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Impact of Producer Groups on the Adoption of Sustainable Agricultural Practices and Technical Efficiency of Small Farmers in Sub-Saharan Africa. Case Study of Ghana Cocoa Producers

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Declaration

I hereby declare that I have completed this thesis entitled "Impact of Producer Groups on the Adoption of Sustainable Agricultural Practices and Technical Efficiency of Small Farmers in Sub-Saharan Africa. Case Study of Ghana Cocoa Producers" independently, all texts in this thesis are original, and that all information sources have been quoted and acknowledged by means of complete references. I also confirm that this work has not been previously submitted, nor is it currently submitted, for any other degree to this or any other university.

In Prague, February 16, 2024

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Ebenezer Donkor

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Abstract

The Ghanaian government has also implemented several policies to assist farmers in adopting sustainable cocoa practices and increasing productivity through producer organizations. The study analyzed the effect of producer groups' participation on adopting sustainable cocoa practices (SCPs) and technical efficiency in Ghana. Since the structure, characteristics, and dynamics of different producer groups vary and, as such, the impact may not be the same for all producer groups, this study analyzed the effect of producer groups by comparing the members of different producer groups and non-members to estimate the degree of impact based on the type of producer group. The study further investigated the effect of sustainable cocoa practices adoption on the technical efficiency of the cocoa farmers. 458 farmers (193 members of cooperatives, 144 members of farmer associations and 121 non-members of groups) were sampled for the study.

The probit regression model was used to estimate farmers' decision to participate in a producer group, the stochastic frontier production model was used to estimate the technical efficiency of the cocoa farmers, the propensity score matching and endogenous treatment regression were adopted to cater for the observed and unobserved bias associated with assessing the impact of producer group membership on SCPs and technical efficiency, and the 3-SLS model was adopted to analyze the effect of SCPs adoption on the technical efficiency of the farmers.

The study results showed that membership in producer groups (cooperatives and farmer associations) significantly affects the adoption of sustainable cocoa practices and the technical efficiency of cocoa farmers. However, the degree of the impact of producer groups was different for members of cooperatives and farmer associations. The study results further showed that the adoption of SCPs has a significant effect on the technical efficiency of cocoa farmers. The study made critical recommendations such as the expansion of producer groups to inaccessible areas, encouragement of more cooperatives development as compared to farmer associations, improvement in infrastructure in cocoa growing areas and cocoa price differentials.

Keywords: Cooperatives, Farmer associations, Sustainable cocoa practices, Technical efficiency, Cocoa farmers, Propensity score matching, Endogenous treatment regression.

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List of Abbreviations

AEAs	Agricultural Extension Agents
ATT	Average treatment effect on the treated
Birr	Ethiopian currency
CHED	Cocoa Health and Extension Division
CMC	Cocoa Marketing Company
CMS	Cocoa Management System
CODAPEC	Cocoa Diseases and Pest Control Program
COCOBOD	Ghana Cocoa Board
Coef.	Coefficient
CRIG	Cocoa Research Institute of Ghana
EU	European Union
FAO	Food and Agriculture Organization
FASDEP II	Food and Agriculture Sector Development Policy II
GDP	Gross Domestic Product
GHS	Ghanaian Cedi (currency of Ghana)
GoG	Government of Ghana
GSGDA	Ghana Shared Growth and Development Agenda
GSS	Ghana Statistical Service
ICA	International Cooperative Alliance

IISD	International Institute for Sustainable Development
Insig2v	Insignificant Variance
IPM	Integrated Pest Management
IV	Instrumental Variables
ln	Natural Logarithm
LBCs	Licensed Buying Companies
ML	Maximum Likelihood
MOFA	Ministry of Food and Agriculture
MT	Metric Tons
NGO	Non-Governmental Organization
Obs	Observations
OLS	Ordinary Least Squares
PSM	Propensity Score Matching
PPRC	Producer Price Review Committee
SCP	Sustainable Cocoa Practices
SCPs	Sustainable Cocoa Practices
SPD	Seed Production Division
SPF	Stochastic Production Frontier
UN	United Nations
UNDO	United Nations Development Organization
Yuan	Chinese currency

1. Introduction

For the majority of the people in the developing nations who produce it, cocoa is a good source of employment and a means of subsistence as well as a significant supply of foreign exchange (van Huellen & Abubakar, 2021). About 40 to 50 million people globally depend heavily on cocoa production, largely controlled by impoverished rural farmers (Nelson et al., 2013). About 70% of the world's annual supply is produced by small-scale farmers (less than 3ha), primarily from Ghana and the Ivory Coast (Nelson et al., 2013). A third of the people in Ghana make their living mostly on cocoa (Bangmarigu, 2019). Ghana is currently among the world's top exporters of cocoa, with cocoa production and export historically dominating the economy (Kolavalli & Vigneri, 2020).

However, cocoa productivity levels are still below potential; the typical Ghanaian farmer only produce 40% of the crop's potential yield (Barrientos, 2014; Wessel & Quist-Wessel, 2015). Ghana has produced 25% less cocoa on average than the ten countries that produce the most cocoa (Mohammed et al., 2012). Low-yielding varieties, poor agricultural practices, and traditional production methods are some of the causes of Ghana's low productivity (Aidoo & Fromm, 2015). By adopting sustainable production methods and increasing technical efficiency, cocoa productivity levels can be raised (Aidoo & Fromm, 2015). In many developing nations, rural development depends on smallholder farmers increasing productivity while pursuing sustainable production methods (Tenaye, 2020).

Unsustainable farming methods decrease the natural resource base's capacity to provide food and jeopardize farm output (FAO, 2011). Lower yields in Sub-Saharan Africa may be attributed to declining soil fertility, land degradation, increased chemical fertilizer costs, unpredictable precipitation, and low adoption of sustainable agriculture practices

(Yengwe et al., 2018). Due to poor farming practices, climate variability, higher precipitation, increased runoff, and soil loss, smallholder farmers in Africa have reported difficulty dealing with land degradation and soil erosion (Ward et al., 2017).

Government actions and growing consumer awareness are likely to increase the supply of sustainable agriculture output (Saitone & Sexton, 2017). Aside from the concerns of customers, governments, and international organizations, smallholder farmers can also reap long-term benefits from adopting sustainable practices. According to Kata & Kusz (2015), sustainable farming methods are essential for maintaining ecosystems, fostering farm economic stability, and raising the standard of living for smallholder farmers. According to Kilian et al. (2006), adopting sustainable agriculture practices also offers farmers cost savings and price advantages.

The European Union (EU) has long been committed to promoting sustainable agricultural practices, with a focus on Ghana's cocoa industry. Acknowledging the severe issues Ghanaian cocoa growers face, the EU has implemented a comprehensive legislative framework to support and encourage adopting of sustainable cocoa production practices (World Cocoa Foundation, 2021). In the cocoa sector, this approach places a high emphasis on the importance of social responsibility, environmental preservation, and financial viability. In Ghana, sustainable cocoa-growing practices have also been aggressively promoted by the UN and other international development organizations (UNDP, 2022). Working with local governments and other relevant parties, these organizations have been instrumental in implementing various projects aimed at raising the standard of life for cocoa producers while also safeguarding the environment. Through targeted funding, technical assistance, and knowledge-sharing platforms, the UN and other international development organizations have helped to adopt sustainable agricultural practices, such as diversified cropping, climate-smart practices, and cutting-edge technologies, to increase productivity and resilience (UNDP, 2022).

Ghana's sustainable development depends on its cocoa industry being produced sustainably. Less shaded cocoa landscapes are becoming more common, which threatens biodiversity preservation and the environmental sustainability of cocoa production. Due to the persistent utilization of zero-input production methods and the reliance on rich soils provided by ancient forests, soil degradation has resulted from low-shade cocoa growing and slash-and-burn land clearance techniques. Thus, essential nutrients, soil carbon, and organic matter are gradually lost from forest soils due to unsustainable production and harvesting methods.

Due to the promotion of zero-shade cocoa production systems, Ghana's cocoa production landscape has expanded over the past three decades, resulting in a significant loss of forest cover (UNDP, 2012). This has gradually resulted in forest landscape fragmentation, loss of wildlife corridors and forest connectedness, and degradation of biodiversity and the goods and services these ecosystems provide. One of the more visible effects of deforestation, which has had a substantial impact on cocoa output, is a considerable loss of critical soil nutrients. This has been a major contributor to the gradual fall in national cocoa yields.

Unsustainable production practices have forced cocoa growers to expand into wooded areas, but they now have little land available for further expansion. Indeed, many cocoa fields in Ghana today require rehabilitation in order to reverse output decreases. To overcome major environmental threats to sustainable cocoa production, such as deforestation and habitat conversion, an unsustainable intensified production system, unsustainable land management practices and resource use, and climate change, a significant shift in cocoa farming and related practices will be required. Because it contributes to biodiversity conservation, cocoa cultivation with higher proportions of shade trees (cocoa agroforestry) is increasingly seen as a more environmentally friendly land use practise than other forms of agriculture activity in tropical forest regions. The establishment and maintenance of forest tree species should be prioritized to promote species richness, alternative income alternatives, habitat construction, crop microclimates, soil fertility, and reduced plant stress (UNDP, 2012). This must be accompanied by other environmentally sound production practices that aid in the revitalization of ecosystem goods and services as well as on-farm biodiversity.

Farmers, on the other hand, do not entirely understand many sustainable practices, such as the optimum practices for composting and soil management, water catchment to maintain soil humidity and pesticide usage. This knowledge gap must be filled by research and education. A thorough investigation will be required due to the lack of market-based alternatives to motivate farmers to embrace environmental best practices (UNDP, 2012).

Adopting sustainable practices in developing countries, on the other hand, is often excessively knowledge-intensive (Wall, 2007; Giller et al., 2009). Smallholder farmers may lack expertise and understanding of such practices. It is also critical to establish communication channels to give smallholder farmers knowledge and understanding of the benefits of adopting sustainable practices (Oya et al., 2018). Cocoa growers need improved access to extension services, which government officials, the commercial sector, and producer groups primarily offer. Given that cocoa is grown in remote rural areas by many smallholder farmers, producer organizations are more accessible than government extension agents and the private sector in terms of agricultural information, extension, and inputs (Develtere et al., 2009).

Governments, researchers, and international development experts have viewed producer groups as potential options for increasing economic scale and lowering transaction costs in rural areas. They can improve efficiency in production and marketing, overcoming the subsistence aspect of smallholder farmers' land cultivation, creating rural jobs, reducing poverty, and raising living standards (Develtere et al., 2009). Not only theoretical economic arguments but also numerous empirical studies show a positive relationship between forming and pursuing producer group operations and smallholder farmers' economic success, such as higher prices and gross margins, as well as improvements in technical efficiency and productivity (Wollni & Zeller, 2007; Bernard & Spielman, 2009; Fischer & Qaim, 2012; Mojo et al., 2017).

Producer groups are critical in assisting farmers to shift their agricultural practises to adopt ecologically sustainable ways due to their tight relationships with their member farmers. Studies by Abebaw & Haile (2013), Liu & Liang (2018), and Yu et al. (2021) empirically demonstrate the significance of cooperative membership in the adoption of environmentally friendly technologies and practices. Producer groups help farmers adopt farmer innovations and sustainable practices by providing extension services, participation in group meetings and training, increased knowledge exchange among members, and a forum to discuss community-level problems (Schulte et al., 2020). Producer groups serve as a social networking and learning medium for smallholder farmers to share their information, know-how, and experiences with sustainable practises, influencing other farmers' knowledge and, as a result, adopting a sustainable environmental approach (Mutyasira et al., 2018). Producer organizations act as conduits and partners for knowledge transfer from government agencies, development organizations, and international funders (Wanyama, 2016; COPAC - Committee for the promotion and advancement of cooperatives, 2018).

Establishing producer groups has found its way into many developing countries' development policies (Bernard et al., 2008). The Ghanaian government has also implemented several policies to assist farmers in increasing productivity through producer organizations (Addai et al., 2014). The current Medium-term National Development Policy Framework, the Ghana Shared, Growth and Development Agenda (GSGDA, 2010-2013), and the Food and Agriculture Sector Development Policy (FASDEP II) all emphasise the importance of establishing and strengthening producer groups in developing the country's smallholder agricultural sector. Cocoa farming input and extension services are provided by producer groups, who guarantee that suitable quantities are allocated to farmers and that such allocations are communicated to members as soon as possible. Producer groups are the only credible partners in rural areas for many donor and NGO programmes and projects (Develtere et al., 2009). Cocoa licenced buying companies (LBCs) have also established farmer groups to help producers improve output through extension services, agricultural supplies, quality control, and other incentives.

Even though membership in producer groups generally benefits smallholder farmers, the structure, characteristics, and dynamics of different producer groups vary (Bray & Neilson, 2017; Bizikova et al., 2020). In Ghana's cocoa sector, for example, farmer associations do not adhere to economic cooperative principles because members have no financial stake in the group, and the group does not exist as a corporate entity. Furthermore, the cooperatives' members have international accreditation, such as Fairtrade, which provides the farmers an additional bonus or premium on every kilogramme of cocoa sold through the cooperatives.

In general, studies assessing the impact of producer groups, such as Addai et al. (2014) and Missiame et al. (2023) compare producer group members with non-members. For instance, prior studies compared the influence of various types of producer groupings under one umbrella to non-members. This study focuses on the impact of different producer groups (cooperatives and farmer associations) on SCP adoption and the technical efficiency of cocoa producers. Furthermore, limited study has been conducted to determine the impact of producer organizations on the adoption of sustainable cocoa practices and cocoa farmer productivity. As a result, the purpose of this research is to examine the impact of varied producer group membership on the adoption of SCPs and the technical efficiency of cocoa producers. The study also aims to investigate the influence of SCP adoption on the technical efficiency of cocoa growers.

The importance of understanding how collective action, facilitated by producer groups, can foster the implementation of sustainable practises, potentially improving the socioeconomic well-being of cocoa farmers, promoting environmental conservation, and ensuring the long-term sustainability of the cocoa industry, which is a critical sector for the Ghanaian economy, is the justification for this study. A thorough examination of the impact of producer organizations on sustainable cocoa practises, and the efficiency of Ghanaian cocoa farmers is critical for several reasons:

1. Addressing global issues: Given the growing global concern about sustainable agricultural practices, particularly in the cocoa business, thoroughly examining how producer organizations might act as enablers of sustainable practices is critical.
2. Socioeconomic development: Because Ghana's cocoa sector contributes significantly to the country's economy and the livelihoods of many farmers, understanding how producer groups can lead to increased efficiency and better living conditions for farmers is critical for overall socioeconomic development.
3. Environmental conservation: The study's findings highlight how sustainable cocoa might help environmental conservation by minimizing deforestation, increasing biodiversity, and lessening the detrimental impact of cocoa cultivation on ecosystems.
4. Policy implications: Insights into the role of producer groups in promoting sustainable practices can help inform policy development at the national and international levels, resulting in the development of more effective and targeted policies to promote sustainable cocoa production and improve the overall agricultural landscape.
5. Industry competitiveness: Understanding the relationship between producer groups and sustainable practices will boost Ghana's cocoa industry's competitiveness in the global market, as sustainability is becoming an essential criterion for international commerce and consumer preferences.
6. Academic contribution: This study will add to the scholarly literature on sustainable agriculture, collective action, and development studies by giving a more nuanced

understanding of the interplay between producer groups and sustainable practices in Ghanaian cocoa cultivation.

The rest of this thesis presents a literature review (Section 2), followed by the study objectives and hypotheses (Section 3). Subsequent sections present the methodology (Section 4), results (Section 5), discussion (Section 6), and the conclusions and policy recommendations (Section 7).

2. Literature Review

2.1 Introduction

This chapter recounts literature on studies done by other researchers and publications relevant to the current research. This review delves into key theoretical frameworks, namely the Rational Choice Theory and Social Capital Theory, to illuminate the decision-making processes of farmers and the role of social networks within producer groups in influencing the adoption of sustainable cocoa practices and economic outcomes. Furthermore, the historical context of the Ghanaian cocoa industry and the pivotal role played by the Cocoa Board provide a foundation for understanding the challenges faced, such as low cocoa productivity, and the potential solutions offered by the emergence of producer groups in mitigating these challenges. Exploring the determinants of cocoa productivity and technical efficiency, this review aims to provide a comprehensive understanding of the intricate dynamics at play, setting the stage for an in-depth analysis of the impact of producer groups on the adoption of sustainable cocoa practices and the economic performance of small-scale farmers in Ghana.

2.2 **Theoretical framework**

2.2 Rational Choice Theory

Following Masten & Saussier (2000) and Pascucci et al. (2012), a farmer's decision to become a member of an agricultural producer group is represented in a double discrete choice model. The assumption is that farmers will choose to become a member of a producer group's services if the expected benefit from membership and patronage is greater than the associated costs.

The discrete choice demonstrates that farmers will become a member of an agricultural producer group if membership benefits exceed costs. The membership benefits of producer groups range from getting prior access to its supply and marketing services to the receipt of additional income from redistributions of the producer groups' rents (Sexton & Iskow, 1988; Sexton, 1990). Membership in the producer group provides farmers with institutional mechanisms to bring economic balances under their control and prevent opportunistic and hold-up situations (Cook, 1995; Sykuta & Cook, 2001). Agricultural producer groups that control the flow of production downstream and the supply of inputs upstream can also result in higher (lower) prices for farmers produce (inputs) and better access to output and input markets (Sexton & Iskow, 1988; Giannakas & Fulton, 2005). Joining forces via producer groups also allows for sharing or internalizing transaction costs (Bonus, 1986; Staatz, 1987; Valentinov, 2007). By internalizing transactions, members in cooperatives directly benefit from common incentives (e.g., farmers wish to sell at the highest price possible, and the producer group wishes to pay its members the highest price possible) and the free flow of information (Sexton & Iskow, 1988).

Moreover, membership in producer groups also provides intangible benefits, such as trust, fairness, reciprocity, and the opportunity to participate in organizational governance (Hansen et al., 2002; Bijman & Verhees, 2011). On the other hand, membership in cooperatives has potential costs. These costs are mainly related to membership commitments and opportunity costs of participation (Fulton & Giannakas, 2001; Bontems & Fulton, 2009). A farmer who decides to become a member must allocate time to decision-making processes, discharge leadership duties, and monitor the performance of the appointed governing bodies.

2.3 Social Capital Theory

Producer group, as an institution, is known for its high level of involvement by its members in decision-making and characterized by its member-ownership and control. Social capital is vital to formal institutions and governance in cooperatives (Valentinov, 2007). Putnam (1993) defined social capital as any characteristics of a social organization, such as norms, networks, and trust, that lead to coordination and cooperation for mutual benefits. Social capital is the relationships or interactions between members which sustainably encourage productive activities (Coleman, 1988). Social capital is vital in terms of access to information, better civic engagement, reduction of opportunist behaviour, efficiency, reduction of transaction costs and solving collective action problems (Coleman, 1988; Putnam, 1993; Fukuyama, 1995).

Coleman (1988) indicated that social capital increases human and physical capital investment. In an experiment study conducted by Putnam (1993), he concluded that social capital may help improve the government's performance and the economy's progress. In contrast, the deficit in social capital can result in declining social activities. Putnam (1995) opined that a high level of social capital facilitates coordination, communication, and incentives for future cooperation and reduces opportunistic behaviour.

Chloupkova et al. (2003) did a comparative study on social Capital in Denmark and Poland producer group movements. The results of the study indicated that there was destruction in social capital in Poland, which can be attributed to the communist system limiting the development of various social organizations. Cooke et al. (2005) found a positive relationship between social capital and the performance of firms (innovation and business growth). Luo & Wang (2010) highlighted that the role of social capital is vital for solving collective action problems in Chinese cooperatives. Liang et al. (2015) also stated that social capital is an informal institutional framework with cooperation, collective action, decision making and shared information.

Social capital can be conceptualized and measured in a specific form (Guiso et al., 2004). Chloupkova et al. (2003) used membership in voluntary organizations, trust and civic participation as indicators of social capital at the macro level. Putnam (1993) used networks, norms and trust to measure social capital. Bhandari & Yasunobu (2009) operationalized social capital as trust, norms, relationships and networks, friends, membership, civic engagement and information flows.

Trust is essential in cooperation. Hansen et al. (2002) highlighted that as individuals seek to achieve their economic goals in cooperatives, others also try to achieve social gains. The study highlighted that trust could develop among members of the producer group and between the members and the managers in pursuing their goals. Hansen et al. (2002) operationalized trust as the process by which one believes that group members are trustworthy. Cohesion in a producer group or any group is built on the members' trust or social relationship with each other. Cohesion in the producer group is built due to members' positive feelings toward each other and the group Hansen et al. (2002). This analysis aims to uncover the relational resources, including shared norms, values, and mutual support, that enable these producer groups to foster a culture of collaboration and knowledge sharing among cocoa farmers.

Bonding social capital refers to the strong ties and connections within close-knit groups, such as family, friends, or members of a particular community or organization (Ito et al., 2019). These relationships are characterized by high trust, reciprocity, and support, contributing to members' sense of belonging and solidarity. On the other hand, bridging social capital involves connections between different social groups or individuals from diverse backgrounds (Ito et al., 2019). These connections bridge social divides, facilitating the exchange of information, resources, and opportunities beyond one's immediate circle. While bonding social capital reinforces identity and provides emotional support, bridging social capital fosters innovation, access to novel ideas, and social integration, ultimately promoting community cohesion and resilience (Poortinga, 2012). Both forms of social capital are essential for building strong and resilient societies, with bonding ties providing a foundation of support and belonging while bridging ties enable collaboration, cooperation, and collective action across diverse communities (Poortinga, 2012).

By understanding the dynamics of bonding and bridging social capital within these groups, the research can illuminate how these social connections facilitate the dissemination of information, best practices, and sustainable farming techniques, thereby promoting the efficient adoption of sustainable cocoa practices among farmers in Ghana.

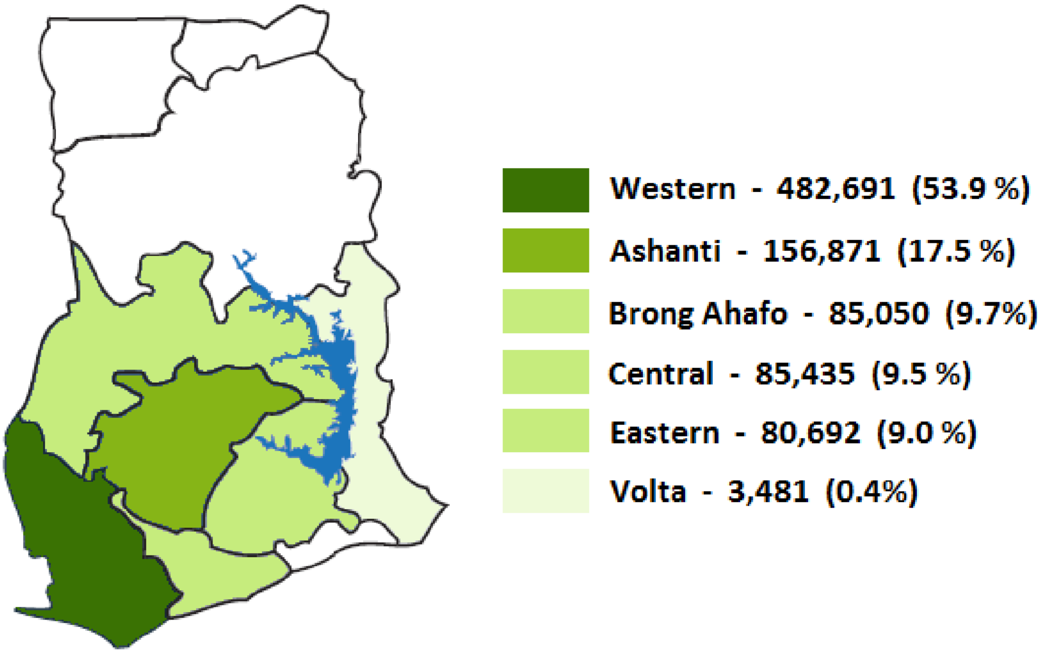
2.4 Ghana’s Cocoa Value Chain and Context

2.4.1 Background

Around 1876, Tetteh Quarshie imported cocoa to Ghana from Fernando Pó, which is now known as Bioko in Equatorial Guinea (Essegbey & Ofori-Gyamfi, 2012). After being planted in the southeast, trees have progressively moved to the west (World bank, 2013). Six of Ghana's ten regions—the Western, Ashanti, Brong-Ahafo, Central, Eastern, and Volta regions—grower cocoa these days (Figure 5). Presently, more than half of

Ghana's cocoa production comes from the Western area alone (Monastyrnaya, 2016). October marks the start of the cocoa growing season, which is divided into two harvesting seasons: the light season (June – September) and the major season (October – May) (USDA, 2012). The quality of the light crop beans is the same, despite their lower volume in comparison to the main crop beans (USDA, 2012).

Smallholder farmers in Ghana produce the majority of the country's cocoa; their farms typically cover little more than four hectares (Anim-Kwapong & Frimpong, 2005). More than 800,000 farmer households are supported by cocoa production (Ghana Statistical Service, 2014), which provides 70–100% of their income and is a significant source of rural employment (Anim-Kwapong & Frimpong, 2005). Growers sell their cocoa beans to Licensed Buying Companies (LBCs), who then ship the beans from the villages to COCOBOD's Cocoa Marketing Company (CMC) marketing division. Cocoa is sold to domestic processors by CMC after being exported. Ninety-five percent of the semi-finished products made from cocoa beans are exported, including butter, liquor, and powder. Toffees, chocolate, and cocoa beverages intended for the local markets are made with the remaining 5% (Monastyrnaya, 2016).



Cocoa production by region in 2013/14, tonnes

Source: (Monastyrnaya, 2016)

One important crop for Ghana's agriculture industry is cocoa. About six million people receive money from it, making up thirty percent of total export revenues (Monastyrnaya, 2016). Ghana, second only to Côte d'Ivoire in global cocoa production, is a significant player in the market, accounting for approximately 20% of it (700000 to 900000 tonnes annually over the last ten years) (Amegbe & Hejkrlik, 2023). Cocoa production has long been the major cash crop contributing significantly to Ghana's GDP. It is Ghana's most important agricultural commodity and the primary crop for the country's economy. Cocoa is Ghana's second largest foreign exchange earner, accounting for roughly 30% of total export revenue. It accounts for approximately 57% of total agricultural exports and exports 22% of the world's cocoa (Amegbe & Hejkrlik, 2023). In 2015/2016, agriculture contributed 19% of Ghana's GDP, with cocoa accounting for 14.6% of that total. This boosted the cocoa sector's growth performance to 3% in 2015/2016 (Amegbe & Hejkrlik, 2023). Cocoa accounts for 20-25% of total export revenue in Ghana, trailing only mineral exports. Statista 2023 estimates that cocoa will contribute GH 4.01 billion ($533 million) to GDP by 2025. For these reasons, cocoa is critical to Ghana's economy regarding foreign exchange profits, employment, and subsistence.

Because of its higher-than-average fat content, mild and rounded flavour, and slightly lower levels of debris and faulty beans, Ghanaian cocoa is renowned for its good quality (USDA, 2012; Monastyrnaya, 2016). Ghana is able to command a 4-6% price premium on the global market due to its consistently high quality (Monastyrnaya, 2016). The main markets for Ghanaian beans are North America, Asia, and the European Union.

The cocoa value chain in Ghana features a marketing structure known as "partially liberalized," which blends aspects of privatization with a significant level of government involvement (World Bank, 2013). The Ghana Cocoa Board (COCOBOD) had complete control over the selling of cocoa in Ghana prior to the implementation of the partial liberalization. This included control over both local purchases and exports abroad. Beginning in the early 1990s, structural changes in the cocoa industry resulted in the privatization of internal marketing. Several private businesses now hold licenses to buy cocoa beans from farmers and supply COCOBOD with them (Monastyrnaya, 2016). Nonetheless, COCOBOD continues to be a key player in controlling the cocoa value chain, which includes quality assurance and cocoa exports.

Government regulation applies to the value chain's pricing determination. The Producer Price Review Committee (PPRC), which comprises representatives of farmers, Bank of Ghana, COCOBOD, licensed buying companies (LBCs), and hauliers, was established by the Government of Ghana (GoG) in 1983–1984. The PPRC is chaired by the Ministry of Finance and Economic Planning (Monastyrnaya, 2016). Price setting is a two-step process that involves projecting revenues and costs as well as PPRC debates (Monastyrnaya, 2016). Initially, COCOBOD forecasts the season's overall industry expenses and revenue (Monastyrnaya, 2016)

2.4.2 Actors of the Cocoa Value Chain

Table 1 presents the key actors of the cocoa value chain.

Input Supply

Cocoa seedlings, fertilizers, insecticides, fungicides, and agricultural tools including harvesting hooks, locally referred to as "go-to-hell" hooks, cutlasses (big blades used to split pods), pruners, and spraying machines are the main inputs for cocoa production (farmers interviews). In the delivery of enhanced planting material and agro-inputs, COCOBOD and the LBCs continue to play a proactive role. For the benefit of the cocoa producers, the COCOBOD Seed Production Division (SPD) multiplies and distributes seedlings (Monastyrnaya, 2016). The Cocoa Health and Extension Division (CHED) assists with seedling distribution, provides fertilizer, and sanitizes cocoa fields. The private input market is, with few exceptions, represented by a large number of small-scale input dealers (World Bank, 2013). The farmers buy the inputs from the private companies directly. Producer groups in rural areas facilitate the supply of cocoa inputs to farmers by procuring them from private companies.

Table 1. Actors of the cocoa value chain

Activity	**Actor**
Input Supply	Private input dealers, Social enterprises and NGOs COCOBOD (CHED, SPD), LBCs Producer groups (Cooperatives and other self-help farmer associations)
Production	Farmers
Internal marketing	LBCs
Transportations	LBCs Haulers
Exports	COCOBOD (CMC)
Local processing	Processors

Production

There are around 800,000 households (Monastyrnaya, 2016), cultivating cocoa on small plots of land. While the majority of farmers (around 80%) own the land that they cultivate, others are sharecroppers – they manage the fields on a share basis (World Bank, 2013). There are two sharecropping systems in Ghana locally known as abunu and abusa (Monastyrnaya, 2016; Amegbe & Hejkrlik, 2023). This arrangement is typically between two parties; one that has the resources for the farming and another who can manage the farm but has limited resources for a farm. The caretaker (one party) takes the responsibility of maintaining the farm whilst the owner (other party) gives resources to the caretaker to ensure weeding, fertilizing, spraying and overall management of the farm (Monastyrnaya, 2016; Amegbe & Hejkrlik, 2023). This agreement is usually important because both parties gain more by cooperating. Depending on the agreement between the two parties, harvest is divided into two or three and shared between parties every season. Alternatively, the caretaker would receive a share of the entire piece of land after a specific period depending on the agreement of both parties; this is usually agreed at the beginning of the agreement (Monastyrnaya, 2016; Amegbe & Hejkrlik, 2023).

In abunu, sharecroppers establish cocoa farms themselves and are responsible for the main activities on the farm such as managing the farm, training, hiring labor and applying inputs (Laven, 2010). In return, abunu sharecroppers receive 50% of the harvest (Laven, 2010). In abusa, owners hire caretakers to manage farms for one-third of the crop, while inputs are usually provided by the landowner, also the quantity may be inadequate ((Monastyrnaya, 2016). Cocoa farmers are responsible for the growing, harvesting, fermenting, and drying of cocoa. Although abunu and abusa is very common, the legal structure is very appalling and often times generate misunderstandings among families.

Internal marketing and transportation

There are several private national and international Licensed Buying Companies (LBCs). At the beginning of every cocoa season, COCOBOD provides LBCs with loans with interests lower than market rates, locally known as a “seed fund”, to purchase cocoa from farmers. LBCs receive a fixed amount of revenue per quantity of cocoa and, therefore, try to increase their profits by maximizing the beans purchases and seek to turn over cocoa quantities as quick as possible (World Bank, 2013; Monastyrnaya, 2016). LBCs employ district managers and purchasing clerks from the local communities to organize purchases and evacuation of cocoa from the villages. Purchasing clerks deliver cocoa to the LBCs’ warehouses (Monastyrnaya, 2016; Amegbe & Hejkrlik, 2023). LBCs hire hauliers (private transport service companies) to transport sealed bags of cocoa to the Cocoa Marketing

Company (CMC). An increasing number of LBCs do not outsource transportation activity anymore and deliver cocoa to CMC themselves (LBCs and hauliers interviews). There are also non-recognized individuals who buy cocoa directly from farms and then sell it either to LBCs, or elsewhere illegally for higher returns (Monastyrnaya, 2016).

Exports

All cocoa is delivered to a subsidiary of COCOBOD – the Cocoa Marketing Company (CMC), which stores cocoa in three take-over centers (Tema, Takoradi and Kaase) prior to shipment (World Bank, 2013). CMC has exclusive rights to the marketing and exports of cocoa beans to local and foreign buyers. In addition, CMC manages pre-harvest forward sales and contracts a fixed price with international merchants and cocoa processors to hedge against price volatility. Around 60% - 80% of cocoa is pre-sold (World Bank, 2013). The forward contracts are then provided as collateral to borrow the funds from an international syndicate (World Bank, 2013).

Processing

Around 80% of Ghanaian cocoa is directly exported in form of raw beans and the rest is domestically processed into semi-finished or consumer products (Monastyrnaya, 2016). The majority (over 95%) of the total processed cocoa is used for semi-finished products (liquor, butter, powder and cake), most of which is exported, and the rest is processed into confectioneries and other cocoa-based products destined for domestic market (Monastyrnaya, 2016).

To attract foreign direct investments into the domestic cocoa processing sector, Ghanaian government offers to investors a competitive package of economic incentives. It includes price discounts, tax free zones and extended payment credit (World Bank, 2013).

These efforts resulted in an increase in domestic grinding capacities from 110,000 MT in the early 2000s to approximately 431,500 MT in 2013 (World Bank, 2013; Monastyrnaya, 2016). For the medium term, the government aims to process at least 60% of the total cocoa output domestically before exporting it (Monastyrnaya, 2016).

COCOBOD offers domestic processors a discount of 20% on beans produced during the light crop season (Monastyrnaya, 2016). The growth of processing capacities in Ghana has increased the competition for discounted beans thus reducing their availability. Although domestic processors can also purchase main crop without a discount or import beans from abroad with 20% duty (Monastyrnaya, 2016), this is often not economically efficient as processors in general face high operational costs (processors interviews). As the result, processors are unable to procure sufficient quantities of beans and cannot operate at full capacity. In 2013/14, only around 60% of capacities of domestic processors in Ghana were used (Monastyrnaya, 2016).

2.5 Producer Groups in Ghana

Previously, extension theories solely focused on supporting individual farm management and promoting farm-level innovations. However, looking at the challenges of today, many of these exceed the level of individual farms or farm households. Issues like managing collective natural resources, value chain management, collective input supply and marketing, building multifunctional agriculture and venturing into new markets require new forms of coordinated action and cooperation among farmers and other stakeholders (Dormon et al., 2004). Producer groups are essential for empowering, alleviating poverty and advancing farmers and the rural poor. Producer groups can also be effective alternatives where the private and public provision of agricultural services have failed. Many innovations involve or depend on the adequate functioning of farmers and producer groups (Dormon et al., 2004)

The renewed interest among both public and private organizations to use producer groups for extension delivery in Ghana stems from their ability to enable cost-effective delivery of extension services and empower the producer groups' members to influence policies that affect their livelihoods (Salifu et al., 2010). Government, donors and partner organizations identify producer groups as necessary in the country's agricultural development and overall food security (Asibey-bonsu, 2012).

Private sector organizations and LBCs establish producer groups in the cocoa industry to reduce transaction costs and increase profitability. The producer groups enable private entities to deal more effectively and efficiently with smallholder farmers in remote rural areas (Gulati et al., 2007). Through producer groups, private investors seek to reduce the cost of dealing with farmers, enhance the volume and quality of farm produce, and increase credit recovery rates in farmers' borrowings. They can better provide stable supplies of quality products (Markelova et al., 2009).

The producer groups and their internal dynamics guarantee that various smallholder farmers are educated and trained on good agronomic practices and business practices to enhance safety, quality and productivity (Wossen et al., 2017). Cocoa farmers in the groups are typically trained on proper agricultural practices, soil management, planting, shade management, pruning, weeding, pest and disease control and prevention, adequate use of fertilizer, proper harvesting techniques and other cocoa cultivation-related activities (Agyeman-Boaten & Fumey, 2021). Members are trained on safety practices, especially during agrochemical application, proper use of various farm tools and equipment, the dire impacts of child labour and many others (Hamenoo et al., 2018; Oyekale, 2018; Afriyie et al., 2019). This training significantly enhances productivity by informing farmers to make smarter business decisions.

Producer groups are also essential for participating members to attain credit (Lin et al., 2022) since smallholder farmers have minimal sources of capital for operations and expansions (Azadi et al., 2021). The risky nature of agriculture and cocoa farming specifically makes financial institutions reluctant to support farmers and for a good reason. In addition, the lack of appropriate collateral limits smallholder farmers from accessing loans from banks and other financial institutions.

Efficient production in all business forms depends significantly on the inputs entering the production (Norton & Nalley, 2013; Kim, 2021). Cocoa productivity relies on the quality of seedlings, the kind of agrochemicals applied, and the tools and equipment available for production, maintenance, harvest and processing (Monastyrnaya et al., 2016). Recently, hybrid cocoa seedlings have been promoted to replace Ghana's old cocoa variety (Wiredu & Mensah-bonsu, 2011). These seedlings are produced by the Cocoa Research Institute of Ghana (CRIG- COCOBOD) and distributed primarily by the Seed Production Division - COCOBOD (SPD) yearly through producer groups. Besides the producer groups, individual farmers can also request seedlings from SPD. Nevertheless, this is usually at a very high transport cost, so smallholder farmers are discouraged. Every year, various cooperatives and farmer groups receive quality spraying materials through mechanized sprayers, pruners, appropriate working gear and agrochemicals from the government and other stakeholders to undertake mass spraying activities and pruning.

However, the effectiveness of extension education through producer groups can depend on various factors, including the quality of the information and advice provided, the level of organization and management of the groups, and the availability of financial and technical support. Overall, extension education through producer groups can be a powerful tool for promoting sustainable and inclusive agricultural development. By working through producer groups, extension agents can reach more farmers, foster peer learning and exchange, and promote participatory and context-specific approaches to agricultural extension.

2.6 Cocoa Cooperatives and Farmer Associations in Ghana and External Support

Cooperatives and other self-help farmer associations formed by Ghana's license-buying companies are the two major producer groups (Amegbe & Hejkrlik, 2023). Cocoa farming is a labour-intensive activity; therefore, many farmers organize into self-help producer groups, locally known as "nnoboa," in order to help each other with harvest and postharvest practices (Laven, 2010). Creation of informal groups also helps farmers to facilitate access to essential resources such as seeds, fertilizers, and equipment, often by collectively purchasing inputs from private companies or accessing government subsidies and extension services (Kadri et al., 2013). The farmer associations in Ghana gets external support from mainly the LBCs and COCOBOD. The license-buying companies (LBCs) and COCOBOD provide training and capacity building or additional livelihood avenues for farmers through farmer associations (Amegbe & Hejkrlik, 2023). The farmer associations enable the farmers to access training and information on best practices. Members of farmer associations do not necessarily have a stake in the organization because no financial commitment is required.

The Cooperatives Act, 2008 (Act 680) in Ghana sets strict conditions for the use of the term "cooperative." Thus, despite similarities in function and roles, not all farmer groups qualify to be called cooperatives. In Ghana, cocoa cooperatives are established similarly to farmer associations and then registered under the 1992 constitution (Amegbe & Hejkrlik, 2023). In Ghana the Cooperatives Act, 2008 (Act 680) explains registration, duties and privileges, settlement of disputes and other miscellaneous topics that governs cooperatives. Cooperatives are governed by a set of principles, values and norms that govern the behaviour of cooperative organizations. These principles were first established by the International Cooperative Alliance (ICA) in 1844 and have been revised several times since then. The cocoa cooperatives follow operative in accordance with the cooperative Act and the seven principles of the International Cooperative Alliance (ICA). According to the ICA in Manchester 1995, there are seven principles;

1. Voluntary and open membership.
2. Democratic Member Control.
3. Member Economic Participation
4. Autonomy and Independence
5. Education, Training and Information
6. Cooperation among Cooperatives
7. Concern for Community

Moreover, members demonstrate commitment to the group through regular meeting attendance, mutual support, and the collective bulking of cocoa through the cooperatives.

These aspects underscore the formal structure and organizational commitment inherent in cooperatives, distinguishing them from informal producer groups.

Most cocoa cooperatives also receive external assistance through COCOBOD and the license buying companies who buy cocoa from the cooperatives. The support includes training, provision of inputs, technical assistance, and other extension services (Amegbe & Hejkrlik, 2023). Furthermore, all cocoa cooperatives in Ghana, including the prominent Kuapa cocoa cooperative, are Fairtrade and other international certification certified. Through these certifications, farmers gain access to information, training, and inputs essential for sustainable cocoa cultivation practices. Additionally, they benefit from farm demonstrations and technical assistance, empowering them to improve crop quality, increase productivity, and contribute to environmental conservation efforts. Moreover, by meeting certification requirements, farmers unlock opportunities for premium prices in the market, enhancing their economic resilience and fostering long-term sustainability in cocoa farming communities.

2.7 Producer Groups and Farmers Adoption of Sustainable Practices

Producer groups have achieved sustainability at both ends of the food supply chain. The seventh cooperative principle, "concern for community," ensures that producer groups have sustainability in their "DNA" (COPAC, 2018). Producer groups are encouraged to invest in sustainable, environmentally friendly practices and raise awareness among their members out of concern for the needs of their members and communities (COPAC, 2018). By educating their members on the importance of sustainable consumption and production, producer groups can have a domino effect in their communities. Producer groups contribute to the economic, social, and environmental goals of sustainable development because they strive to meet members' economic needs while also satisfying their socio-cultural interests and protecting the environment (Wanyama, 2014).

The primary goals of farmer producer groups in developing countries are to promote innovation, provide professional training, facilitate members' access to new technologies and equipment, and promote sustainable management practices among smallholder farmers (Wollni & Zeller, 2007; Ma et al., 2018). Farmer producer groups act as intermediaries and platforms for technology adoption by facilitating information exchanges between smallholder farmers and technology suppliers (universities, research institutes, agricultural extension agents, and technology firms) (Zhang et al., 2020). According to Cruz et al. (2022), Spanish researchers regard agricultural producer groups technicians as farmers' primary source of information. Farmers can gain experiential learning through producer groups, which is critical for knowledge acquisition and innovation adoption (Cruz et al., 2022). Producer groups understand their members' needs and maintain direct contact with them, making them an effective channel for horizontal learning and information sharing among farmers (Thorat et al., 2008). Producer groups serve as service system coordinators, bridging the gap between the policy system and sustainable farm management practices (Kilelu et al., 2011).

Through transparency, participation, and collaboration with local communities, businesses, and local and international governments, the agricultural cooperative governance model has a positive impact on sustainable development (Cato, 2012; Wanyama, 2014). The internal organization of the groups makes knowledge and technical information sharing more efficient. Producer groups improve the efficiency of local strategies to achieve extension services goals among farmers while adhering to the governmental legal framework (Franks, 2011). These strategies rely on members' knowledge of specific local conditions, past experiences, and decision-making to identify the main problems and allocate resources at a faster rate than central authorities and top-down approaches (Stallman, 2011; Prager, 2015).

Face-to-face communication boosts producer groups' social capital through collective action. Social capital in producer groups increases advice, mutual support, collaboration, trust, commitment, and willingness to follow rules and regulations, resulting in a sense of belonging to a social group and esteem for their contributions (Stallman, 2011; Prager, 2015). Furthermore, the peer-pressure mechanism of the farmer group changes farmers' attitudes, values, and aspirations, increasing the rates of adoption and harmonization of environmental and agricultural measures and practices (Prager, 2015).

According to empirical evidence, agricultural producer groups encourage the adoption of new farming practices and technologies (Abebaw & Haile, 2013; Wossen et al., 2017; Yu et al., 2021). Ma & Abdulai (2019) found that cooperative membership has a positive impact on integrating pest management (IPM) technology in China. According to Yu et al. (2021), cooperative membership has a significant positive influence on China's adoption of green control techniques (ecological regulation, biological and physical control, and the scientific use of chemical pesticides). Candemir et al. (2021) conducted a review of empirical studies on the impact of producer groups on farm sustainability of their members. In their review, they discovered that cooperatives significantly contribute to the adoption of sustainable environmental practices. Gonzalez (2018) confirms in his book "Farmer's Producer Groups and Sustainable Food Systems in Europe" that producer groups can influence farmers' adoption of sustainable environmental practices and agricultural innovations. Bro et al. (2019) discovered that cooperative members adopt more sustainable practices than non-members in their study in Nicaragua. Nkomoki et al. (2018) discovered a significant impact of farmer group membership on crop diversification strategy adoption in Zambia. According to Ma et al. (2018), cooperative membership has a significant influence on the likelihood of investing in organic amendment practice. The availability of technical assistance increased farmers' willingness to adopt sustainable environmental practices in Vietnam's vegetable sector (Naziri et al., 2014). Furthermore, a study conducted by Ji et al. (2019) in the Chinese hog industry concluded that farmers involved in producer groups have significantly higher incentives to adopt safe production practices.

2.8 Impact of Producer Groups on the Economic Performance of Farmers

Several studies have found that participation in producer groups leads to improved agricultural techniques, better resource utilization, and the sharing of vital information among members. The effect of farmers' producer group membership on farm productivity was found by Verhofstadt & Maertens (2014), Ma et al. (2018) and Missiame et al. (2023). These groups have been instrumental in improving the overall yield of small-scale farmers through collective actions such as joint purchasing of agricultural inputs, shared knowledge of efficient farming methods, and coordinated marketing strategies. Furthermore, the shared access to resources and collective bargaining power that such groups frequently facilitate has enabled farmers to access higher-quality inputs and technology, improving crop yields and overall farm productivity.

Individual farm producers' primary motivation for forming or joining producer groups is frequently to improve farm-gate prices in the event of input supply and output demand market failures. In theory, by pooling commodities, organized farm producers gain bargaining power over monopolists and monopsonists, allowing them to command higher farm-gate prices than non-organized farm producers. Wollni & Zeller (2007) developed an ordinary least squares (OLS) model and used a binary variable to estimate the causal impact of producer group membership. Wollni & Zeller (2007) concluded that the price of coffee increased by $0.05 per pound for members compared to non-members using survey data from 216 random coffee producers in Costa Rica. Bernard et al. (2008) used cereal prices as the outcome variable in a large-scale household study in Ethiopia. According to the study, members received prices 7.2-10.89% higher than non-members. Similarly, Fischer & Qaim (2012) reported that in the Kenyan banana industry, growers who supplied producer groups saw a 23% increase in per kilogram price. Chagwiza et al. (2016) found no evidence of a significant relationship between producer group membership and milk or butter pricing in Ethiopia after polling 192 dairy producer group members and 192 non-members.

Almost all studies found that belonging to a producer group has a positive but variable effect on income. When farm size is used as a mediator, there is disagreement about the precise direction of the heterogeneous influence. Furthermore, all empirical data is generated in a developing country. It is unclear whether producer group membership has a positive impact on farm revenue in North America and Europe, where there are arguably fewer market failures in agriculture, or if the effect is similar to that seen in developing countries. Getnet & Anullo (2012) estimated a treatment effect of producer group membership on crop production income ranging from 847 Birr (kernel matching) to 3,998

Birr (stratification matching) in Ethiopia. However, the estimated impact on total household income was statistically insignificant. Ito et al. (2012) found that the treatment effect of producer group membership on farm income ranged from 28.3 to 44.0 Yuan per day for the entire sample of 318 Chinese watermelon producers. Ma & Abdulai (2016) estimated a treatment effect of 4.66% on the household income of apple producers in China using switching regression rather than propensity score matching. Ma & Abdulai (2016) observed a stronger effect of producer group membership for relatively small members (5.73%) than for relatively large members (3.81%). Finally, Ahmed & Mesfin (2017) used switching regression to study a sample of 250 farm producers in Ethiopia, with consumption expenditure per adult as the outcome variable. The study found a treatment effect on consumption expenditure of 17.6-26.5%. However, Ahmed & Mesfin (2017) discovered that the treatment effect increased with farm size. To add to the ambiguity, Mojo et al. (2017) found that membership in Ethiopian coffee producer groups had a positive impact on farm income when using switching regression but not when using propensity score matching.

2.9 Determinants of SAPs Adoption

Adopting multiple SAPs is unavoidable when farm households are subjected to various climatic shocks that can reduce expected productivity levels. Farm households, however, are bound to face conflicting or complementary options based on their perceived utility. Joint adoption decisions vary widely and are well-documented across Sub-Saharan Africa (Abdulai et al., 2011; Teklewold et al., 2013). Previous research has revealed varying contradictory results of factors driving adoption based on SAP type and location

(Teklewold et al., 2013; Wainaina et al., 2016; Makate & Makate, 2019), confirming the heterogeneity that exists in household adoption behaviours.

Regarding socio-economic characteristics, gender is an example of a factor driving or constraining SAP adoption. Gender differences in adoption may exist within conservation packages. Also, differences in SAP adoption decisions can be skewed to a specific class of SAP. For example, in the study by Theriault et al. (2017), female plot managers were less likely to adopt yield-enhancing (inorganic fertilizer and or improved seed variety) and soil-restoring strategies (fungicide, herbicide/pesticide). However, there were no differences in yield-protecting strategies (e.g. manure, compost and planting pits). In the literary context, variations in results based on the gender variable used can also be related to the women population under consideration. For example, there are differences in adoption decisions when female plot managers are household heads and wives in male households (Peterman, 2011). Doss & Morris (2000) discovered a similar finding: female farmers living in male-headed households adopted maize varieties at a significantly higher rate than female farmers living in female-headed households.

Educated farm households are enlightened about the evolution of modern practices and should quickly adopt them. Joint adoption studies, on the other hand, revealed diverse effects on adoption decisions with differing perspectives (Ndiritu et al., 2014; Wainaina et al., 2016). Adoption studies have also revealed that conservation practices are labour intensive. Household size is an important proxy for labour supply that can influence adoption decisions. According to some studies, larger farm households are more likely to invest in labour-intensive sustainable practices (Ndiritu et al., 2014). Proxies of household assets represent wealth status and ease in purchasing modern varieties and employing labour for manufacturing activities. Adoption of agricultural innovations has been found to have a significant impact on livelihood using asset measurement as a proxy (Awotide et al., 2015).

However, disparities in SAP adoption can also be attributed to wealth disparities. In this study, we used the value of household assets as a proxy to assess its interaction with identified SAPs. The role of SAPs in ensuring food security in various contexts in adoption studies is well established in the literature (Kassie et al., 2015; Jaleta et al., 2018). Food insecurity may influence adoption decisions because food-insecure households may be willing to adopt SAP portfolios to improve productivity. Furthermore, while the use of food security indicators as a factor of adoption is uncommon, in the context of this study, we used a subjective measure of households' food security status based on access to healthy and nutritious food to assess how households' food security status interacts in the joint adoption of improved seeds and conservative practices.

Extension institutions are typically endogenous in interventions, promoting the adoption of modern varieties and conservation practices in particular. However, heterogeneity exists in extension proxies in terms of driving or constraining adoption. According to Makate et al. (2019), access to extension services varies depending on agricultural practices; for example, while it drives the adoption of conservation agriculture and improved legumes, it does not drive the adoption of drought-tolerant maize varieties.

Land is a critical asset in household agriculture and is central to development policies (Goldstein & Udry, 2014). It is a valuable resource for agricultural development and poverty alleviation efforts (Khonje et al., 2015), and it is relevant in encouraging agricultural growth investment for development gains (Lawry et al., 2014). Land ownership drives adoption decisions in long-term investment innovations such as conservation practices, whereas a lack of it can prevent farmers from investing in agricultural innovations due to the risk of eviction (Abdulai et al., 2011; Zeng et al., 2018). Furthermore, the role of land ownership in driving adoption varies (Wainaina et al., 2016; Bedeke et al., 2019). Production shocks are positively associated with agricultural innovation adoption, and different shocks interact differently with different SAPs. In the of Gebremariam & Tesfaye (2018), while production shock was positively associated with the adoption of organic fertilizers, it was negatively associated with the adoption of chemical fertilizers and irrigation practices.

2.10 Determinants of Cocoa Productivity and Technical Efficiency

This section explores the critical determinants of cocoa productivity and technical efficiency, drawing on relevant research studies and empirical evidence.

Effective farm management practices significantly impact cocoa productivity and technical efficiency. Adequate planting material selection, proper crop maintenance, and timely adoption of agronomic practices are essential for achieving higher cocoa yields. Niether et al. (2018) emphasized the importance of pruning, shade management, and effective weed control in cocoa farms. Furthermore, adopting integrated pest and disease management strategies, including resistant varieties, biocontrol agents, and proper chemical application, is crucial for reducing yield losses (Dara, 2019). Cocoa trees can become less productive as they age, with yields declining after reaching peak productivity. Aikpokpodion (2010) conducted a study in Nigeria and found that older cocoa trees exhibited lower yields compared to younger trees. They observed a decline in pod production, growth rate, and increased susceptibility to black pod disease as trees aged.

The availability and accessibility of quality inputs and appropriate technology are critical for enhancing cocoa productivity and technical efficiency. Access to improved cocoa varieties with high yield potential, disease resistance, and desirable quality traits is crucial. Wongnaa et al. (2022) demonstrated that adopting improved cocoa varieties significantly increased productivity in Ghana. Similarly, access to quality agrochemicals, fertilizers, and irrigation facilities can positively impact cocoa yields (Effendy et al., 2019).

Farmers' knowledge and skills play a significant role in cocoa productivity and technical efficiency. Education and training programs targeted at cocoa farmers can enhance their understanding of best practices, sustainable farming methods, and effective management techniques. Wonde et al. (2022) highlighted the positive impact of farmer training on productivity and income. Levai et al. (2015) highlighted the positive impact of farmer training on productivity and income. Training programs focused on integrated soil fertility management, pest and disease control, and post-harvest handling can improve cocoa yields and reduce losses.

Access to credit and market information is crucial for cocoa farmers to invest in productivity-enhancing inputs, adopt new technologies, and expand their operations. Studies have shown that limited access to credit is a significant constraint for cocoa farmers, hindering their ability to invest in farm inputs and improve productivity (Kehinde & Ogundeji, 2022). Moreover, access to market information, price transparency, and linkages to buyers and exporters enable farmers to make informed decisions, negotiate better prices, and reduce post-harvest losses (Neza et al., 2023).

The presence of well-functioning farmer organizations and effective extension services can contribute to cocoa productivity and technical efficiency. Farmer organizations can provide collective bargaining power, facilitate access to credit and inputs, and enable knowledge sharing among farmers. Studies have shown that farmer organizations are crucial in improving cocoa productivity and profitability (Amfo et al., 2021; Olagunju et al., 2021). Extension services, including agricultural advisory support, training, and dissemination of best practices, are instrumental in enhancing farmers' technical knowledge and skills (Cawley et al., 2018). Effective extension services can also promote adopting sustainable farming practices and facilitate technology transfer to cocoa farmers.

Various socioeconomic factors influence cocoa productivity and technical efficiency. Farm size and land tenure systems can affect farmers' incentives and investment decisions. Darkwah & Verter (2014) found a positive relationship between farm size and cocoa productivity in Ghana. Deininger & Jin, (2006) conducted a study in Ghana and found that farmers with land access and secure land tenure had higher investments in cocoa cultivation, leading to increased productivity and efficiency. Additionally, household characteristics such as education level, gender, and access to social capital can influence cocoa productivity. Gender disparities in access to resources, decision-making power, and training opportunities can also impact cocoa productivity (Danso-Abbeam, 2014).

Enhancing cocoa productivity and technical efficiency requires a multi-faceted approach considering various determinants. Climate and environmental factors, farm management practices, access to inputs and technology, farmer education and training, credit and market information, farmer organizations and extension services, and socioeconomic factors contribute to cocoa productivity.

2.11 Conclusion

The interaction between producer groups, sustainable agricultural practices, and the economic performance of Ghana's small-scale cocoa farmers is a complex and multifaceted issue. Rational choice theory has been used to understand farmers' decision-making processes better when adopting sustainable agricultural practices. According to research, adopting such practices is frequently influenced by the perceived benefits, costs, and risks involved, emphasizing farmers' rational decision-making processes in the context of their socioeconomic environment. Furthermore, social capital theory has shed light on the role of social networks, trust, and cooperation within producer groups, emphasizing their potential to facilitate knowledge sharing, resource pooling, and collective action among small farmers. Strong social networks within these groups, according to research, can promote the spread of sustainable practices and improve economic performance by increasing access to markets, technology, and financial resources.

The research on the Ghanaian cocoa industry reveals the historical significance of cocoa production in Ghana, as well as the pivotal role played by the Cocoa Board in regulating and promoting the industry. Low cocoa productivity, on the other hand, has been attributed to various factors, including poor farming practices, limited access to credit and inputs, and inadequate infrastructure. Producer groups have emerged as a potential solution to these challenges by providing technical assistance, training, and market access to small farmers. According to research, small farmer participation in producer groups has increased the adoption of sustainable cocoa practices, thereby increasing productivity and economic performance. Furthermore, the literature emphasizes the importance of factors such as education, access to information, farm size, and land tenure in influencing the adoption of sustainable agricultural practices and determining cocoa productivity and technical efficiency among Ghanaian small-scale farmers. Understanding these determinants is critical for developing effective policies and interventions to promote sustainable cocoa production and improve the livelihoods of Ghana's small farmers.

3. Research Objectives and Hypotheses

3.1 Research Objectives

The primary goal of this study is to assess the impact of producer groups on the adoption of sustainable cocoa practices and the economic performance of Ghanaian smallholder cocoa farmers. This study aims to elucidate the intricate relationship between membership in producer groups and the adoption of sustainable agricultural techniques and technical efficiency, specifically focusing on the cocoa farming sector, using a multifaceted approach. Furthermore, this study will investigate how sustainable agricultural techniques adoption affects the technical efficiency of small cocoa farmers. Specifically, the study aims to:

1. Analyze the impact of producer groups' participation on cocoa farmers' adopting sustainable cocoa practices (SCPs).
2. Analyze the impact of producer groups' participation on cocoa farmer's technical efficiency.
3. Determine the relationship between SCPs adoption and technical efficiency.

3.2 Research Hypotheses

The role of producer groups in Ghana's cocoa farming sector has received increased attention due to its potential impact on sustainable agricultural practices and the overall economic performance of smallholder farmers. Efficiency and sustainable production methods remain important empirical study subjects in Ghana's cocoa sector, where most farmers are resource poor (Binam et al., 2008; Aidoo & Fromm, 2015; Olagunju et al., 2021). Several studies have examined the positive relationship between the producer groups' participation and the adoption of sustainable agricultural practices (Abebaw & Haile, 2013; Verhofstadt & Maertens, 2014; Ma et al., 2018; Yu et al., 2021) and the economic performance of farmers (Mojo et al., 2017; Ahado et al., 2021; Olagunju et al., 2021). The research evaluates the impact of producer groups on the adoption of sustainable cocoa practices and the economic performance of smallholder cocoa farmers in Ghana based on the evidence from previous research.

1. H1: Participation in producer groups positively leads to greater adoption of SCPs among cocoa farmers.
2. H2: Active involvement in producer groups is positively associated with increased cocoa farmers' technical efficiency.
3. H3: There is a positive correlation between adopting sustainable cocoa practices (SCPs) and the technical efficiency of cocoa farmers.

3.3 Conceptual Framework

Figure 1 illustrates the effect of producer groups' participation (cooperatives or farmer associations) on the adoption of sustainable cocoa practices and the technical efficiency of the farmers (technical efficiency). The figure also shows how the adoption of SCPs intends to impact the technical efficiency of the farmers (technical efficiency).

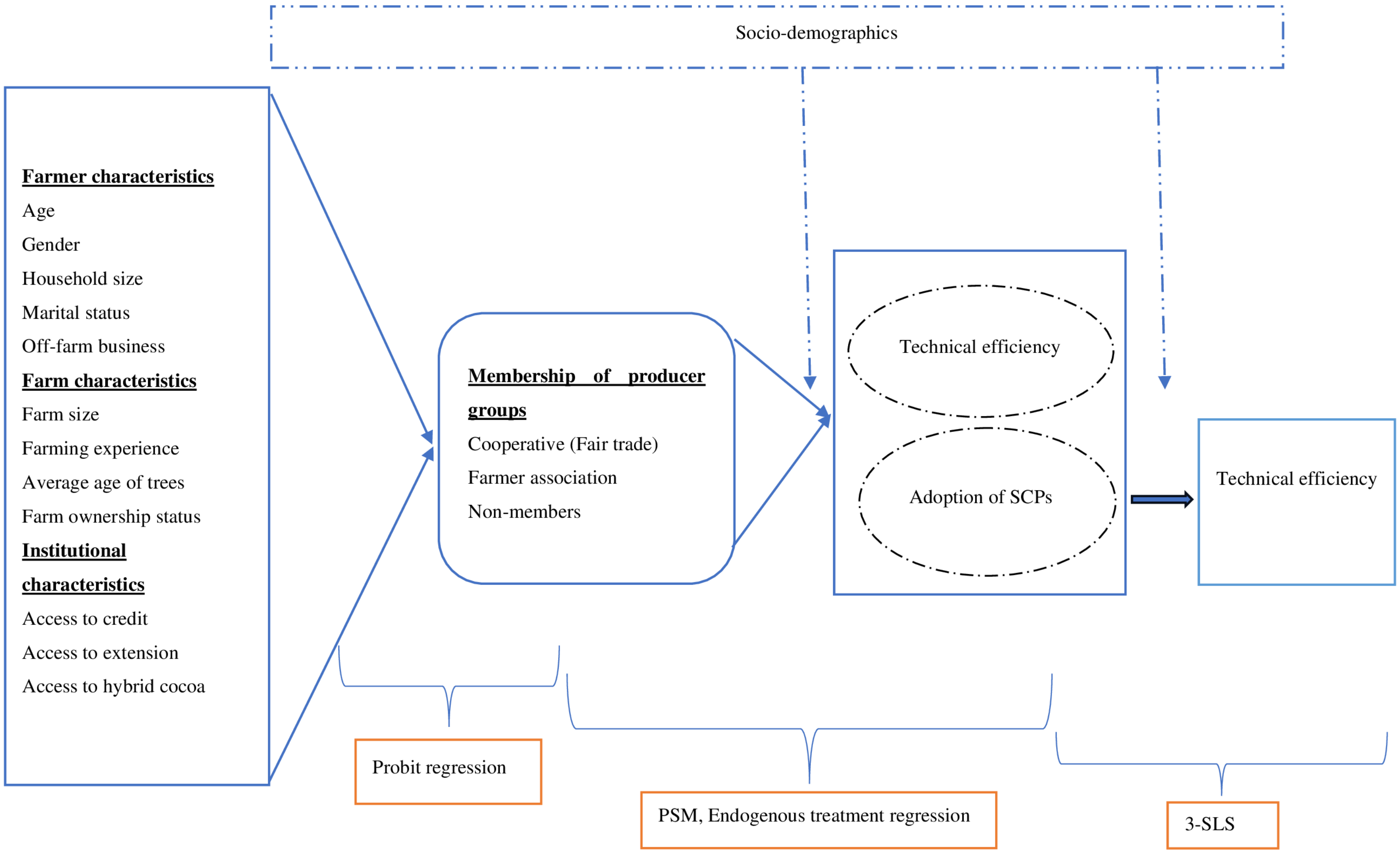
The study conceptualizes that participation in producer groups significantly affects the adoption of sustainable cocoa practices (Abebaw & Haile, 2013; Verhofstadt & Maertens, 2014; Ma et al., 2018; Yu et al., 2021) and the technical efficiency of the farmers (Mojo et al., 2017;Ahado et al., 2021; Olagunju et al., 2021).. However, the degree of sustainable cocoa practices' adoption and the technical efficiency is dependent on the type of producer group that the farmer participates in (Bray & Neilson, 2017). Small-scale cocoa farmers affiliated with cooperatives benefit from comprehensive training programs, workshops, and extension services, leading to an enhanced understanding of sustainable cocoa farming practices (Schulte et al., 2020). They have access to up-to-date market information, technological advancements, and best agricultural practices, contributing to improved decision-making and increased productivity. Even though other self-help farmer associations provide benefits and support farmers, the benefits of farmers in other associations are moderate compared to cooperative farmers. While the information provided may not be as extensive as that offered by cooperatives, it still contributes to a better understanding of basic agricultural practices, and resource mobilization contributes to improving the economic well-being of their members (Bizikova et al., 2020).

The adoption of sustainable cocoa practices directly influences various aspects of technical efficiency and productivity. Improved farming methods increase yields and better crop quality, resulting in higher production levels for farmers (Tennhardt et al., 2022).

The framework also shows how various socio-demographic factors, such as farmer characteristics, farm characteristics and institutional factors, affect farmers' decision to participate in producer groups (cooperative or farmer association) or not (Fischer & Qaim, 2012; Mojo et al., 2017; Ahado et al., 2021). The farmer chracterisitcs such as age, gender, household size, marital status, and engagement in off-farm businesses play significant roles. Older farmers may join producer groups to share their farming experience and knowledge, while younger farmers may see it as an opportunity for learning and networking. Gender dynamics also affect participation, with access to resources and decision-making power shaping both male and female farmers' involvement (Fischer & Qaim, 2012; Mojo et al., 2017; Ahado et al., 2021). Household size and marital status impact labor availability and resource pooling, affecting the feasibility of participating (Fischer & Qaim, 2012). Farm characteristics such as farm size, farming experience, average age of trees, and ownership status also influence participation. Farmers with larger farms or more experience may have different motivations for joining producer groups compared to those with smaller farms or less experience (Fischer & Qaim, 2012; Mojo et al., 2017; Ahado et al., 2021). Institutional characteristics, including access to credit, extension services, and hybrid cocoa varieties, further influence participation by providing resources, knowledge, and incentives to farmers (Fischer & Qaim, 2012; Mojo et al., 2017; Ahado et al., 2021).

Socio-demographics are also among the control variables that affect the adoption of SCPs and technical efficiency (Addai et al., 2014; Ma et al., 2018; Olagunju et al., 2021). Socio-demographic characteristics such as age, gender, household size and marital status influence farmers' attitudes and access to information and resources related to SCPs. Older farmers may be more resistant to change, while younger farmers may be more open to adopting new techniques (Wossen et al., 2017; Ma et al., 2018). Gender dynamics affect decision-making within households, potentially influencing the adoption of SCPs (Wossen et al., 2017). Household size impacts labor availability and resource allocation, affecting the feasibility of adopting SCPs (Wossen et al., 2017; Ma et al., 2018). Marital status may also influence resource distribution within households. Additionally, engagement in off-farm businesses may affect the time and resources available for adopting SCPs (Wossen et al., 2017; Ma et al., 2018). Farm characteristics such as farm size, farming experience, and average age of trees also play crucial roles. Larger farms may have more resources for investing in SCPs, while more experienced farmers may have better knowledge and skills for implementation (Wossen et al., 2017; Ma et al., 2018). Ownership status may impact farmers' incentives to invest in SCPs. Institutional characteristics, including access to credit, extension services, and hybrid cocoa varieties, significantly influence the adoption of sustainable cocoa practices (SCPs) among farmers (Wossen et al., 2017; Ma et al., 2018). Access to credit plays a vital role in providing farmers with the financial resources needed to invest in SCPs, such as purchasing sustainable inputs or equipment. Farmers who have access to credit are more likely to adopt SCPs as they can afford the initial costs associated with transitioning to sustainable farming practices. Furthermore, extension services provide farmers with essential information, training, and technical support related to SCPs.

Socio-demographic factors such as age, gender, household size, marital status, and engagement in off-farm businesses affect labor availability, decision-making dynamics, and resource allocation within households, impacting technical efficiency (Addai et al., 2014; Ahado et al., 2021; Olagunju et al., 2021). Farm characteristics such as farm size, farming experience, and average age of trees also play significant roles. Larger farms may benefit from economies of scale, while more experienced farmers may have better knowledge and skills for improving efficiency. The average age of trees can affect productivity levels. Ownership status may influence investment incentives and resource allocation decisions, further impacting technical efficiency. Access to credit, extension services, and hybrid cocoa varieties, provide farmers with the necessary resources, knowledge, and incentives to improve technical efficiency through better farming techniques and management practices.



Source: Author's construct

Figure 1. Conceptual framework

4. Methodology

4.1 Study Area

The study area is the Ashanti and Ahafo regions of Ghana (see Figure 2). The regions of Ashanti and Ahafo have total surface areas of around 24,389 square kilometres and 5193 square kilometres, respectively. With a heavy emphasis on cocoa planting as a principal agricultural activity, both regions of Ghana play a significant role in the agricultural production of the nation (Ghana Statistical Service[GSS], 2014). However, these areas also produce many other agricultural goods besides cocoa, substantially contributing to Ghana's total agricultural production.

The primary terrain type in both areas is distinguished by lush tropical forests and excellent soils, which make it ideal for growing various crops, including cocoa. Rich, reddish-brown earth soils are suitable for producing cash and food crops. The Ashanti Region's terrain also has gently rolling hills and undulating landscapes, which create ideal circumstances for various agricultural practices. Due to the availability of these rich lands, the area has grown to be a significant centre for producing cocoa, significantly boosting Ghana's total agricultural output (Ghana Statistical Service[GSS], 2014)

In terms of precipitation patterns, the area has a bimodal regime that is typical of the tropical climate of the nation. There are two separate rainy seasons in the area, from April to June and September to November, during which the region experiences substantial rainfall. In addition to the fertile soils of the area, these regular rainfall patterns also foster the growth of a wide variety of agricultural goods, including plantains, cocoa, and different food crops (Ghana Statistical Service[GSS], 2014). To maintain agricultural operations, the area may experience sporadic dry periods in the following months. In these cases, efficient water management and irrigation techniques will be required.

These regions are known for their significant contributions to Ghana's cocoa industry, and various producer groups, cooperatives, and associations are actively involved in supporting small-scale cocoa farmers and promoting sustainable agricultural practices (Ghana Statistical Service[GSS], 2014). The Ashanti and Ahafo regions have been the focus of numerous initiatives aimed at enhancing the productivity and livelihoods of cocoa farmers. These initiatives often involve the establishment of cooperative societies, farmer-based organizations, and community-led associations to facilitate knowledge sharing, provide access to resources, and promote collective bargaining power among small-scale farmers. These groups play a critical role in disseminating information on best farming practices, providing technical support, and advocating for the interests of their members within the cocoa supply chain.

These regions are significant contributors to Ghana's agricultural sector, with a substantial portion of their land dedicated to cocoa cultivation, making them key areas for studying the impact of sustainable cocoa practices on small-scale farmers and their overall technical efficiency. Almost all the communities in the districts are farming communities with an Agricultural Extension Agents (AEAs) ratio of 1:7,604 (Forestry Commission, 2022). With the higher AEA to farmer ratio, producer groups are vibrant in reaching out to cocoa farmers in the area. Training and workshops are organized through producer groups. Some of the key programs carried out via FBOs in the districts to improve cocoa production are the Cocoa Rehabilitation Program, Cocoa Diseases and Pest Control Program (CODAPEC), Cocoa HiTech (Fertilizer) Program, Free Hybrid Cocoa Seedling Distribution, Artificial Hand Pollination, Mass Cocoa

Pruning, Cocoa Management System (CMS) (Forestry Commission, 2022).

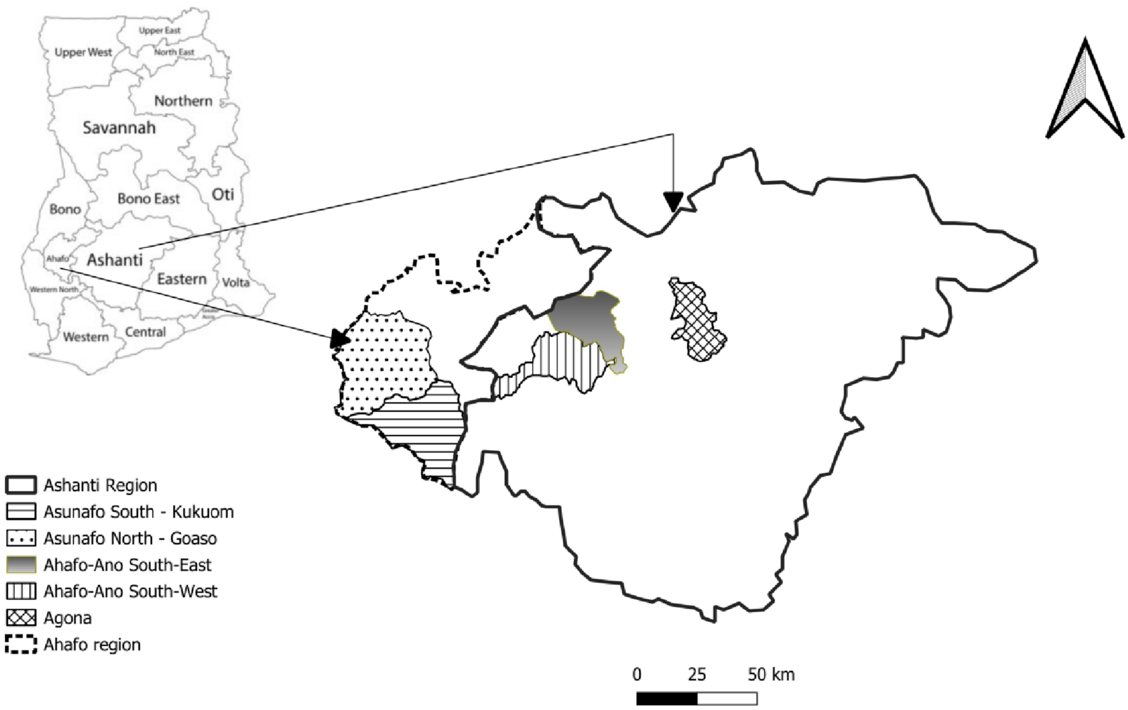


Figure 2. Map of study area

4.2 Data Collection and Sample Size

The target group for this study were smallholder cocoa farmers who were members and non-members of producer groups. Before the data collection, exploratory and transect walk was performed in April 2021 and August 2022 to understand better the topic and the type of sustainable agricultural practices that cocoa farmers adopt. For the producer groups, we focused on farmers who belong to cooperatives and farmer associations. Hence, the study used three groups for estimating the impact of producer groups on the adoption of SCPs and technical efficiency. Multi-stage sampling technique was used for the data collection. Firstly, purposive sampling technique was used to select 3 districts and 2 districts from the Ashanti and Ahafo regions, respectively. The 5 districts were selected with the help of agricultural extension officers in the two regions based on the existence of both cooperatives and other farmer associations. The 5 districts used in the study were Agona, Ahafo Ano Southwest, Ahafo Ano Southeast, Asunafo North and Asunafo south districts. The data was collected by obtaining a list of cocoa producer groups in the 5 districts from the district cocoa cooperative officers. 20 communities were purposively selected from the 5 districts based on the presence of cooperatives and farmer associations in the communities. In each producer group, ten members were randomly selected from the list of all members. In total, after data cleaning and removing missing data, 193 members of cooperatives and 144 members of other self-help farmer association were used for the analysis.

For the non-members, because we didn't have a list of the farmers, we used the purposive and convenience sampling technique to interview farmers in selected communities based on their availability during data collection. The non-members were identified with the help of extension agents and officers of LBCs at the community levels. In total, we interviewed 121 non-members. Therefore, the sample size for the study was 458 farmers. In addition to the questionnaire data collection, personal interviews were conducted with the producer groups' leaders and COCOBOD district officers to understand the support the producer groups provide to the members regarding training, awareness events and inputs. The data was collected from August 2023 to October 2023. In addition to the quantitative data, we collected qualitative data from the farmers to serve as a triangulation. Also, the non-members were interviewed to assess the reasons for non-participation in producer groups.

Data from Cocoa Health and Extension Division (CHED) of COCOBOD shows that there is an estimate of 40000 cocoa farmers in the selected cocoa district. This information was confirmed by the district manager of the Ministry of Food and Agriculture (MOFA). The sample size was thus calculated according to the formula;

$$(z^2 * p * (1-p)/e^2)/\left(1 + (z^2 * p * (1-p)/e^2 * N)\right)$$

Where z is the critical value of normal distribution at the required confidence level (1.96 for 5% confidence level), e is margin of error, p is sample proportion which is expressed as decimal, and N is the population size (400000 cocoa farmers). Considering p as 5% and e as 6%, the sample size would be 384. This means the sample size of 459 farmers is a good representation of the population. Table 2 shows summary of data collection from the 5 districts.

Table 2. Sample size estimation

Districts	No Coop	No. of FS	Members coop interviewed	Members FS interviewed	Non-members interviewed
Ashanti Region					
Agona	3	3	50	34	29
Ahafo South Ano East	2	2	42	25	20
Ahafo Soth Ano West	2	2	37	31	25
Ahafo Region					
Asunafo North	2	1	33	28	24
Asunafo South	2	1	31	26	23
Total	11	9	193	144	121

Note: Coop represents cooperatives and FS represents farmer associations

Data was collected on farmers' farms, households, institutional characteristics, and output of cocoa in the 2022 farming period. To ensure the accuracy and reliability of the cocoa output data, we triangulated the cocoa output data provided by the farmers with the records of the license buying companies officers in the communities since they have records of the quantity sold by each farmer for the farming period. The data on the traditional inputs for cocoa production (labour, agrochemicals, and farm equipment) were computed in monetary value for data reliability and accuracy purposes. The farmers were able to recall the cost incurred in the farming season on inputs as compared to the quantity they used. Inspiration for collection the traditional inputs in monetary value was obtained from Olagunju et al. (2021).

4.3 Empirical Analysis

4.3.1 Stochastic Production Frontier

This study employed the stochastic frontier model proposed by Aigner et al. (1977) and extended by Battese & Coelli (1995).

$$\ln(Y_i) = x_i\beta + v_i - u_i x_i = Z_i + \varepsilon_i \quad (1)$$

where, Y_i is the log value of the output of ith unit; x_i is a vector of exogenous and endogenous variables; x_i is an endogenous variable, Z_i is a vector of all exogenous variables associated with technical inefficiency of the production units, β is a vector of unknown coefficient, v_i and ε_i are two-sided error terms, while $u_i \geq 0$ is a one-sided error term which signposts inefficiency in production. The inefficiency component (u_i) is a log difference between maximum attainable output (y_i^*) and observed output (y_i), namely $u_i = \ln y_i^* - y_i$. The technical efficiency can be expressed as a ratio of observed output (y_i) to the frontier output $f(x_i;\beta)exp\{v_i\}$. This is maximum output feasible (with given technology) in an environment with stochastic element $\{v_i\}$. Since $u_i \geq 0$, this ratio lies between 0 and 1. The value 1 signifies that the firm can achieve maximum efficiency. TE $\leq$ 1 indicates a deficit of output from maximum feasible output within the given condition. This indicates that vi is stochastic and varies across households (Kumbhakar & Lovell, 2003):

$$TE_i = \exp(-u_i) = \frac{y}{y_i^*} = \frac{y_i}{f(x_i;\beta)exp\{v_i\}} \quad (2)$$

The Cobb Douglas function form of stochastic frontier analysis was estimated as:

$$ln(Y_i) = \beta_0 + \sum_{j=1}^{4} \beta_{jk} \, lnx_{ij} + (v_i - u_i) \qquad (3)$$

Here, ln is the natural logarithm, Y_i represents the cocoa output in 2022, k represents the number of inputs used, x_{ij} is input variables used by the ith farmer, and β is a vector parameter to be estimated. Also, the error term $\varepsilon_i = v_i - u_i$, where $u_i \geq 0$. The random error v_i accounts for stochastic effect is beyond the producers' control, measurement errors, or other statistical noise, and u_i measures the production inefficiency.

Producer group membership decisions are likely to be self-selected, which means it is correlated to inefficiency term ui, hence we adopted the propensity score matching and endogenous treatment regression model to account for the self-selection or observed bias.

4.3.2 Self Selection and Endogeneity Issues

The cocoa farmers may self-select into producer groups membership, unobserved characteristics such as inherent abilities, motivation and risk preference can potentially affect the decision to join producer groups and outcome variables under study. To fully address self-selection bias and endogeneity issues in estimating the impact of producer groups membership on outcomes of interest, the perception of benefits associated with participation in producer groups was used as an instrument. The instrument should affect participation in producer groups membership rather than adoption of sustainable cocoa practices and technical efficiency. The instrument was validated using a probit model for the selection equation and OLS regression for estimated yield and technical efficiency levels. The validity test result shows that the instrument affects producer groups membership ($LR(4)\chi2$=22.02,p=0.01) in equation but is not significant on sustainable cocoa practices ($F = 0.39, p = 0.560$ and $F = 2.04, p = 0.158$) for producer groups members and non-members, respectively and technical efficiency ($F = 0.04, p = 0.972$ and $F = 1.09, p = 0.406$) for producer groups members and non-members, respectively, using the matched sample.

It is important to note that farmers access to extension and participation in off-farm work pose an issue of endogeneity. Farmers could receive more extension visits due to producer group membership. Also, farmers may face challenges allocating resources to cooperative activities and off-farm work. Therefore, extension visits and off-farm work may be jointly determined with farmers' decision to participate in producer group memberships and thus making it potentially endogenous. These potential endogeneities in the analysis are corrected using the two-stage control function approach proposed by Wooldridge (2015). The first stage entails estimating separately the extension visits and off-farm work with identification variables and other explanatory variables employed in the probit model. In this case, the extension visits and off-farm work were the dependent variables in each scenario of the control function approach. In the case of extension visits, the number of farm plots owned by the farmer was the instrument. For the off-farm work, distance to the nearest market was the instrument. The instruments should significantly influence extension visits and off-farm work and not directly affect membership in the producer group. In the second stage analysis, the extension visits and the off-farm work variables, together with their predicted residuals from the first stage, are incorporated into the producer group membership probit model. The results of the endogeneity test are presented in the Appendix 1.

4.3.3 Producer Group Membership Decision

Probit Regression Model

The decision to join in producer group was modelled under the random utility theory, denoting that a farmer will choose to participate in producer group based on the perceived utility. Under the assumption of the risk-averse nature of farmers, their decision to participate in producer groups may be influenced by the perceived cost and benefits they will derive from the producer group.

The perceived benefits of participating in producer group can be represented by a latent variable D_J^* expressed as a function of the observed characteristics and attributes, denoted as Z in the following latent variable model:

$$D_J^* = Z_J\gamma + \varepsilon_J;\ D_J = 1\ if\ D_J^* > 0;\ D_J = 0\ if\ D_J^* \leq 0 \qquad (4)$$

where D_J^* is a dummy variable that equals 1 for producer group membership and 0 for non-membership; γ represents the estimated parameters. ε is the error term with a mean of zero; Z represents the factors that influence farmers decision to participate. We estimated three binary models. The first model is farmer's decision to participate in cooperative or other self-help farmer association, the second model represents farmer's decision to participate in cooperative or a non-member of any group and the third model is about farmer's decision to participate in other self-help farmer association or a non-member of any group.

The binary choice model was estimated by using the probit regression model. Based on the existing evidence in the literature, the independent variables potentially influencing the farmers' participation in producer groups were the socio-demographic characteristics.

Narrative Analysis

In terms of analysing the qualitative interviews of the non-members as to why they don't join producer groups, the study used the narrative analytical approach to draw valuable insight from the farmers response.

4.3.4 Propensity Score Matching

PSM was adopted to control selection bias due to the observable characteristics between the members and non-members (Rosenbaum & Rubin, 1983).

In the first stage, propensity scores or covariates $\mathrm{P(x)}$ were generated from a probit regression model to show the probability of farmers to participate in producer group. The decision to join in producer group was modelled under the random utility theory, denoting that a farmer will choose to participate in cooperative based on the perceived utility. Under the assumption of the risk-averse nature of farmers, their decision to participate in cooperatives may be influenced by the perceived cost and benefits they will derive from the integration strategy.

As the second step of our analysis, we constructed a control group by matching members and non-members according to the generated propensity scores. Members and non-members whom we could not find appropriate matches were then be dropped. The impact of participation in the cooperative on the outcome variables (y) was estimated using matched observations. Empirically, ATT is represented as:

$$ATT = E_{P(X)(C=1)}\{\mathrm{E[y\ (1)|C = 1, P(x)]|} - \mathrm{[E\ y(0)|C = 0, P(x)]} \qquad (5)$$

where y(1) and y(0) are the outcomes for those farmers in the treated and control groups without treatment, respectively, while C=1 for treated farmers and C=0 for control farmers. The difference between the two outcomes refers to the treatment effect on the treated (ATT).

4.3.5 Endogenous Treatment Regression Model

The PSM only influences observable elements that determine producer group participation, not unobservable factors such as a farmer's motivation to engage in a group. We employed the endogenous treatment regression model to increase the robustness of our analysis. To account for selection bias, the endogenous treatment regression model was used to estimate the influence of producer group participation on adopting sustainable cocoa practices and technical efficiency. Supposing the impact of producer group membership is Y_m, and the endogenous treatment is t_m, the outcome equation for the endogenous regression was estimated as follows:

$$Y_m = X_m\beta + \delta t_m + \varepsilon_m, \text{ and } t_m = \begin{cases} 1, if\ w_m\lambda + u_m > 0 \\ 0, if w_m\lambda + u_m \leq 0 \end{cases} \quad (6)$$

where X_m are the covariates that affect SCPs awareness and adoption and technical efficiency and yield, and w_m refers to the covariates used to model the producer group membership. The covariates x_m and w_m are exogenous. ε_m and u_m are error terms that are bivariate normal with a mean of zero, and the covariate matrix is as follows:

$$\begin{bmatrix} \sigma^2 & \rho^\sigma \\ \rho^\sigma & 1 \end{bmatrix} \quad (7)$$

The likelihood function for observation m of the endogenous treatment regression model was estimated as follows:

$$lnL_m = \begin{cases} ln\phi\left\{\frac{w_m\lambda + (y_m - x_m\beta - \delta)\rho/\sigma}{\sqrt{1-\rho^2}}\right\} - \frac{1}{2}\left(\frac{y_m - x_m\beta - \delta}{\sigma}\right)^2 - \ln\left(\sqrt{2\pi}\sigma\right) & t_m = 1 \\ ln\phi\left\{\frac{-w_m\lambda - (y_m - x_m\beta - \delta)\rho/\sigma}{\sqrt{1-\rho^2}}\right\} - \frac{1}{2}\left(\frac{y_m - x_m\beta}{\sigma}\right)^2 - \ln\left(\sqrt{2\pi}\sigma\right) & t_m = 0 \end{cases} \quad (8)$$

where $\phi(.)$ is the cumulative distribution function of the standard normal distribution. The ATE estimates from the treatment regression model maximum likelihood estimation can be used as ATT when the outcome is not conditionally independent of the treatment (StataCorp, 2017). The study adopted two endogenous treatment models (SCPs adoption and technical efficiency).

4.3.6 Three Stage Least Square Regression Model

The three-stage least square regression model was used to examine the influence of adopting sustainable cocoa practices on the productivity and efficiency of cocoa growers. The three-stage least square (3SLS) estimator was utilized instead of the two-stage least square (2SLS) estimator. The main disadvantage of utilizing 2SLS is that the distribution of error terms is wasteful, according to Greene (2012). As a result, we used 3SLS to confirm the accuracy of the estimations and to address the endogenous relationship between producer group membership and cocoa farmers' performance (production and efficiency) through the adoption of sustainable cocoa practices.

Following Makate & Makate (2019), the productivity and efficiency model was expressed as;

$$FP = \alpha_0 + \alpha_1 SCP + \delta X + \varepsilon \qquad (9)$$

where FP represents productivity and technical efficiency of the cocoa farmers, SCP is sustainable cocoa practices adoption, PM is producer groups participation, X is a vector of institutional and socioeconomic and farm characteristics of the cocoa farmers.

The structural equations for the instrumental variables' estimation are given as;

$$SCP = \beta_0 + \beta_1 PM + \beta_2 X + \delta Z + u_i \qquad (10)$$

where Z is an instrument that is correlated with the error term but uncorrelated with the outcome variables. A critical requirement in IV estimation is that the equations be identified (i.e., there is enough information to estimate the structural parameters of interest in the models consistently). We needed to include identifying variables such as farmers' perceived economic and social benefits from producer group membership. When the number of exogenous variables excluded from a specific equation is equal to or more than the number of endogenous variables less than one, identification is guaranteed.

4.4 Description of Variables in the Study

4.4.1 Description and Summary of Outcome Variables

The study aimed to use both production and post-harvest side of sustainable cocoa production but based on the summary of the outcome variables of the study sample, the study focused on farmers' adoption of production sustainable cocoa practices. The production sustainable practices considered in the study were farm, pest, and disease management (pruning), agrochemicals management (the use of approved agrochemicals on the Ghana COCOBOD approved list), and deforestation management (planted shade trees and retention of trees on the farm). These sustainable production practices are compulsory practices to be implemented by cocoa farmers in Ghana (Foundjem-Tita et al., 2016; Fairtrade International, 2022; Rainforest Alliance, 2022). Based on the findings from the exploratory research and interviews with farmers in 2021 and 2022, this study decided to use these three SCPs. From the exploratory data collection, the cocoa extension officers highlighted that the main practices adopted by cocoa farmers in Ghana were the abovementioned practices. We measured technical efficiency as technical efficiency. Table 3 below shows the description of the outcome variables of this study.

Table 3.Description of outcome variables

Variable	Description	Measurement
Dependent Variables ***SCPs***		
Pruning	Farmer practiced pruning in the last three years. Removing dead, diseased, or overcrowded branches. It encompasses improved tree health, enhanced yields, pest and disease management, and sustainable agricultural practices (Rainforest Alliance, 2020).	5 points ordinal scale with 5 as highest and 1 as lowest
Shade trees	Farmer planted shade trees or retained treees on the farm in the last three years. Besides buffering cocoa plants, shade trees also enhance soil fertility due to leaf shedding and pruning residues. These enrich the soil in organic matter and recycle nutrients and reduce soil erosion. (UNDO, 2021)	5 points ordinal scale with 5 as highest and 1 as lowest
Agrochemicals	Farmer used only COCOBOD approved agrochemicals in the last three years on the farm. These agrochemicals have high efficacy and low environmental toxicity (Adejori, 2022). Approved agrochemicals are subject to strict regulatory standards that ensure their safety for human health and the environment. By using these approved products, cocoa farmers adhere to the recommended guidelines and minimize the potential negative impact of agrochemicals on the environment and surrounding ecosystems.	5 points ordinal scale with 5 as highest and 1 as lowest
Fermenting and drying	Farmer ferment and dry cocoa beans according to the standards. Fermenting and drying the cocoa according to the 5-7 days standard by COCOBOD are crucial for enhancing the flavour and aroma of cocoa beans (Dzelagha et al., 2020). Proper fermentation and drying lead to the development of desirable cocoa flavours, which can ultimately fetch higher prices in the international market. This can contribute to the economic sustainability of cocoa farming communities, leading to improved livelihoods for the farmers and their families.	Number of days for fermenting and drying cocoa.
Technical efficiency		
Yield	Quantity of cocoa harvested in 2022 season (Kg) divided by number of trees on the farm	Kg/tree

Table 4 presents a summary of the outcome variables used in the study. The degree of adoption of production side SCPs by the producer groups (cooperatives and farmer associations) was higher than the non-members of a group. However, the level of adoption of the SCPs by the cooperative members was higher than that of the farmer association members. For the post-harvest SCPs, all the groups follow the quality standard of Ghana COCOBOD which is 5-7 days for drying and fermentation, respectively. In terms of technical efficiency, the yield of the producer groups was higher than the non-members, but the members of cooperatives had higher yields than the members of the farmer association. Based on the summary of the outcome variables, the study used only the production SCPs and the technical efficiency for the analysis.

Table 4. Summary of outcome variables

Variables	Pool	Coops	Farmer asso.	Non-members
Production SCPs				
Pruning	4.34 (1.14)	4.76 (0.61)	4.58 (0.76)	3.38 (1.55)
Shade trees	3.76 (1.23)	3.83 (1.31)	3.77 (1.13)	3.62 (1.19)
Agrochemicals	4.28 (1.16)	4.83 (0.49)	4.50 (0.90)	3.12 (1.38)
Post Harvest SCP				
Fermentation	6.19 (0.72)	6.30 (0.63)	6.11 (0.77)	6.15 (0.78)
Drying	5.37 (1.08)	5.72 (1.01)	5.14 (1.06)	5..09 (1.05)
Technical efficiency				
Yield (Kg/tree)	1.53 (1.16)	1.69 (1.41)	1.53 (1.01)	1.25 (0.66)

*** p<.01, ** p<.05, * p<.1 Standard deviation reported in parentheses

4.4.2 Description and Summary of Independent Variables

Based on a review of the empirical literature, the variables in Table 5 were used as independent variables for the various models of the study. Inspiration was obtained from (Addai et al., 2014; Wossen et al., 2017; Ma & Abdulai, 2019; Ahado et al., 2021). Table 5 below shows the variables used in the study and their description and measurements. Table 6 also summarizes the independent variables used in the study.

Table 5. Description of independent variables

Variable	***Description and measurement***
Farmer characteristics	
Age	Age of respondent
Gender	Sex of respondent (male=1)
Household size	Number of people in the house
Education	Years of farmer education
Off-farm job	Farmer involved in an off-farm business (yes=1)
Farm characteristics	
Farm size	Size of the cocoa farm (Ha)
Age of trees	The average age of cocoa trees (years)
Cocoa land ownership	Owner of cocoa farmland (yes=1)
Sharecropping	If not owner of the cocoa land, what is the sharecropping agreement with the land owner (Abunu=1)
Institutional factors	
Extension	Number of times a farmer receives extension visits in the 2022 farming period
Hybrid cocoa	Farmer gets access to hybrid cocoa
Access to credit	Farmer get access to credit (yes=1)
Farmer perceived factors	
Trust	Farmer level of trust for other people in the community (5 points ordinal scale with 5 as highest and 1 as lowest)
Perceived economic benefits	Farmer perception about the economic benefits of producer groups (5 points ordinal scale with 5 as highest and 1 as lowest)
Perceived social benefits	Farmer perception about the social benefits of producer groups (5 points ordinal scale with 5 as highest and 1 as lowest)
Variables used for	

Stochastic frontier

Agrochemical cost	The total cost of agrochemicals used for cocoa production in 2022 (GHS
Farm equipment cost	The total cost of cocoa farm equipment used for cocoa production in 2022 (GHS
Labour cost	The total cost of labour used for cocoa production in 2022 (GHS)

Table 6. Summary of independent variables

Variables	Pool	Coops	Farmer asso.	Non-members
Farmer characteristics				
Age	51.2 (24.64)	51.13 (14.27)	51.42 (14.46)	51.22 (41.68)
Gender	0.63 (0.48)	0.61 (0.49)	0.64 (0.48)	0.67 (0.47)
Household size	5.45 (2.60)	5.70 (2.68)	5.19 (2.71)	5.35 (2.31)
Education	6.86 (5.73)	7.08 (5.88)	7.64 (5.86)	5.57 (5.15)
Off-farm job	0.84 (0.37)	0.79 (0.41)	0.81 (0.39)	0.95 (0.22)
Farm characteristics				
Farm size	2.31 (2.10)	2.48 (2.60)	2.41 (1.91)	1.92 (1.22)
Age of trees	15.36 (63.05)	18.95 (95.59)	11.52 (16.09)	14.12 (10.54)
Cocoa land ownership	0.72 (0.45)	0.80 (0.40)	0.77 (0.42)	0.54 (0.50)
Sharecropping (Abunu)	0.39 (0.27)	0.37 (1.24)	0.29 (0.21)	0.48 (0.36)
Institutional factors				
Extension	2.73 (2.50)	3.37 (2.77)	2.92 (2.41)	1.49 (1.46)
Hybrid cocoa	0.83 (0.37)	0.86 (0.35)	0.83 (0.37)	0.79 (0.41)
Access to credit	0.21 (0.40)	0.23 (0.42)	0.20 (0.40)	0.17 (0.38)
Farmer perceived factors				
Trust	4.10 (1.10)	4.11 (1.06)	4.06 (1.18)	4.13 (1.09)
Perceived economic benefits	3.63 (1.28)	4.27 (0.78)	3.94 (0.95)	2.16 (1.40)
Perceived social benefits	3.61 (1.35)	4.33 (0.66)	3.78 (1.23)	2.33 (1.12)

Variables used for Stochastic frontier				
Agrochemical cost	644.98 (642.36)	790.34 (829.37)	597.30 (440.05)	469.47 (412.94)
Farm equipment cost	335.90 (453.85)	291.23 (321.45)	360.02 (598.83)	378.44 (431.35)
Labour cost	1309.66 (1688.31)	1227.11 (1677.51)	1236.28 (1581.18)	1528.63 (1818.68)

*** p<.01, ** p<.05, * p<.1 Standard deviation reported in parentheses

4.5 Data Analytical Tools and Test of Hypotheses

The study used stata version 15, SPSS version 29 and Microsoft excel 365 as the main tools to analyze the data. The normality test (Shapiro-Wilk) showed that the data is normally distributed. Pearson Correlation test was conducted among the independent variables used in the study and there was issue of multicollinearity.

Cobb-Douglas Stochastic Frontier

In agricultural production economics research, various mathematical models are used to assess efficiency. Among these models, the most utilized ones are the Cobb-Douglas and translog models. We performed a likelihood ratio (LR) test to compare these two mathematical models. Also, we tested if there is presence of inefficiency in the stochastic production function (Table 7). The LR test statistic was calculated using the formula: $\text{LR} = -2\{\ln[H_0] - \ln[H_1]\}$. H_0 was determined by the log-likelihood value for the translog model, while H_1 represented the alternative hypothesis and was determined by the log-likelihood value for the Cobb-Douglas model. The results of the test indicated that the null hypothesis for the translog model was rejected at a 5% significance level. This suggests that the Cobb-Douglas Stochastic Frontier Production Function is a more suitable model for analyzing the survey data in the study areas. Consequently, this study utilized the Cobb-Douglas function specification to draw conclusions.

The likelihood test ratio for the null hypothesis of no technical inefficiency in the stochastic production frontier model is significantly different from zero. The likelihood ratio test also led to the rejection of the null hypothesis H0 at a 5% significance level. This rejection implies that there is indeed inefficiency present in the study areas, and it suggests that the traditional average response function was not a sufficient representation of the data.

Table 7. Hypothesis testing for functional form selection

Null hypothesis	Test statistic	P-value	Decision
$H0 : \beta1 = \beta2 = ... = \beta n = 0$	Test for Cobb–Douglas vs translog model		
	$\chi2\ (10) = 73.55$	0.000	Rejected H0
Sigma_u = 0	Test for absence of technical inefficiency		
	$\chi2(01) = 77.90$	0.000	Rejected H0

Propensity Score Matching

After matching, the substantial overlap in the distribution of propensity scores, as shown in (Figure 3,4 and 5), indicates that the condition of common support has been fulfilled (Fischer & Qaim, 2012; Mojo et al., 2017). The majority of the active members are comparable to the passive members. Additionally, the balancing properties of the PSM indicate that the matching is of good quality. The test shows that the mean bias and median bias have been reduced (the radius and kernel algorithms are not significant).

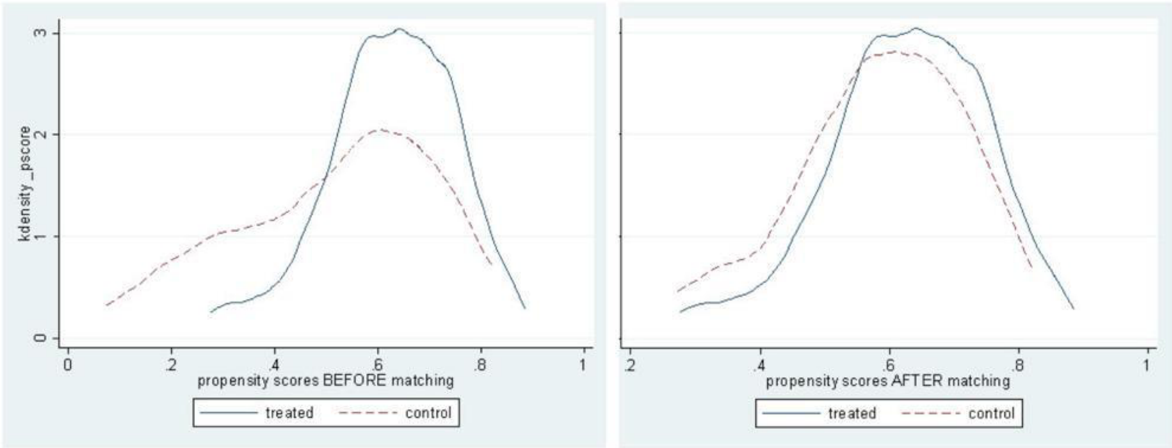


Figure 3. Members of cooperative and members of farmer association

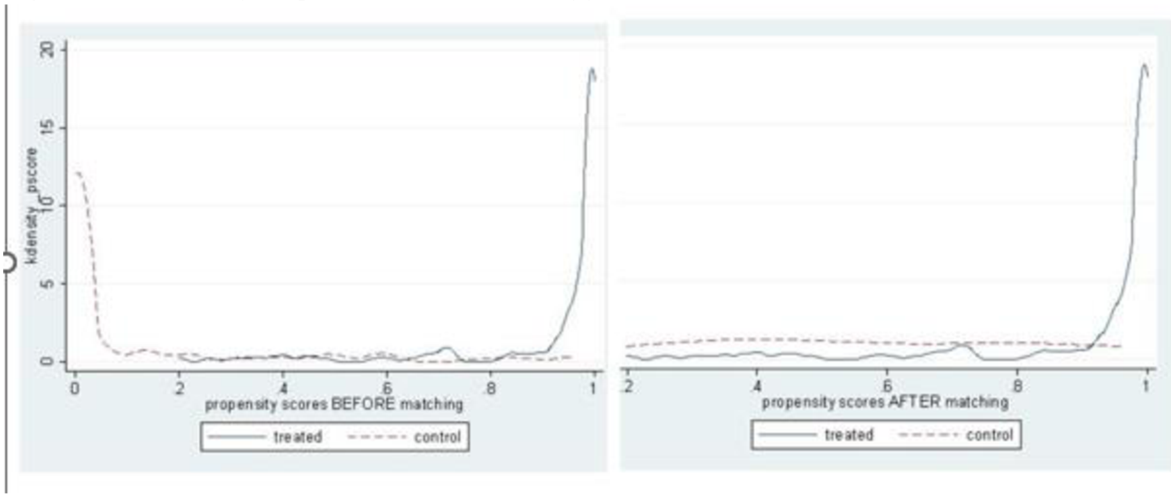


Figure 4. Members of cooperative and non-members of producer groups

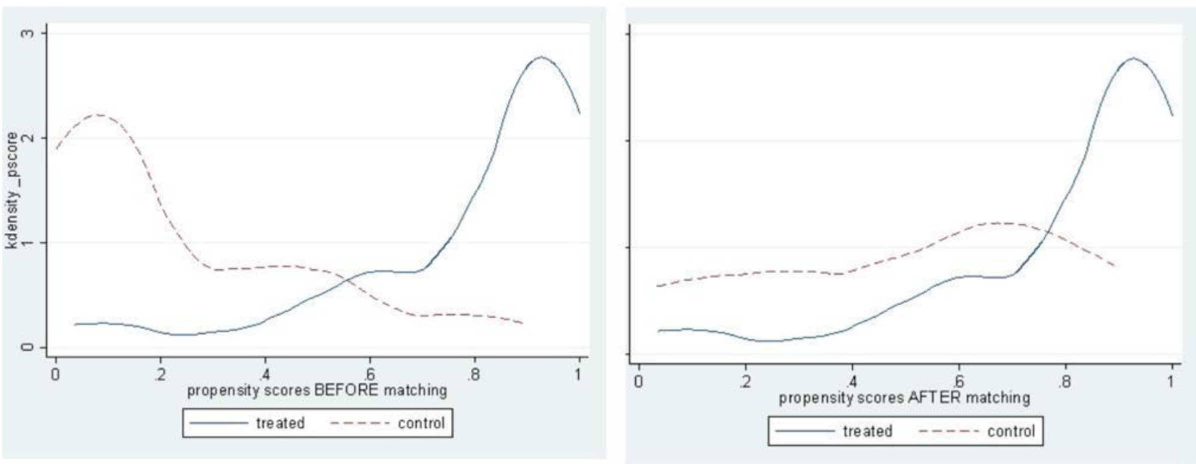


Figure 5. Members of farmer association and non-member of producer Groups

Endogenous Treatment Regression

The likelihood ratio tests of joint independence are significant at 1% probability levels for all the models, indicating that the two equations are dependent on each other. The signs and significance of the error of correlation terms show that the covariance terms of cooperative membership are statistically significant. This means that self-selection occurred, hence the relevance of adopting the linear regression with endogenous treatment regression model.

5. Results

5.1 Determinants of Producer Groups Membership

The analysis reveals several significant determinants influencing farmer participation in cooperative or self-help farmer associations (Table 8). Household size emerges as a critical factor, with larger households exhibiting a greater propensity to engage in collective action, potentially driven by perceptions of increased benefits from collaboration. Additionally, farmers' perceptions of the advantages they anticipate from joining the producer group play a crucial role, with positive perceptions likely to encourage participation. Furthermore, farmers' frequency of extension service significantly influences participation decisions, indicating that greater exposure to information and support may enhance understanding of cooperative benefits and foster participation.

According to the cooperative and non-membership model, several key factors influence farmers' decisions regarding cooperative involvement or non-participation. Among these factors, female farmers play a significant role, as their participation patterns reflect broader socio-economic dynamics and access to resources within agricultural communities. Moreover, farmers' perceptions of the economic and social benefits they anticipate from joining the producer group are pivotal determinants. Positive perceptions, such as expectations of improved market access, enhanced bargaining power, and social cohesion, are likely to motivate cooperative involvement. Additionally, the frequency of extension assistance obtained by farmers emerges as a crucial factor, with higher levels of engagement indicating greater exposure to knowledge and support systems that may encourage cooperative participation.

From the farmer association and non-membership model, farmers' decisions regarding membership or non-membership in a farmer association are significantly influenced by their perceptions of the economic and social benefits they expect to derive from the producer group and the frequency of extension service received. Positive perceptions of benefits, such as anticipated improvements in market access, increased knowledge sharing, and enhanced social capital, are likely to incentivize farmers to become members of the association. Moreover, the frequency of extension service received plays a crucial role, as it indicates the level of support and access to information available to farmers, which can influence their understanding of the benefits of association membership.

Table 8. Determinants of producer groups

Variables	Coop and farmer asso. Coef.	Coop and non-members Coef.	Farmer asso. and non-members Coeff
Gender	-0.13 (0.16)	-0.71 (0.34)**	-0.32 (0.25)
Age	0.01 (0.01)	-0.03 (0.03)	0.02 (0.04)
Education	-0.02 (0..02)	-0.01 (0.02)	0.02 (0.02)
Cocoa land ownership	0.14 (0.20)	0.42 (0.38)	0.22 (0.25)
Household size	0.05 (0.03)*	-0.04 (0.06)	-0.03 (0.04)
Farm size	0.03 (0.03)	0.03 (0.09)	0.05 (0.07)
Perceived economic benefits	0.32 (0.09)***	1.138 (0.18)***	0.312 (0.093)***
Perceived social benefits	0.09 (0.10)	0.68 (0.13)***	0.42 (0.09)***
Trust	0.03 (0.10)	-0.01 (0.14)	-0.01 (0.11)
Extension	0.05 (0.03)*	0.30 (0.11)***	0.17 (0.07)**
Off-farm job	-0.14 (0.20)	-0.60 (0.45)	-0.60 (0.34)
Off- farm residual	-3.54 (1.74)**	1.09 (2.60	5.31 (2.10)*
Extension residual	0.16 (0.19)	0.22 (0.37)	0.01 (0.27)
Constant	-2.23 (0.76)***	-6.66 (1.40)***	-2.98 (0.73)***
Number of obs.	337	314	265
P-value	0.00	0.00	0.00
Pseudo R-square	0.21	0.76	0.48

*** p<.01, ** p<.05, * p<.1 Standard deviation reported in parentheses

5.1.1 Reasons for Non-membership of Producer Groups

Qualitative interviews were conducted with the non-members of the producer groups, and they highlighted that they didn't join the producer group based on the factors highlighted in Figure 6. From the qualitative interviews, the four main factors that the non-members indicated as reasons for not joining producer groups were the uniform pricing of cocoa in the country, the logistical challenges associated with accessing producer groups, perception of requirements for group participation as burdensome or restrictive, and the ability to sell to producer groups without formal membership.

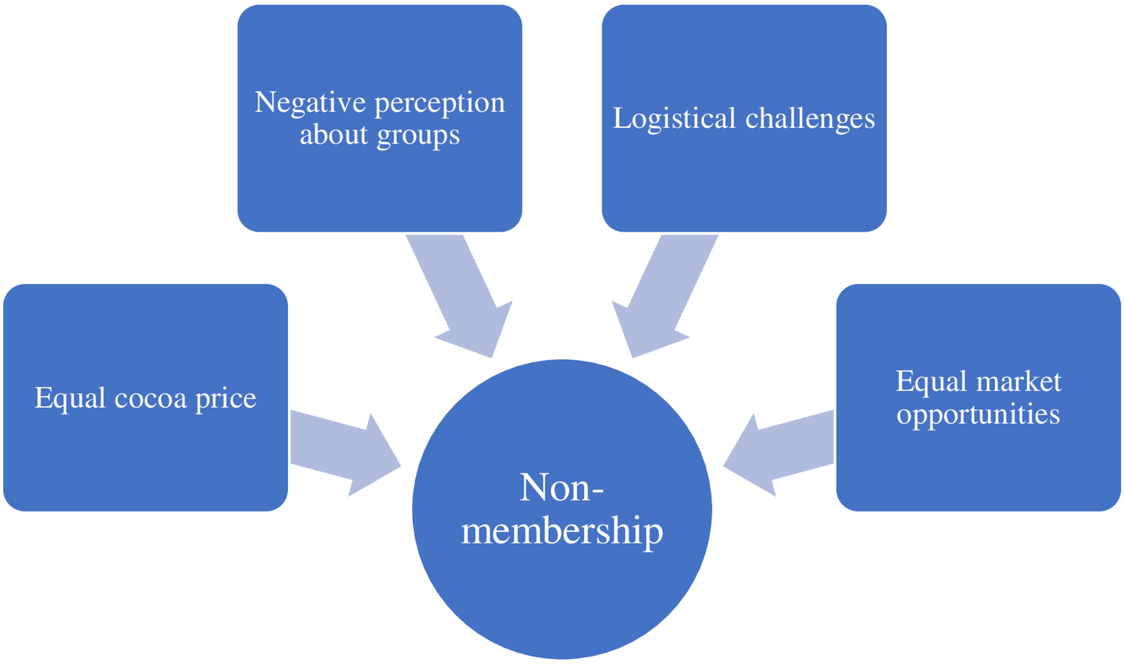


Figure 6. Reasons for not joining producer groups by cocoa farmers

5.2 Impact of Producer Groups on the Adoption of Sustainable Cocoa Practices by Cocoa Farmers

5.2.1 PSM Estimates of the Impact of Producer Groups Membership on SCPs

The PSM estimate indicates that the producer group membership (cooperatives and farmer associations) positively correlates with farmers adoption of sustainable cocoa practices. It is evident that cooperative membership significantly influences farmers' adoption of SCPs compared to farmer association membership. While farmer participation in farmer associations does not yield higher adoption of SCPs as compared to the cooperative membership, the members of farmer associations have higher adoption rates of SCPs as compared to farmers who do not belong to any group. The PSM estimate highlights a positive relationship between membership in producer groups, encompassing cooperatives and farmer associations, and the adoption of sustainable cocoa practices. This finding suggests that farmers who are affiliated with such groups are more inclined to embrace sustainable farming methods in their cocoa production.

However, when examining the adoption of planting shade trees, no significant influence was observed among members of cooperatives and farmer associations and between members of farmer associations and non-members. Similarly, no significant influence was detected between cooperative members and non-members regarding pruning. Table 9 showcases the PSM estimates of sustainable cocoa practices; these findings suggest that membership in producer groups may not necessarily correlate with adopting specific practices such as planting shade trees or pruning. This lack of significance may indicate other factors at play or variability in the effectiveness of producer groups in promoting certain sustainability practices within the cocoa industry.

Table 9. PSM estimates of SCPs.

		Cooperative	Farm ass.	ATT	S.E.	T-stat
	Kernel	4.77	4.52	0.25	0.08	3.02**
Pruning	Radius	4.77	4.53	0.24	0.08	2.88**
	Kernel	3.85	3.77	0.06	0.15	0.52
Shade trees	Radius	3.85	3.77	0.06	0.15	0.53
	Kernel	4.83	4.49	0.40	0.10	3.44***
Agrochemicals	Radius	4.83	4.50	0.34	0.10	3.42***
		Cooperative	**Non-members**	**ATT**	**S.E.**	**T-stat**
	Kernel	4.77	4.36	0.41	0.11	0.49
Pruning	Radius	4.77	4.34	0.43	0.11	0.50
	Kernel	3.83	1.45	2.38	0.89	2.68***
Shade trees	Radius	3.83	1.40	2.43	0.92	2.63**
	Kernel	4.83	3.25	1.58	0.77	2.07**
Agrochemicals	Radius	4.83	3.32	1.50	0.77	1.91*
		Farm ass.	**Non-members**	**ATT**	**S.E.**	**T-stat**
	Kernel	4.65	3.86	0.79	0.52	1.50
Pruning	Radius	4.67	3.80	0.87	0.46	1.90*
	Kernel	3.76	3.73	0.03	0.44	0.07
Shade trees	Radius	3.74	3.62	0.12	0.38	0.32
	Kernel	4.53	2.62	1.91	0.47	4.03***
Agrochemicals	Radius	4.51	2.69	1.82	0.41	4.41***

**** p<.01, ** p<.05, * p<.1*

5.2.2 Endogenous Treatment Effect Estimation of the Impact of Producer Groups Membership on SCPs

The estimates from the linear regression with the endogenous treatment effect model (refer to Table 10) align closely with the results obtained from the Propensity Score Matching (PSM) estimates. The findings from the linear regression with the endogenous treatment effect model confirm that participation in producer groups correlates significantly with the adoption of Sustainable Cocoa Practices (SCPs). However, the effects vary between members of cooperatives and farmer associations.

Specifically, the model for cooperatives and farmer associations reveals that membership in a cooperative correlate significantly and positively with the degree of adoption of SCPs, including pruning, planting shade trees, and using approved agrochemicals.

Moreover, factors beyond producer group membership significantly influence the adoption of SCPs in Ghana. The analysis indicates that several variables in the model significantly affect the adoption of at least one of the SCPs examined in the study.

Regarding pruning adoption, variables such as the farmer's age, household size, and age of cocoa trees exhibit significant positive influences on farmers' adoption.

Similarly, for planting shade trees or retaining trees on cocoa farms, cocoa land ownership and respondents' gender emerge as significant positive determinants. However, the age of cocoa trees significantly negatively affects this aspect of adoption.

Regarding the use of approved agrochemicals, the age of respondents, the age of cocoa trees, and involvement in off-farm business are significant positive influencers. Conversely, farm size shows a significant negative influence on farmers' use of approved agrochemicals.

Table 10. Endogenous treatment regression estimates of SCPs

	Coop and Farmer ass			Coop and non-members			Farmer ass and non-members		
Variables	Shade trees	Pruning	Agrochems	Shade trees	pruning	Agrochems	Shade trees	pruning	Agrochems
Age	-0.07 (0.05)	0.02 (0.03)	0.03 (0.03)	0.01 (0.02)	0.04 (0.02)**	0.03 (0.02)*	0.01 (0.02)	0.04 (0.02)**	0.03 (0.02)*
Gender	-0.11 (0.15)	-0.09 (0.09)	0.08 (0.10)	0.32 (0.10)***	-0.18 (0.14)	0.004 (0.16)	0.33 (0.10)***	-0.18 (0.14)	0.04 (0.12)
Household size	0.01 (0.03)	0.04 (0.02)***	-0.02 (0.02)	0.03 (0.02)	0.06 (0.03)**	-0.04 (0.22)	0.03 (0.02)	0.06 (0.03)**	-0.04 (0.22)
Education	-0.09 (0.01)	0.05 (0.07)	-0.08 (0.08)	0.01 (0.09)	0.01 (0.01)	0.01 (0.01)	0.01 (0.09)	0.01 (0.01)	0.01 (0.01)
Cocoa land ownership	0.36 (0.17)**	-0.10 (0.10)	-0.07 (0.11)	0.29 (0.11)**	-0.06 (0.15)	-0.11 (0.12)	0.29 (0.11)**	-0.06 (0.15)	-0.11 (0.12)
Farm size	-0.03 (0.03)	0.01 (0.02)	-0.03 (0.02)*	-0.01 (0.02)	0.03 (0.03)	0.02 (0.02)	-0.01 (0.02)	0.03 (0.03)	0.02 (0.03)
Extension	0.01 (0.03)	-0.02 (0.02)	-0.01 (0.02)	-0.02 (0.02)	-0.01 (0.03)	0.02 (0.02)	-0.02 (0.02)	-0.01 (0.03)	0.02 (0.02)
Age of cocoa tree	-0.02 (0.01)***	0.02 (0.01)***	0.02 (0.01)***	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)
Off-farm job	0.19 (0.18)	-0.07 (0.11)	-0.13 (0.13)	0.21 (0.14)	0.02 (0.19)	0.32 (0.17)**	0.21 (0.14)	0.02 (0.12)	0.32 (0.16)**
Hybrid cocoa	0.08 (0.18)	0.04 (0.11)	-0.02 (0.13)	-0.16 (0.13)	-0.08 (0.17)	0.07 (0.15)	-0.16 (0.13)	-0.08 (0.17)	0.07 (0.15)
Membership	0.86 (0.28)***	1.76 (0..17)***	2.78 (0.24)***	2.09 (0.12)***	1.17 (0.17)***	1.70 (0.14)***	2.09 (0.12)***	1.17 (0.17)***	1.70 (0.14)***
Constant	3.60 (0.59)***	2.47 (0.36)***	1.98 (0.42)***	1.42 (0.30)***	3.20 (0.39)***	2.59 (0.34)***	1.42 (0.30)***	3.20 (0.39)***	2.59 (0.34)***
athrho	0.51 (0.15)***	0.38 (0.15)**	0.11 (0.18)	-0.14 (0.14)	-0.06 (0.17)	0.01 (0.16)	-0.14 (0.14)	-0.06 (0.18)	0.01 (0.16)
lnsigma	0.20 (0.01)***	-0.32 (0.05)***	-0.18 (0.04)***	-0.18 (0.04)***	0.09 (0.04)**	-0.06 (0.04)	-0.18 (0.04)***	0.09 (0.04)**	-0.063 (0.04)
Chi-square	38.21	134.88	141.48	410.09	70.33	183.16	410.09	70.33	183.16
Number of obs	337	337	337	314	314	314	265	265	265
Prob > chi2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

**** p<.01, ** p<.05, * p<.1. Standard deviation reported in parentheses.*

5.3 Determinants of Technical Efficiency

The results from Table 11 indicate that the partial elasticities of conventional inputs such as land and the cost of agrochemicals, as well as the adoption of innovative agricultural practices like hybrid cocoa cultivation, have a significant influence on cocoa output. Specifically, these findings suggest that the use of hybrid cocoa and the efficient allocation of land and agrochemical resources positively contribute to cocoa productivity.

Producer group membership, involvement in off-farm employment, being male, and larger household sizes are identified as factors that negatively influence technical efficiency. This suggests that farmers who are members of producer groups, engage in off-farm jobs, are male, or have larger household sizes tend to exhibit higher levels of technical inefficiency in cocoa production.

Conversely, the number of times a member receives agricultural extension services is found to have a positive influence on technical inefficiency. This indicates that increased access to agricultural extension services contributes to lower levels of technical inefficiency among cocoa farmers.

Table 11. Maximum Likelihood (ML) estimates of the parameters for the Stochastic Production Frontier (SPF) function and technical inefficiency determinants

lnoutput	**Coef.**	**St.Err.**
Hybrid cocoa	0.14*	0.08
Land	0.40**	0.05
Cost of farm equipment	0.05	0.04
Labour cost	-0.02	0.02
Cost of agro chemicals	0.08**	0.04
Constant	6.34***	0.29
Insig2v	-1.86***	0.19
Inefficiency		
Age	0.01	0.01
Gender	-0.55***	0.21
Household size	-0.06*	0.04
Education	0.01	0.02
Cocoa land ownership	-0.24	0.23
Off-farm job	-1.48***	0.28
Producer group membership	-0.48**	0.23
Extension	0.07*	0.04
Age of cocoa trees	0.01	0.00
Constant	1.43***	0.55
Chi-square	103.23	
Number of obs	459.00	
Prob > chi2	0.00	
**** p<.01, ** p<.05, * p<.1*		

5.4 Impact of Producer Groups on Technical Efficiency

5.4.1 PSM Estimates of the Impact of Producer Groups Membership on Technical Efficiency

Table 12 presents the technical efficiency levels of cooperative members, other farmer association members, and non-members. The Propensity Score Matching (PSM) estimates indicate that, on average, members of producer groups exhibit higher technical efficiency than non-members. However, a notable distinction emerges between cooperative members and members of other self-help farmer associations, with cooperative members demonstrating higher efficiency levels compared to their counterparts in other associations.

Moreover, the results highlight the prevalence of technical (managerial) inefficiency among cocoa farmers, as evidenced by the significance of Insig2v (see Table 11). This suggests that while members of producer groups generally exhibit higher technical efficiency, there remains room for improvement across all groups. Additionally, the significance of Insig2v implies limited impact from random shocks such as climatic changes or production risks, further emphasizing the potential for enhancing technical efficiency through improved practices and technology adoption.

In the short run, there exists substantial scope for increasing cocoa production by addressing technical inefficiencies. Specifically, cooperative members, farmer association members, and non-members could potentially increase cocoa production by approximately 7%, 20%, and 40%, respectively, through the adoption of new technologies, innovative practices, and efficient allocation of production factors.

Table 12. PSM estimates of technical efficiency

		Cooperative	Farm ass.	ATT	S.E.	T
	Kernel	0.934	0.809	0.125	0.017	7.510***
Technical Efficiency	Radius	0.934	0.809	0.125	0.017	7.430***
		Cooperative	Non-members	ATT	S.E.	T
	Kernel	0.934	0.646	0.288	0.121	2.38***
Technical Efficiency	Radius	0.934	0.644	0.289	0.127	2.27***
		Farm ass.	Non-members	ATT	S.E.	T
	Kernel	0.841	0.527	0.314	0.063	4.99
Technical Efficiency	Radius	0.841	0.526	0.316	0.062	5.08

*** *p<.01*, ** *p<.05*, * *p<.1*

5.4.2 Endogenous Treatment Effect Estimation of the Impact of Producer Groups Membership on Technical efficiency

The findings from all three endogenous treatment regression models affirm the robustness of the estimates derived from the Propensity Score Matching (PSM) analysis (refer to Table 13). These models provide further insight into the nuanced effects of producer group membership on technical efficiency among cocoa farmers.

In particular, the regression models comparing cooperative membership with farmer association membership and non-membership highlight the superior impact of cooperative membership on technical efficiency. This suggests that farmers affiliated with cooperatives exhibit significantly higher levels of technical efficiency compared to their counterparts in farmer associations or those who are not affiliated with any group. Similarly, the model comparing farmer association membership with non-membership underscores the positive influence of farmer association participation on technical efficiency.

Beyond the influence of producer group membership, the regression models identify several additional factors that significantly affect technical efficiency among cocoa farmers. Notably, access to credit emerges as a key determinant positively associated with technical efficiency, indicating that farmers with access to credit are better equipped to invest in inputs and technologies that enhance productivity. Furthermore, the adoption of hybrid cocoa, characterized by its improved traits and resilience, is found to positively impact technical efficiency. This underscores the importance of embracing innovative agricultural practices to optimize cocoa production. The age of cocoa trees is identified as another significant factor positively associated with technical efficiency. This suggests that older cocoa trees, which are likely more established and productive, contribute to higher levels of efficiency in cocoa farming. Household size exhibits a positive correlation with technical efficiency, indicating that larger households may benefit from economies of scale or enhanced labor availability, leading to improved productivity in cocoa production.

On the other hand, certain variables are found to exert a negative influence on technical efficiency. These include factors such as the age of farmers, gender, farm size, frequency of extension services, and the cost of labor. These findings highlight the need for targeted interventions aimed at addressing barriers to efficiency, such as improving access to training and extension services, reducing labor costs, and promoting gender-inclusive agricultural policies.

Table 13. Endogenous treatment regression estimates of technical efficiency.

	Coop and Farmer asso	Coop and non-members	Farmer asso. and non-mem
Efficiency	Coef.	Coef.	Coef.
Gender	-0.02 (0.01)*	0.01 (0.01)	-0.01 (0.02)
Age	0.01 (0.01)	-0.01 (0.01)**	-0.01 (0.01)**
Education	0.01 (0.01)	0.01 (0.01)	0.01 (0.02)
Household size	0.02 (0.02)***	0.02 (0.01)***	0.036 (0.01)***
Farm size	0.01 (0.02)	-0.03 (0.03)	-0.02 (0.01)*
Access to credit	0.01 (0.01)	0.03 (0.02)*	0.03 (0.021)
Age of cocoa tree	0.01 (0.01)***	0.02 (0.03)***	0.03 (0.01)
Hybrid cocoa	0.05 (0.01)***	0.06 (0.02)***	0.08 (0.02)***
Labour cost	-0.05 (0.02)**	0.02 (0.01)***	0.02 (0.01)***
Equipment cost	0.02 (0.01)***	0.02 (0.01)*	0.01 (0.01)
Agrochemicals cost	0.02 (0.01)*	-0.02 (0.01)	0.023 (0.01)***
Extension	-0.03 (0.01)***	-0.02 (0.01)***	-0.02 (0.02)
Membership	0.14 (0.02)***	0.41 (0.02)***	0.32 (0.03)***
Constant	0.65 (0.04)***	0.24 (0.06)***	-0.01 (0.07)
athrho	-0.12 (0.23)	-0.14 (0.19)	-0.13 (0.19)
lnsigma	-2.72 (0.04)***	-2.23 (0.04)***	-2.09 (0.04)***
Chi-square	575.19	875.39	327.74
Number of obs	337	314	265
Prob > chi2	0	0	0

**** p<.01, ** p<.05, * p<.1. Standard deviation reported in parentheses.*

5.5 Relationship Between the Adoption of SCPs and Technical efficiency

The results from the three-stage least squares (3SLS) regression model, presented in Table 14, provide insights into the relationship between Sustainable Cocoa Practices (SCPs) adoption and the technical efficiency of cocoa farmers, alongside the influence of other significant variables.

The analysis reveals a significant and positive association between the adoption of SCPs, specifically pruning and the use of approved agrochemicals, and the technical efficiency of cocoa farmers. This finding suggests that farmers who embrace these practices tend to achieve higher levels of efficiency in cocoa production. Pruning, aimed at optimizing tree health and yield potential, along with the judicious use of approved agrochemicals, contributes to improved productivity and efficiency in cocoa farming. However, the study identifies a non-significant negative relationship between planting shade trees and the technical efficiency of cocoa farmers.

Moreover, the analysis underscores the significant influence of other variables on the technical efficiency of cocoa farmers, as demonstrated in Table 12 regarding producer group membership.

Table 14. 3SLS estimates of the relationship between SCPs and technical efficiency

	Pruning	Shade trees	Approved agrochemicals
Efficiency	Coef.	Coef.	Coef.
Gender	0.01 (0.03)	-0.05 (0.02)**	-0.02 (0.03)
Age	-0.02 (0.01)***	-0.02 (0.01)**	-0.01 (0.01)***
Education	0.02 (0.01)	0.03 (0.02)*	0.01 (0.01)
Household size	0.03 (0.01)**	0.03 (0.01)***	0.02 (0.01)***
Farm size	0.03 (0.06)	0.01 (0.05)	0.07 (0.06)
Access to credit	0.05 (0.03)	0.03 (0.03)	0.04 (0.03)
Age of cocoa tree	-0.03 (0.01)***	-0.04 (0.01)***	-0.02 (0.01)***
Hybrid cocoa	0.07 (0.02)***	0.07 (0.03)	0.07 (0.02)***
Labour cost	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)
Equipment cost	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)
Agrochemicals cost	0.01 (0.01)	0.03 (0.01)***	0.08 (0.09)
Extension	-0.01 (0.01)	-0.01 (0.01)	-0.05 (0.02)**
SCPs Adoption	0.18 (0.02)***	-0.06 (0.04)	0.16 (0.02)***
Constant	-0.08 (0.11)	0.47 (0.17)***	-0.01 (0.09)
R square	0.72	0.69	0.73
Number of obs	406	406	406
P value	0.00	0.00	0.00

**** p<.01, ** p<.05, * p<.1. Standard deviation reported in parentheses.*

6. Discussion

The primary objective of this study was to assess the impact of producer groups on the adoption of sustainable cocoa practices and the economic performance of Ghanaian smallholder cocoa farmers. This study aimed to elucidate the intricate relationship between membership in producer groups and the adoption of sustainable agricultural techniques and technical efficiency, specifically focusing on the cocoa farming sector, using a multifaceted approach. Furthermore, this study investigated how sustainable agricultural techniques adoption affects the technical efficiency of small cocoa farmers.

The study results showed positive relationship between participation in producer groups and adoption of sustainable cocoa practices as well as the technical efficiency of the cocoa farmers.

Firstly, as anticipated in our hypothesis (H1), active involvement in producer groups indeed correlates with higher levels of adoption of sustainable cocoa practices (SCPs) among farmers. This not only validates the importance of collective action and knowledge-sharing within such groups but also highlights their role in fostering sustainable agricultural practices. Secondly, consistent with our second hypothesis (H2), our results reveal that farmers actively engaged in producer groups demonstrate enhanced technical efficiency in cocoa production. This suggests that beyond knowledge exchange, these groups may offer avenues for skill enhancement, resource optimization, and technological adoption. The findings confirm the empirical review done by Candemir et al. (2021) on cooperatives and farm sustainability, demonstrating the positive impact of cooperative members on adopting environmentally sustainable practices. The results of positive impact of producer groups on SCPs adoption imply that collective actions and rural institutions linked to external consultancy systems are good channels for remote smallholder farmers in rural areas to access and learn environmentally sustainable practices. Through internal communication mechanisms, the producer groups distribute information from government extension agents or various development non-governmental organizations connected to the cooperative leaders. The leaders of the producer groups are usually lead-farmers and main opinion-makers in their communities. There is also an excellent opportunity for members to gain from the farmer-to-farmer learning experience and the social interactions facilitated by the cooperative. Also, attending joint cropping events increases the chance for farmers to know and adopt sustainable agricultural practices (D'Emden et al., 2008; Ashrit & Thakur, 2021).

Studies such as Onumah et al. (2013), Addai et al. (2014), Ma et al. (2018) and Olagunju et al. (2021) found a significant positive relationship between producer group membership and the technical efficiency of farmers. The higher technical efficiency among the cooperative members can be linked to the fact that producer group participation offers the cocoa farmers benefits such as access to relevant information regarding cocoa production, access to relevant and government-approved cocoa inputs, and a farmer-to-farmer learning experience among the farmers. Group members have the opportunity to access quality/recommended agrochemicals. In most cases, smallholder cocoa farmers are often isolated and far from agrochemical shops and have minimal chances to buy agrochemicals even when they have money to purchase. However, members of various farmer groups can buy agrochemicals and other farm inputs collectively. This reduces transportation costs and, consequently, cost per unit. The field visits and the cocoa spraying activities performed by trainers and leaders in the producer groups also increase the chance for the members to be efficient with their cocoa operations. In addition, producer groups can help to improve the quality of the goods they produce. By working together to set quality standards and monitor compliance, they can ensure that their products meet market demand and command higher prices.

While there is a generally positive relationship between participation in farmer groups and SCPs and technical efficiency, farmers who belong to cooperatives often experience a more significant impact compared to those affiliated with other forms of self-help farmer associations (Bizikova et al., 2020). This distinction can be attributed to the unique structure and benefits offered by cooperatives, which typically provide members with improved access to credit, technical assistance, market information, and collective marketing opportunities. The cooperative framework facilitates better resource pooling and negotiation power, enabling members to benefit from economies of scale and more favourable terms when accessing critical agricultural resources and services (Grashuis & Ye, 2019; Candemir et al., 2021). The inclusion of Fairtrade certification among farmers in cocoa cooperatives further enhances the adoption of SCPs and the technical efficiency of the cooperative cocoa farmers compared to the farmer association members. Fairtrade certification ensures that the cocoa is produced and traded in a manner that is socially and environmentally sustainable, providing farmers with fairer prices for their produce, along with the additional Fairtrade premium (Foundjem-Tita et al., 2016; Fairtrade International, 2022). Through Fairtrade, the farmers who belong to cooperatives receive benefits such as fair prices, promoting environmental and social standards, providing training and support, and reinvesting in communities. In contrast, other self-help farmer associations may need more organizational capacity and support systems to offer their members similar comprehensive benefits and opportunities for growth.

The findings outlined above resonate strongly with rational choice theory, which posits that individuals make decisions based on rational calculations aimed at maximizing their utility.

In the context of smallholder cocoa farmers participating in producer groups, the decision to join and engage in collective actions can be viewed through the lens of rational choice theory. These farmers likely weigh the potential benefits against the costs of participation, including the time and effort required for meetings and collaborative activities. The positive relationship observed between producer group membership and the adoption of sustainable cocoa practices suggests that farmers perceive significant utility in accessing information, resources, and learning opportunities facilitated by these groups. By pooling their resources and leveraging collective knowledge, farmers can overcome barriers to adopting environmentally sustainable practices, ultimately enhancing the productivity and sustainability of their cocoa farming operations.

Furthermore, the higher technical efficiency observed among cooperative members aligns with rational choice theory principles. By participating in producer groups, farmers gain access to vital resources such as quality inputs, technical assistance, and training programs, which can significantly improve their productivity and efficiency. Rational actors seeking to maximize their agricultural output while minimizing costs would naturally gravitate towards such groups where they can benefit from economies of scale in input procurement, knowledge sharing, and collective action. The ability to purchase inputs collectively reduces transaction costs and enhances resource allocation efficiency, reflecting the rational decision-making process of farmers striving to optimize their agricultural production outcomes within the constraints of their operating environment.

The adherence to the COCOBOD standards of 5-7 days for the drying and fermenting of cocoa is predominantly observed among all farmers, regardless of their producer group membership status. The adherence to the COCOBOD standards of 5-7 days for drying and fermenting of cocoa is deeply ingrained in the cocoa farming practices in Ghana, primarily due to the traditional nature of cocoa cultivation and the intergenerational knowledge transfer that has occurred over time. With cocoa being a conventional crop in Ghana, many farmers have inherited and learned the intricacies of cocoa farming from their ancestors, including the importance of adhering to the established standards for drying and fermenting. These time-tested methods have been passed down through generations, underscoring their significance in maintaining the quality and value of cocoa beans. Moreover, the adherence to these standards is reinforced by the understanding that deviating from the prescribed drying and fermenting periods can compromise the overall quality of the cocoa beans, leading to a reduction in market value and potential income for the farmers. Given the competitive nature of the cocoa market, where adherence to quality standards directly impacts pricing, farmers are incentivized to strictly follow the COCOBOD standards to ensure that their produce meets the required quality benchmarks. Consequently, the adherence to these traditional standards is not only a reflection of the cultural heritage and ancestral knowledge within the cocoa farming community but also a pragmatic approach for farmers to secure fair prices and sustain their livelihoods within the cocoa industry.

The study results show that SCP adoption (pruning and approved agrochemicals) has a statistically significant impact on cocoa farmers' technical efficiency. As hypothesized in H3, the findings robustly demonstrate a statistically significant positive correlation between the adoption of SCPs, encompassing pruning techniques and approved agrochemicals, and the technical efficiency of cocoa farmers. This empirical evidence not only corroborates the theoretical underpinnings of the relationship but also underscores the pivotal role of sustainable practices in enhancing cocoa farm productivity and overall performance. Pruning in agricultural settings, such as cocoa farming, establishes a positive relationship with technical efficiency, contributing to enhanced crop productivity and overall farm management (Hoffmann et al., 2020; Tosto et al., 2022). Pruning involves carefully removing specific plant parts, such as branches or buds, which aids in controlling the growth and development of cocoa trees. By selectively trimming overgrown or unproductive branches, farmers can direct the plant's resources toward the growth of healthier, more productive branches, leading to improved cocoa yield and quality (Riedel et al., 2019; Esche et al., 2023). Furthermore, pruning helps manage pests and diseases, preventing their rapid spread throughout the plantation (Riedel et al., 2019). The use of approved agrochemicals by the Ghana Cocoa Board (COCOBOD) fosters a positive relationship with the technical efficiency of cocoa farmers, thereby enhancing overall crop yield and quality. COCOBOD's endorsement of specific agrochemicals ensures farmers can access high-quality inputs that effectively manage pests, diseases, and soil nutrition. By adhering to COCOBOD's recommendations and guidelines, farmers safeguard their crops from potential threats, thereby securing a stable and robust yield, which contributes significantly to the technical efficiency and productivity of cocoa farming operations.

In terms of the determinants of SCP adoption, it is clear from the results that the age of a farmer has a significant positive relationship with a farmer practicing pruning and using approved agrochemicals. Older farmers, who often have decades of experience and traditional knowledge, are more open to innovative farming techniques, such as effective pruning methods and adopting sustainable agricultural practices. For the usage of approved agrochemicals, the accumulated knowledge of the older farmers on cocoa farming and the potential risks associated with improper chemical usage fosters a heightened awareness of the importance of complying with safety protocols and using approved agrochemicals. The age of a farmer does not only affect the pruning and the use of approved agrochemicals but, more broadly, as found by Beyene & Kassie (2015) and Oyetunde-Usman et al. (2021), on sustainable agricultural practices (SAPs) adoption. The results show a positive effect of the age of cocoa trees on the practice of pruning and approved agrochemical usage but a negative effect on the planting and retaining of trees on the farm.

The age of cocoa trees has a positive impact on farm, pest, and disease management because mature trees benefit from refined agricultural practices and a better understanding of pest and disease patterns acquired over years of cultivation. Based on interviews with cocoa extension officers in the regions, we found that older cocoa trees are more susceptible to pests and diseases due to their prolonged exposure to various environmental stressors (Marelli et al., 2019; Cilas & Bastide, 2020), leading farmers to prioritize the application of approved agrochemicals to maintain tree health and ensure sustained productivity. However, this same factor has a negative effect on deforestation management, owing to the difficulties that older plantations have in accommodating the integration of shade trees and preserving forest ecosystems.

The study revealed a positive relationship between household size and pruning practice. Household size does influence pruning practices, influencing various aspects of farm management, such as pest and disease control, as well as the adoption of sustainable agricultural practices (SAPs) in general (Million et al., 2020; Kudama et al., 2021). Larger households frequently provide a significant labour force, allowing for more efficient and thorough pruning activities contributing to improved farm hygiene and pest and disease control.

Cocoa land ownership stands out as a significant positive determinant for planting shade trees or retaining trees based on the results. The ownership of cocoa land provides farmers with a vested interest in the long-term sustainability of their agricultural practices and environmental conservation (Zerihun et al., 2014; Ngango et al., 2023). With a sense of stewardship over their land, farmers are more inclined to adopt agroforestry practices that integrate shade trees, recognizing their role in maintaining soil fertility, preventing erosion, and fostering a conducive microclimate for sustainable cocoa production. 62% of the cocoa farmers who are not owners of the cocoa land are into the abusa (70% harvest) sharecropping. In the abusa sharecropping system, where owners hire caretakers to manage farms for one-third of the crop and provide inputs, the relationship between the landowner and the farm is more detached. Despite becoming legal owners of the land, these farmers may still lack a strong sense of stewardship and ownership mentality due to their historical engagement in a sharecropping arrangement where they were not directly responsible for farm management. This disconnects between ownership and management responsibilities could affect the willingness of these farmers to invest in sustainable cocoa practices. While they now have legal ownership rights, their mindset and incentives may still align more closely with those of caretakers rather than traditional landowners. The reliance on caretakers for farm management and the historical lack of direct involvement in farm operations may lead to a more transactional approach to land use, where short-term gains take precedence over long-term sustainability.

The study highlighted that the gender of the farmer serves as a significant determinant in the planting of shade trees or retention of trees for effective deforestation management within cocoa farming. The societal roles and decision-making authority of male farmers often position them to actively participate in sustainable land management, contributing to the preservation of forest ecosystems and fostering a more resilient and ecologically balanced cocoa farming environment (Sanou et al., 2019).

Participation of cocoa farmers in off-farm business has been shown to have a significant positive effect on the use of approved agrochemicals in cocoa farming. Off-farm income may enable farmers to invest in high-quality agrochemical inputs, enhancing their ability to maintain the health and productivity of their cocoa crops (Ruben & Van Den Berg, 2001; Kurgat et al., 2018).

Farm sizes are associated with a higher likelihood of cocoa farmers utilizing approved agrochemicals compared to those with larger farm sizes. Danso-Abbeam & Baiyegunhi (2020) found similar results in Ghana. This pattern is often attributed to the relatively manageable scale of smaller farms, which allows for more precise and targeted application of agrochemicals. Given the limited financial resources of smaller farms, farmers are often more inclined to allocate a more significant proportion of their budget to securing approved agrochemicals, viewing them as indispensable investments to protect their crops and ensure optimal yields.

The negative relationship between farm size and the partial elasticity of production reflects the diminishing returns associated with increasing agricultural land size. As farm size expands, the additional units of land may yield little increases in output, leading to a decrease in the partial elasticity of production (Massaquoi et al., 2022). This phenomenon is often attributed to limited access to resources, diminishing soil fertility, and challenges in effectively managing larger farming areas. As farms become larger, it becomes increasingly difficult to maintain the same level of efficiency and productivity due to potential constraints related to labour, capital, and management.

The negative relationship between labour cost or the number of labour inputs and the partial elasticity of cocoa production indicates the impact of rising labour costs on the use of labour inputs and, subsequently, on the overall productivity of cocoa cultivation (Tsiboe et al., 2018). As labour costs increase, farmers may need more support in hiring additional labour, leading to a reduction in the number of available labour inputs. This decline in available labour inputs, coupled with the cost burden, can contribute to a decrease in the partial elasticity of cocoa production. This phenomenon highlights the potential challenges cocoa farmers face in optimizing labour utilization and achieving efficient cocoa production in escalating labour costs.

The positive relationship between agrochemicals and farm equipment and the partial elasticity of production reflects the significant role of modern agricultural inputs and technology in enhancing overall agricultural productivity. As the use of agrochemicals and farm equipment increases, the partial elasticity of production rises, indicating that additional investments in these inputs lead to proportional increases in agricultural output. This positive relationship underscores the importance of leveraging advanced technologies and agricultural inputs to optimize resource utilization, improve crop yields, and enhance overall farming efficiency (Ma al., 2018; Oyetunde-Usman et al., 2021).

Farmers' age has been found to have a negative relationship with technical efficiency in cocoa farming, as similarly found by Agom et al. (2012). This finding emphasizes the difficulties associated with the transmission of generational knowledge and the adoption of modern agricultural practices. Older farmers may be more resistant to change and innovation, which may lead to a reluctance to implement new technologies or more efficient farming methods. Furthermore, physical limitations may affect farmers' ability to engage in labour-intensive tasks as they age, resulting in decreased productivity and overall efficiency in cocoa production. Furthermore, older farmers' lack of exposure to updated farming techniques and technologies may contribute to suboptimal decision-making processes, impeding the implementation of best practices and resulting in lower yields.

Gender has a negative effect on technical efficiency. This implies that female farmers are more technically efficient than male farmers (Mukete et al., 2016). This finding underscores the significant contributions of women to the agricultural sector and their adeptness in managing various agricultural tasks (Doss, 2018). Women often showcase a strong aptitude for adopting and implementing sustainable farming practices, leveraging their knowledge and skills to enhance productivity and optimize resource utilization. Additionally, their active participation in the entire agricultural value chain, from planting to harvesting, processing, and marketing, further emphasizes their integral role in promoting the efficiency and sustainability of cocoa production.

The household size has been found to correlate with cocoa farmers' technical efficiency positively. This relationship exemplifies the critical role of family dynamics and labour availability in optimizing cocoa cultivation. Larger households usually have more labour resources, allowing for better management of farming tasks like weeding, pruning, and harvesting (Danso-Abbeam, 2014). Farmers can allocate resources more efficiently with more hands to support various agricultural activities, resulting in increased productivity and better overall farm management.

Access to credit is a significant factor contributing to the enhancement of the technical efficiency of cocoa farmers, and it is consistent with the findings of Binam et al. (2008) and Mukete et al. (2016). By providing farmers with the financial resources necessary to invest in modern farming technologies, high-quality inputs, and improved production processes, credit access empowers them to optimize their agricultural operations and achieve higher productivity levels.

Utilizing hybrid cocoa varieties has a positive relationship with the technical efficiency of cocoa farmers in Ghana. These hybrid strains are renowned for their improved yield potential, disease resistance, and adaptability to varying environmental conditions, enabling farmers to achieve higher levels of productivity and profitability (Yiadom-Boakye & Ohene-Yankyera, 2013).

We confirmed that the old cocoa trees cause inefficiency because aged trees cannot produce more cocoa pods (Onumah et al., 2013). Old cocoa trees typically have lower yields, are more susceptible to pests and diseases, and require more inputs such as fertilizers and pesticides to maintain their productivity. Additionally, older trees can become less responsive to management practices, such as pruning and fertilizer application, reducing yields and lower quality beans. Furthermore, old cocoa trees can also limit the adoption of new technologies and management practices - farmers may hesitate to invest in inputs or new planting materials for old trees with a limited lifespan.

The number of times a farmer accesses an extension officer has been found to have a negative relationship with cocoa farmers' technical efficiency in Ghana. This relationship underscores the importance of the quality and effectiveness of the interactions between farmers and extension officers rather than the frequency alone (Baloch & Thapa, 2018). In Ghana, the general extension officers often serve a broader agricultural advisory role rather than specializing solely in cocoa production. Their responsibilities encompass various agricultural activities and practices, catering to diverse farming needs across various crops and livestock. As a result, more than the information provided by these extension officers may be specific to cocoa production, potentially leading to a disconnect between the general agricultural advice and the specific requirements of cocoa farming. This generalist approach might result in a need for more specialized knowledge and tailored guidance for optimizing cocoa farming techniques and addressing the unique challenges associated with cocoa cultivation. Therefore, the advice and recommendations provided by extension officers may only sometimes be directly applicable to the intricacies of cocoa production, potentially limiting the technical efficiency of cocoa farmers who rely on these generalized agricultural advisory services.

As previously noted by Abate et al. (2014) and Mojo et al. (2017), the decision to join cooperatives is positively correlated with household size. From this study, the propensity to join a producer group also rises with household size. A more prominent family frequently encourages a sense of belonging and support among its members, which makes it easier for them to share resources, information, and experiences. Numerous recent empirical studies have reported that farmers' participation in producer groups was positively influenced by their interactions with extension officers (Mojo et al., 2017; Ahado et al., 2021). The results demonstrate the critical role these intermediaries play in fostering agricultural development and promoting collective action. Extension officers provide crucial technical assistance, training, and information on best practices through interactions and advisory services, which not only improve farmers' understanding of cooperative functioning but also build their confidence in engaging with such organized groups. In addition to the personal, household, and social network traits, the cocoa farmers in Ghana who have positive views about the advantages of membership (their cognitive dimension of social capital) tend to give up their independence and make independent decisions regarding their farms in favour of participating in group activities. The relational component of social capital, or trust, also influences farmers' decisions to join cooperatives. These results are in line with other research, such as modelling cooperation in Croatia, Romania, and China by Bakucs et al. (2012), Liang et al. (2015), Möllers et al. (2018) and Ma & Abdulai (2018).

The qualitative interview with the non-members highlights the reasons why the non-members chose not to join producer groups. Firstly, the logistical challenges associated with accessing these groups can deter participation. In the remote areas where cocoa is cultivated, infrastructure is often limited, and the proximity to the nearest producer group is significant (World Cocoa Foundation, 2021). The distance not only increases the cost and time required for transportation but also poses difficulties for farmers (Lee et al., 2023), especially those with limited resources or transportation options. Consequently, they find it more convenient to manage their cocoa production independently rather than overcoming the hurdles of accessing producer groups.

Secondly, the farmers perceive the requirements for group participation as burdensome or restrictive. Some producer groups have specific guidelines regarding farming practices and quality standards, which do not align with their traditional methods or capabilities. Adherence to these guidelines might necessitate changes in farming techniques or investments in new equipment (IISD, 2021), which some smallholders may view as financially unfeasible or incompatible with their existing practices. Consequently, the farmers avoid the constraints of group membership and prefer to maintain autonomy over their farming decisions, even if it means forgoing the potential benefits of belonging to a collective entity.

In addition to the logistical challenges and perceived restrictions, the uniform pricing of cocoa across different producer groups and individual farmers is a key factor contributing to smallholder cocoa farmers not joining producer groups in Ghana. According to the non-members, despite being part of a collective action and not working towards following standards and sustainable farming practices, they receive the same base price as the group members. This lack of differentiation in cocoa pricing based on individual farming practices or quality outputs disincentivizes the farmers from participating in collective efforts, as they may feel that their hard work and dedication do not translate into fair financial rewards.

Moreover, even if the non-member farmers choose not to join producer groups, these groups accept the cocoa from non-member farmers. This practice provides an avenue for independent farmers to sell their cocoa produce without the commitments or obligations that come with group membership. The ability to sell to producer groups without formal membership is a more flexible and convenient option for the non-members, allowing them to retain control over their farming practices and decisions while still accessing the market facilitated by these groups. This arrangement enables the non-member farmers to maintain their autonomy while accessing the benefits of selling to established market channels.

6.1 Limitation of the Study

There were some limitations of this study since there was reliance on farmers for the data. The data provided by farmers might be subject to recall biases, leading to inaccuracies and inconsistencies in the information provided. This can affect the reliability of the data and the subsequent analysis. Also, the farmers may have different perceptions of sustainable agricultural practices and technical efficiency, leading to subjective interpretations of the data. This subjectivity can influence the findings and conclusions of the study. The data provided by farmers might not represent the entire population accurately, leading to sampling bias. This limitation could affect the generalizability of the study's findings to the broader population of small farmers in Ghana.

There was a lack of control over the quality and consistency of the data provided by farmers, which can impact the validity of the study's findings and limit the ability to draw definitive conclusions. In addition, collecting data over a period of time through estimates and recall might not capture real-time changes or sudden fluctuations in the variables being studied, potentially leading to an incomplete understanding of the dynamics at play. Trained administrators collected the data without supervision and, as such, can influence the reliability of the data.

One limitation of the current analysis is the lack of direct investigation into the relationship between sustainable farming practices, technical efficiency, and farm or household income. While the study focuses on the adoption of SAPs and technical efficiency, it does not explore the ultimate impact on farmers' economic well-being, which is a crucial aspect for understanding the effectiveness and sustainability of such practices. This limitation underscores the need for further research to fill this gap and provide a more comprehensive understanding of the dynamics at play in cocoa production.

Some measures were taken to mitigate these limitations. Two exploratory and transect walks were done in 2021 and 2022 to gain a deeper understanding of the experiences and perspectives of the small farmers involved and the key sustainable cocoa practices adopted in cocoa production. Pilot testing was done for a week by trained administrators. These measures were done to check if the farmers would understand the questions and for the administrators to get used to the questions. Apart from the survey data collection, personal interviews were done with the leadership of the producer groups, some of the members and extension officers in the two regions to triangulate the data collection.

7. Conclusions and Recommendations

The study analysed the effect of producer groups participation on adopting sustainable cocoa practices (SCPs) and technical efficiency in Ghana. Since the structure, characteristics, and dynamics of different producer groups vary and, as such, the impact may not be the same for all producer groups, this study analysed the effect of producer groups by comparing the members of different producer groups and non-members to estimate the degree of impact based on the type of producer group. The study further investigated the effect of sustainable cocoa practices adoption on the technical efficiency of the cocoa farmers. We adopted different methodological approaches to analyse the data for this study. The probit regression model was used to estimate farmers' decision to participate in a producer group, the stochastic frontier production model was used to estimate the technical efficiency of the cocoa farmers, the propensity score matching and endogenous treatment regression were adopted to cater for the observed and unobserved bias associated with assessing the impact of producer group membership on SCPs and technical efficiency, and the three-stage least square regression model was adopted to analyse the effect of SCPs adoption on the technical efficiency of the farmers.

The study results showed that membership in producer groups (cooperatives and farmer associations) significantly affects the adoption of sustainable cocoa practices and the technical efficiency of cocoa farmers. However, the degree of the impact of producer groups is different for both members of cooperatives and farmer associations. The members of cooperatives' levels of SCP adoption were higher than the members of the farmer associations. Therefore, the first (H1: Participation in producer groups positively leads to greater adoption of SCPs among cocoa farmers) and second (H2: Active involvement in producer groups is positively associated with increased cocoa farmers' technical efficiency) hypotheses of this study are accepted.

Regarding the trade-off between SCP adoption and the technical efficiency of the cocoa farmers, the 3-stage least square regression model showed that the adoption of SCPs has a significant effect on the technical efficiency of the cocoa farmers. Therefore, the third hypothesis (H3: There is a positive correlation between adopting sustainable cocoa practices (SCPs) and the technical efficiency of cocoa farmers) is accepted.

The various endogenous treatment regression models showed that apart from membership in producer groups, other farm, farmer, and institutional factors significantly affect the adoption of SCPs. The study showed that the farmer's age, respondents' gender, household size, farm size, age of cocoa trees, cocoa land ownership, and farmer involvement in off-farm business significantly affect the adoption of SCPs. However, the influence of the socio-demographic factors on SCP adoption is dependent on the type of SCP.

Also, the stochastic frontier model highlighted that except for the cost of agrochemicals, the partial elasticities of all the conventional inputs (land, cost of labour, and cost of cocoa farm equipment) influence cocoa output significantly. Both the inefficiency model of the stochastic frontier function and the endogenous treatment regression highlighted other factors that affect the efficiency of cocoa farmers apart from producer groups' participation. The significant factors were the age of a farmer, gender, farm size, household size, credit access, use of hybrid cocoa, age of cocoa trees and the number of times a farmer receives extension education.

The probit regression model highlighted empirically that the determinants of producer group participation (cooperative or farmer associations) were household size, farmers' perceptions of the benefits they will receive from the producer group, and the number of times a farmer receives extension service. Based on the qualitative interview with the non-members, the study revealed that farmers decide not to join producer groups in Ghana because of the uniform pricing of cocoa in the country, the logistical challenges associated with accessing producer groups, perception about requirements for group participation as burdensome or restrictive, and the ability to sell to producer groups without formal membership.

7.1 Recommendations

Based on the findings from this study, several recommendations can be made to the Ghanaian government, COCOBOD (Ghana's cocoa regulatory body), the licensed cocoa buying companies and other stakeholders in Ghana to foster a more inclusive and sustainable cocoa industry:

Because of the proven positive impact of producer groups, even though cooperatives have a higher impact, there should be an emphasis on expanding the formation of producer groups across various cocoa-producing regions in Ghana. The government and relevant organizations should support establishing new producer groups, especially in areas where such groups are currently lacking. This expansion ensures that more smallholder farmers can access the resources and knowledge necessary to adopt sustainable cocoa practices. Also, the study encourages the development and promotion of cooperatives over farmer associations, which should be prioritized, as cooperatives provide a more self-sufficient and empowering structure for farmers. By emphasizing the cooperative model, farmers can benefit from shared resources, collective decision-making, and collaborative problem-solving, leading to a more sustainable and resilient agricultural community. With an internal focus on capacity-building and knowledge sharing within the cooperative framework, farmers rely less on external support, allowing them to cultivate self-sufficiency and sustainable practices tailored to their specific needs and contexts. This approach not only fosters a stronger sense of ownership and autonomy among farmers but also promotes a culture of collective responsibility and long-term sustainability within the agricultural sector.

From the results of farmers' decision not to participate in producer groups, to encourage participation in producer groups, the government should prioritize improving infrastructure, particularly in remote cocoa-growing areas. This could involve investing in better road networks and transportation facilities, making it easier for farmers to access producer groups and marketplaces. Also, implementing a zoning strategy within producer groups is a practical approach to address the challenges faced by farmers residing in remote areas. This strategy can involve appointing local leaders or coordinators within these zones to facilitate communication, training, and information dissemination from the producer group to the individual farmers. Such an initiative can help bridge the gap between remote farmers and the central operations of the producer groups, ensuring that all members, regardless of their geographical location, have access to the necessary resources and support.

Additionally, the producer group's headquarters or leadership can establish communication channels or platforms that allow for continuous interaction and feedback between the central producer group and the zonal leaders, thereby ensuring that the information provided is up-to-date and relevant to the specific needs of each zone. By implementing a zoning strategy with trained local leaders, producer groups can effectively reach and support smallholder farmers in remote areas, fostering a stronger sense of community and collaboration within the cocoa industry. This approach can empower farmers with the necessary knowledge and resources to improve their farming practices and overall productivity, leading to a more sustainable and inclusive cocoa sector in Ghana.

Also, to motivate the farmers to participate in producer groups, the Ghana COCOBOD and the cocoa-buying companies should consider introducing pricing differentials based on implementing sustainable cocoa practices (SCPs) and quality standards. Like the current standards for drying and fermentation, where adherence ensures fair compensation, incorporating sustainability differentials motivates cocoa farmers to dry and ferment cocoa based on the required 5-7 days (Table 3). Recognizing that adherence to SCPs and production standards is directly linked to price premiums, non-member farmers may be motivated to join producer groups to access the resources, training, and knowledge necessary to improve their farming practices. This can enable them to meet the required quality and sustainability benchmarks, ultimately leading to better financial returns for their produce. As a result, the implementation of fair pricing mechanisms based on SCP adoption and production standards not only encourages adherence to quality standards but also fosters more significant participation in producer groups, promoting a more sustainable and inclusive cocoa industry in Ghana. Even though the farmers who are members of producer groups receive bonuses based on their certification with international certification schemes like Fairtrade and Rainforest Alliance, the base price of cocoa is the same for all cocoa farmers, so the non-members don't see the need to be involved in producer groups and undertake sustainability training.

The study confirms the adoption of sustainable agricultural practices affects the technical efficiency (technical efficiency) of cocoa farmers positively. As a result, we recommend launching comprehensive education and awareness campaigns highlighting the long-term benefits of adopting SAPs. These campaigns should emphasize how sustainable practices contribute to improved soil health, increased resilience to climate change, and enhanced crop productivity over time. Providing farmers a clear understanding of the long-term positive impact can motivate them to prioritize adopting sustainable practices. Also, case studies and demonstrations should be conducted to showcase the economic viability of sustainable cocoa farming to cocoa farmers. Highlights should be on the cost savings, increased market access, and potential for premium prices associated with sustainably produced cocoa. Demonstrating the financial benefits of adopting SAPs can incentivize farmers to make the necessary investments and changes to their farming practices, knowing that these efforts will improve yields and economic returns in the long run.

Given the identified gap in the current analysis regarding the lack of exploration into the direct impact of sustainable farming practices (SAPs) and technical efficiency on farm and household income in cocoa production, it is recommended that future research be conducted to address this crucial aspect. This research could involve a comprehensive study that delves into the relationship between the adoption of SAPs, technical efficiency measures, and the resulting effects on farm and household income among cocoa farmers.

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9. List of Author's Scientific Contributions

List of Scientific Publications

1. Donkor, E., & Hejkrlik, J. (2021). Does commitment to cooperatives affect the economic benefits of smallholder farmers? Evidence from rice cooperatives in the Western province of Zambia. *Agrekon*, *60*(4), 408-423.
2. Donkor, E., Ratinger, T., & Hejkrlik, J. (2023). The Awareness and Adoption of Environmentally Sustainable Practices by Agricultural Cooperative Members in Zambia. *New medit: Mediterranean journal of economics, agriculture and environment= Revue méditerranéenne d'economie, agriculture et environment*, *22*(1), 67-84.
3. Donkor, E., Dela Amegbe, E., Ratinger, T., & Hejkrlik, J. (2023). The effect of producer groups on the productivity and technical efficiency of smallholder cocoa farmers in Ghana. *Plos one*, *18*(12), e0294716.

Conference Contributions

1. Donkor E, Hejkrlik J. (2020). Economic benefit of commitment to rice cooperatives in Zambia. The World of Tomorrow - A Green and Sustainable Society. Euro League for Life Sciences Conference 2020, Boku, Austria.
2. Donkor E, Hejkrlik J. (2021). Impact of Active Participation in Cooperatives on the Adoption of Sustainable Agricultural Practices in Western part of Zambia: Cooperatives in transitions facing crisis: ICA CCR European Research Conference 2021, Paris, France.
3. Donkor E, Hejkrlik J. (2022). Impact of Cooperative Membership on the Adoption of SAPs by Smallholder Farmers in Zambia. 9th EAAE PhD WORKSHOP 2022, Parma, Italy.

4. Donkor E, Hejkrlik J. (2022). Impact of cooperatives on the efficiency of smallholder farmers in Rethinking cooperatives: From local to global and from the past to the future: ICA CCR European Research Conference 2022, Athens, Greece.

Manuscripts in Preparation

1. Impact of Fairtrade Producer Groups on the Adoption of Sustainable Cocoa Practices among Smallholder Farmers in Ghana.
2. Impact of the adoptions of SAPs on the yield of smallholder rice farmers in Zambia
3. The Interceding Role of Producer Groups on the Farm Performance Impact of Sustainable Cocoa Technology Adoption. Evidence from Ghana
4. The role of homegardens in ensuring food security in Sahel region: Example from Northern regions in Ghana

Project Participation

1. Agribusiness for LIFE – Livelihoods, Innovation, Food & Empowerment. Funded by Czech Development Agency (CzechAid) (2018-2021)

Awards

1. AEASA - SJJ de Swardt Prize for the best paper in Agrekon Journal (2021/2022)
2. Euroleague for Life Sciences Distinguished Fellowship Prize in the Category Best Oral Presentation within the Subtheme Innovation in Life Sciences (2020).

10. Appendices

1. Test for Endogeneity or Self Selection

	Membership		Extension		Membership		Off farm job	
Variables	**coeff.**	**St.Err.**	**coeff.**	**St.Err.**	**coeff.**	**St.Err.**	**coeff.**	**St.Err.**
Age	-0.01	0.01	0.01	0.01	0.00	0.00	-0.01**	0.00
Gender	-0.65	0.24	0.27	0.24	-0.12	0.20	0.00	0.17
Household size	-0.14	0.06	0.05	0.04	-0.01	0.04	-0.06**	0.03
Education	-0.14	0.05	0.08***	0.02	0.01	0.02	-0.02	0.01
Cocoa Farm size	-0.14	0.12	0.12**	0.06	0.03	0.06	-0.11***	0.04
Ownership status	-1.72	0.65*	1.17***	0.26	0.31	0.21	-0.27	0.19
Hybrid cocoa	-1.05	0.46	0.57*	0.30	0.15	0.23	-0.51**	0.25
Off farm job	0.13	0.36	-0.41	0.32	-0.61*	0.32		
Extension	2.10	0.51***			0.22***	0.06	-0.04	0.03
Perceived economic benefits	0.74	0.07***	0.24***	0.08	0.48***	0.08	-0.03	-0.06
Perceived social benefits	0.48	0.07***	0.23	0.25	0.49***	0.07	-0.18**	0.08
Distance to market					0.09	0.09	0.17**	0.07
Distance to extension	0.15	0.11	0.17*	0.10				
Constant	-2.49	2.49	-1.13	0.78	-3.26***	0.71	2.23***	0.49

2. MEMBERS QUESTIONNAIRE

These questionnaires have been designed to execute research purposely for academic work. The principal objective is to analyse the Impact of producer groups on the adoption of sustainable agricultural practices and economic performance of small farmers. All information provided will be used solely and exclusively for academic purpose and all respondents will remain anonymous to the public domain. Information provided would be used to make sound empirical analysis and suggest policy recommendations that would help improve market access and farmer's socio-economic well-being and standard of living in the region. The entire interview will take 30 minutes of your time and you are kindly requested to provide honest and genuine answers within your possible best.

Interview date……../………/20..…….

Demographic and socio-economic data

Filled by enumerator:

1. GPS coordinates ……………………………………………….
2. Name of province ……………………………………………….
3. Name of ward/community ……………………………………………….

   Is there cocoa cultivated in a protected forest area? Yes [ ] No [ ]
4. Type of Producer groups membership. Fairtrade group[ ] Non-Fairtrade (other certifications) [ ] Non-Fairtrade (no-certification) [ ]
5. Gender [1] Male [0] Female
6. How many people are in your household?.................

7. Marital status….. [ ] Married [ ] Other

8. How many other crops you produce in addition to your main crop? ....

9. Age of respondent in years ……………………………………………….

10. Years of education of respondent……………………………..

11. What is your total land holding (in hectares)? ………………………………………..

12. How many of the agricultural land do you use to cultivate cocoa [in hectares]? ……………………

13. How many of the agricultural land do you use to cultivate other crops [in hectares]?

14. Is there a cooperative or farmer association in your community? Yes [ ] No [ ]

15. What is the distance from your farm to the your cooperative headquarter/centre in your community/nearest community?.............

16. Do you agree that the cooperative or farmer association can bring you economic benefits?

    Strongly Disagree [ ] Partly Agree [ ] Neither agree nor disagree [ ] Partly Agree [ ] Strongly Agree [ ]

17. Do you agree that the cooperative or farmer association can bring you social benefits?

    Strongly Disagree [ ] Partly Agree [ ] Neither agree nor disagree [ ] Partly Agree [ ] Strongly Agree [ ]

18. Are you involved in any business other than farming?

    Yes [ ] No [ ]

19. Are you the owner of the cocoa farmland? Yes [ ] No [ ]

    19b. If No, what is the arrangement with the owner?

30% for you and 70% for owner [ ] 50%-50% [ ] 70% for you and 30% for owner [ ] Other, please specify………………………

20. Do you have access to extension agents? Yes [ ] No [ ]
21. What is the number of times extension agents visit you in the 2022 cocoa farming season?..............................
22. What is the average age of the cocoa trees?......................................
23. In the last 3 years have you got access to credit? Yes [ ] No [ ]
24. In the last 3 years have you used hybrid cocoa on your farm? Yes [ ] No [ ]
25. What percentage of your farm have you cultivated hybrid cocoa trees?..........................

Economic Performance

Labour

a. Please indicate the quantity of labour (in man days) that you utilized in the 2022 cocoa farming season……………………………………………………………..
b. What is the total cost of labour (GHS) in the 2022 farming season? ....

Agrochemicals

c. Please indicate the quantity of agrochemicals (litres) that you utilized in the 2022 farming season ……………………………………………………………………….
d. What is the total cost of agrochemicals (GHS) in the 2022 farming season? ....

Equipment

e. How much did you spend on farm equipment (sprayer, machetes, etc) in the 2022 farming period (GHS)?....................

Revenue

a. What quantity of cocoa (Kg) were you able to harvest in the 2022 cocoa farming season? ....
b. How many cocoa trees are on your cocoa farm?....................................
c. What quantity (Kg) were you able to sell in the 2022 farming season? ………
d. What is the price per (64kg) bag of cocoa in the 2022 farming season?...............
e. How much did you receive as bonus/premium for the 2019 cocoa farming period?..........................
f. How much did you receive as bonus/premium for the 2022 cocoa farming period?..........................

Trust Statements

a) Most people in my community, farmer association or cooperative can be trusted.

Strongly Disagree [ ] Partly Agree [ ] Neither agree nor disagree [ ] Partly Agree [ ] Strongly Agree [ ]

b) Most people in my community, farmer association or cooperative have trust in me.

Strongly Disagree [ ] Partly Agree [ ] Neither agree nor disagree [ ] Partly Agree [ ] Strongly Agree [ ]

c. Members of the producer group/community help me on my farm operations when I need help.

Strongly Disagree [ ] Partly Agree [ ] Neither agree nor disagree [ ] Partly Agree [ ] Strongly Agree [ ]

d. Members of the producer group/community help me on my off-farm operations when I need help.

Strongly Disagree [ ] Partly Agree [ ] Neither agree nor disagree [ ] Partly Agree [ ] Strongly Agree [ ]

e. Members of the producer group/community help when I need financial support.

Strongly Disagree [ ] Partly Agree [ ] Neither agree nor disagree [ ] Partly Agree [ ] Strongly Agree [ ]

Sustainable Agricultural Practices

Please indicate your level of agreement or disagreement to these statements…

i. In the last three years you practiced pruning on your far.

Strongly Disagree [ ] Partly Agree [ ] Neither agree nor disagree [ ] Partly Agree [ ] Strongly Agree [ ]

ii. In the last 3 years you planted shade trees and retained trees on your cocoa farm.

Strongly Disagree [ ] Partly Agree [ ] Neither agree nor disagree [ ] Partly Agree [ ] Strongly Agree [ ]

iii. In the last 3 years you used agrochemicals that are approved on the list of approved agrochemicals by Ghana COCOBOD.

Strongly Disagree [ ] Partly Agree [ ] Neither agree nor disagree [ ] Partly Agree [ ] Strongly Agree [ ]

iv. How do you dispose off container of agrochemicals after usage?

Leave on farm [ ] Bury [ ] Burn [ ] Throw anywhere [ ] Throw at refuse dump [ ] Reuse container [ ]

v. Do you wear personal protective equipment when applying agrochemicals on your farm?

Yes [ ] Partial (use some) [ ] No [ ]

vi. What PPE do you use when applying agrochemicals on your farm?

Wear rubber groves [ ] Wear goggles [ ] Wear Overalls [ ] Wear Wellington boots [ ] Wear respirators or nose masks [ ] Wear caps/hats [ ]

vii. I ferment my cocoa beans according to the recommended standards of COCOBOD.

Strongly Disagree [ ] Partly Agree [ ] Neither agree nor disagree [ ] Partly Agree [ ] Strongly Agree [ ]

viii. How many days do you use to ferment your cocoa beans after harvest?.....

ix. I dry my cocoa beans according to the recommended standards of COCOBOD.

Strongly Disagree [ ] Partly Agree [ ] Neither agree nor disagree [ ] Partly Agree [ ] Strongly Agree [ ]

x. How many days do you use to dry your cocoa beans after harvest?.....

Qualitative

1. What is the bonus structure of the group and how is it distributed to the members?
2. How many times do the group meet in a year?
3. What is the monthly or yearly contribution of the members to the group?
4. How many sustainable cocoa production trainings do the group facilitate to the members in a year?
5. How is the training facilitated?
6. What are the main benefits that the group gets from the LBCs?
7. What benefit do the group vets from other private organisations, NGOs, and other private extension providers?
8. Are the group supported by the government (COCOBOD) in terms of the training delivery to the members what other benefits do the farmers receive from COCOBOD?
9. From whom they receive most of the support – COCOBOD, LBC, group, or other organizations.

1. NON-MEMBERS QUESTIONNAIRE

These questionnaires have been designed to execute research purposely for academic work. The principal objective is to analyse the Impact of producer groups on the adoption of sustainable agricultural practices and economic performance of small farmers. All information provided will be used solely and exclusively for academic purpose and all respondents will remain anonymous to the public domain. Information provided would be used to make sound empirical analysis and suggest policy recommendations that would help improve market access and farmer's socio-economic well-being and standard of living in the region. The entire interview will take 30 minutes of your time and you are kindly requested to provide honest and genuine answers within your possible best.

Interview date……../………/20...…….

Demographic and socio-economic data

Filled by enumerator:

26. GPS coordinates ……………………………………………….
27. Name of province ……………………………………………….
28. Name of ward/community ……………………………………………….
29. Gender [1] Male [0] Female
30. How many people are in your household?.................
31. Marital status….. [ ] Married [ ] Other
32. Main crop cultivated by farmer (Rice, Cassava, maize, etc)
33. How many other crops you produce in addition to your main crop?

    ....

34. Age of respondent in years ……………………………………………….
35. Years of education of respondent……………………………..

36. Do you own television, radio, and mobile phone? Yes [ ] No [ ]

37. What is your total land holding (in hectares)? …………………………………………..

38. How many of the agricultural land do you cultivate [in hectares]? ……………………

39. What is the distance from your farm to the nearest bigger regional market centre where you can sell your products? [km] …………………………………………….

40. Is there a cooperative or farmer association in your community? Yes [ ] No [ ]

41. What is the distance from your farm to the available cooperative headquarters in your community/nearest community?.............

42. Do you agree that the cooperative or farmer association can bring you economic and non-economic benefits?

Strongly Disagree [ ] Partly Agree [ ] Neither agree nor disagree [ ] Partly Agree [ ] Strongly Agree [ ]

43. Are you involved in off-farm business?

Yes [ ] No [ ]

44. Are you the owner of the cocoa farmland? Yes [ ] No [ ]

19b. If No, what is the arrangement with the owner?

30% for you and 70% for owner [ ] 50%-50% [ ] 70% for you and 30% for owner [ ] Other, please specify………………………

45. Do you have access to extension agents? Yes [ ] No [ ]

46. What is the number of times extension agents visit you in the 2022 cocoa farming season?..............................

47. What is the distance from your farm to the district extension office (Km)?.............

48. What is the average age of the cocoa trees?......................................

49. In the last 3 years have got access to credit? Yes [ ] No [ ]

50. In the last 3 years have you used hybrid cocoa on your farm? Yes [ ] No [ ]

51. What percentage of your farm have you cultivated hybrid cocoa trees?...........................

Economic Performance

Labour

f. Please indicate the quantity of labour (in man days) that you utilized in the 2022 cocoa farming season…………………………………………………………………..

g. What is the total cost of labour (GHS) in the 2022 farming season? ....

Agrochemicals

h. Please indicate the quantity of agrochemicals (litres) that you utilized in the 2022 farming season …………………………………………………………………………

i. What is the total cost of agrochemicals (GHS) in the 2022 farming season? ....

Equipment

j. How much did you spend on farm equipment (sprayer, machetes, etc) in the 2022 farming period (GHS)?....................

Revenue

a. What quantity of cocoa (Kg) were you able to harvest in the 2022 cocoa farming season? ....

b. What quantity (Kg) were you able to sell in the 2022 farming season? Market Access

Trust Statements

c) Most people in my community, farmer association or cooperative can be trusted.

Strongly Disagree [ ] Partly Agree [ ] Neither agree nor disagree [ ] Partly Agree [ ] Strongly Agree [ ]

d) Most people in my community, farmer association or cooperative have trust in me

Strongly Disagree [ ] Partly Agree [ ] Neither agree nor disagree [ ] Partly Agree [ ] Strongly Agree [ ]

Sustainable Agricultural Practices

xi. In the last three years you practiced pruning on your far.

Strongly Disagree [ ] Partly Agree [ ] Neither agree nor disagree [ ] Partly Agree [ ] Strongly Agree [ ]

xii. In the last 3 years you planted shade trees and retained trees on your cocoa farm.

Strongly Disagree [ ] Partly Agree [ ] Neither agree nor disagree [ ] Partly Agree [ ] Strongly Agree [ ]

xiii. In the last 3 years you used agrochemicals that are approved on the list of approved agrochemicals by Ghana COCOBOD.

Strongly Disagree [ ] Partly Agree [ ] Neither agree nor disagree [ ] Partly Agree [ ] Strongly Agree [ ]

xiv. How do you dispose off container of agrochemicals after usage?

Leave on farm [ ] Bury [ ] Burn [ ] Throw anywhere [ ] Throw at refuse dump [ ] Reuse container [ ]

xv. Do you wear personal protective equipment when applying agrochemicals on your farm?

Yes [ ] Partial (use some) [ ] No [ ]

xvi. What PPE do you use when applying agrochemicals on your farm?

Wear rubber groves [ ] Wear goggles [ ] Wear Overalls [ ] Wear Wellington boots [ ] Wear respirators or nose masks [ ] Wear caps/hats [ ]

xvii. I ferment my cocoa beans according to the recommended standards of COCOBOD.

Strongly Disagree [ ] Partly Agree [ ] Neither agree nor disagree [ ] Partly Agree [ ] Strongly Agree [ ]

xviii. How many days do you use to ferment your cocoa beans after harvest?.....

xix. I dry my cocoa beans according to the recommended standards of COCOBOD.

Strongly Disagree [ ] Partly Agree [ ] Neither agree nor disagree [ ] Partly Agree [ ] Strongly Agree [ ]

xx. How many days do you use to dry your cocoa beans after harvest?.....

Open Ended Questions

1. What are the reasons for not joining any farmer association or cooperative?
2. What you want to be improved to be able to join cooperative or farmer association based on the response to question 1?