	3409.25
1.1	4.0e-13	1.4e-15	2596.82	2853.83	2103.97	3594.18
1.2	3.8e-12	1.1e-16	2504.27	3008.07	2019.87	3774.93
1.3	2.5e-11	0	2395.03	3132.64	1940.76	3976.32
1.4	1.3e-10	0	2316.57	3260.96	1864.19	4128.33

1.5	5.3e-10	0	2240.32	3363.5	1801.33	4272.71
1.6	1.8e-09	0	2184.33	3472.36	1747.3	4495.81
1.7	5.5e-09	0	2110.13	3588.13	1684.53	4644.48
1.8	1.5e-08	0	2056.98	3699.91	1624.71	4820.32
1.9	3.5e-08	0	2004.55	3803.78	1568.53	4982.38
2	7.7e-08	0	1958.12	3922.17	1514.86	5156.25
2.1	1.6e-07	0	1909.19	4040.28	1473.19	5314.5
2.2	3.0e-07	0	1869.28	4120.28	1421.96	5439.36
2.3	5.5e-07	0	1839.93	4205.14	1376.8	5536.05
2.4	9.5e-07	0	1795.39	4316.51	1335.38	5650.43
2.5	1.6e-06	0	1764.43	4440.59	1300.77	5777.81
2.6	2.5e-06	0	1731.15	4528.33	1268.46	5874.31
2.7	3.8e-06	0	1700.58	4614	1246.12	5954.51
2.8	5.7e-06	0	1659.55	4697.63	1223.7	6055.73
2.9	8.4e-06	0	1635.84	4808.84	1204.62	6175.98
3	.000012	0	1602.75	4881.1	1182.98	6271.6
3.1	.000016	0	1569.05	4976.26	1159.24	6396.5
3.2	.000022	0	1541.05	5077.56	1124.48	6502.06
3.3	.00003	0	1509.61	5162.65	1094.99	6614.92
3.4	.000039	0	1486.51	5229.32	1078.35	6716.92
3.5	.000051	0	1471.12	5317.71	1047.98	6815.84
3.6	.000065	0	1447.04	5401.95	1017.92	6893.88
3.7	.000082	0	1417.47	5444.69	992.261	6929.39
3.8	.000102	0	1386.77	5491.99	974.013	6987.15
3.9	.000125	0	1368.13	5539.78	958.315	7048.22
4	.000153	0	1348.31	5592.92	932.195	7129.65
4.1	.000185	0	1332.11	5664.82	915.452	7189.38
4.2	.000221	0	1313.55	5725.98	899.585	7252.23
4.3	.000263	0	1298.51	5788.91	882.029	7294.23
4.4	.000309	0	1282.98	5836.48	868.027	7365.26
4.5	.000362	0	1267.81	5877.47	852.167	7394.49
4.6	.000421	0	1254.53	5919.31	832.411	7439.79
4.7	.000486	0	1244.52	5956.11	820.62	7499.16
4.8	.000559	0	1234.35	6009.45	804.384	7590.24
4.9	.000638	0	1223.7	6055.73	795.509	7627.9
5	.000725	0	1212.38	6119.54	782.109	7673.44

5.1	.00082	0	1206.21	6167.32	767.369	7692.98
5.2	.000924	0	1194.56	6223.02	755.644	7737.59
5.3	.001035	0	1186.9	6256.75	746.637	7805.19
5.4	.001156	0	1177.84	6303.02	734.537	7865.24
5.5	.001286	0	1166.88	6346.34	715.481	7938.51
5.6	.001425	0	1154.32	6411.5	704.6	7968.34
5.7	.001573	0	1135.05	6459.09	682.775	8057.22
5.8	.001732	0	1124.01	6517.54	671.923	8089.69
5.9	.0019	0	1110.05	6546.83	662.695	8151.36
6	.002078	0	1102.25	6597.19	645.931	8209.11
6.1	.002267	0	1086.49	6650.35	640.957	8251.52
6.2	.002467	0	1082.27	6695.32	634.035	8284.39
6.3	.002677	0	1070.31	6764.42	624.936	8328.46
6.4	.002897	0	1056.29	6786.82	613.872	8347.81
6.5	.003129	0	1046.29	6818.88	605.01	8359.25
6.6	.003372	0	1038	6876.23	589.469	8405.73
6.7	.003626	0	1021.66	6891.96	575.957	8443.85
6.8	.003891	0	1007.47	6902.2	560.227	8463.88
6.9	.004167	0	998.725	6919.58	549.375	8489.36
7	.004454	0	985.141	6952.18	542.032	8508.48
7.1	.004753	0	978.669	6970.91	536.33	8577.75
7.2	.005063	0	974.183	6986.93	526.506	8601.14
7.3	.005384	0	967.157	7016.07	522.444	8660.16
7.4	.005717	0	964.294	7037.37	517.4	8686.81
7.5	.006061	0	953.075	7059.25	510.169	8726.82
7.6	.006416	0	945.873	7094.04	508.393	8733.24
7.7	.006783	0	932.255	7111.65	501.297	8746.17
7.8	.007161	0	929.106	7148.96	496.293	8766.03
7.9	.00755	0	918.254	7165.19	493.419	8799.15
8	.00795	0	912.171	7192.28	484.688	8799.98
8.1	.008361	0	905.518	7225.65	480.19	8844.41
8.2	.008784	0	900.134	7252	475.251	8879.84
8.3	.009217	0	892.587	7255.08	472.218	8916.74
8.4	.009661	0	888.367	7277.63	460.986	8943.82
8.5	.010116	0	882.029	7294.23	453.141	8972.37
8.6	.010581	0	875.687	7315.97	441.971	9035.63

8.7	.011057	0	872.65	7364.57	438.241	9075.57
8.8	.011544	0	866.418	7369.27	434.055	9123.45
8.9	.012041	0	861.435	7376.36	431.584	9132.19
9	.012548	0	855.566	7388.98	421.367	9148.48
9.1	.013066	0	848.246	7403.45	415.481	9177.12
9.2	.013594	0	843.866	7411.24	411.608	9197.51
9.3	.014131	0	832.411	7439.79	408.574	9214.54
9.4	.014678	0	827.568	7457.47	405.03	9227.43
9.5	.015236	0	823.472	7492.28	403.959	9245.18
9.6	.015802	0	820.62	7499.16	392.553	9296.11
9.7	.016378	0	814.464	7510.01	388.782	9334.06
9.8	.016964	0	807.59	7551.49	384.635	9429.07
9.9	.017558	0	802.443	7594.17	379.549	9434.16
10	.018162	0	800.463	7602.58	376.868	9494.78
10.1	.018775	0	796.394	7619.98	374.254	9508.71
10.2	.019396	0	792.376	7638.94	363.528	9524.22
10.3	.020026	0	787.196	7651.16	354.776	9569.58
10.4	.020665	0	784.359	7657.59	346.114	9673.7
10.5	.021312	0	778.188	7673.53	342.924	9682.57
10.6	.021967	0	776.039	7679	330.878	9693.25
10.7	.022631	0	772.495	7687.44	321.518	9756.67
10.8	.023302	0	767.177	7702.37	306.98	9776.88
10.9	.023982	0	765.679	7711.7	300.913	9805.41
11	.024669	0	756.585	7721.79	300.132	9811.83
11.1	.025364	0	754.827	7742.43	295.3	9840.3
11.2	.026066	0	750.563	7767.65	294.226	9879.63
11.3	.026776	0	746.782	7801.25	271.888	9891.45
11.4	.027492	0	744.506	7805.97	271.292	9893.14
11.5	.028216	0	741.696	7831.08	260.445	9926.72
11.6	.028947	0	737.656	7849.37	249.466	9961.61
11.7	.029685	0	730.534	7880.26	249.034	10005.6
11.8	.030429	0	723.654	7895.64	246.443	10043.7
11.9	.03118	0	719.011	7905.94	241.112	10154.2
12	.031937	0	715.481	7938.51	233.129	10155
12.1	.032701	0	713.758	7947.22	224.168	10163.8
12.2	.033471	0	710.149	7955.38	215.299	10215.6

12.3	.034247	0	704.6	7968.34	212.734	10238.7
12.4	.035029	0	699.757	8021.5	207.648	10276.1
12.5	.035816	0	696.723	8031.76	203.727	10276.5
12.6	.03661	0	687.595	8055.96	192.617	10279
12.7	.037409	0	681.7	8060.2	191.627	10306
12.8	.038213	0	674.448	8084.93	187.624	10341.4
12.9	.039023	0	673.732	8085.01	183.755	10362.5
13	.039838	0	671.728	8100.73	176.101	10475.5
13.1	.040658	0	669.828	8133.33	126.919	10512.7
13.2	.041483	0	666.438	8140.79	114.727	10519
13.3	.042313	0	660.967	8155.29	103.021	10519.6
13.4	.043148	0	660.509	8159.97	99.9873	10576
13.5	.043988	0	654.773	8196.75	83.016	10583.1
13.6	.044832	0	646.043	8198.37	72.164	10588.5
13.7	.04568	0	645.424	8214.79	70.9624	10616.3
13.8	.046533	0	643.522	8217.52	24.58	10677.3
13.9	.047391	0	642.897	8229.44	21.9375	10679.8
14	.048252	0	640.957	8251.52	8.71271	10717.5
14.1	.049118	0	637.069	8261.8	.112091	10754.5
14.2	.049987	0	635.191	8271.46	.11203	10754.5
14.3	.05086	0	634.035	8284.39	-2.50568	10867.5
14.4	.051737	0	630.105	8292.74	-16.2252	10971.7
14.5	.052618	0	626.184	8322.1	-36.6197	10981.4
14.6	.053503	0	625.035	8327.19	-39.4069	11053.7
14.7	.054391	0	624.936	8328.46	-41.7058	11078.1
14.8	.055282	0	622.652	8337.06	-41.7058	11078.1
14.9	.056176	0	620.932	8339.28	-45.6269	11117.1
15	.057074	0	614.084	8347.19	-57.7267	11146.5
15.1	.057975	0	613.872	8347.81	-61.7303	11233.6
15.2	.058879	0	610.08	8350.48	-61.7303	11233.6
15.3	.059786	0	605.359	8357.43	-67.5473	11317.3
15.4	.060696	0	605.01	8359.25	-73.2526	11420
15.5	.061609	0	599.871	8383.15	-100.939	11515.5
15.6	.062525	0	598.558	8386.34	-100.939	11515.5
15.7	.063443	0	595.468	8395.49	-119.435	11611.1
15.8	.064364	0	589.469	8405.73	-122.435	11674.5

15.9	.065287	0	583.534	8430.13	-122.435	11674.5
16	.066213	0	579.878	8432.33	-146.333	11755.9
16.1	.067141	0	575.957	8443.85	-149.367	11846.6
16.2	.068071	0	567.196	8447.86	-149.367	11846.6
16.3	.069004	0	563.858	8449.76	-153.216	11910.1
16.4	.069939	0	563.139	8459.96	-167.218	11959.6
16.5	.070875	0	560.227	8463.88	-167.218	11959.6
16.6	.071814	0	559.854	8465.19	-178.392	12023
16.7	.072755	0	558.053	8468.96	-178.392	12023
16.8	.073698	0	554.132	8483.29	-189.493	12060
16.9	.074642	0	549.375	8489.36	-221.044	12072.9
17	.075589	0	548.332	8495.9	-221.044	12072.9
17.1	.076537	0	546.802	8503.35	-229.906	12156.7
17.2	.077487	0	543.58	8505.7	-229.906	12156.7
17.3	.078438	0	542.032	8508.48	-330.645	12238.7
17.4	.079391	0	541.716	8527.52	-330.645	12238.7
17.5	.080345	0	538.029	8528.62	-341.497	12302.1
17.6	.0813	0	537.795	8566.78	-341.497	12302.1
17.7	.082258	0	536.33	8577.75	-350.293	12308.4
17.8	.083216	0	536.33	8577.75	-350.293	12308.4
17.9	.084176	0	533.296	8588.6	-391.724	12421.4
18	.085136	0	528.389	8595.11	-391.724	12421.4
18.1	.086098	0	526.506	8601.14	-413.549	12594.1
18.2	.087061	0	526.407	8613.15	-413.549	12594.1
18.3	.088025	0	525.695	8613.79	-429.886	12700.4
18.4	.08899	0	525.478	8623.39	-429.886	12700.4
18.5	.089956	0	525.478	8623.39	-450.281	13151.5
18.6	.090923	0	522.444	8660.16	-450.281	13151.5
18.7	.091891	0	521.691	8677.21	-455.367	13330.8
18.8	.09286	0	521.321	8684.77	-455.367	13330.8
18.9	.093829	0	517.4	8686.81	-459.288	13387
19	.094799	0	517.085	8688.08	-459.288	13387
19.1	.09577	0	516.77	8689.34	-471.388	13394.2
19.2	.096741	0	516.235	8698.2	-471.388	13394.2
19.3	.097713	0	512.314	8713.31	-475.391	13457.6
19.4	.098685	0	510.169	8726.82	-475.391	13457.6

19.5	.099659	0	510.169	8726.82	-475.391	13457.6
19.6	.100632	0	509.827	8729.75	-486.914	13500
19.7	.101606	0	509.799	8731.42	-486.914	13500
19.8	.10258	0	508.393	8733.24	-536.096	13779
19.9	.103555	0	508.393	8733.24	-536.096	13779
20	.10453	0	505.3	8735.73	-536.096	13779

Total consumption

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.257852	.257852	243.647	243.647	-342.109	925.111
1.1	.388739	.154142	119.834	407.759	-464.189	1062.56
1.2	.520814	.087301	-12.5751	533.462	-601.942	1197.5
1.3	.640673	.047319	-116.131	681.965	-704.864	1312.6
1.4	.740855	.024743	-213.625	788.233	-831.453	1455.69
1.5	.81932	.01256	-308.748	873.418	-920.811	1581.17
1.6	.87765	.006221	-384.218	974.92	-1010.76	1716.26
1.7	.919209	.003019	-463.152	1054.39	-1115.85	1838.71
1.8	.947799	.001439	-548.982	1153.18	-1190.33	1956.46
1.9	.966901	.000676	-623.108	1220.28	-1245.07	2047.78
2	.979354	.000314	-677.665	1283.91	-1298.82	2125.87

Per capita consumption

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.288721	.288721	60.2538	60.2538	-116.129	286.199
1.1	.424793	.177257	24.2223	101.41	-162.722	364.753
1.2	.557817	.103057	-15.5776	151.706	-206.327	413.617
1.3	.675054	.05731	-43.7434	190.325	-243.225	467.034
1.4	.770397	.030727	-71.4764	230.611	-285.969	507.204

1.5	.843164	.015985	-98.4651	268.504	-319.95	554.42
1.6	.89594	.00811	-132.988	313.074	-355.455	580.768
1.7	.932662	.004029	-159.932	363.402	-382.548	603.943
1.8	.957353	.001966	-184.11	393.848	-409.885	643.512
1.9	.97349	.000945	-212.856	428.017	-440.753	671.469
2	.983785	.000449	-233.743	458.952	-456.722	695.904

Poverty (Weighted deprivation scores)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	3.9e-07	3.9e-07	-.085873	-.085873	-.109696	-.059455
1.1	5.3e-08	2.3e-06	-.09136	-.078464	-.115346	-.052797
1.2	7.3e-09	.00001	-.096258	-.073225	-.120581	-.047698
1.3	9.9e-10	.000036	-.100229	-.068825	-.124467	-.042591
1.4	1.3e-10	.000105	-.104977	-.064964	-.128519	-.038955
1.5	1.8e-11	.000264	-.108689	-.061156	-.132398	-.036143
1.6	2.4e-12	.000584	-.111636	-.057126	-.136151	-.032347
1.7	3.3e-13	.001171	-.11527	-.053068	-.139208	-.028293
1.8	4.4e-14	.002161	-.118854	-.049605	-.142709	-.02498
1.9	5.9e-15	.003718	-.1214	-.04656	-.146004	-.020223
2	7.8e-16	.006027	-.123828	-.043447	-.149246	-.016491
2.1	1.1e-16	.009284	-.125794	-.040895	-.151266	-.014682
2.2	0	.013684	-.128297	-.039088	-.153327	-.012261
2.3	0	.019411	-.131042	-.03766	-.155435	-.009774
2.4	0	.026629	-.132578	-.035805	-.158475	-.00703
2.5	0	.035472	-.134617	-.033478	-.161164	-.003848
2.6	0	.046039	-.137092	-.03143	-.163107	-.001315
2.7	0	.05839	-.138696	-.0289	-.166311	.001759
2.8	0	.072547	-.141055	-.026993	-.16919	.003877
2.9	0	.088493	-.142445	-.025421	-.171794	.007165
3	0	.106176	-.144308	-.022751	-.173785	.010111

Table S7: Sensitivity analysis- Rosenbaum bounds results for Uncertified cocoa farmers and food crop farmers

Total household income

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.000198	.000198	1128.5	1128.5	638.75	1681.25
1.1	.000712	.000048	1021	1250	542.5	1814
1.2	.002023	.000011	927.5	1353.75	442.5	1930
1.3	.004809	2.6e-06	831.5	1451.25	342.5	2075
1.4	.009933	6.0e-07	744	1526.75	251.25	2214
1.5	.018338	1.4e-07	670	1622.75	167.5	2332.5
1.6	.030911	3.1e-08	607.5	1714	81.5	2445
1.7	.048357	7.0e-09	552.5	1790.5	5.00012	2580
1.8	.071102	1.6e-09	500	1858.75	-87.5	2675
1.9	.09925	3.5e-10	437.5	1937.5	-162.5	2776.75
2	.132589	7.8e-11	382.5	2020	-243.75	2887.5

Per capita income

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.000088	.000088	497.338	497.338	255.504	727.403
1.1	.000337	.00002	449.74	530.215	222.316	789.171
1.2	.001016	4.3e-06	399.752	579.928	189.711	861.249
1.3	.002546	9.3e-07	351.501	615.863	164.101	930.994
1.4	.005512	2.0e-07	319.297	655.254	126.443	984.499
1.5	.010617	4.3e-08	276.052	686.393	96.5209	1025.19
1.6	.018603	9.1e-09	248.693	739.426	65.1607	1067.14
1.7	.030154	1.9e-09	227.676	780.374	38.3322	1123.92
1.8	.045814	4.0e-10	206.965	820.431	2.53457	1170.94
1.9	.065925	8.4e-11	188.337	861.913	-16.9105	1206.47
2	.090598	1.8e-11	173.303	913.633	-51.4015	1253.25
2.1	.119714	3.7e-12	155.627	935.69	-94.6728	1301.49
2.2	.152946	7.7e-13	135.411	970.8	-124.641	1335.85
2.3	.189797	1.6e-13	116.649	998.011	-181.387	1373.14
2.4	.22965	3.3e-14	102.315	1022.09	-220.095	1425.26
2.5	.271816	6.9e-15	80.757	1043.64	-264.985	1464.77
2.6	.315576	1.4e-15	65.1607	1067.14	-292.5	1490.28

2.7	.360226	3.3e-16	52.3922	1092.65	-359.362	1515.32
2.8	.405098	1.1e-16	37.6098	1127.21	-427.042	1546.06
2.9	.44959	0	15.4158	1156.12	-462.161	1563.21
3	.493176	0	1.10696	1177.05	-509.052	1590

Total household consumption

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.096626	.096626	-762.5	-762.5	-1686.5	235
1.1	.048574	.172036	-973	-550	-1880	475
1.2	.023363	.266289	-1146.5	-347.5	-2040	676
1.3	.010849	.371133	-1332.5	-190	-2184	862
1.4	.004898	.47767	-1490	-49.9999	-2310	1058.5
1.5	.002161	.578454	-1609.75	135.25	-2472.5	1255
1.6	.000936	.668471	-1727.5	305	-2590	1410
1.7	.000399	.745193	-1850	431	-2660	1561
1.8	.000168	.808108	-1955	544	-2780	1687.5
1.9	.00007	.858064	-2045	682.5	-2900	1807.5
2	.000029	.89667	-2120.5	787	-3002.5	1914

Per capita consumption

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.130668	.130668	-247.159	-247.159	-639.573	133.847
1.1	.069322	.221194	-329.976	-172.62	-723.56	198.045
1.2	.035128	.327958	-410.227	-106.71	-812.261	258.136
1.3	.01716	.440562	-485.764	-30.7349	-887.086	329.706
1.4	.008139	.54946	-542.385	29.3711	-942.457	395.622
1.5	.003768	.647799	-607.42	100.83	-994.44	464.074
1.6	.00171	.731846	-653.106	143.841	-1044.55	531.989
1.7	.000763	.800529	-714.385	182.367	-1088.86	609.091
1.8	.000336	.85462	-766.886	229.185	-1139.55	672.54
1.9	.000146	.895926	-813.536	258.972	-1185.77	710.394
2	.000063	.926661	-848.701	297.568	-1244.35	761.122

Total weighted deprivation score

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.252778	.252778	-.027778	-.027778	-.055556	.027778
1.1	.154465	.376158	-.027778	-3.4e-07	-.055556	.027778
1.2	.090035	.50138	-.027778	-3.4e-07	-.055556	.027778
1.3	.050506	.616746	-.027778	3.4e-07	-.083334	.055556
1.4	.027459	.715351	-.027778	3.4e-07	-.083334	.055556
1.5	.01455	.794785	-.055556	.027778	-.083334	.055556
1.6	.007546	.855806	-.055556	.027778	-.083334	.055556
1.7	.003845	.900906	-.055556	.027778	-.083334	.055556
1.8	.001929	.933194	-.055556	.027778	-.111111	.083334
1.9	.000956	.955704	-.055556	.027778	-.111111	.083334
2	.000468	.971052	-.083334	.027778	-.111111	.083334

Farm income

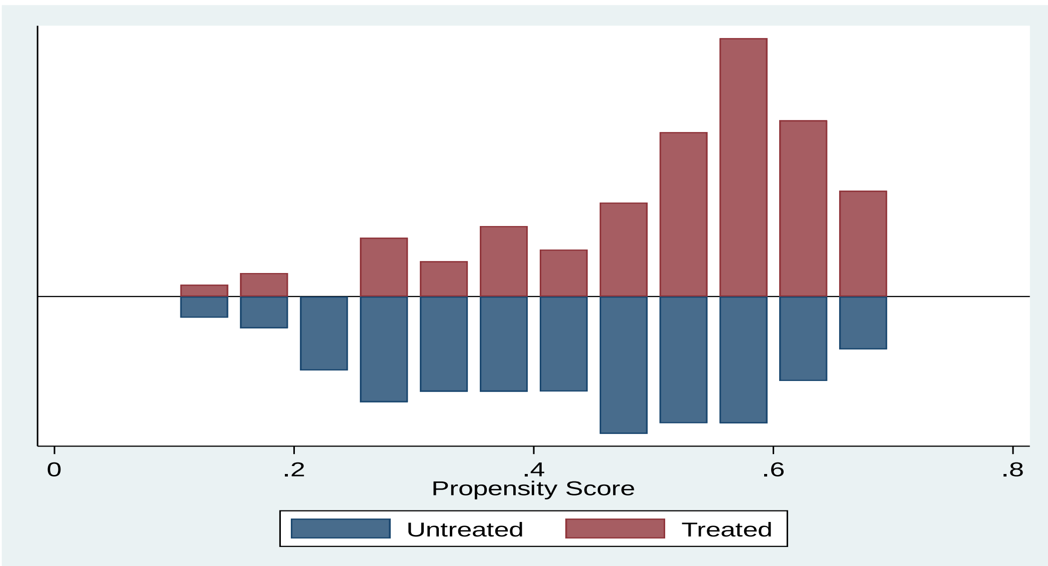
Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	1.6e-10	1.6e-10	1936.5	1936.5	1481.5	2612.5
1.1	1.4e-09	1.4e-11	1851.25	2087.5	1382.5	2782.7
1.2	8.7e-09	1.3e-12	1749	2201.25	1290	2895.75
1.3	4.1e-08	1.2e-13	1666.5	2331.25	1185	3067.5
1.4	1.5e-07	1.0e-14	1606.45	2445	1122.5	3195
1.5	4.9e-07	1.0e-15	1537.5	2555	1058.75	3317.5
1.6	1.3e-06	1.1e-16	1447.5	2635	976.25	3434
1.7	3.3e-06	0	1393.75	2741.75	920	3556.25
1.8	7.2e-06	0	1346.25	2841.5	883.75	3642.5
1.9	.000015	0	1290	2900	841.25	3732.7
2	.000028	0	1232.5	3017.5	800	3800
2.1	.000049	0	1175	3081.25	757.5	3863.75
2.2	.000084	0	1138.75	3152.5	718.75	3957.5
2.3	.000135	0	1100	3250	681.25	4037.5
2.4	.00021	0	1062.5	3295	655	4100
2.5	.000315	0	1026.25	3356.25	623.047	4181.25
2.6	.000457	0	976.25	3434	593.75	4228.75
2.7	.000646	0	948.75	3505	573.75	4275.55

2.8	.000891	0	917.5	3557.5	540	4321.25
2.9	.001201	0	902.5	3600	507.5	4373.75
3	.001588	0	876.25	3663.75	487.5	4432.5
3.1	.002061	0	857.5	3708.75	457.5	4475
3.2	.002632	0	831.25	3748.05	437.5	4512.5
3.3	.003311	0	812.5	3785	413.75	4550
3.4	.004109	0	792.5	3813	400	4595
3.5	.005036	0	762.5	3846.75	383.75	4650
3.6	.006102	0	744.5	3887	362.5	4692.5
3.7	.007317	0	725	3927.7	340	4737.5
3.8	.008688	0	712.5	3981.5	318.75	4768
3.9	.010224	0	687.5	4018.75	287.5	4810
4	.011932	0	675.625	4038	256.25	4852.5
4.1	.013819	0	668.75	4062.5	240	4900
4.2	.01589	0	647.5	4113.75	218.047	4965
4.3	.018151	0	638.75	4143.75	200	4987.5
4.4	.020605	0	621.25	4188	172.5	5025.5
4.5	.023255	0	611.25	4213	162.5	5062.5
4.6	.026104	0	592.5	4233.75	142.5	5130
4.7	.029154	0	581.25	4250	128.75	5182.5
4.8	.032406	0	573.75	4275.55	112.5	5205.5
4.9	.035859	0	557.75	4290	81.25	5243.75
5	.039513	0	541.25	4315.2	52.5	5331.25
5.1	.043367	0	528.75	4340	32.7001	5405
5.2	.04742	0	510.547	4357.5	8.75003	5430
5.3	.051669	0	500	4387.5	-12.5	5462.5
5.4	.056111	0	490	4415	-27.4999	5487.5
5.5	.060742	0	478.75	4443.75	-37.5	5503.75
5.6	.06556	0	470	4467.7	-44.9999	5525
5.7	.07056	0	457.5	4475	-61.2499	5580
5.8	.075738	0	450	4501.25	-75	5642.5
5.9	.081088	0	443.75	4512.5	-75	5687.5
6	.086606	0	435.547	4527.5	-95	5725
6.1	.092287	0	418.75	4542.5	-111.25	5738
6.2	.098124	0	410	4557.5	-118.75	5767.7
6.3	.104112	0	406.25	4567.5	-127.5	5842.5

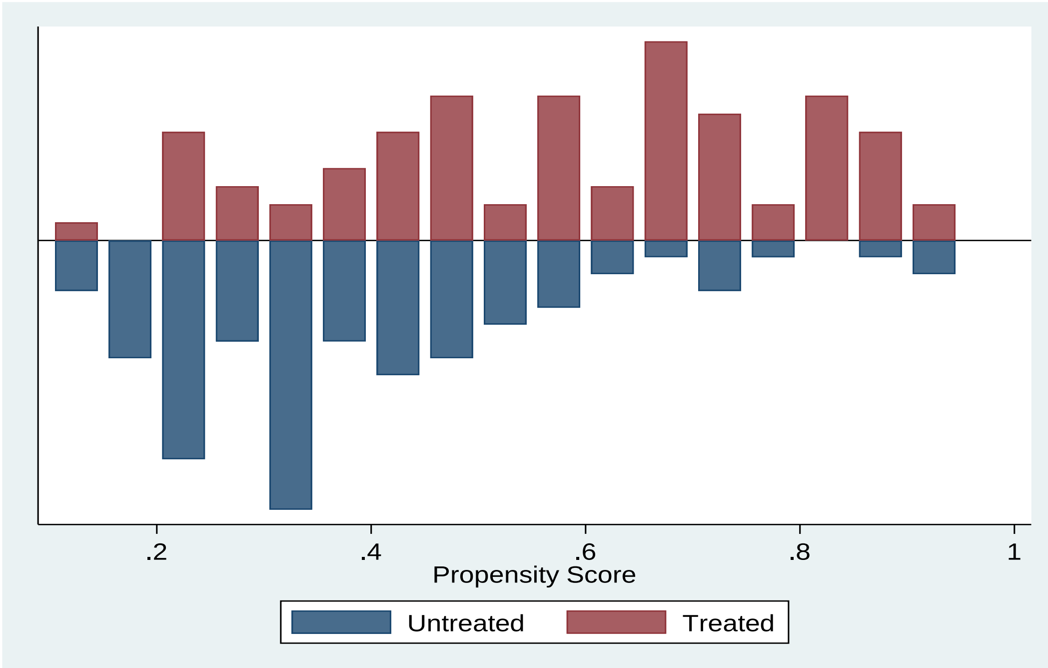
6.4	.110246	0	400.625	4595	-145	5931.25
6.5	.116519	0	393.75	4625	-163	5977.7
6.6	.122926	0	391.797	4642.5	-182.5	6055
6.7	.12946	0	381.25	4662.5	-195	6140
6.8	.136114	0	367.5	4683.75	-212.5	6193.75
6.9	.142884	0	362.5	4692.5	-222.5	6212.5
7	.149763	0	350	4715	-262.5	6282.5

Figure S1: Histogram of propensity scores

Certified cocoa and uncertified cocoa farmers



Certified cocoa farmers and food crop farmers



Uncertified cocoa farmers and food crop farmers

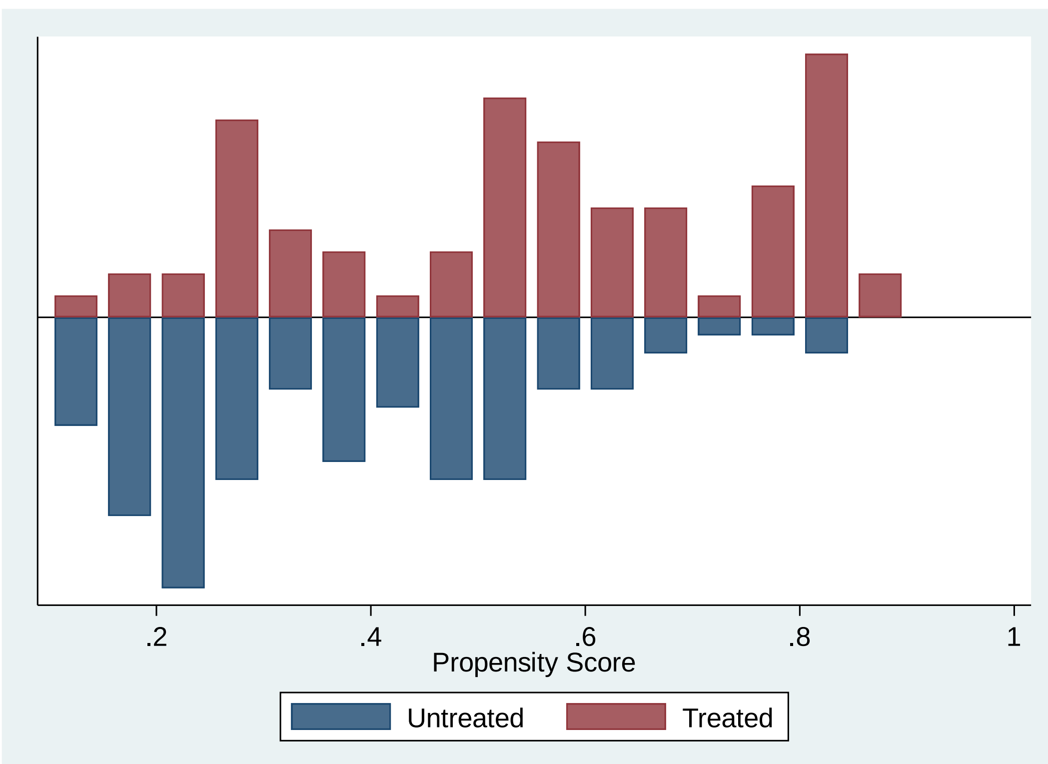


Table S8: Balancing test for certified and uncertified oil palm farmers

	No. Of Significant. Variables	Pseudo R2	p-Value LR* Test	Mean Bias
Impact of involvement in certification				
Household Income				
Before matching	2	0.097	0.003	16.7
Radius Caliper (0.1)	0	0.005	0.988	4.2
Nearness neighbour	1	0.050	0.143	17.0
Kernel common trim (0.1)	0	0.014	0.927	8.2
Oil palm income				
Before matching	2	0.097	0.003	16.7
Radius Caliper (0.1)	0	0.005	0.988	4.2
Nearness neighbour	1	0.050	0.143	17.0
Kernel common trim	0	0.014	0.927	8.2
Per capita income				
Before matching	2	0.097	0.003	16.7
Radius Caliper (0.1)	0	0.005	0.988	4.2
Nearness neighbour	1	0.050	0.143	17.0
Kernel common trim	0	0.014	0.927	8.2
Farm income				
Before matching	2	0.097	0.003	16.7
Radius Caliper (0.1)	0	0.005	0.988	4.2
Nearness neighbour	1	0.050	0.143	17.0
Kernel common trim	0	0.014	0.927	8.2
Total household consumption				
Before matching	2	0.097	0.003	16.7
Radius Caliper (0.1)	0	0.005	0.988	4.2
Nearness neighbour	1	0.050	0.143	17.0
Kernel common trim (0.1)	0	0.014	0.927	8.2

Per capita consumption				
Before matching	2	0.097	0.003	16.7
Radius Caliper (0.1)	0	0.005	0.988	4.2
Nearness neighbour	1	0.050	0.143	17.0
Kernel common trim (0.1)	0	0.014	0.927	8.2
Yield				
Before matching	2	0.097	0.003	16.7
Radius Caliper (0.1)	0	0.005	0.988	4.2
Nearness neighbour	1	0.050	0.143	17.0
Kernel common trim (0.1)	0	0.014	0.927	8.2
Poverty (MPI weighted score)				
Before matching	2	0.097	0.003	16.7
Radius Caliper (0.1)	0	0.005	0.988	4.2
Nearness neighbour	1	0.050	0.143	17.0
Kernel common trim (0.1)	0	0.014	0.927	8.2

Table S9: Balancing test for certified oil palm and food crop farmers

	No. Of Significant. Variables	Pseudo R2	p-Value LR* Test	Mean Bias
Impact of involvement in certification				
Household Income				
Before matching	3	0.212	0.000	29.2
Radius Caliper (0.1)	0	0.016	0.908	10.4
Nearness neighbour	0	0.045	0.285	16.7
Kernel common trim (0.1)	0	0.014	0.935	9.6

Per capita income				
Before matching	3	0.212	0.000	29.2
Radius Caliper (0.1)	0	0.016	0.908	10.4
Nearness neighbour	0	0.045	0.285	16.7
Kernel common trim	0	0.014	0.935	9.6
Total household consumption				
Before matching	3	0.212	0.000	29.2
Radius Caliper (0.1)	0	0.016	0.908	10.4
Nearness neighbour	0	0.045	0.285	16.7
Kernel common trim (0.1)	0	0.014	0.935	9.6
Per capita consumption				
Before matching	3	0.212	0.000	29.2
Radius Caliper (0.1)	0	0.016	0.908	10.4
Nearness neighbour	0	0.045	0.285	16.7
Kernel common trim (0.1)	0	0.014	0.935	9.6
Farm income				
Before matching	3	0.212	0.000	29.2
Radius Caliper (0.1)	0	0.016	0.908	10.4
Nearness neighbour	0	0.045	0.285	16.7
Kernel common trim (0.1)	0	0.014	0.935	9.6
Poverty (Weighted score)				
Before matching	3	0.212	0.000	29.2
Radius Caliper (0.1)	0	0.016	0.908	10.4
Nearness neighbour	0	0.045	0.285	16.7
Kernel common trim (0.1)	0	0.014	0.935	9.6

Table S10: Balancing test for uncertified oil palm and food crop only farmers

	No. Of Significant. Variables	Pseudo R2	p-Value LR* Test	Mean Bias
Impact of involvement in certification				
Household Income				
Before matching	3	0.111	0.003	23.8
Radius Caliper (0.1)	0	0.004	1.000	4.3
Nearness neighbour	0	0.033	0.625	10.5
Kernel common trim (0.1)	0	0.005	0.999	4.0
Per capita income				
Before matching	3	0.111	0.003	23.8
Radius Caliper (0.1)	0	0.004	1.000	4.3
Nearness neighbour	0	0.033	0.625	10.5
Kernel common trim	0	0.005	0.999	4.0
Total household consumption				
Before matching	3	0.111	0.003	23.8
Radius Caliper (0.1)	0	0.004	1.000	4.3
Nearness neighbour	0	0.033	0.625	10.5
Kernel common trim (0.1)	0	0.005	0.999	4.0
Per capita consumption				
Before matching	3	0.111	0.003	23.8
Radius Caliper (0.1)	0	0.004	1.000	4.3
Nearness neighbour	0	0.033	0.625	10.5
Kernel common trim (0.1)	0	0.005	0.999	4.0
Poverty (MPI weighted score)				
Before matching	3	0.111	0.003	23.8
Radius Caliper (0.1)	0	0.004	1.000	4.3
Nearness neighbour	0	0.033	0.625	10.5

Kernel common trim (0.1)	0	0.005	0.999	4.0
Farm income (MPI weighted score)				
Before matching	3	0.111	0.003	23.8
Radius Caliper (0.1)	0	0.004	1.000	4.3
Nearness neighbour	0	0.033	0.625	10.5
Kernel common trim (0.1)	0	0.005	0.999	4.0

Table S11: Sensitivity analysis- Rosenbaum bounds results for certified oil palm and uncertified oil palm farmers

Total household income

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	4.8e-07	4.8e-07	5206.25	5206.25	3529.95	6648.47
1.1	3.4e-06	5.4e-08	4843	5576.87	3117.03	6998.5
1.2	.000017	6.0e-09	4444.3	5879.48	2760.61	7314.78
1.3	.000068	6.5e-10	4120	6181.85	2459.96	7652.19
1.4	.000213	7.1e-11	3773.17	6459.65	2127.3	7991.88
1.5	.000568	7.6e-12	3465.09	6712.92	1892.34	8284.8
1.6	.00132	8.1e-13	3173.4	6924.69	1596.18	8588.01
1.7	.002743	8.7e-14	2962.87	7111.14	1374.9	8849.4
1.8	.005194	9.2e-15	2734.22	7344.85	1119.97	9155.69
1.9	.009093	1.0e-15	2522.34	7565.68	884.148	9416.17
2	.014895	1.1e-16	2364.31	7769.7	645.494	9630.45
2.1	.02305	0	2140.08	7963.8	438.582	9823.6
2.2	.033962	0	1997.6	8180	235.65	10062.5
2.3	.047959	0	1842.19	8312.7	45.0582	10298.1
2.4	.065261	0	1656.35	8550.34	-210	10469.6
2.5	.085969	0	1507.12	8707.74	-465.419	10670.3
2.6	.110057	0	1392	8848.35	-707.536	10845.2
2.7	.137379	0	1229.72	9061.86	-967.43	10989
2.8	.167683	0	1089.35	9218.12	-1132.35	11162.8

2.9	.20063	0	930.494	9323.99	-1349.8	11351
3	.235814	0	827.402	9472.5	-1581.05	11489.2

* gamma - log odds of differential assignment due to unobserved factors

sig+ - upper bound significance level

sig- - lower bound significance level

t-hat+ - upper bound Hodges-Lehmann point estimate

t-hat- - lower bound Hodges-Lehmann point estimate

CI+ - upper bound confidence interval (a= .9)

CI- - lower bound confidence interval (a= .9)

Oil palm income

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	2.3e-14	2.3e-14	2147.02	2147.02	1853.92	2443.37
2	3.2e-07	0	1628.99	2696.9	1271.65	3054.2
3	.00008	0	1308.29	3028.1	888.582	3491.46
4	.00128	0	1080.75	3269.37	608.402	3960.31
5	.006708	0	888.582	3491.46	396.58	4421.76
6	.020113	0	734.902	3725.8	213.35	4950.43
7	.043739	0	619.97	3922.27	22.896	5308.12
8	.077749	0	521.402	4141.5	-137.058	5619.56
9	.120754	0	431.2	4336.12	-242.214	5921.06
10	.170594	0	362.935	4503.52	-330.006	6239.58

Per capita income

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	1.6e-08	1.6e-08	1782.26	1782.26	1267.95	2362.43
1.1	1.5e-07	1.4e-09	1646.75	1905.46	1152.1	2523.4
1.2	9.2e-07	1.2e-10	1531.53	2057.74	1034.65	2691.87
1.3	4.3e-06	1.0e-11	1431.85	2180.26	923.599	2843.79
1.4	.000016	8.8e-13	1342.28	2300.76	819.515	3021.11
1.5	.000049	7.4e-14	1253.89	2389.77	735.353	3162.99
1.6	.000129	6.3e-15	1176.39	2493.98	652.932	3288.32
1.7	.000303	5.6e-16	1097.17	2599.96	584.811	3433.61
1.8	.000642	0	1026.89	2701.19	508.908	3559.33

1.9	.001247	0	953.41	2792.69	460.067	3679.54
2	.00225	0	890.97	2906.54	398.78	3781.27
2.1	.003815	0	823.215	3014.67	346.55	3914.76
2.2	.006127	0	765.098	3100.62	286.318	4012.23
2.3	.009385	0	704.865	3188.75	237.357	4130.55
2.4	.013796	0	672.105	3260.4	194.362	4212.31
2.5	.019559	0	625.882	3353.71	140.439	4305.86
2.6	.026856	0	587.972	3431.48	90.6522	4406.43
2.7	.035842	0	542.609	3505.08	41.6812	4474.28
2.8	.046639	0	500.15	3580.27	12.2785	4571.36
2.9	.059331	0	467.114	3653.51	-26.6725	4630.69
3	.073957	0	438.217	3709.25	-64.0306	4689.2
3.1	.090517	0	405.924	3767.95	-104.302	4779.69
3.2	.108969	0	381.063	3849.87	-139.31	4848.13
3.3	.129233	0	346.55	3914.76	-162.041	4918.07
3.4	.151194	0	307.808	3972.79	-198.671	4973.14
3.5	.174713	0	279.735	4024.5	-241.843	5056.85
3.6	.199624	0	252.304	4112.95	-259.388	5115.7
3.7	.225746	0	226.37	4148	-297.091	5171.61
3.8	.252888	0	200.122	4197.81	-325.885	5284.28
3.9	.28085	0	183.988	4234.17	-349.972	5345.49
4	.309434	0	154.013	4291.98	-383.62	5402.4

Farm income

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	1.1e-16	1.1e-16	2275.08	2275.08	1859.04	2647.97
2	4.8e-09	0	1572.18	3007.71	1210.86	3688.38
3	2.1e-06	0	1239.94	3621.52	936.369	4320.26
4	.000046	0	1055.56	4032.97	766.741	4975.92
5	.000298	0	936.369	4320.26	651.758	5443.27
6	.001054	0	842.686	4586.5	543.26	5780.12
7	.002624	0	777.071	4914.01	454.721	6046.97
8	.00524	0	721.925	5178.17	388.981	6230.82
9	.009024	0	671.848	5327.82	323.896	6509.1
10	.014003	0	633.35	5499.5	261.989	6767.14

11	.020133	0	587.101	5646.84	207.994	6938.16
12	.027326	0	549.01	5749.98	127.72	7058.66
13	.035473	0	527.122	5864.39	85.1279	7229.17
14	.044454	0	496.321	5938.75	39.828	7432.73
15	.05415	0	464.477	6015.34	-20.5387	7628.88
16	.06445	0	442.437	6079.55	-51.7614	7722.02
17	.075249	0	420.511	6135.15	-97.6125	7872.69
18	.086455	0	403.027	6182.31	-175.177	8143.91
19	.097983	0	386.275	6267.61	-238.682	8340.05
20	.10976	0	370.958	6358	-326.145	8560.55

Total household Consumption

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.090066	.090066	586.222	586.222	-124.81	1332.64
1.1	.175099	.040099	386.475	754.919	-314.571	1566.57
1.2	.285934	.016729	219.46	938.032	-490.976	1754
1.3	.410248	.006627	87	1107.22	-621.556	1957.38
1.4	.534291	.002518	-32.2259	1236.17	-770.525	2177.54
1.5	.647109	.000924	-152.525	1373.85	-912.493	2371.1
1.6	.74234	.00033	-286.421	1527.79	-1014.8	2545.34
1.7	.817975	.000115	-395.797	1649.61	-1132.58	2730.97
1.8	.8751	.000039	-498.889	1764.73	-1270.53	2884.53
1.9	.916469	.000013	-584.958	1905.55	-1371.41	3056.11
2	.945385	4.4e-06	-675.078	2038.43	-1467.31	3198.75

Per capita consumption

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.126635	.126635	298.169	298.169	-121.948	778.719
1.1	.230842	.060402	189.12	410.395	-223.006	889.031
1.2	.356968	.026939	96.9303	516.996	-314.653	1017.23
1.3	.489111	.011385	10.6114	622.215	-388.467	1138.66
1.4	.612857	.004606	-78.7369	713.352	-469.212	1242.56
1.5	.718878	.001798	-137.355	790.843	-536.597	1366.75
1.6	.803439	.000682	-206.067	868.434	-607.779	1469.09

1.7	.867056	.000252	-266.503	951.556	-675.567	1562.6
1.8	.912664	.000091	-321.789	1032.16	-728.497	1672.37
1.9	.94407	.000033	-374.327	1103.9	-779.218	1747.06
2	.964974	.000011	-417.003	1177.42	-822.815	1818.31

Yield (ton/ha)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.00116	.00116	.814587	.814587	.41717	1.29367
1.1	.004124	.000273	.711397	.938686	.324751	1.40042
1.2	.011364	.000062	.628645	1.05302	.214007	1.49166
1.3	.025757	.000014	.545028	1.15832	.110753	1.57292
1.4	.050119	2.9e-06	.473799	1.23535	-.000617	1.63068
1.5	.086408	6.0e-07	.39999	1.30929	-.101999	1.69327
1.6	.135164	1.2e-07	.344467	1.37642	-.170769	1.76807
1.7	.19537	2.5e-08	.273017	1.44319	-.252486	1.84984
1.8	.2647	5.1e-09	.20747	1.50085	-.314964	1.92557
1.9	.340005	1.0e-09	.139582	1.54621	-.385418	2.00833
2	.417863	2.0e-10	.079051	1.59667	-.448927	2.0726

Poverty (Weighted score)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.001092	.001092	-.023647	-.023647	-.04386	-.009284
1.1	.000255	.003906	-.030307	-.018518	-.051503	-.006823
1.2	.000057	.01082	-.035256	-.015156	-.059783	-.004765
1.3	.000013	.024643	-.038492	-.012561	-.063271	-.002684
1.4	2.7e-06	.048163	-.041723	-.010453	-.066009	-.000053
1.5	5.5e-07	.083373	-.044239	-.008862	-.068502	.003783
1.6	1.1e-07	.130904	-.04921	-.007243	-.071428	.009157
1.7	2.3e-08	.189865	-.055555	-.005787	-.075244	.012946
1.8	4.6e-09	.258061	-.060668	-.004683	-.07955	.015614
1.9	9.1e-10	.33245	-.062378	-.003119	-.083286	.017324
2	1.8e-10	.409681	-.064418	-.001596	-.085185	.018921

Table S12: Sensitivity analysis- Rosenbaum bounds results for certified oil palm farmers and food crop farmers

Total household income

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.080241	.080241	1342.84	1342.84	-201.186	2855.42
1.1	.140951	.041456	1074.35	1601.88	-498.748	3160.88
1.2	.217894	.020713	809.869	1859.14	-697.91	3405.01
1.3	.305841	.010078	542.289	2166.49	-900.953	3611.75
1.4	.398628	.004801	295.143	2387.99	-1103.54	3821.11
1.5	.490523	.002248	5.79645	2641.28	-1298.93	4050.73
1.6	.577031	.001038	-169.335	2819.42	-1514.16	4315.2
1.7	.65517	.000474	-352.685	3023.06	-1678.68	4568.98
1.8	.723391	.000214	-498.77	3162.74	-1912.14	4801.27
1.9	.781285	.000096	-607.286	3283.99	-2074.81	4981.1
2	.829259	.000043	-719.813	3425.56	-2252.84	5163.6

Per capita income

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.007262	.007262	1069.32	1069.32	334.325	1915.9
1.1	.017094	.002753	917.167	1226.6	210.458	2114.44
1.2	.034056	.001021	785.742	1355.17	84.4776	2285.03
1.3	.059706	.000372	638.006	1494.19	-31.0792	2439.28
1.4	.094715	.000134	529.762	1612.97	-137.541	2575.36
1.5	.138779	.000047	443.08	1759.44	-232.864	2745.54
1.6	.19074	.000017	366.358	1878.12	-314.359	2853.81
1.7	.248844	5.9e-06	297.542	2005.19	-403.723	2978.95
1.8	.311031	2.0e-06	210.426	2115.26	-454.748	3098.44
1.9	.375198	7.0e-07	128.773	2208.29	-512.434	3217.75
2	.439401	2.4e-07	66.7345	2308.37	-571.564	3302.79

Farm income

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-

1	2.6e-12	2.6e-12	3598.45	3598.45	3089.61	4233.49
2	5.3e-07	0	2929.9	4475.85	2539.76	5199.13
3	.000034	0	2630.38	4991.21	2267.91	5939.1
4	.00028	0	2461.06	5324.07	2084.12	6718.55
5	.001014	0	2332.39	5662.65	1954.45	7278.45
6	.002422	0	2250.85	6004.28	1848.33	7611.25
7	.00455	0	2173.99	6351.2	1747.95	8054.68
8	.007347	0	2119.7	6622.45	1659.94	8415.15
9	.010716	0	2057.67	6847.75	1569.5	8669.72
10	.014546	0	2029.24	7020.28	1489.51	8827.98
11	.018731	0	1982.94	7174.23	1428.81	9277.4
12	.023179	0	1951.96	7280.94	1357.73	9559.93
13	.027813	0	1923.81	7348.11	1280.56	9862.67
14	.032567	0	1898.07	7425.64	1198.17	10211
15	.037391	0	1875.04	7529.87	1110.78	10822
16	.042244	0	1840.71	7614.59	1033.61	11439.2
17	.047094	0	1815.68	7682.79	938.548	13030.4
18	.051916	0	1801.62	7800.2	-99	99
19	.056691	0	1787.4	7908.3	-99	99
20	.061405	0	1763.8	8012.3	-99	99
21	.066047	0	1742.79	8075.89	-99	99
22	.070609	0	1725.26	8125.11	-99	99
23	.075085	0	1717.76	8196.1	-99	99
24	.079472	0	1708.45	8314.05	-99	99
25	.083766	0	1676.85	8356.35	-99	99
26	.087968	0	1669	8380.58	-99	99
27	.092077	0	1656.41	8435.33	-99	99
28	.096092	0	1637.88	8491.25	-99	99
29	.100016	0	1620.34	8494.33	-99	99
30	.103849	0	1618.03	8568.68	-99	99

Total household consumption

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-

1	.002018	.002018	1909	1909	827.683	3120.75
1.1	.005391	.000669	1671.27	2152.36	662.107	3350.39
1.2	.011992	.000218	1470.01	2327.68	485.08	3573.9
1.3	.02317	.00007	1324.36	2501.81	322.44	3745.49
1.4	.040085	.000022	1181.84	2696.01	43.0612	3919.62
1.5	.063501	7.0e-06	974.48	2884.92	-114.64	4051.44
1.6	.093676	2.2e-06	862.036	3067.83	-250.405	4178.78
1.7	.130355	6.8e-07	775.395	3231.6	-407.063	4336.23
1.8	.17284	2.1e-07	659.048	3352.27	-522.969	4523.33
1.9	.220108	6.5e-08	557.676	3445.47	-621.469	4696.87
2	.270944	2.0e-08	475.016	3597.76	-745.454	4777.84

Per capita consumption

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.000745	.000745	1139.47	1139.47	546.138	1728.35
1.1	.002177	.000225	996.056	1250.57	429.629	1875.73
1.2	.005236	.000067	895.014	1342.42	328.708	2015.64
1.3	.010835	.00002	789.215	1440.34	261.802	2135.7
1.4	.019929	5.7e-06	703.463	1519.23	168.342	2259.83
1.5	.033366	1.7e-06	631.822	1599.21	84.2269	2355.58
1.6	.051758	4.8e-07	562.892	1690.31	-7.19799	2472.4
1.7	.075414	1.4e-07	493.195	1789.91	-71.5125	2555.9
1.8	.104316	3.9e-08	427.185	1875.73	-129.67	2650.64
1.9	.138142	1.1e-08	372.804	1951.85	-217.23	2751.43
2	.176324	3.1e-09	314.142	2032.85	-275.462	2859.24

Poverty (Weighted scores)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-

1	.108917	.108917	-.011367	-.011367	-.034426	.006216
1.1	.059062	.182807	-.014434	-.008243	-.038677	.010318
1.2	.030923	.27177	-.016992	-.006619	-.044707	.013929
1.3	.015746	.368794	-.01999	-.004865	-.049287	.016096
1.4	.00784	.466799	-.023196	-.002312	-.055887	.019018
1.5	.003834	.559983	-.028526	.002174	-.061453	.020995
1.6	.001847	.644385	-.033114	.004915	-.062995	.022869
1.7	.000879	.717873	-.035805	.008136	-.065468	.027204
1.8	.000414	.779809	-.038679	.010367	-.068868	.030671
1.9	.000193	.830613	-.042917	.012359	-.071755	.034114
2	.00009	.871348	-.045482	.014057	-.073601	.036679

Table S13: Sensitivity analysis- Rosenbaum bounds results for uncertified oil palm famers and food crop farmers

Total household income

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.010685	.010685	-2114.5	-2114.5	-3931	-601
1.1	.003524	.027848	-2548.5	-1771.5	-4392.5	-269
1.2	.001111	.059022	-2934.5	-1404	-4938	105
1.3	.000338	.106868	-3390	-1172	-5385	443.75
1.4	.0001	.171267	-3637.5	-865	-5910	792
1.5	.000029	.249373	-3927.13	-603.375	-6708.75	1090
1.6	8.2e-06	.336476	-4198	-380	-7284.5	1455
1.7	2.3e-06	.427176	-4510	-214	-8035.75	1675
1.8	6.4e-07	.516419	-4895	51	-8550	1952
1.9	1.7e-07	.600167	-5115	262	-9066.5	2250
2	4.7e-08	.675679	-5474.37	479.5	-9740	2503.25

Per capita income

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-

1	.022604	.022604	-932.607	-932.607	-1445.5	-215.701
1.1	.008297	.05322	-1087.62	-790.573	-1572.68	8.77021
1.2	.002899	.103271	-1197.75	-653.043	-1702.8	248.4
1.3	.000975	.173066	-1312.63	-507.797	-1836.34	471.618
1.4	.000318	.259054	-1384.39	-364.283	-1967.91	643.947
1.5	.000101	.355081	-1444.89	-226.384	-2062.53	793.955
1.6	.000031	.454164	-1519.02	-57.7968	-2155.1	892.683
1.7	9.6e-06	.550005	-1602.61	57.7211	-2240.01	1035.34
1.8	2.9e-06	.637891	-1688.24	208.233	-2323.04	1134.38
1.9	8.7e-07	.714968	-1771.1	359.935	-2432.98	1255.99
2	2.6e-07	.780071	-1861.81	509.42	-2501.52	1363.83

Farm income

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.507345	.507345	1.78986	1.78986	-308.682	349.887
1.1	.354891	.658735	-60.8532	87.0231	-402.653	404.863
1.2	.232873	.778279	-125.27	167.739	-488.236	485.295
1.3	.144737	.863552	-196.112	230.44	-567.151	557.351
1.4	.085941	.91977	-254.225	292.992	-618.968	610.181
1.5	.049107	.954597	-308.494	349.423	-690.019	652.224
1.6	.027165	.975121	-371.523	387.21	-758.382	707.462
1.7	.014621	.986734	-432.641	422.714	-798.343	768.059
1.8	.007687	.993089	-480.882	475.879	-850.448	799.691
1.9	.003962	.996471	-528.661	515.675	-901.848	837.922
2	.002007	.998228	-573.296	560.434	-958.972	873.682

Total household consumption

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-

1	.008677	.008677	1499.73	1499.73	453.347	2662.59
1.1	.023226	.002782	1256.97	1808.46	223.044	3058.87
1.2	.050386	.000854	1045.72	2056.33	-2.09058	3327.15
1.3	.09312	.000253	814.056	2254.73	-275.905	3584.87
1.4	.15197	.000073	556.448	2442.37	-520.66	3906.71
1.5	.224881	.000021	454.951	2656.17	-692.557	4140.37
1.6	.307834	5.7e-06	281.211	2899.62	-805.023	4339.89
1.7	.395867	1.6e-06	189.25	3120.94	-964.053	4615.36
1.8	.484067	4.2e-07	34.6059	3320.45	-1102.56	4882.71
1.9	.568284	1.1e-07	-101.238	3429.67	-1257.45	5119.87
2	.645501	3.0e-08	-302.321	3603.01	-1361.61	5328.58

Per capita consumption

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.038745	.038745	750.829	750.829	53.7868	1545.19
1.1	.084278	.015463	574.914	933.351	-131.625	1756.43
1.2	.152714	.005856	416.427	1100.03	-301.171	1912.32
1.3	.241094	.002128	280.769	1237.44	-430.906	2120.29
1.4	.342515	.000748	175.936	1398.51	-581.344	2302.66
1.5	.448501	.000256	61.5026	1536.71	-735.063	2435.3
1.6	.551216	.000086	-63.0958	1669.7	-890.214	2599.48
1.7	.644822	.000028	-188.093	1794.87	-1016.62	2772.6
1.8	.725899	9.1e-06	-268.637	1886.12	-1115.88	2864.05
1.9	.793206	2.9e-06	-363.437	2034.37	-1258.2	2977.86
2	.847116	9.2e-07	-451.711	2144.29	-1420.72	3125.54

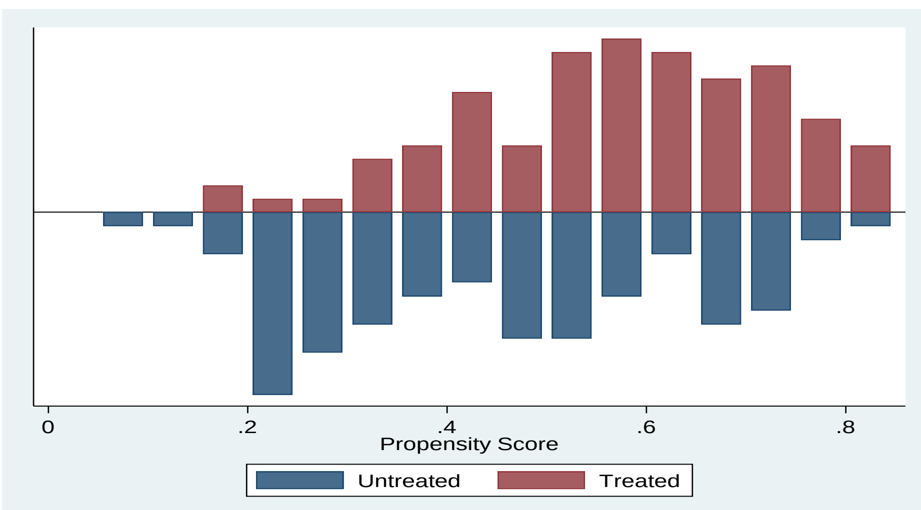
Poverty (Weighted deprivation score)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-

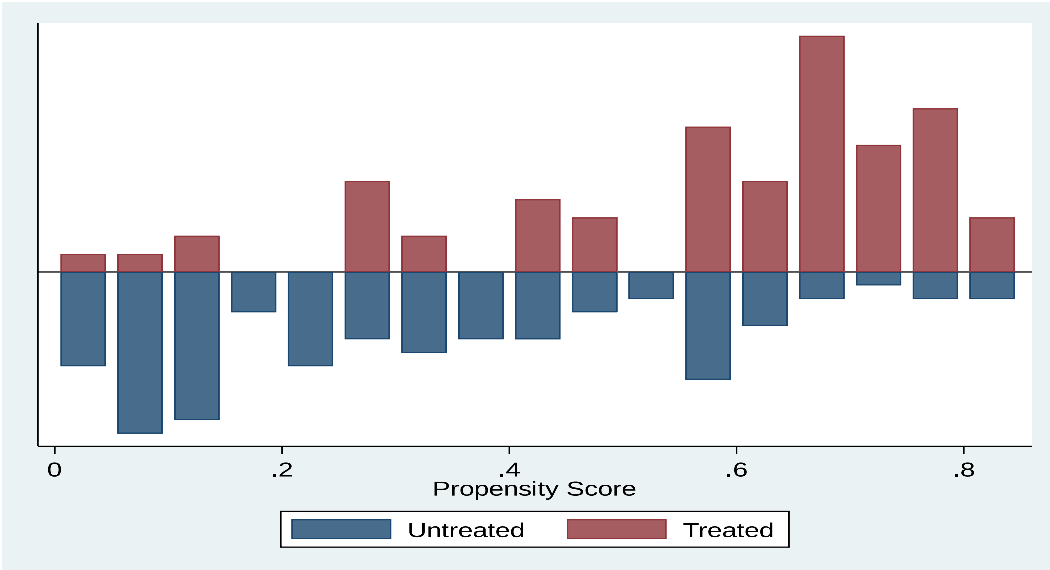
1	.600123	.600123	-.002079	-.002079	-.020644	.01437
1.1	.740356	.445699	-.005616	.001014	-.024881	.019387
1.2	.841937	.311004	-.009115	.004855	-.028923	.023032
1.3	.908807	.205612	-.01311	.007861	-.033096	.027451
1.4	.949683	.129816	-.017569	.011863	-.036856	.031625
1.5	.97325	.078817	-.02056	.014322	-.040803	.034269
1.6	.986215	.046289	-.023371	.017504	-.044817	.038423
1.7	.99308	.026427	-.026192	.020296	-.048964	.042648
1.8	.996603	.014726	-.028509	.022501	-.052063	.047902
1.9	.998364	.008037	-.03102	.025689	-.055041	.051223
2	.999225	.004308	-.033422	.027754	-.057502	.05438

Figure S2: Histogram of propensity scores

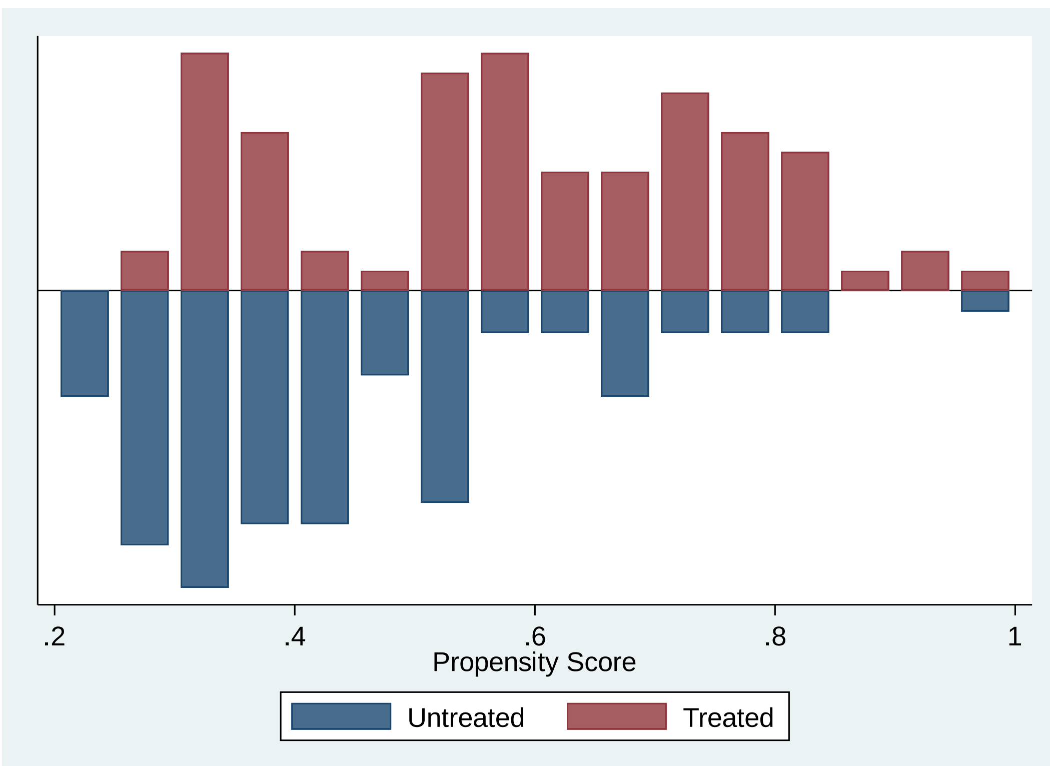
Certified oil palm farmers and uncertified oil palm farmers



Certified oil palm farmers and food crop farmers



Uncertified oil palm farmers and food crop farmers



Food security

Table S14: Sensitivity analysis- Rosenbaum bounds results for certified cocoa and uncertified cocoa farmers

Food security (FCS)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.030903	.030903	2.81579	2.81579	.367857	5.24121
1.1	.06954	.011899	2.1969	3.38324	-.291429	5.82236
1.2	.129755	.004353	1.67817	3.84806	-.865915	6.24089
1.3	.21014	.00153	1.17177	4.32402	-1.45265	6.70207
1.4	.305259	.000521	.8125	4.8033	-1.99093	7.10345
1.5	.407555	.000173	.382423	5.23319	-2.534	7.53766
1.6	.509419	.000056	-.057658	5.59411	-2.93663	7.88158
1.7	.604675	.000018	-.482859	5.92568	-3.30191	8.26429
1.8	.689245	5.6e-06	-.775208	6.2059	-3.77717	8.51113
1.9	.761142	1.7e-06	-1.1129	6.42153	-4.26467	8.79591
2	.82007	5.4e-07	-1.52065	6.7242	-4.64011	9.0125

Food security (HFIAS)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.000106	.000106	-2.54915	-2.54915	-3.38462	-1.31667
1.1	.000021	.000453	-2.73558	-2.25843	-3.61542	-1.04916
1.2	3.9e-06	.001478	-2.99236	-2.03133	-3.74199	-.77245
1.3	7.4e-07	.003921	-3.13684	-1.77245	-3.84748	-.466044
1.4	1.4e-07	.008835	-3.25526	-1.56579	-3.93002	-.278846
1.5	2.5e-08	.017482	-3.37642	-1.31995	-4.02851	-.175676
1.6	4.4e-09	.031134	-3.54813	-1.16667	-4.08253	-.090116
1.7	7.9e-10	.050857	-3.64318	-.973793	-4.12806	.010493
1.8	1.4e-10	.077335	-3.7194	-.789082	-4.17915	.13587
1.9	2.5e-11	.110767	-3.79574	-.652381	-4.21574	.219828
2	4.4e-12	.150843	-3.86288	-.409849	-4.25043	.3

Food Security (CSI)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.999807	.999807	-3.21048	-3.21048	-99	99
1.1	.99996	.999219	-3.27411	-3.10861	-99	99
1.2	.999992	.997571	-3.33182	-3.00913	-99	99
1.3	.999998	.993828	-3.37349	-2.80261	-99	99
1.4	1	.986616	-3.42218	-2.37531	-99	99
1.5	1	.974423	-3.46548	-2.14852	-99	99
1.6	1	.955874	-3.50627	-2.04865	-99	99
1.7	1	.929988	-3.5475	-1.94308	-99	99
1.8	1	.896355	-3.57529	-1.795	-99	99
1.9	1	.855192	-3.61091	-1.55833	-99	99
2	1	.807293	-3.63246	-1.27456	-99	99

Table S15: Sensitivity analysis- Rosenbaum bounds results for certified cocoa and food crop farmers

Food security (FCS)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.129467	.129467	2.2842	2.2842	-.929962	5.17005
1.1	.223005	.067027	1.39277	2.94531	-1.7503	5.81978
1.2	.334061	.032995	.834229	3.6264	-2.43266	6.3384
1.3	.451132	.015601	.198209	4.14395	-3.03842	6.97981
1.4	.56366	.007141	-.280187	4.57215	-3.73282	7.50652
1.5	.664205	.003183	-.729615	5.02993	-4.23533	7.92216
1.6	.748922	.001388	-1.28421	5.40255	-4.667	8.31557
1.7	.816971	.000594	-1.70394	5.81098	-5.04966	8.73174
1.8	.869516	.000251	-2.11379	6.1087	-5.38737	9.00866
1.9	.908778	.000104	-2.58043	6.4658	-5.74247	9.33706
2	.937312	.000043	-2.89296	6.84618	-6.27456	9.66058

Food security (HFIAS)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.830935	.830935	-.580445	-.580445	-1.27245	.433282
1.1	.907756	.722687	-.747711	-.355528	-1.43293	.678738
1.2	.952216	.601399	-.98663	-.186057	-1.54966	.937253
1.3	.976258	.480173	-1.09879	.082351	-1.62524	1.15121
1.4	.988596	.369291	-1.17482	.27065	-1.68597	1.32441
1.5	.994672	.274739	-1.22982	.393521	-1.73855	1.47454
1.6	.997567	.198527	-1.31114	.526107	-1.79293	1.60849
1.7	.99891	.139852	-1.43106	.672691	-1.85621	1.73685
1.8	.999519	.096356	-1.51285	.849846	-1.90985	1.86358
1.9	.999791	.065115	-1.55923	.966785	-1.98864	2.11029
2	.99991	.043263	-1.61049	1.10455	-2.05511	2.22452

Food security (CSI)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.004365	.004365	-2.43892	-2.43892	-3.56718	-.291918
1.1	.001479	.011338	-2.45698	-2.31341	-3.69695	-.182546
1.2	.000488	.02444	-2.55991	-2.13346	-4.0452	-3.1e-07
1.3	.000158	.045656	-2.80259	-1.74838	-4.34193	-3.1e-07
1.4	.00005	.076263	-3.24211	-1.56435	-4.57827	-3.1e-07
1.5	.000016	.116556	-3.56435	-.323731	-4.7502	.136027
1.6	4.9e-06	.165832	-3.57731	-.246505	-4.90094	.835067
1.7	1.5e-06	.222576	-3.61487	-.182546	-5.29385	1.77429
1.8	4.7e-07	.284756	-3.84292	-3.1e-07	-5.64949	2.2498
1.9	1.4e-07	.350126	-4.13824	-3.1e-07	-5.88058	3.27902
2	4.3e-08	.416489	-4.19306	-3.1e-07	-6.01113	3.70612

Table S16: Sensitivity analysis- Rosenbaum bounds results for uncertified cocoa and food crop farmers

Food security-FCS

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.0364	.0364	4.25	4.25	.499999	8.5
1.1	.074952	.015685	3.5	5.25	-.5	9.25
1.2	.131489	.006501	2.75	6	-1.5	10
1.3	.204275	.002614	2	6.75	-2.25	11
1.4	.288961	.001026	1.25	7.25	-2.75	11.75
1.5	.379906	.000395	.75	8	-3.25	12.25
1.6	.471478	.00015	.25	8.75	-3.75	12.75
1.7	.558964	.000056	-.499999	9	-4.5	13.25
1.8	.639001	.000021	-.999999	9.75	-5	13.75
1.9	.709623	7.6e-06	-1.5	10	-5.5	14.25
2	.770067	2.7e-06	-1.75	10.5	-6	14.75

Food security- HFIAS

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.001528	.001528	1.5	1.5	.5	3
1.1	.004094	.000507	1	2	2.7e-07	4
1.2	.009154	.000166	1	2	-2.7e-07	4.5
1.3	.017813	.000054	.5	2.5	-2.7e-07	5
1.4	.03108	.000017	.5	3	-2.7e-07	5
1.5	.049703	5.4e-06	.5	3	-2.7e-07	5.5
1.6	.074067	1.7e-06	.5	3	-2.7e-07	5.5
1.7	.104166	5.4e-07	.499999	3.5	-2.7e-07	6
1.8	.13963	1.7e-07	-2.7e-07	4	-2.7e-07	6
1.9	.179795	5.3e-08	-2.7e-07	4.5	-.5	6
2	.223795	1.7e-08	-2.7e-07	4.5	-.5	6

Food security (CSI)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.040584	.040584	-2.6e-07	-2.6e-07	-2.6e-07	-2.6e-07
1.1	.063825	.024509	-2.6e-07	-2.6e-07	-2.6e-07	-2.6e-07
1.2	.092562	.01473	-2.6e-07	-2.6e-07	-2.6e-07	.499998
1.3	.126112	.008822	-2.6e-07	-2.6e-07	-2.6e-07	2
1.4	.163597	.00527	-2.6e-07	-2.6e-07	-2.6e-07	3
1.5	.204057	.003142	-2.6e-07	-2.6e-07	-2.6e-07	5.5
1.6	.246547	.00187	-2.6e-07	-2.6e-07	-2.6e-07	6.5
1.7	.29019	.001112	-2.6e-07	-2.6e-07	-2.6e-07	6.5
1.8	.334213	.000661	-2.6e-07	-2.6e-07	-2.6e-07	6.5
1.9	.377959	.000392	-2.6e-07	.499999	-2.6e-07	8
2	.420889	.000233	-2.6e-07	2	-2.6e-07	8.5

Table S17: Sensitivity analysis- Rosenbaum bounds results for certified oil palm and uncertified oil palm farmers

Food security (FCS)

1	.078928	.078928	-2.2963	-2.2963	-4.70318	.425325
1.1	.034259	.157147	-2.87121	-1.53496	-5.32527	1.18399
1.2	.013946	.261877	-3.47838	-1.01726	-5.93512	1.86859
1.3	.005394	.382282	-3.89372	-.460526	-6.43035	2.41318
1.4	.002002	.505217	-4.41193	.011753	-6.88333	2.95192
1.5	.000719	.619466	-4.79154	.564815	-7.23958	3.46739
1.6	.000251	.7179	-5.19015	1.03125	-7.69009	3.93634
1.7	.000086	.797624	-5.61157	1.51778	-8.05808	4.41027
1.8	.000029	.858979	-5.97838	1.90614	-8.46429	4.87731
1.9	9.5e-06	.904225	-6.27126	2.24	-8.82164	5.30556
2	3.1e-06	.936413	-6.59677	2.57057	-9.1227	5.58553

Food security (HFIAS)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	1.1e-06	1.1e-06	-2.08423	-2.08423	-2.55398	-1.0921
1.1	1.3e-07	7.4e-06	-2.2357	-1.90212	-2.65242	-.93295
1.2	1.6e-08	.000035	-2.35526	-1.73545	-2.71795	-.808823
1.3	1.8e-09	.000131	-2.42312	-1.46759	-2.75112	-.664087
1.4	2.1e-10	.000396	-2.49167	-1.19045	-2.84692	-.586182
1.5	2.4e-11	.001015	-2.57312	-1.06469	-2.8859	-.529221
1.6	2.7e-12	.002277	-2.63985	-.959678	-2.91171	-.448485
1.7	3.1e-13	.004582	-2.68591	-.87037	-2.93689	-.389694
1.8	3.5e-14	.008421	-2.71955	-.787082	-2.97037	-.293011
1.9	3.9e-15	.014338	-2.7471	-.689258	-2.9925	-.173334
2	4.4e-16	.022885	-2.77778	-.641667	-3.0125	-.128788
2.1	0	.03456	-2.84259	-.590909	-3.0359	-.062121
2.2	0	.049765	-2.87193	-.556818	-3.06577	-.00303
2.3	0	.068765	-2.88978	-.518518	-3.07955	.037879
2.4	0	.091668	-2.90821	-.480263	-3.10667	.099282
2.5	0	.118418	-2.91884	-.42589	-3.13337	.159888
2.6	0	.148807	-2.93689	-.389694	-3.14423	.19773
2.7	0	.182491	-2.95736	-.351852	-3.15043	.273504
2.8	0	.219022	-2.9791	-.262463	-3.17045	.385965
2.9	0	.257876	-2.98064	-.207535	-3.20192	.458333
3	0	.298484	-3.00543	-.164141	-3.21053	.512545

Food security (CSI)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	1.4e-12	1.4e-12	-1.04167	-1.04167	-1.13636	-.961539
2	0	7.6e-07	-1.31579	-.666667	-1.58696	-.5
3	0	.000066	-1.56844	-.5	-1.80303	-3.2e-07
4	0	.000641	-1.70833	-.481482	-1.96759	-3.2e-07
5	0	.002564	-1.80303	-3.2e-07	-2.08333	-3.2e-07
6	0	.00655	-1.9067	-3.2e-07	-2.12862	-3.2e-07
7	0	.012922	-1.96154	-3.2e-07	-2.21154	-3.2e-07

8	0	.021663	-2.0032	-3.2e-07	-2.25	-3.2e-07
9	0	.032547	-2.0485	-3.2e-07	-2.27733	-3.2e-07
10	0	.045259	-2.08696	-3.2e-07	-2.31579	-3.2e-07
11	0	.059466	-2.0979	-3.2e-07	-2.33696	-3.2e-07
12	0	.07485	-2.11579	-3.2e-07	-2.38636	-3.2e-07
13	0	.091129	-2.13636	-3.2e-07	-2.40275	-3.2e-07
14	0	.108063	-2.17391	-3.2e-07	-2.40275	17.3636
15	0	.125447	-2.17803	-3.2e-07	-2.45215	17.4583

Table S18: Sensitivity analysis- Rosenbaum bounds results for certified oil palm and food crop farmers

Food security (FCS)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.062571	.062571	-3.42489	-3.42489	-6.52477	.217955
1.1	.031141	.113852	-4.15279	-2.66501	-7.08116	1.03666
1.2	.015008	.181423	-4.79928	-1.89396	-7.83879	1.78801
1.3	.007051	.261451	-5.2467	-1.37741	-8.2902	2.49832
1.4	.003247	.348703	-5.56528	-.795126	-8.79618	3.16875
1.5	.001471	.437813	-6.08283	-.418142	-9.3603	3.77227
1.6	.000657	.524169	-6.45066	.151132	-9.76975	4.34593
1.7	.000291	.604356	-6.80939	.61597	-10.2091	5.01389
1.8	.000127	.676242	-7.08442	1.04081	-10.6338	5.36692
1.9	.000055	.738822	-7.49632	1.5571	-11.0275	6.0097
2	.000024	.791973	-7.87876	1.85231	-11.2752	6.30667

Food security (HFIAS)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.597338	.597338	-.097793	-.097793	-1.3337	.512246
1.1	.717602	.467225	-.283979	.017376	-1.50863	.627742
1.2	.80988	.351053	-.547541	.101861	-1.61106	.739838
1.3	.876255	.254853	-.770612	.184192	-1.70792	.854573
1.4	.921676	.179698	-.984619	.262213	-1.79613	.943133
1.5	.951563	.123614	-1.15333	.39137	-1.88316	1.03449

1.6	.970621	.08327	-1.29428	.488451	-1.92403	1.15328
1.7	.98247	.055101	-1.42895	.557875	-1.97193	1.26668
1.8	.989684	.035908	-1.50926	.631572	-2.03899	1.35197
1.9	.994001	.023095	-1.54914	.690238	-2.07027	1.52381
2	.996546	.014687	-1.62649	.766386	-2.08721	1.67185
2.1	.998029	.009248	-1.68318	.821047	-2.15397	1.84217
2.2	.998884	.005773	-1.72523	.871683	-2.18427	2.00638
2.3	.999372	.003577	-1.78924	.911024	-2.21274	2.11562
2.4	.999649	.002202	-1.82236	.984972	-2.23273	2.23735
2.5	.999805	.001347	-1.8689	1.00746	-2.24974	2.32409
2.6	.999892	.00082	-1.89774	1.07776	-2.30399	2.43129
2.7	.99994	.000497	-1.91961	1.14885	-2.34117	2.47845
2.8	.999967	.0003	-1.93803	1.19249	-2.35072	2.55824
2.9	.999982	.00018	-1.96723	1.26258	-2.37816	2.61557
3	.99999	.000108	-2.01348	1.31352	-2.40515	2.69314

Food security (CSI)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.993398	.993398	-4.4e-07	-4.4e-07	-4.4e-07	-4.4e-07
1.1	.995751	.990109	-4.4e-07	-4.4e-07	-4.4e-07	-4.4e-07
1.2	.997255	.986103	-4.4e-07	-4.4e-07	-4.4e-07	-4.4e-07
1.3	.998222	.981421	-4.4e-07	-4.4e-07	-4.4e-07	-4.4e-07
1.4	.998845	.976119	-4.4e-07	-4.4e-07	-4.4e-07	-4.4e-07
1.5	.999248	.970257	-4.4e-07	-4.4e-07	-4.4e-07	-4.4e-07
1.6	.99951	.963899	-4.4e-07	-4.4e-07	-4.4e-07	-4.4e-07
1.7	.99968	.957109	-4.4e-07	-4.4e-07	-.165939	-4.4e-07
1.8	.99979	.949945	-4.4e-07	-4.4e-07	-.165939	-4.4e-07
1.9	.999863	.942463	-4.4e-07	-4.4e-07	-.178942	-4.4e-07
2	.99991	.934712	-4.4e-07	-4.4e-07	-.178942	-4.4e-07

Table S19: Sensitivity analysis- Rosenbaum bounds results for uncertified oil palm and food crop farmers

Food security (FCS)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.23763	.23763	-1.30193	-1.30193	-4.1017	1.93995
1.1	.134505	.372904	-2.06031	-.622458	-4.90554	2.49893
1.2	.071484	.512365	-2.7412	.127227	-5.55619	3.07225
1.3	.036092	.639739	-3.12904	.670362	-6.22378	3.59119
1.4	.017475	.745628	-3.50212	1.33407	-6.6895	4.08322
1.5	.008174	.827343	-4.0957	1.93589	-7.06549	4.67084
1.6	.003715	.886743	-4.6442	2.25228	-7.74822	5.33573
1.7	.001649	.927867	-5.02225	2.66126	-8.16911	5.83726
1.8	.000717	.955216	-5.40809	3.00951	-8.43307	6.45726
1.9	.000307	.972803	-5.92391	3.37528	-8.88784	6.81728
2	.000129	.983799	-6.26861	3.64105	-9.20168	7.22344

Food security (HFIAS)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.036391	.036391	1.20598	1.20598	.135646	1.89166
1.1	.079774	.014413	.987971	1.35532	-.089937	2.05309
1.2	.145585	.005421	.746807	1.48087	-.302511	2.22003
1.3	.231349	.001958	.438419	1.73047	-.444201	2.33494
1.4	.330642	.000684	.261365	1.81048	-.576721	2.39719
1.5	.435312	.000233	.149398	1.89074	-.701698	2.5
1.6	.537626	.000078	-.01123	1.95235	-.806466	2.6474
1.7	.63166	.000025	-.170283	2.10397	-.92958	2.76507
1.8	.713796	8.2e-06	-.265187	2.21124	-1.03662	2.83806
1.9	.782551	2.6e-06	-.375133	2.28457	-1.07672	2.89514
2	.83808	8.2e-07	-.497962	2.3418	-1.14515	2.94231

Food security (CSI)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	1.1e-11	1.1e-11	-.615441	-.615441	-.833186	-.500845
2	0	7.0e-06	-.972281	-.349036	-1.19218	-.206087
3	0	.000613	-1.16291	-.211046	-1.57314	-.111397
4	0	.005742	-1.45511	-.161905	-1.86017	-4.0e-07
5	0	.021818	-1.56352	-.111397	-2.12838	-4.0e-07
6	0	.052642	-1.73825	-.032886	-2.29493	-4.0e-07
7	0	.097824	-1.82928	-.015939	-2.41885	9.99645
8	0	.154292	-1.94632	-4.0e-07	-2.52351	10.4912
9	0	.218083	-2.04292	-4.0e-07	-2.76661	10.692
10	0	.285443	-2.14299	-4.0e-07	-2.92348	11.1484

Assessing the outcomes of certification standards on oil palm and cocoa smallholders in Ghana

Household questionnaire

District:							**Community:**
Household ID	1	**Date of interview**	2	**Name interviewer**	3	**GPS** E: S:	
Start time:				**End time:**			

Which category does the respondent belong? (Circle only one)

1. Certified Farmers		**2. Independent grower household**		**3. Food Crop only**	

SECTION A: DEMOGRAPHIC PROFILE: RESPONDENT CHARACTERISTICS

The table below should capture key information on the respondent. Ask questions on age, sex, and educational level of the respondent as well as headship of the household, and fill in/circle the appropriate response.

1	2	3	4	5	6
Age of respondent	Sex of respondent	Are you the head of the household?	Relation to household head	Highest level of education attained	Total number of years in school
_________ *Years*	*1=Male* *2=Female*	*1=Yes* *2=No*	*1=Head* *2= Wife or husband*	1: None=0 2: Primary=6 3: JHS/Middle school= 3 4: O-level=4 5: A-level=2 6: SSS/SHS=3 7: Undergraduate=3/4 8: Polytechnic=3 9: Teacher training=3 10: Postgraduate= 2 11: Other (specify) **…….**	___________

7. What is the religion of the head of the household? *Circle?* *1=Christian* *2=Muslim* *3=Traditional* *4= No religion* *5= Other (Specify)* _____________	8. What is your ethnic group *1=Wassa* *2=Ga-Adangbe* *3=Ewe* *4=Ashanti* *5=Fante* *6=Others*________________
9. Were you born in this area? *1=Yes* *2=No*	10. If No, did you move here less than 10 years ago? *1=Yes* *2=No*
11. If you have moved to this area as an adult, why did you move? *1=My wife/husband is from here* *2=I obtained land here* *3=Employment opportunity with plantation*	12. How many people are there in your household? …………………………….. ***(Household is a group of people who share the same dwelling place, cooking arrangements and consider one person as a head)***

<table>
<tr><td colspan="1">4=Other employment opportunity
5=Other reason (Specify) __________________</td><td colspan="2"></td></tr>
<tr><td>13. What is this person’s MAIN occupation
1= Cocoa
2= Oil palm farmer
3= Food crop farmer
4= Artisan (Mason, Mechanic, shoemaker, hairdresser etc)
5= Civil Servant (teacher, nurse, doctor, assembly etc)
6= Other formal employment (security, fuel attendant etc)
7=Self-employed/own business (Petty trading, food selling etc)
8=Student
9=Retired
10=Other (specify)________</td><td>14. Months per year this person is employed
1=Full time
2=6-11 months/yr
3=3-6 months/yr
4=Less than 3 month/yr</td><td>15. Monthly salary (GH¢)
(If not cocoa, oil palm or food crop farmer)
____
16. Range if no absolute value
1= < 100
2= 100-500
3= 501-1000
4= 1001-2000
5= 2001-3000
6= 3001-4000
7= >4000</td></tr>
</table>

Household Roster: Adults

For each member of your household *(not yourself)*, please tell us the following ***(exclude children below 18 years of age)***

17. What is his/her relation to you? *Insert the response in the relevant column in the table below.*
18. What is his/her age? *Insert age (in years) (18.1) or if not known in the range provided (18.2)*
19. Gender. *Insert (1) if male, (2) if female*
20. How many months per year does this person live in your house? *Insert the number of months per year*
21. What is the highest education level he/she has attained?
22. What is his/her MAIN occupation? *Insert as appropriate.*
23. How many months is he/she **EMPLOYED** every year? *Insert number*
24. ***What is her/his monthly salary? (Please insert the exact amount for people willing to provide or skip to range in question 26)***
25. What is her/his monthly salary? *Insert as appropriate*

	17	18.1	18.2	19	20	21	22	23	24	25
	HH-member Relation to respondent *1=Respondent* *2=Spouse* *3 = Child (>18)* *4 = Brother/Sister* *5 = Grand Child* *6 = Other (Specify)______*	Age Exact age	Age (years) 1=18-25 2=26-35 3=36-45 4=46-55 5=56-65 6=>65	Gender *1=Male* *2=Female*	Months per year this person lives in the house	*Years of Education* 1: None=0 2: Primary=6 3: JHS/Middle school= 3 4: O-level=4 5: A-level=2 6: SSS/SHS=3 7: Undergraduate=3/4 8: Polytechnic=3 9: Teacher training=3 10: Postgraduate= 2 11: Other (specify) **…….**	What is this person's **MAIN** occupation? *1=Farmer* *2= Other agricultural laborer* *3= Artisan (Mason, Mechanic, shoemaker, hairdresser etc)* *4= Civil Servant* *5= Other formal employment (security, fuel attendant etc)* *6=Self-employed/own business (Petty trading, food selling etc)* *7=Unemployed,* *8=Retired* *9=Other (specify)________*	Months per year this person is employed	Monthly salary (exact amount (GHC)	Monthly salary (GHC) 1= < 100 2= 100-500 3= 501-1000 4= 1001-2000 5= 2001-3000 6= 3001-4000 7= 4001-5000 8= > 5000
HHM 1										
HHM 2										
HHM 3										

Household Roster: Children

26-33. For Household members below 18 years, please provide their details as follows:

	26	27	28	29	30	31	32	33
	Age (years)	Gender *1 = Male* *2 = Female*	Months per year this person lives in the house	Is this household member still in school? 1=Yes 2=No	*If Yes, Years of schooling* 1: None=0 2: Primary=6 3:JHS/Middle school = 3 4: O-level=4 5: A-level=2 6: SSS/SHS=3 7: Undergraduate=3/4 8: Polytechnic=3 9: Teacher training=3 10: Postgraduate= 2 11: Other (specify) ……	Is this person employed? 1=Yes 2=No	If yes? Source of employment? 1: *Artisan* *2: Other agric. Employment* *3: Family farm*	Months per year this person is employed 1=Full time 2=6-11 months/yr 3=3-6 months/yr 4=Less than 3 month/yr
HHM8								
HHM9								
HHM10								
HHM11								
HHM12								
HHM13								

C. AGRONOMIC CHARACTERISTICS: FARM YIELD AND INCOME

1. Kindly answer the following questions pertaining to **cocoa or oil palm production for the 2017/2018 cropping season.**
Are you able to give information on individual plots? Yes=1 No=0
If No, give the bulk information as plot 1.

1.1 How many plots of cocoa/oil palm farms do you cultivate? …………… 1= Cocoa 2= Oil Palm			**What is the size, age, yield, land holding nature**												
	1. Is this plot certified? Yes=1 No=0	Crop type	1.2 What variety of crop is grown?	1.3 What is the Size? (acres/hectares/poles/ropes)	1.4 What is the Landholding nature? 1=own land 2=Sharecropping 3=Family owned 4=Leased 5=Other	1.5 What is the age of the trees (years)	1.6 What quantity was harvested? 1.Bags 2. kg 2. Ton 3. FFB	1.7 What quantity was sold? 1.Bags 2. kg 2. Ton 3. FFB	1.8 What is the Price per unit?	1.9 If all produce was not sold, why was the rest not sold? ……… ……… ……… ……… ……… ……… ……… ………..	1.10 Which months did you receive payment for the produce? ***Select as many as may apply from 1-12*	1.11 Did you receive any premium? 1=Yes 0=No If No, skip to 2.10	1.12 If Yes, How much did you receive?	1.13 Which month did you receive the premium? ***Select as many as may apply from 1-12*	1.13 Who received the money 1=Household head 2=Spouse 3=Other household member (specify) 4=Shared between family
	Plot 1	Cocoa													
		Oil palm													
		Wet maize													
		Dry maize													
		Groundnut													
		Cassava													
		Plantain													
		Cocoyam													
		Coconut													

		Orange														
		Others….														
	Plot 2	Cocoa														
		Oil palm														
		Wet maize														
		Dry maize														
		Groundnut														
		Cassava														
		Plantain														
		Cocoyam														
		Coconut														
		Orange														
		Others….														

*****Months: January=1; February=2; March=3; april=4; May=5; June=6; July=7; August=8; September=9; October=10; November=11; December=12***

COCOA FARMERS

PLOT 1

AGRONOMIC CHARACTERISTICS: FERTILIZER APPLICATION

Please indicate the quantity and cost of fertilizer used for farming in 2017/2018 season.

Plot	**3.1 What is the quantity of fertilizer used**				**3.2 How much does it cost per Unit for 50kg bag (Gh¢)**			
	Asaasewura (50kg)	Sidalco (50kg/L)	Cocofeed (50kg)	Other (specify)	Asaasewura (50kg)	Sidalco (50kg)	Cocofeed (50kg)	Other (specify)
Plot 1								

AGRONOMIC CHARACTERISTICS: AGROCHEMICAL APPLICATION

Please indicate the type of agro-chemical used for the 2017/2018 season farming on Plot 1

Plot	**Weedicides used**			**Pesticides used**		
	3.3 What is the Name of the weedicide used?	3.4 What was the quantity used (Litres)	3.5 What is the cost per unit of the weedicide? (GHC)	3.6 What is the name of the pesticide used?	3.7 What was the quantity used? (Litres)	3.8 What is the cost per unit of the pesticide used? (GHC)
Plot 1						

AGRONOMIC CHARACTERISTICS: FARM LABOUR REQUIREMENTS

Plot 1

Farm Activity	3.9 How many times did you perform this activity?	**How many persons were used for this activity? Family Labor**				**How many persons were used for this activity? Hired Labor**					
		Male		**Female**		**Male**			**Female**		
		3.10 Number	3.11 Hours worked per day	3.12 Number	3.13 Hours worked per day	3.14 Numb er	3.15 Hours worked per day	3.16 Unit cost per day (Gh¢)	3.17 Number	3.18 Hours worked per day	3.19 Unit cost per day (Gh¢)
Fertilizer application											
Spraying											
Weeding											
Harvesting											
Transportation											
Pruning											
Pod Breaking											
Fermentation											
Drying											
Other ………………..											
Other ………………..											

COCOA- PLOT2

AGRONOMIC CHARACTERISTICS: FERTILIZER APPLICATION

Please indicate the quantity and cost of fertilizer used for farming in 2017/2018 season.

Plot	**3.1 What is the quantity of fertilizer used**				**3.2 How much does it cost per Unit for 50kg bag (Gh¢)**			
	Asaasewura (50kg)	Sidalco (50kg)	Cocofeed (50kg)	Other (specify)	Asaasewura (50kg)	Sidalco (50kg)	Cocofeed (50kg)	Other (specify)
Plot 2								

AGRONOMIC CHARACTERISTICS: AGROCHEMICAL APPLICATION

Please indicate the type of agro-chemical used for the 2017/2018 season farming on Plot 1

Plot	**Weedicides used**			**Pesticides used**		
	3.3 What is the Name of the weedicide used?	3.4 What was the quantity used (Litres)	3.5 What is the cost per unit of the weedicide? (GHC)	3.6 What is the name of the pesticide used?	3.7 What was the quantity used? (Litres)	3.8 What is the cost per unit of the pesticide used? (GHC)
Plot 2						

AGRONOMIC CHARACTERISTICS: FARM LABOUR REQUIREMENTS

Plot 2

Farm Activity	3.9 How many times did you perform this activity?	**How many persons were used for this activity? Family Labor**				**How many persons were used for this activity? Hired Labor**					
		Male		**Female**		**Male**			**Female**		
		3.10 Number	3.11 Hours worked per day	3.12 Number	3.13 Hours worked per day	3.14 Numb er	3.15 Hours worked per day	3.16 Unit cost per day (Gh¢)	3.17 Number	3.18 Hours worked per day	3.19 Unit cost per day (Gh¢)
Fertilizer application											
Spraying											
Weeding											
Harvesting											
Transportation											
Pruning											
Pod Breaking											
Fermentation											
Drying											
Other ………………..											

Other ………………..											

AGRONOMIC CHARACTERISTICS: FARM EQUIPMENT

1. Which of the following farm equipment did you use for the 2017/2018 production season (For oil palm, cocoa smallholders and food crops smallholders)

Item	**3.1 How many did you use for the 2017/2018 season.**	**3.2 Do you hire or purchased? 1= Hire 2=Purchased If Hired, skip➡ ➡ 3.6**	**3.3 Which year was it purchased?**	**3.4 What is the price per unit of the item (Gh¢)**	**3.5 what is the lifespan of the item? Move ➡➡ 3 If cocoa Move➡ ➡4 oil palm Move ➡5 Food crop**	**3.6 How many days did you hire?**	**3.7 How much did you pay per day for hiring? Move ➡ ➡3 If cocoa Move ➡ ➡4 oil palm Move ➡ ➡ 5 Food crop**
Knapsack sprayer							
Motor sprayer							
Cutlass							
Overall coat							
Wellington Boot							
Oil palm harvesting chisel							
Cocoa harvesting knife							
Drying mat							
Cane basket							
Gloves							
Hoe							
Others (specify)							
Others (specify)							
Others (specify)							

2.12. Do you cultivate food crops apart from cocoa? Yes [ ] No [ ]

If Yes, Move to FOOD CROP

OIL PALM FARMERS

PLOT 1

AGRONOMIC CHARACTERISTICS: FERTILIZER APPLICATION

Please indicate the quantity and cost of fertilizer used for farming in 2017/2018 season.

Plot	5.1 What quantity of fertilizer was used?				5.2 What is the cost per Unit of the fertilizer (Gh¢)			
	Name of fertilizer ……………………	Name of fertilizer	Name of fertilizer …………………	Name of fertilizer	Name of fertilizer **1**	Name of fertilizer **2**	Name of fertilizer **3**	Name of fertilizer 4

		……………….		……………….				
Plot 1								

AGRONOMIC CHARACTERISTICS: AGROCHEMICAL APPLICATION
Please indicate the type of agro-chemical used for the 2017/2018 season farming

Plot	**Weedicides used**			**Pesticides used**		
	5.3 What is the Name of the weedicide used?	5.4 What was the quantity used (Litres)	5.5 What is the cost per unit of the weedicide? (GHC)	5.6 What is the name of the pesticide used?	5.7 What was the quantity used? (Litres)	4.8 What is the cost per unit of the pesticide used? (GHC)
Plot 1						

AGRONOMIC CHARACTERISTICS: FARM LABOUR

What were the farm labour requirements for Farm labor activity and requirements for the 2017 crop season
Plot 1

Farm Activity	4.9 How many times did you perform this activity?	**How many persons were used for this activity? Family Labor**				**How many persons were used for this activity? Hired Labor**					
		Male		**Female**		**Male**			**Female**		
		4.10 Number	4.11 Hours worked per day	4.12 Number	4.13 Hours worked per day	4.14 Number	4.15 Hours worked per day	4.16 Unit cost per day (Gh¢)	4.17 Number	4.18 Hours worked per day	4.19 Unit cost per day (Gh¢)
Fertilizer application											
Spraying											
Weeding											
Harvesting											
Transportation											
Pruning											
Other ………………..											
Other ………………..											

PLOT 2

AGRONOMIC CHARACTERISTICS: FERTILIZER APPLICATION

Please indicate the quantity and cost of fertilizer used for farming in 2017/2018 season.

Plot	5.1 What quantity of fertilizer was used?				5.2 What is the cost per Unit of the fertilizer (Gh¢)			
	Name of fertilizer ……………………	Name of fertilizer …………….	Name of fertilizer …………………	Name of fertilizer ……………… ….	Name of fertilizer **1**	Name of fertilizer **2**	Name of fertilizer **3**	Name of fertilizer 4
Plot 2								

AGRONOMIC CHARACTERISTICS: AGROCHEMICAL APPLICATION
Please indicate the type of agro-chemical used for the 2017/2018 season farming

Plot	**Weedicides used**			**Pesticides used**		
	5.3 What is the Name of the weedicide used?	5.4 What was the quantity used (Litres)	5.5 What is the cost per unit of the weedicide? (GHC)	5.6 What is the name of the pesticide used?	5.7 What was the quantity used? (Litres)	4.8 What is the cost per unit of the pesticide used? (GHC)
Plot 2						

AGRONOMIC CHARACTERISTICS: FARM LABOUR
What were the farm labour requirements for Farm labor activity and requirements for the 2017 crop season
Plot 2

Farm Activity	4.9 How many times did you perform this activity?	**How many persons were used for this activity? Family Labor**				**How many persons were used for this activity? Hired Labor**					
		Male		**Female**		**Male**			**Female**		
		4.10 Number	4.11 Hours worked per day	4.12 Number	4.13 Hours worked per day	4.14 Number	4.15 Hours worked per day	4.16 Unit cost per day (Gh¢)	4.17 Number	4.18 Hours worked per day	4.19 Unit cost per day (Gh¢)
Fertilizer application											
Spraying											
Weeding											

Harvesting											
Transportation											
Pruning											
Other ………………..											
Other ………………..											

AGRONOMIC CHARACTERISTICS: FARM EQUIPMENT

1. Which of the following farm equipment did you use for the 2017/2018 production season (For oil palm, cocoa smallholders and food crops smallholders)

Item	**3.1 How many did you use for the 2017/2018 season.**	**3.2 Do you hire or purchased?** **1= Hire** **2=Purchased** **If Hired, skip⇨⇨ 3.6**	**3.3 Which year was it purchased?**	**3.4 What is the price per unit of the item (Gh¢)**	**3.5 what is the lifespan of the item?** **Move ⇨⇨ 3 If cocoa** **Move⇨ ⇨4 oil palm** **Move ⇨5 Food crop**	**3.6 How many days did you hire?**	**3.7 How much did you pay per day for hiring?** **Move ⇨ ⇨3 If cocoa** **Move ⇨ ⇨4 oil palm** **Move ⇨ ⇨ 5 Food crop**
Knapsack sprayer							
Motor sprayer							
Cutlass							
Overall coat							
Wellington Boot							
Oil palm harvesting chisel							
Drying mat							
Cane basket							
Gloves							
Hoe							
Others (specify)							
Others (specify)							
Others (specify)							

Do you cultivate food crops apart from cocoa? Yes [ ] No [ ]

If Yes, Move to FOOD CROP

FOOD CROPS FARMERS

Kindly answer the following questions pertaining to Food crop **production for the 2017/2018 cropping season.**

Are you able to give information on individual plots? Yes=1 No=0?

If No, give the bulk information as plot 1.

PLOT 1

For **2017/2018 CROPPING SEASON**, fill in the following table in relation to the type of **FOOD CROPS** grown by the household, the amount sold, the cash received
1. Ask **FOOD CROPS** consequently and specify amounts produced and sold for each crop from ALL farmer' plots in the last season.
In the questions below, (…) denotes the different types of crops.
1.1 Did you grow any (….) in the last season? *Enter response in the table*
If Yes, continue with the following questions
8.2 What was the area under (…) in ALL your plots?
8.4-8.5 How much (…) did you produce last season? *Insert in table below in local units (if applicable) and calculate in kilos (Kg) last season*
8.6 Did you sell any of the (…) you produced last season?
8.7-8.8 How much (…) did you sell last season? *Insert in table below in local units and calculate in Kg*
8.9 How much money did you receive for the (…) you sold last season? *Insert in table amount received last season*
9.10 Which member of the household received this cash?

8 **Crop**	**8.1** **Did you grow any last season** 1=Yes 2=No	**8.2** **Area** (Acre)	**1.4 What is the Landholding nature?** **1=Purchased own land** **2=Sharecropping** **3=Family owned** **4=Leased** **5=Other**	**8.4** **Amount produced (local unit)**	**8.5** **Amount produced** (KG last season)	**8.6** **Sold?** 1=Yes 2=No	**8.7** **Amount sold (local unit) (bag/sack, bucket, pan, olonka),**	**8.8** **Amount sold** (KG last season)	**8.9** **Cash received** *(GHC)*	**8.10** **Who received the money** 1=Household head 2=Spouse 3=Other household member (specify) 4=Other person (specify) 5=Shared between family
Dry Maize										
Green/wet maize										
Rice										
Plantain										
Groundnut										
Cassava										
Beans										
Vegetables										
Fruits/berries										
Yam										
Cocoa										
Cowpea										
Oil palm										

Other Specify…………										

2. For the **FOOD CROPS you sold within 2017/2018 season**, please specify the months you **RECEIVED THE CASH FROM SELLING THEM**. *Ask for each crop sold as indicated in previous Table and tick the appropriate month(s)*

	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Dry Maize												
Green/wet maize												
Rice												
Millet												
Plantain												
Groundnut												
Cassava												
Beans												
Vegetables												
Fruits/berries												
Yam												
Cowpea												
Others______												
Others______												

AGRONOMIC CHARACTERISTICS: FERTILIZER APPLICATION

5. Please indicate the quantity and cost of fertilizer used for farming in 2017/2018 season.

Plot	5.1 Quantity of fertilizer used				5.2 Unit cost per 50kg bag (Gh¢)			
	Name of fertilizer ………………… …	Name of fertilizer ……………….	Name of fertilizer …………….. …	Name of fertilizer …………………	Name of fertilizer 1 ………………… …	Name of fertilizer 2 ……………..	Name of fertilizer 3 ……………..	Name of fertilizer 4 ……………
Plot 1								

AGRONOMIC CHARACTERISTICS: AGROCHEMICALS APPLICATION

Please indicate the type of agro-chemical used for the 2017/2018 season farming

Plot	**Weedicides used**			**Pesticides used**		
	6.3 What is the Name of the weedicide used?	6.4 What was the quantity used (Litres)	6.5 What is the cost per unit of the weedicide? (GHC)	6.6 What is the name of the pesticide used?	6.7 What was the quantity used? (Litres)	6.8 What is the cost per unit of the pesticide used? (GHC)
Plot 1						

AGRONOMIC CHARACTERISTICS: FARM LABOUR REQUIREMENT

What were the farm labour requirements for Farm labor activity and requirements for the 2017 crop season
Plot 1

Farm Activity	5.9 How many times did you perform this activity?	**How many persons were used for this activity? Family Labor**				**How many persons were used for this activity? Hired Labor**					
		Male		**Female**		**Male**			**Female**		
		6.10 Number	6.11 Hours worked per day	6.12 Number	6.13 Hours worked per day	6.14 Number	6.15 Hours worked per day	6.16 Unit cost per day (Gh¢)	6.17 Number	6.18 Hours worked per day	6.19 Unit cost per day (Gh¢)
Fertilizer application											
Spraying											
Weeding											
Harvesting											
Transportation											
Pruning											
Drying											
Other ………………..											
Other ………………..											

PLOT 2

For **2017/2018 CROPPING SEASON**, fill in the following table in relation to the type of **FOOD CROPS** grown by the household, the amount sold, the cash received

3. Ask **FOOD CROPS** consequently and specify amounts produced and sold for each crop from ALL farmer' plots in the last season.

In the questions below, (…) denotes the different types of crops.
3.1 Did you grow any (….) in the last season? *Enter response in the table*
If Yes, continue with the following questions
8.2 What was the area under (…) in ALL your plots?
8.4-8.5 How much (…) did you produce last season? *Insert in table below in local units (if applicable) and calculate in kilos (Kg) last season*
8.6 Did you sell any of the (…) you produced last season?
8.7-8.8 How much (…) did you sell last season? *Insert in table below in local units and calculate in Kg*
8.9 How much money did you receive for the (…) you sold last season? *Insert in table amount received last season*
9.10 Which member of the household received this cash?

8 Crop	**8.1 Did you grow any last season**	**8.2 Area** (Acre)	**1.4 What is the Landholding nature?**	**8.4 Amount produced**	**8.5 Amount produced**	**8.6 Sold?** 1=Yes 2=No	**8.7 Amount sold (local unit)**	**8.8 Amount sold** (KG last season)	**8.9 Cash received** *(GHC)*	**8.10 Who received the money** 1=Household head 2=Spouse

	1=Yes 2=No		**1=Purchased own land 2=Sharecropping 3=Family owned 4=Leased 5=Other**	**(local unit)**	(KG last season)		**(bag/sack, bucket, pan, olonka),**			3=Other household member (specify) 4=Other person (specify) 5=Shared between family
Dry Maize										
Green/wet maize										
Rice										
Plantain										
Groundnut										
Cassava										
Beans										
Vegetables										
Fruits/berries										
Yam										
Cocoa										
Cowpea										
Oil palm										
Other Specify………….										

For the **FOOD CROPS you sold within 2017/2018 season**, please specify the months you **RECEIVED THE CASH FROM SELLING THEM**. *Ask for each crop sold as indicated in previous Table and tick the appropriate month(s)*

	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Dry Maize												
Green/wet maize												
Rice												
Millet												
Plantain												
Groundnut												

Cassava												
Beans												
Vegetables												
Fruits/berries												
Yam												
Cowpea												
Others______												
Others______												

AGRONOMIC CHARACTERISTICS: FERTILIZER APPLICATION

5. Please indicate the quantity and cost of fertilizer used for farming in 2017/2018 season.

Plot	5.1 Quantity of fertilizer used				5.2 Unit cost per 50kg bag (Gh¢)			
	Name of fertilizer …………………………	Name of fertilizer ……………….	Name of fertilizer …………………	Name of fertilizer …………………	Name of fertilizer 1 ………………………	Name of fertilizer 2 ………………	Name of fertilizer 3 ………………	Name of fertilizer 4 ……………
Plot 2								

AGRONOMIC CHARACTERISTICS: AGROCHEMICALS APPLICATION

Please indicate the type of agro-chemical used for the 2017/2018 season farming

Plot	**Weedicides used**			**Pesticides used**		
	6.3 What is the Name of the weedicide used?	6.4 What was the quantity used (Litres)	6.5 What is the cost per unit of the weedicide? (GHC)	6.6 What is the name of the pesticide used?	6.7 What was the quantity used? (Litres)	6.8 What is the cost per unit of the pesticide used? (GHC)
Plot 2						

AGRONOMIC CHARACTERISTICS: FARM LABOUR REQUIREMENT

What were the farm labour requirements for Farm labor activity and requirements for the 2017 crop season
Plot 2

Farm Activity	5.9 How many times did you	**How many persons were used for this activity? Family Labor**		**How many persons were used for this activity? Hired Labor**	
		Male	**Female**	**Male**	**Female**

	perform this activity?	6.10 Number	6.11 Hours worked per day	6.12 Number	6.13 Hours worked per day	6.14 Number	6.15 Hours worked per day	6.16 Unit cost per day (Gh¢)	6.17 Number	6.18 Hours worked per day	6.19 Unit cost per day (Gh¢)
Fertilizer application											
Spraying											
Weeding											
Harvesting											
Transportation											
Pruning											
Drying											
Other ………………..											
Other ………………..											

AGRONOMIC CHARACTERISTICS: FARM EQUIPMENT

1. Which of the following farm equipment did you use for the 2017/2018 production season

Item	**3.1 How many did you use for the 2017/2018 season.**	**3.2 Do you hire or purchased?** **1= Hire** **2=Purchased** **If Hired, skip ➡ ➡ 3.6**	**3.3 Which year was it purchased?**	**3.4 What is the price per unit of the item (Gh¢)**	**3.5 what is the lifespan of the item?** **Move ➡➡ 3 If cocoa** **Move ➡ ➡4 oil palm** **Move ➡ 5 Food crop**	**3.6 How many days did you hire?**	**3.7 How much did you pay per day for hiring?** **Move ➡ ➡ 3 If cocoa** **Move ➡ ➡ 4 oil palm** **Move ➡ ➡ 5 Food crop**
Knapsack sprayer							
Motor sprayer							
Cutlass							
Overall coat							
Wellington Boot							
Oil palm harvesting chisel							
Drying mat							
Cane basket							
Gloves							
Hoe							
Others (specify)							
Others (specify)							
Others (specify)							

INSTITUTIONAL FACTORS- EXTENSION & CREDIT

1. Kindly answer the following questions relating to your production of **cocoa or oil palm or Food crop farmers for the 2017/2018 season (Institutional Factors)**

1.1	**1.2**	**1.3**	**1.4**	**1.5**	**1.6**	**1.7**
Do you belong to any farmer group (FBO)? 1=Yes 0= No	If Yes, how long have you been a member of this FBO? ………………	Please indicate the importance of this group? 1=Information and training on new technology 2=Information on price 3= Fund Mobilization 5=Book keeping training 6=Credit access 7=Other ……………	Did you use credit in 2017/2018 production season? 1=Yes 0 = No	If yes, where is the source of the credit? 1=Family 2=Friends 3=Rural/community bank 4=Microfinance institution 4= Cooperative 5= Others ………………………….	What was the amount received? ……………………… …	How did you service the credit? 1= In-cash 2=In-Kind

1.8	**1.9**	**1.10**	**1.11**	**1.12**	**1.13**
If in-cash, how much did you pay on monthly basis AND for how long? (interest rate) ………………………….	Did you have contact with extension agents in the season? 1 =Yes 0=No	If yes, how many times did contact with extension agents in the season? ……………………….	What were the services received from extension officers? 1=agronomic training 2=farm inspection 3=Credit application 4=Book keeping training 5=Others (specify)	What is the main source of extension service you received? Government=1 Licensed buying company (uncertified)= 2 Licensed Buying Company/oil palm company certified=3 NGOs =4	If you received extension from Certified Licensed Buying Company, what is the name of the certification? Fairtrade=1 UTZ/Rainforest Alliance= 2 RSPO=3

CERTIFICATION ADOPTION

1.14	**1.15**	**1.16**	**1.17**	**1.18**	**1.19**	**1.20**	**1.21**

Have you adopted certification? 1=Yes 0=No ***If No, skip to 1.21***	If Yes, How long have you been a member of the certification group?	Which certification group do you belong to? 1=RA/UTZ 2=FAIRTRADE 3=RSPO	Why did you adopt certification? 1= Input/ Credit access [ ] 2= Yield increase [ ] 3= To increase income [ ] 4= Capacity building on recommended practices [ ] 5= Better produce pricing [ ] 6= Priority purchase [ ] 7= Other (specify)……….	Since joining the certification group has it been beneficial to you? **Yes=1** **No=0**	If Yes, what has been the benefits since you joined? 1= Input credit access (Fertilizer, etc) [ ] 2= Yield increase [ ] 3= Premium (extra income) [ ] 4= Capacity building on recommended technologies [ ] 5= Capacity building on social issues (Child labour, health) [ ] 6= Capacity building on environmental management [ ] 7= Better produce pricing [ ] 8= Priority purchase [ ] 9= Other………… [ ]	What are some of the challenges you face since you joined the certification group? 1= Expensive input cost[ ] 2= Extremely demanding criteria [ ] 3= Low level of education [ ] 4= Unpaid premium/ Little premium [ ] 5= Unprofitable [ ] 6= High audit cost [ ] 7= Other(specify)… [ ]	Why have you not joined any certification scheme? 1= Expensive input cost [ ] 2= Extremely demanding criteria [ ] 3= Low level of education……….. 4= Unpaid premium/ Little premium…. 5=Unprofitable [ ] 6= High audit cost [ ] 7= Higher yields[ ] 8= Input access [ ] 9= Not approached 10= Do not want to join any group [ ]

CERTIFICATION/NON-CERTIFICATION PRACTICES

To be answered by both certified and uncertified farmers

1. Do you have non-cocoa trees on your farm? Yes [ ] No [ ]
2. How many farm trees do you have? ……………………..
3. Do you clear forests or cut trees? Yes [ ] No [ ]
4. If Yes, what is the major reason for logging/cutting trees? 1=Expanding farm 2=For commercial purposes 3= Hazardous to people 4=Others(specify)……………………………
5. Do you hunt for bush meat? Yes [ ] No [ ]
6. If yes, why? For food [ ] Commercial purposes [ ] Other (specify)………………………………………………………………………

7. Is your farm located close to aquatic ecosystems? Yes [ ] No [ ]
8. Are the zones located to aquatic ecosystems protected (buffer zones)? Yes [ ] No [ ]
9. Do you use organic matter on the farm? Yes [ ] No [ ]
10. What kind of organic matter do you use? Animal waste [ ] Cocoa pod [ ] Compost [ ] Green manure [ ] Other(specify)………………….
11. Is your farm slopy? Yes [ ] No [ ]
12. If Yes, do you practice terracing, mulching, strips, etc? Yes [ ] No [ ]
13. Do you practice integrated pest management? Yes [ ] No [ ]
14. Do **you use** more pesticides compared to previous farming practices? Yes [ ] No [ ] Same [ ]
15. Where are your pesticides kept? Bedroom [ ] Kitchen [ ] Separate storage room [ ] Other, specify………………………………….
16. How are empty pesticide containers handled? Kept in storage room [ ] Returned to supplier [ ] Perforated [ ] Used for other household activities [ ] Other specify ………………………………………………….
17. For non-household members who work on your farm, which groups of people do you employ? Adults(15 and above) [ ] Children (below 15) [ ] Anybody who is willing to work to work [ ]
18. For children who work on your farm, what kind of work do they undertake? Harvesting [ ] Pod breaking [ ] Agrochemical spraying [ ] Weeding [ ] other specify…………………………………………………………..
19. For children who worked on your farm recent weeks, how many days per week and hours per day did they work? Days per week……… Hours per day ……….
20. For people who work on your farm, do you have specific roles for different groups of people? Yes [ ] No [ ]
21. If Yes, why? Anybody can perform any farm activity [ ] To protect vulnerable groups [ ] To protect the health of workers [ ]
22. How often do you or your workers wear PPEs? Occasionally [ ] Always [ ] Never [ ] When I can afford [ ] During pesticide application [ ]
23. Are you trained to undertake record keeping of farm activities? Yes [ ] No [ ]
24. Do you undertake record keeping of farm activities? Yes [ ] No [ ]
25. How do you sell your produce? To local purchasing clerk [ ] Transport to nearby community [ ] Purchased by local certified buyer [ ]
26. How long does it take for your produce to be paid for? Immediately [ ] Few weeks [ ] Several months later [ ]
27. In a typical working day on the farm, how long do you work on your farm? …………………………………….
28. Since you joined certification scheme, has the time spent on farming activities changed? Spend More time [ ] Less time [ ] Same time [ ]
29. If you spend more or less time, what are the reasons? ………
30. If you spend less time on your farm, what other activities do you do with the free time? Undertake other non-farm income generating activities [ ] Take care of family [ ] Undertake other crop farm activities [ ]

PERCEPTION OF CERTIFICATION- ADOPTION & IMPACT

To be answered by both certified and non-certified oil palm and cocoa smallholders **ONLY**

No.	Statements	Increased substantially (1)	Increased moderately (2)	Remained same (3)	Decreased moderately (4)	Decreased substantially (5)	Don't know (6)
	Economic perceptions						
1.1	How has the adoption of certification affected your yield/farm efficiency?						

1.2	How has the adoption of certification affected your income from cocoa/oil palm?						
1.3	How has the adoption of certification affected your access to cocoa/oil palm associated services(market information, inputs, extension and credit)?						
	Social perceptions						
1.4	How has the adoption of certification affected your household in accessing better healthcare?						
1.5	How has the adoption of certification affected your households in accessing better access to education?						
1.6	How has the adoption of certification affected the reduction of child labour in your household?						
1.7	How has the adoption of certification affected your household access to social amenities (schools, clinics, standing pipes, etc)?						
	Environmental perceptions						
1.8	Has the adoption of certification affected your awareness on agrochemical use?	Yes= 1 No= 0					
1.9	If Yes, how has it affected your awareness on agrochemical use?						
1.10	Has the adoption of certification affected your protection of water bodies?	Yes= 1 No= 0					
1.11	If Yes, How has the adoption of certification affected your protection of water bodies?						
1.12	Has the adoption of certification affected your protection of wild animals?	Yes= 1 No= 0					
1.13	If Yes, how has the adoption of certification affected your protection of wild animals?						
1.14	Has the adoption of certification affected your protection of forests?	Yes= 1 No= 0					
1.15	If Yes, how has the adoption of certification affected your protection of forests?						
1.18	Has the adoption of certification affected the fertility of your farmland?	Yes= 1 No= 0					
1.19	If Yes, how has the adoption of certification affected the fertility of your farmland?						
2.00	Has the adoption of certification affected the use of fertilizer on your farmland?	Yes= 1 No= 0					
	If Yes, How has the adoption of certification affected the use of fertilizer on your farmland?						
	Has the adoption of certification affected the use of recommended pesticides on your farmland?	Yes= 1 No= 0					
	If Yes, how has the adoption of certification affected the use of fertilizer on your farmland?						

	Has the adoption of certification affected the use of organic matter on your farmland?	Yes= 1 No= 0					
	If Yes, how has the adoption of certification affected the use of organic matter on your farmland?						
	Has the adoption of certification affected the use of pesticides on your farmland?	Yes= 1 No= 0					
	If Yes, how has the adoption of certification affected the use of pesticides on your farmland?						

SECTION D: FOOD SECURITY
To be administered to all respondents

FOOD SECURITY: FOOD CONSUMPTION SCORE

1. How many meals does your household usually eat per day? ________ meals

2. Could you tell me how many days in the past 7days your household has eaten the following foods? *Ask consequently each food category. Insert 0-7 in the table below*
3. What is the primary source of each food item you ate this week? *Insert responses in the table below*
4. What is the second main source of food (if any)? *Insert responses in table below as specified*

	2. Days eaten in past 7 days (0-7)	3. Primary source 1=Own production 2=Purchase 3=From environment 4=Borrowed 5=Received as gift 6=Food Aid 7=Other, specify	4.Secondary source 1=Own production 2=Purchase 3=From environment 4=Borrowed 5=Received as gift 6=Food Aid 7=Other, specify
Maize			
Rice			
Bread/wheat/other cereals			

Tubers (cassava/potatoes/sweet potatoes/yams/etc.)			
Groundnuts, beans and peas			
Fish			
Meat from livestock			
Meat from poultry			
Vegetable oils/fats			
Eggs			
Milk and dairy products			
Vegetables (incl leaves)			
Fruits			
Sugar and sweets			

FOOD SECURITY: HOUSEHOLD FOOD INSECURITY ACCESS SCALE

5. *For each of the questions in the following table first ask the occurrence question – that is, whether the condition in the question happened at all in the past four weeks (yes or no). If the respondent answers "yes" to an occurrence question, then ask the frequency-of-occurrence question to determine whether the condition happened rarely (once or twice), sometimes (three to ten times) or often (more than ten times) in the past four weeks.*

	5.1 1= Yes 2 = No	5.2 How often did this happen? 1 = Rarely (once or twice) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)
In the past four weeks, did you **worry that your household would not have enough food?**		
In the past four weeks, were **you or any household member not able to eat the kinds of foods you preferred** because of a lack of resources?		
In the past four weeks, **did you or any household member have to eat a limited variety of foods** due to a lack of resources?		
In the past four weeks, **did you or any household member have to eat some foods that you really did not want to eat** because of a lack of resources?		
In the past four weeks, **did you or any household member have to eat a smaller meal than you felt you needed** because there was not enough food?		
In the past four weeks, **did you or any other household member have to eat fewer meals in a day** because there was not enough food?		
In the past four weeks, **was there ever no food to eat of any kind in your household** because of lack of resources to get food?		
In the past four weeks, **did you or any household member go to sleep at night hungry** because there was not enough food?		
In the past four weeks, **did you or any household member go a whole day and night without eating anything** because there was not enough food?		

6. How many months in the year did you or any household member go to sleep at night hungry because there was not enough food? __________

7. During which months does your household not have enough food? *Tick relevant month*

Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**

FOOD SECURITY: RECOMMENDED DAILY CALORIES

	10.1	**10.2**	**10.3**	**10.4**	**10.5**
	Do you eat …….? 1 - Yes 0 - No	How often do you eat ……………? Every day=1 Weekly= 2	What quantity of ……….. did you consume in the past 24hr?	How many times per week did you consume?	What quantity of .. did you consume in the past 7days?
		If 2 skip to 10.5	**Quantity**	**Number**	**Quantity/Unit**
Cereals					
Maize					
Rice					
Other ( )					
Other ( )					
Roots					
Cassava					
Yam					
Plantain					
Cocoyam					
Other ( )					
Other ( )					

	10.1	10.2	10.3	10.4	10.5
	Do you eat ……..? 1 - Yes 2 - No	How often do you eat ………….. ? Every day=1 Weekly= 2	What quantity of ………. did you consume in the past 24hrs?	How many times per week did you consume?	What quantity of .. did you consume in the past 7days?
		If 2 skip to 10.5	**Quantity/Unit**	**Number**	**Quantity/Unit**
Nuts and Seeds					
Groundnuts					
Beans					
Peas					
Other ( )					
Other ( )					
Vegetables & Fruits					
Tomato					
Okro					
Eggplant					
Onions					
Mango					
Banana					
Pineapple					
Oranges					
Other ( )					
Other ( )					
Meat and Poultry					
Beef					
Pork					
Goat					

Chicken					
Fish					
Other ( )					
Other ( )					

	10.1	10.2	10.3	10.4	10.5
	Do you eat…….? 1 - Yes 2 - No	How often do you eat …………… Every day=1 Weekly= 2	What quantity of ……….. did you consume in the past 24hr?	How many times per week did you consume?	What quantity of .. did you consume in the past 7days?
		If 2 skip to 10.5	**Quantity/Unit**	**Number**	**Quantity/Unit**
Dairy					
Milk					
Cheese					
Egg					
Other ( )					
Other ( )					
Miscellaneous					
Oil palm					
Shea butter					
Butter					
Sugar					
Chocolate					
Other ( )					
Other ( )					
Food Consume outside the home					
Dish 1					
Dish 2					
Dish 3					

Dish 4					
Dish 5					

FOOD SECURITY: COPING STRATEGIES

8. In the past 7 days, if there have been times when you did not have enough food or money to buy food, how many days has your household had to?
Use numbers 0 – 7 to answer number of days; Use NA for not applicable

Behavior	**8. Frequency**
Rely on less preferred and less expensive foods?	
Borrow food, or rely on help from a friend or relative?	
Purchased on credit?	
Gather wild food, hunt, or harvest immature crops?	
Consume seed stock held for next season?	
Send household members to eat elsewhere?	
Send household members to beg?	
Limit portion size at meal times?	
Restrict consumption by adults in order for children to eat?	
Feed working members of HH at the expense of non-working members?	
Reduce number of meals eaten in a day?	
Skip entire day without eating?	
Borrow money to buy food	
Engage in Casual labour for food (as payment)	

FOOD PURCHASE Did your household purchase the following?

*For LAST SEASON, fill in the following table in relation to the type of **FOOD CROPS BOUGHT** by the household.*
We need the amount bought, the cash spent, and the reason for purchasing.
9.1 Did you buy any (…) last season? *If yes, continue with the following questions*
9.2-9.3 How much did you buy?
Insert in table below amount bought in local units and calculate in Kg for the entire season
9.4 How much did it cost?
9.5 What was the reason buying this (…)?

Crop	**9.1 Did you purchase any last season** 1=Yes 2=No	**9.2 Amount purchased** (local unit)	**9.3 Amount purchased** (KG last season)	**9.4 Cost** (Local currency	**9.5 Reason for buying** 1=Food 2=Re-sell 3=Other (specify)
Dry Maize					
Green/wet maize					
Rice					
Plantain					
Groundnut					
Cassava					
Beans					
Vegetables					
Fruits/berries					
Yam					
Cowpea					
Other __________					

SECTION E: LIVELIHOOD, OTHER INCOME AND ASSETS
To be administered to all respondents
How much **income** did your household **as a whole** receive in the past twelve months from each of the following activities?

How much did your household spend in the past 12 months for each of the following expenditure items

1. Income (please ask for absolute values)

Duration	**Own Business/self-employment**	**Remittances**	**Pension**	**Other 1 (Specify)______**	**Other 2 (Specify)______**
Monthly					
12 months					

2. Expenditure (Use the following scale). ***First ask for absolute value. If not known, then scale***

Scale for monthly	*Scale for 12 month (yearly)*
1= < 100 5= 2001-3000 2= 100-500 6= 3001-4000 3= 501-1000 7= 4001-5000 4= 1001-2000 8= > 5000	1=<1,000 5=15,001-20,000 2=1,001-5,000 6=>20,000 3=5001-10,000 4=10,001-15,000

	Farming	Food	Education	Health	Housing	Clothing	Energy (cooking/lighting)	Savings	Supporting relatives	Communication	Ceremonies	Others _________
Monthly												
12 months												

3. During the past 12 months, did your household borrow money to meet its needs if household income was not enough? *Circle* 1=Yes 2=No

4. If Yes, how much did you borrow for each for the following categories? *First ask for absolute value. If not known, then scale as in Question 2*

Duration	Farming food crop	Food	Education	Health	Housing	Clothing	Energy (cooking and lighting)	Farming feedstock	Supporting relatives	Communication	Ceremonies	Others _________
Monthly												

12 months												

5. Does your household own the following assets?
For Other insert only important assets (i.e. not clothes, chairs, etc.)

	Tick if you have	Indicate the number of those Ticked
Watch/clock		
Radio		
Television		
CD/DVD Player		
Mobile phone		
Refrigerator		
Improved stove		
Sofa set		
Chairs and Table		
Truck		
Bicycle		
Motorcycle/scooter		
Bed		
Mattress		
Car		
Sewing machine		
Tractor		
Axe		
Spade		
Hoe		
Electricity generator		
Pressure lamp		
LED lantern		
Solar panel		
Water pump		
Sprayer		
Other (specify)		

6. Do you or any member of your household own livestock? 1=Yes 2=No

Type of livestock	1=Yes 2=No	Number	Purpose (Specify One For Each Livestock)? 1=Household Consumption 2=Sale 3=Both Sale And Consumption 4= Traction 5=Wealth Accumulation/ Means of Cash Reserves 6=Others, Specify	Management System 1=Intensive 2=Extensive 3=Semi Intensive	Have you sold any within the season? 1= Yes 2= No	If Yes, how many	How much were they sold for?	Month sold?
Cows								
Donkey								
Sheep And Goat								
Pigs								
Fowl								
Others, Specify								

SECTION F: POVERTY INDICATORS

To be administered to all respondents

F1. Water supply and Sanitation

1. What is the main source of water for members of your household? Insert code

Use	Source
	1 = Piped water to dwelling *6= Spring* *2= Piped water to plot/yard* *7= Rainwater* *3= Piped water to public tap/stand-pipe* *8= River/lake/pond/dam* *4= Borehole* *9= Tanker truck* *5= Dug well*
For drinking	
For cooking	
For washing/cleaning/showering	
Others (specify______	

2. How far is the water source for different household uses and how much do you pay? *Insert distance (in meters)* and time it takes to get to the source and back *(in minutes)*

Use	2.1 Distance (in meters)	2.2 Time spent per day (in minutes)	2.3 Cost per month (in GHS)
For drinking			
For cooking			
For washing/cleaning/showering			
Others (specify______			

3. How would you describe the quality of water you use for cooking and drinking, now?
1=Very good
2=Good
3=Bad
4=Very bad

4. Do you (now) have enough water for cooking and drinking?
1=Always enough
2=Sometimes enough
3=Usually not enough
4=Never enough

5. What kind of toilet is available in your house? *Circle*.
1=Pour flash toilet to pit latrine
2=Flush to piped sewer system
3=Open pit latrine
4=Pit latrine with slab
5=KVIP latrine
6=Bucket toilet
7=Bush/field

*8=Other (Specify)*_____________

6. Do you share your toilet facility with other households?
   1=Yes
   2=No

F2. Housing

What is the MAIN construction material of the MAIN dwelling of the household? *Observe and circle only one for each category.*

7. Floor	8. Roof	9. Exterior walls	10. How old is your house?	11. How many habitable room do you have?
1=Natural floor/ earth/sand *2=Dung* *3=Palm/bamboo* *4=Wood* *5=Ceramic tiles* *6=Cement* *7=Carpet* *8=Other (Specify)* ______________	*1=Leaf/ palm/ bamboo* *2 = Mud* *3=Wood planks* *4=Card-board* *5=Corrugated iron* *6=Asbestos* *7=Cement/concrete* *8=Other (Specify)* ___________________	*1=Mud* *2= Leaf/ palm/ bamboo* *3=Card-board* *4=Wood* *5=Stone* *6=Cement blocks* *7=Mud bricks* *8 = commercial bricks* *9=Other (Specify)* ___________________	*1=<10 years* *2=10-20* *3=21-30* *4=31-40* *5=51-50* 12. Are you the owner of the house you stay in? 1=Yes 2=No	*1=1-3* *2=4-6* *3=7-9* *4=10-12* *5=>12*

F3: Health

13. Has any member of your Household under 5 years died in the past 5 years?	14. Are your household members covered by Health Insurance?	15. How many members of your household are covered by health insurance?	16. How long does it take to reach your nearest health facility?
1=Yes 2=No If yes, how many?_______	1=Yes 2=No	*1=All* *2=1-3* *3=7-9* *4=4-6* *5=10-12*	_________ (in minutes)
17. Has any member of your household suffered from any sickness in the past 12 months? 1=Yes 2=No		18. What is the type of sickness? 1=Malaria 4= Tetanus 7=Diarrhoea 2=Measles 5= Whooping cough 8= Pneumonia 3=Meningitis 6= Tuberculosis 9=Other ……………	

SECTION G: ENERGY ACCESS AND USE

To be administered to all respondents

1. Please indicate which of the following sources of energy is used for cooking and lighting?

	Firewood	Charcoal/ briquettes	Electricity	Ethanol	Kerosene/paraf fin	Coal	Biogas	LPG	Agricultural residues	Dung	Other fuel 1	Other fuel
1.1 Fuel used cooking 1=Yes 2=No												
1.2 Used for lighting 1=Yes 2=No												
1.3 Indicate the distance to access this source (meters)												

H. Wellbeing (to be asked to all groups)
To be asked to all groups

1 Overall, how satisfied are you with your life? *1= Not at all satisfied;* *2= Somewhat satisfied* *3 = Moderately satisfied* *4=Very satisfied*	2. Overall, to what extent do you feel the things you do in your life are worthwhile? *1 = Not at all* *2= Somewhat worthwhile* *3= Moderately worthwhile* *4=Very worthwhile*
3. Overall, how happy do you feel? *1 = Not at all;* *2 = Somewhat happy;* *3 = Moderately happy;* *4=Very happy*	4. Overall, how anxious do you feel? *1= Not at all;* *2= Somewhat anxious;* *3=Moderately anxious;* *4 =Very anxious*