THE PROFITABILITY AND ENVIRONMENTAL SUSTAINABILITY OF COCOA FARMING MODELS IN GHANA

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Executive Summary

Objective of the study

This report assesses the profitability of the different cocoa production models in Ghana, including the drivers of profitability and environmental sustainability. With the benefit of a comprehensive survey, the report highlights the dynamics involved in implementing three common cocoa farming models in Ghana—full sun, shaded and high tech—the comparative profitability indices of these models, and how to make cocoa a profitable business in Ghana. Several trade-offs exist between the three production systems: yield, extra food products, input use, labour cost, and environmental effect. These trade-offs drive farmer's choice of production model.

The report intends to contribute to improving the existing knowledge and information on how best to ensure sustained profitability of the cocoa industry in Ghana. The report recommends sustainable interventions that can improve the profitability of cocoa farming in Ghana.

Specifically, the report seeks answers to the following questions:

1. What are the **common cocoa farming models** used by farmers in the major cocoa-growing areas in Ghana?

2. What are the **linkages** between productivity, income, and profitability of the current cocoa farming models in Ghana?

3. What are the **linkages** between cocoa farming and environmental sustainability in Ghana?

4. What are the **available policy entry points** to promote the profitable cocoa farming models and the role of the private sector and development partners in promoting profitable cocoa farming?

In answering the above questions, **we surveyed 353 farmers in Ghana's top three cocoa-producing regions**: Western, Ashanti, and Eastern Region. This was done with a COCOBOD technical team to map the top-producing districts in these regions. A survey of this type, while seeking to capture views of cocoa farmers in the top-producing regions, may still not fully represent the overall cocoa farmers in Ghana. This is despite our sample frame consisting of all cocoa farmers in the three regions with the highest level of cocoa production in Ghana, which we selected from the highest-producing districts in these regions. To ascertain which model provides the most benefits, a cost-benefit analysis was conducted to ascertain the cash flows associated with each.

Key findings

KF1: Common cocoa farming models used by farmers in the major cocoa-growing areas

1. **The shaded and full sun models are the dominant cocoa farming models in the three high-producing regions**. More than half (55%) of the respondents use the shaded cocoa farming model, while about a third (34%) use the full sun model. About 7% of the farmers use the high-tech model, and the remaining 3% combine the three farming models (others).
2. **At the regional level, we also find that shaded farming is most dominant in Ashanti and Brong Ahafo, while full sun is more dominant in the Western Region**. This finding is consistent with existing literature, where the shaded cocoa model has gained traction in recent years due to its positive effects on the environment and overall sustainability in terms of biodiversity, soil fertility and carbon absorption. Nevertheless, the choice depends on several factors, including weather patterns. The Ashanti and Brong Ahafo regions are located in the middle belt of Ghana, where most of Ghana's forest zones are. As a result, the shaded cocoa farming model seems the most economical method for most of the cocoa farmers sampled. Even though the Western region forms part of the high forest zones of Ghana, we postulate that rainfall patterns make the full sun reduce their exposure to black pod disease.

3. **There is an even split of farm sizes between three (1.2 hectares) to five acres (2 hectares) and those above five acres.** In all, 43% of farms had acreage above 5 acres, 41% had between 3 and 5 acres, and 16% had less than 3 acres. Within the full-sun model, 50 farmers (42%) cultivated on land above 5 acres, 49 farmers (41%) cultivated between 3 and 5 acres, and 21 farmers (17%) cultivated less than 3 acres. Under high-tech farming, 12 farmers (46%) cultivated land above 5 acres, nine farmers (35%) cultivated between 3 and 5 acres, and five farmers (19%) were on land less than 3 acres. Likewise, shaded farming encompassed 83 farmers (43%) cultivating land above 5 acres, 82 farmers (43%) between 3 to 5 acres, and 28 farmers (14%) on less than 3 acres. These findings also reflect the 2017/18 Ghana Agricultural Census and other studies, where most cocoa farmers operate on farms below or up to 5 acres (2 hectares).
4. **There were some notable statistical differences across farm-level and household (farmer) characteristics on the type of farming model employed.** For example, the educational attainment of the farmers, region and district were significant predictors of the type of farming and, eventually, the cocoa yield. The latter is the key indicator of farm productivity used in this report. It is measured in **kilogrammes (kg) per hectare** of land farmed. This metric is consistent with several other published studies in the field.

KF2: Linkages between productivity, income, and profitability

Productivity

1. **The sampled farmers' average productivity is estimated at 457 kg/ha of cocoa output with a median of 395 kg/ha and a range of 20-1333 kg/ha**. This finding is consistent with about 400 kg/ha reported in several studies cited such as Barrientos & Akyere (2012), Asamoah et al. (2013), Lambert et al. (2014), Wessel & Quist-Wessel (2015), Oomes et al. (2016), Donovan et al. (2016), Vigneri and Serra, Bymolt et al. (2018) and Kalischek et al. (2023). The regional productivity also shows that respondent cocoa farmers in **the Brong-Ahafo region had the highest average yield of 628 kg/ha, followed by Western at 450 kg/ha and Ashanti at 360 kg/ha**.
2. Worryingly, **most (61%) of the sampled cocoa farmers of the country's three top-most cocoa-producing regions have meagre yields averaging 262 kg/ha (below 500 kg/ha)**. On the other hand, 33% of our sample have cocoa operations in the medium productivity band of 500-999 kg/ha (actual average of 709 kg/ha). The rest (5%) operate at high productivity levels above 1,000kg/ha (actual average of 1,145 kg/ha).
3. **The analysis of mean yields also shows shaded and high-tech farming models with the most productivity outcome for farmers compared to full-sun cocoa**. Based on the respondent data, the full-sun cocoa farming model yielded an average of 366 kg/ha in 2022. In contrast, the shaded and high-tech cocoa models produced an average of 500 kg/ha and 481 kg/ha output. The findings confirm the higher yield performance of the shaded and high-tech models without considering production costs.
4. **The regression analysis of cocoa yield using a set of farm and farmer characteristics (Model 3) shows that the relevant statistically significant variables affecting output were the soil type, sex, and region**. For example, gender differences were highly significant at the 5% level, with male farmers having better cocoa yields than females—a difference of 76kg/ha. Also, compared with the Ashanti region, farmers from Brong-Ahafo had better statistically significant average yields.

Revenue, Cost & Profitability

1. **None of the farming models meets the Living Income Community of Practice (LICOP) standard of US$1.96 per person per day (US$298/GHS 2,324 per month or US$3,576/GHS27,893 per annum) in Ghana in 2022 to afford a decent living.** We find average annual incomes of about US$1,087 versus benchmark household needs of US$3,576 per year. This is equivalent to $0.60 per person per day based on a five-person household from just cocoa farming. Farmers would have to almost triple their output from 0.87 metric tonnes (MT) to over 2 MT annually, or there has to be an extreme windfall from cocoa prices in the international market to have a decent living standard based on LICOP.

2. **Income from cocoa is the primary source of revenue for cocoa farmers across all the models, accounting for an average of 78% of reported household farming income.** In addition, revenues from food crops represent up to about a fifth of the overall revenue, which indicates some attempt to diversify incomes. This corroborates existing research where cocoa farmers in Ghana identified food crop investment as their second strategy for enhancing resilience.
3. **The shaded model is the most profitable cocoa farming model compared to the hi-tech and full sun models.** The shaded and the hi-tech models recorded a per-hectare net income of GHS2,505 and GHS2,042, respectively, while the full sun model recorded the lowest net income per hectare of GHS523.
4. **Complementary income food crops represent up to about a fifth of the farmers' overall income**. However, the food crops market does not have a guaranteed price and market, making the income from the food crops unpredictable. In addition, poor cocoa farmers are less likely to benefit from income diversification because they do not have sufficient financial resources to cover the cost of food crop farming.
5. **Comparatively, the models have few differences based on their cost profile.** On average, the three models had similar costs per hectare with relatively little difference in the cost associated with the hi-tech model. The average cost per hectare was GHS5,164, GHS5,080, and GHS5,051 for the shaded, full sun, and hi-tech models. Thus, the hi-tech model is profitable because of the relatively high returns, given that the three models have a similar cost profile. Additionally, farm management costs represent the largest cost component, particularly activities related to cocoa farming. Activities related to land preparation, spraying and weeding, and farm equipment drive the cost.

KF-3 Cocoa farming and environmental sustainability

Illegal mining practices

1. **About 14% or 1 in 10 cocoa farmers have been approached by people involved in galamsey to buy their farms and use them for mining activities.** While we could not find any baseline statistic to compare this to in terms of whether this is a rising or declining trend, various anecdotal and news reports highlight the growing prevalence of the practice of more cocoa farmers being willing to sell their land to illegal miners or engaging in galamsey themselves to supplement or replace their incomes. A recent study by Siaw et al. (2023) found evidence of what they call 'coerced to sell' strategies deployed by miners in the acquisition of farmlands.
2. **Farmers in the Western Region (almost 20% or 2 in 10 farmers compared to 14% in the full sample) faced more pressure to sell their cocoa farms for galamsey activities, while those in the Brong-Ahafo faced less pressure.** Ghana's Western Region is home to some of the richest deposits of gold in the country. A 2021 NASA Earth Observatory report highlights the following: *"although individual galamsey sites cover less area than an industrial mine, their cumulative effect on the landscape outweighs those of larger mines. In the* ***southwestern forests*** *of Ghana, for instance,* ***the footprint of small-scale mines is nearly*** ***seven times greater*** *than that of industrial mines*." Data on cocoa production data by region shows that the total production from the Western North (the same as the Western Region), which is Ghana's highest-producing region, has consistently declined since 2016, partly due to galamsey

Climate change awareness

1. **Overwhelmingly, almost all the farmers (97%) indicated that they know about climate change—which refers to changing weather patterns indicated by excessive rainfall and extremely** hot temperatures. Many farmers indicated that cocoa production on their farms is being affected by conditions such as too little rainfall, delay in onset rain starting, extremely high temperature, or delay in rain stopping, among others.
2. **Regarding the causes of climate change, a little over half of the respondents (52%) indicated that it was caused by human activities such as illegal logging, excessive**

wood fuel usage, and slash-and-burn agriculture. This was more pronounced among farmers in the Western Region (59%). Likewise, another 48% of the farmers surveyed indicated that climate change was due to natural phenomena, with those from the Ashanti region (54%) believing more in this relative to the sample average. Practices that farmers are using to boost the production of cocoa to mitigate the impact of climate change include more fertilizer application, afforestation, pegging of plants, hand pollination and manure application, among others.

Recommendations

1. **Government should collaborate with development partners to accelerate the re-adoption of the agroforestry models in major cocoa-growing areas.** Cocoa is typically cultivated under forestry systems, however, several practices have led to the conversion of forest for cocoa farming, largely because of limited understanding and lack of support to maintain agroforestry systems. Currently, there is a National Implementation Plan, which is intended to promote forest conservation and promote agroforestry cocoa farming. Ongoing initiatives such as the Cocoa and Forest Initiative (CFI) must be expanded to increase farmers' access to shaded trees for new and existing farmers. Stronger government support is needed to intensify the education and adoption of the shaded model.
2. **Government and stakeholders shsould intensify work with farmers to encourage more commercial scale cocoa farming, improve productivity and total output to make cocoa farming a viable business:** there is a need to encourage more commercial scale cocoa farming beyond the current subsistence level being practised by most farmers. As the analysis shows, most farm sizes (average of about 5 acres or 2 hectares) and yields (average of 457 kg/ha of cocoa output) are too small in order for cocoa farming alone to generate living incomes for farming households. None of the farming models meets the LICOP standard of US$1.96 per person per day (US$298/GHS 2,324 per month or US$3,576/GHS27,893 per annum) in Ghana in 2022 to afford a decent living. Subsistence level farmers must be supported through new agronomic practices that can double or triple farm yields to 1,000–1,900 kg/ha. New commercial scale cocoa farms could be based on the shaded model as this supports increased yields and better agroforestry practices that are more environmentally friendly.
3. **Expand the coverage of the Cocoa Pest and Disease Control (CODAPEC), and Cocoa Rehabilitation and Intensification Programmes (CRIP):** Initiatives such as CODAPEC and CRIP must be expanded with subsidised inputs and mass spraying as these help reduce farm management costs and ultimately improve yields.
4. **Deepen education and training offered through extension services to farmers:** The findings also show specific soil types [and agronomic practices] support productivity. The central government and related agencies such as COCOBOD should increase the scope and coverage of ongoing farmer engagements and education on sustainable agricultural techniques, such as environmental preservation and responsible input usage.
5. **Increase income diversification activities of cocoa farmers.** The findings indicate food crops as the second highest income source of farmers, but most government and donor programmes tend to only focus on cocoa production. Stakeholders (DPs, licensed buying companies and other industry players) could introduce initiatives that allows farmers to expand their income diversification activities. Along with investing in the shaded or high-tech production model, encouraging farmers to grow other food and tree crops might help lessen the industry's sensitivity to price changes, pests, and diseases. Intercropping with fruit trees, oil palms, and rubber can give farmers alternate sources of income. In addition, the diversification of products through manufacture of specialised chocolates, cocoa beverages, or cosmetics utilising cocoa derivatives can create new markets and sources of income for farmers through small-scale or cottage industries.

1 Background

Despite several years of political and administrative reforms, Ghana's cocoa sector has not delivered sustainable living income to many farmers. Ghana has yet to identify the bundle of policy actions that can deliver sustainable living income for the cocoa sector's 800,000 farmers and their families. Over the last three decades, the Government of Ghana, to make cocoa a sustainable business for Ghanaian farmers, has implemented several productivity enhancement programmes combined with price adjustments. However, many cocoa farmers are poor and living far below a sustainable livelihood. As a result, the triple challenge – low income, environmental protection, and child labour- remains unresolved. These factors are discrete; however, they are intertwined and driven by a common factor: poverty. Farmers will likely put high incomes ahead of environmental protection and child labour rights issues. Farmers need sustainable incomes to meet their children's educational needs and the inputs for environmentally sustainable practices. When farmers are poor, they have limited options to prioritise environmental protection and child labour. Thus, the common thread to the triple challenge is the living income of farmers. It is the cause of poverty, human rights, and environmental protection issues in the cocoa sector.

Addressing the living income challenge is complex and has been approached from several perspectives. The common determinant of farmers' living income is the price of cocoa and output levels. Productivity, agricultural practices, and income diversification have been identified as significant predictors of sustainable living income. High prices can increase farmers' income significantly; however, the fluctuations in farm gate prices make pricing alone a difficult lever to sustainably support the profitability [financial viability] of cocoa farming. In addition, the prices must be complemented with additional payments for farmers to achieve a living income. For instance, the Living Income Differential (LID) implemented by Ghana and Cote d'Ivoire provides additional payment directly to the farmer to achieve a living income.[2] Farmers can benefit from high prices when productivity can respond positively to the rising prices.

Given that more than half of cocoa farmers in Ghana operate at the small-scale level (below 5 acres), they cannot significantly increase their productivity to benefit from the potentially high prices. Also, increased production is accompanied by increased cost of production (labour and inputs), which can potentially affect expected incomes. Thus, high prices and productivity have the potential to bring farmers closer to a living income, but farmers must do more than focus on price and production.

Other countries have pursued profitable cocoa farming through income diversification for cocoa farmers. The diversified income of cocoa farmers increases the farmer's income sources and supports farmers' resilience during low prices and disease epidemics that affect productivity. However, diversifying the farmer's income—the cost involved in investing in other crop value chains- is not factored in cocoa prices and other support programmes implemented to support farmers. This means that farmers have to rely on the income from cocoa to invest in other value chains. Thus, low-income farmers are less likely to diversify their sources of income fully. This implies that diversified income sources can support the profitability of cocoa farming. Other sustainable agricultural practices can support productivity, but these are insufficient to maintain a profitable firm. This indicates that achieving a living income for farmers and making cocoa farming a profitable business requires multiple approaches to be effective.

Farming models are least explored in the quest to understand the optimal approaches to making cocoa farming profitable. Over the years, the government's policy responses to making cocoa a sustainable business have focused on productivity enhancement programmes that increase access to high-yield seedlings, mass spraying and hi-tech fertiliser applications, cocoa rehabilitation, and artificial pollination. However, the recent Cocoa Barometer report[3] suggests that productivity enhancement programmes have been less optimal in raising the net income of cocoa farming households because high investment inputs and labour costs accompany them. Given the low financing opportunities and the risk of declining prices, productivity enhancement methods alone are ineffective in making cocoa profitable. Furthermore, existing studies have focused on a comparative

[2] https://chocolateglossary.com/chocolate-entries/living-income-differential

[3] https://cocoabarometer.org/wp-content/uploads/2022/12/Cocoa-Barometer-2022.pdf

analysis of the advantages/disadvantages between the three main production systems and isolated profitability analysis due to a lack of accurate data on the cocoa sector.

Ghana has three standard production systems: full sun, shaded cocoa (agroforestry), and high-tech plantations.[4] Shaded cocoa, also called agroforestry production, has been identified as a sustainable and environmentally friendly model. It refers to a cocoa plantation model with over 50% of the tree canopy above the cocoa. The full sun model relates to cocoa farms with less than 13 shade trees per hectare, intercropped with food crops such as plantain and banana. The high-tech plantations relate to highly intensified production systems requiring high input use and mostly without shade. Several trade-offs between the three production systems include yield, extra food products, input use, labour cost, and environmental effects.

This report critically examines the different models of production to identify the most profitable cocoa production model, the drivers of profitability, and their linkages with environmental sustainability. The long-term objective of this paper is to influence both government policies and the Embassy of the Kingdom of Netherlands' strategy towards creating a sustainable cocoa sector in Ghana.

1.1 Economic contributions of cocoa production

The contributions made by the cocoa industry to the economy of Ghana include export earnings, employment generation, poverty reduction, and rural development. Most of the country's export revenue has historically come from cocoa exports. Exports of cocoa help build up the country's foreign exchange reserves, essential for managing its external debt and maintaining its currency. The income received from this sector has supported Ghana's import requirements for necessary products and services and stabilised its balance of payments. For example, **in 2021, cocoa contributed about a fifth of the country's total export earnings (US$2.8 billion of the US$14.7 billion)**[5] **and a third of the total earnings of non-traditional exports (US$1.02 billion of the US$3.3 billion) through cocoa derivatives**[6]**—**see Figure 1-1**.** The cocoa bean market, where Ghana is the second largest exporter after Cote d'Ivoire, is projected to grow at a compound annual growth rate (CAGR) of 7.3% from 2019 to 2026, increasing from US$8.6 billion in 2017 to about US$16.32 billion in 2026.[7] In addition, the retail market value of the chocolate industry is expected to grow from US$106.19 billion in 2017 to US$189.89 billion in 2026.

Regarding income generation, countless smallholder farmers in Ghana make a living by growing cocoa. The Sale of cocoa gives farmers the means to provide for their families, invest in their children's education and healthcare, and raise their standard of living.[8] This trend has had an amplified effect on other sectors of the economy. The Ghanaian economy is diverse due to the cocoa business. Profits from this industry have been invested in other parts of the economy, fostering overall growth and progress.

[4] Wainaina, P.; Minang, P.A.; Duguma, L.; Muthee, K. A Review of the Trade-Offs across Different Cocoa Production Systems in Ghana. Sustainability 2021, 13, 10945. https:// doi.org/10.3390/su131910945

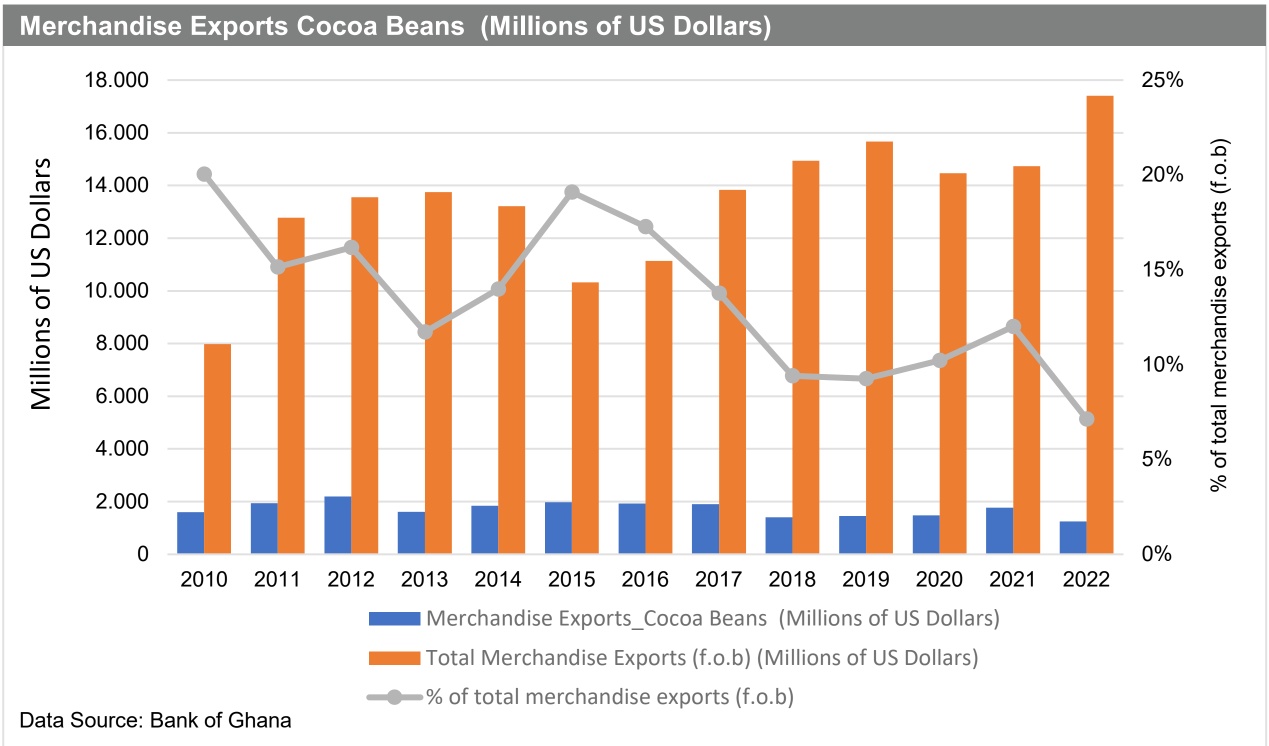
[5] ''Summary of Economic and Financial Data'' Bank of Ghana (2022).. Summary-of-Economic-Financial-Data-May-2022.pdf (bog.gov.gh)

[6] ''Highlights of 2021 Non-Traditional Export Performance''- Ghana Exports Promotion Authority (2022) 2021-Export-Statistics-Highlight-.pdf (gepaghana.org)

[7] ''Global Market Report''- Cocoa International Institute for Sustainable Development (2021) Global Market Report: Cocoa (iisd.org)

[8] Bymolt, R., Laven, A., Tyszler, M. ''Demystifying the cocoa sector in Ghana and Côte d'Ivoire'' Chapter 7-The Importance of Cocoa. The Royal Tropical Institute (KIT). (2018) p.134 https://www.kit.nl/wp-content/uploads/2018/10/Demystifying-cocoa-sector-chapter7-the-importance-of-cocoa.pdf

Fig 1-1 Contribution of cocoa beans to Ghana's export earnings, 2010-2022



1.2 Cocoa farming productivity and other challenges

Notwithstanding the important economic benefits, cocoa growing and the chocolate industries have not positively impacted all actors in the value chain in Ghana. The trend is similar to other cocoa-growing countries, especially in Africa. For example, Ghana and Cote d'Ivoire produce more than two-thirds of the global cocoa bean supply. However, both countries earn about 3%-6% of the total value of the global chocolate industry[9], reflecting an unequal allocation of the overall rent across the value chain. Cocoa farmers are victims of unequal rent and wealth distribution in the cocoa value chain. Several stakeholders' efforts to achieve a sustainable cocoa sector that prioritises human rights, guarantees forest recovery and environmental protection, and helps farmers achieve remunerable incomes have not led to significant results. Farmers remain poor and are unable to pursue economically sustainable farming mechanisms.

The 2017-18 agricultural census by the Ghana Statistical Service indicates that about seven of every ten cocoa farmers cultivate less than 5 acres (2.02 hectares), and about half of these small-scale farmers cultivate up to 2 acres (0.81 hectares) — see Table 1-1[10]**.** Also, almost 95% of smallholder cocoa farmers produce **up to 650kg/hectare** [kg/ha] annually, indicating relatively low productivity.[11] Several other studies[12] confirm this: the majority of cocoa farmers in Ghana have

[9]Teye, J.K and Nikoi, E. ''The Political Economy of the Cocoa Value Chain in Ghana'' Working Paper, WP 53- Agricultural Policy Research in Africa (2021) https://www.future-agricultures.org/wp-content/uploads/2021/03/APRA-WP53_The_Political_Economy_of_The_Cocoa_Value_Chain_in_Ghana.pdf

[10]''Ghana Census of Agriculture (GCA) 2017/18'' Ghana Statistical Service. (2020). https://statsghana.gov.gh/gssmain/fileUpload/pressrelease/Final%20Report%2011%2011%202020%20printed%20version.pdf

[11]Teye, J.K and Nikoi, E. ''The Political Economy of the Cocoa Value Chain in Ghana'' Working Paper, WP 53- Agricultural Policy Research in Africa (2021) https://www.future-agricultures.org/wp-content/uploads/2021/03/APRA-WP53_The_Political_Economy_of_The_Cocoa_Value_Chain_in_Ghana.pdf

[12] Kalischek, N., Lang, N., Renier, C., Daudt, R. C., Addoah, T., Thompson, W., ... & Wegner, J. D. (2023). Cocoa plantations are associated with deforestation in Côte d'Ivoire and Ghana. *Nature Food*, *4*(5), 384-393. https://doi.org/10.1038/s43016-023-00751-8

average farm sizes of 5-12 acres (2-5 hectares)[13] with an average cocoa yield of **400 kilograms per hectare (kg/ha)**[14] [typical range: 400-530 kg/ha] for these small scale producers; only 10% of cocoa farmers operate on large scale[15].

Ghana's production is similar to other producing nations, such as Cote d'Ivoire and Indonesia, with estimated yields of 350-650 kg/ha[16] and 400-800 kg/ha[17] hectare, respectively (Table 1-2). However, these yields are low compared to South America (2,500 kg/ha) and Asia (2,000 kg/ha).[18] In other words, **Ghana's yields are below an estimated yield potential of 1,000–1,900 kg/ha**[19].

Table 1-1 Land parcels by type of tree crop, and by land size (acres)

Area of crop production (acres)	< 2	2 - < 5	5 - < 10	10+	Total
Total	**370,855**	**363,278**	**205,924**	**99,364**	**1,039,421**
All tree crops	35.7	35.0	19.8	9.6	100.0
Avocado	43.4	27.7	18.5	10.4	3,148
Banana	54.9	27.1	12.6	5.4	9,137
Cashew	14.4	42.6	25.9	17.1	95,136
Cocoa	35.9	34.6	20.3	9.2	795,614
Coconut	63.8	23.0	8.2	5.0	10,918
Coffee	59.7	26.3	10.2	3.8	1,265
Cola	43.5	34.2	13.8	8.5	1,173
Citrus	56.6	27.2	10.5	5.6	17,991
Mango	52.3	25.1	10.9	11.7	5,640
Oil-palm	43.7	35.1	14.9	6.3	92,213
Guava	73.9	11.6	6.7	7.7	284
Pawpaw	49.4	28.9	14.0	7.8	1,939
Shea nut	73.1	15.3	6.9	4.6	391
Rubber	50.6	25.2	10.1	14.1	4,572

Source: Ghana Statistical Service (2020: p.162)

[13] Bymolt, R., Laven, A., Tyszler, M. (2018). Demystifying the cocoa sector in Ghana and Côte d'Ivoire. Chapter 10, Production and yield. The Royal Tropical Institute (KIT). https://www.kit.nl/wp-content/uploads/2018/11/Demystifying-cocoa-sector-chapter10-production-and-yield.pdf

[14] Opoku-Ameyaw, K., Baah, F., Gyedu-Akoto, E., Anchirinah, V., Dzahini-Obiatey, H.K., Cudjoe, A.R., Acquay, S. and Opoku, S.Y., 2010. Cocoa Manual—A Source Book for Sustainable Cocoa Production. Cocoa Research Institute of Ghana, Tafo, Akim.
https://www.researchgate.net/publication/283018115_Cocoa_Manual_A_source_book_for_sustainable_cocoa_production

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[16] Barry Callebaut (2023). Farmer yield and income in Côte d'Ivoire an analysis of Farmer Field Books (FFBs).
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See also https://www.barry-callebaut.com/en-GB/group/media/news-stories/barry-callebaut-releases-report-key-findings-cocoa-farming-cote-ivoire

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Daymond, A. J., Prawoto, A., Abdoellah, S., Susilo, A. W., Cryer, N. C., Lahive, F., & Hadley, P. (2020). Variation in Indonesian cocoa farm productivity in relation to management, environmental and edaphic factors. *Experimental Agriculture*, *56*(5), 738-751. doi:10.1017/S0014479720000289

[18] See https://www.un-redd.org/news/why-are-cote-divoires-cocoa-yields-so-low

[19] Supra, n.18

Table 1-2 Summary of recent yield estimates for Ghana and Cote d'Ivoire, kg/ha

Yield	Source	Yield	Source
Ghana		**Cote d'Ivoire**	
+/- 400 kg/ha	Barrientos & Akyere (2012)[20]	447 kg/ha	Tano (2012)[21]
>400 kg/ha	Asamoah et al. (2013)[22]	493 kg/ha	Ingram et al. (2013)[23]
500 kg/ha	Lambert et al. (2014)[24]	300-500 kg/ha	Ingram et al. (2014)[25]
400 kg/ha	Wessel & Quist-Wessel (2015)[26]	500 kg/ha	Lambert et al. (2014)
400 kg/ha	Kumi & Daymond (2015)[27]	500 kg/ha	Barry Callebaut (2014)[28]
420 kg/ha	Oomes et al. (2016)[29]	300-400 kg/ha	FLA (2015)[30]
400-530 kg/ha	Donovan et al. (2016)[31]	350-620 kg/ha	Barry Callebaut (2023)[32]
402 kg/ha	Vigneri and Serra[33]		
100-500 kg/ha	Bymolt et al. (2018)[34]		
250-380 kg/ha	Kalischek et al. (2023)[35]		

Source: Adapted from Bymolt et. al. (2018)

[20] Barrientos, S.W, Asenso Akyere, K. (2012). Mapping sustainable production in Ghanaian cocoa, Report to Cadbury. Institute of Development Studies & University of Ghana. https://hummedia.manchester.ac.uk/institutes/gdi/research/impact/Mapping%20Sustainable%20Production%20in%20Ghanaian%20Cocoa.pdf

[21] Tano, M.A. (2012). Crise cacaoyère et stratégies des producteurs de la sous-préfécture de Meadji au sud-ouest ivoirien (Doctoral dissertation, Université Toulouse le Mirail-Toulouse II). https://theses.hal.science/tel-00713662

[22] Asamoah, M., Ansah, F. O., Anchirinah, V., Aneani, F., Agyapong, D. (2013). Insight into the standard of living of Ghanaian Cocoa Farmers. Greener Journal of Agricultural Sciences, 3(5), 363-370. http://cocoa.kit-ipp.org/cocoa/sites/default/files/publication/standard%20of%20living%20of%20ghanaian%20cocoa%20farmers.pdf

[23] Ingram V., Waarts Y., van Vugt S.M., Ge L., Wegner L., Puister-Jansen L. (2013). Towards sustainable cocoa: Assessment of Cargill and Solidaridad cocoa farmer support activities in Côte d'Ivoire 2008-2012. LEI, Wageningen UR. Wageningen. https://library.wur.nl/WebQuery/wurpubs/fulltext/314177

[24] Lambert, A., Gearhart, J. McGill, A., Wrinkle, H. (2014). The Fairness Gap: Farmer incomes and root cause solutions to ending child labor in the cocoa industry. International Labour Rights Forum, Washington D.C. https://laborrights.org/sites/default/files/publications/Fairness%20gap_low_res.pdf

[25] Ingram, V., Waarts, Y., Ge, L., van Vugt, S., Wegner, L., Puister-Jansen, L., Ruf, F., Tanoh, R. (2014). Impact of UTZ certification of cocoa in Ivory Coast; Assessment framework and baseline. Wageningen, LEI Wageningen UR (University & Research centre), LEI Report 2014-010.

[26] Wessel, M., Quist-Wessel, P. F. (2015). Cocoa production in West Africa, a review and analysis of recent developments. NJAS-Wageningen Journal of Life Sciences, 74, 1-7. https://doi.org/10.1016/j.njas.2015.09.001

[27] Kumi, E., Daymond, A. J. (2015). Farmers' perceptions of the effectiveness of the Cocoa Disease and Pest Control Programme (CODAPEC) in Ghana and its effects on poverty reduction. American Journal of Experimental Agriculture, 7(5), 257-274. https://purehost.bath.ac.uk/ws/portalfiles/portal/112730478/Kumi752015AJEA16388_2_.pdf

[28] Barry Callebaut (2014). Cocoa Sustainability Report 103/2014. https://www.barry-callebaut.com/sites/default/files/2019-01/barry-callebaut-cocoa-sustainability-report-2013-14.pdf

[29] Oomes, N., Tieben, B., Laven, A., Ammerlaan, T., Appelman, R., Biesenbeek, C., Buunk, E. (2016). Market concentration and price formation in the global cocoa value chain. SEO Amsterdam Economics. https://www.tonysopenchain.com/resources/uploads/2019/03/2016-79_Market_Concentration_and_Price_Formation_in_the_Global_Cocoa_Value_Chain.pdf

[30] FLA (2015). Evaluer la situation actuelle des femmes et des jeunes agriculteurs et l'état nutritional de leurs familles dans deux communautés productrice de cacao en Côte d'Ivoire. Rapport prepare par Fair Labour Association, Juillet 2015. https://docplayer.fr/15038411-Evaluer-la-situation.html

[31] Donovan, J., Stoian, D., Foundjem, D., Degrande, A. (2016). Fairtrade Cocoa in Ghana: Taking Stock and Looking Ahead. Sweet Vision, Vol. 61(3), 14-17. https://cgspace.cgiar.org/bitstream/handle/10568/78255/Fairtrade_Stonian_2016.pdf?sequence=4&isAllowed=y

[32] https://www.barry-callebaut.com/en-GB/group/media/news-stories/barry-callebaut-releases-report-key-findings-cocoa-farming-cote-ivoire

[33] Vigneri, M. and Serra, R. (2016). Researching the Impact of Increased Cocoa Yields on the Labour Market and Child Labour Risk in Ghana and Côte d'Ivoire. ICI Labour market research study. https://www.cocoainitiative.org/sites/default/files/market_research_full_web.pdf

[34] Supra, n.18

[35] Kalischek, N., Lang, N., Renier, C., Daudt, R. C., Addoah, T., Thompson, W., ... & Wegner, J. D. (2023). Cocoa plantations are associated with deforestation in Côte d'Ivoire and Ghana. *Nature Food*, *4*(5), 384-393. https://doi.org/10.1038/s43016-023-00751-8

Typically, farmers cultivating about 2 hectares (up to about 5 acres) with an average dependent of six individual household members in Ghana live below the poverty line (US$2.00/day) with a daily income of US$0.45/day.[36] Given that revenues from cocoa represent about 70% of the income of farmers, most of the farmers are living on poverty income, which is insufficient to support a decent livelihood. Furthermore, about 35% to 45% of Ghanaian cocoa farmers live below the poverty line, and almost 90% do not earn a living income.[37] Low farmer incomes often translate to food insecurity and poverty, exacerbated by fluctuating cocoa prices, old cocoa trees, and low productivity.

In addition, environmental and social sustainability issues pose further risks to the industry's overall sustainability.[38] These include deforestation and forest degradation; illegal mining (known locally as '*galamsey*'); excessive use of pesticides and chemicals; soil erosion; child labour and forced labour; difficulties of land tenure and access; lack of access to quality education and healthcare; gender inequality in the industry; slow-paced community development and the impact of climate change.[39]

To ensure the sector's sustainability, past governments and private businesses have responded to the increasing living income gaps and poverty among cocoa farmers by addressing the myriad of issues that affect the farm productivity and profitability of cocoa farming in Ghana—see Box 1.[40]

While appreciable attention has been directed towards these interventions, the models used on cocoa farms have yet to be studied comprehensively to ascertain the models which retain comparative advantages in ensuring the future sustainability of the cocoa industry in Ghana. This report responds to this gap in policymaking.

Box 1 – Living Income Differential (LID) in Ghana and Cote d'Ivoire

- In 2019, the governments of Ghana and Cote d'Ivoire, through their respective cocoa marketing boards, Le Conseil du Café-Cacao (CCC) and Ghana Cocoa Board (COCOBOD), enacted Living Income Differential (or LID).
- LID's primary objective is higher farmgate prices whereby an additional US$400 per metric ton (MT) premium is affixed to all cocoa sales from both countries starting in the 2020/21 main crop season. Cocoa production from both countries accounts for about 70% of global output.
- The initial reaction to the LID was contentious.
- Some recent studies[41] also show that LID gains are relatively low regarding poverty and living income.

[36] ''The Fairness Gap in the Cocoa Sector'' International Labour Rights Forum (2014). Fairness Gap Report. https://laborrights.org/sites/default/files/publications/Fairness gap_low_res.pdf

[37] ''Towards a Living Income for Cocoa Framers in Ghana; Assessing Companies Efforts to Date'' OXFAM (2023). Towards a Living Income for Cocoa Farmers in Ghana: Assessing companies' efforts to date. https://oxfamilibrary.openrepository.com/bitstream/handle/10546/621485/rr-ghana-cocoa-farmers-living-income-140223-en.pdf

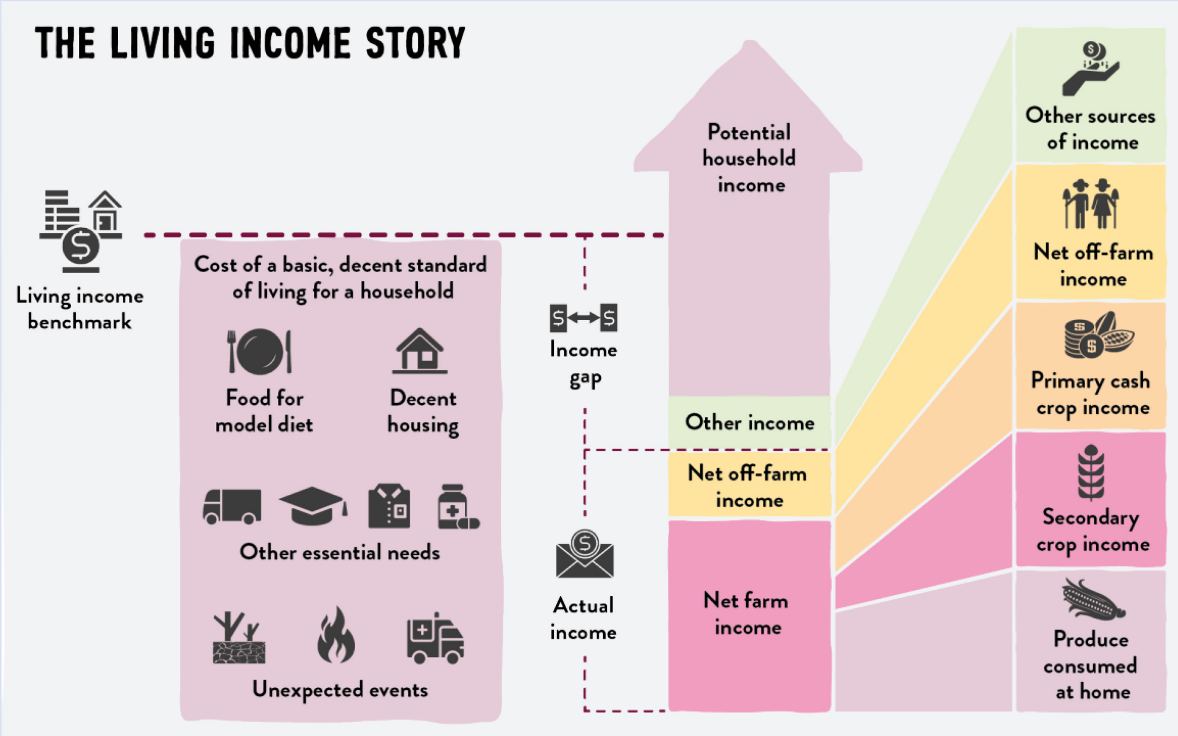
[38] Monastyrnaya, E. Joerin, J. Dawoe, E. and Six, J. ''Assessing the resilience of the cocoa value chain in Ghana-Swiss Federal Institute of Technology Zurich, ETH-Department of Environmental Systems Science Sustainable Agroecosystems Group(2016) p.iii https://www.cocoainitiative.org/sites/default/files/resources/Assessing-the-Resilience-of-the-cocoa-value-chain-in-ghana.pdf

[39] Schroth, G., Läderach, P., Martinez-Valle, A. I., Bunn, C., & Jassogne, L. (2016). Vulnerability to climate change of cocoa in West Africa: Patterns, opportunities and limits to adaptation. *Science of the Total Environment*, *556*, 231-241. https://doi.org/10.1016/j.scitotenv.2016.03.024

Amfo, B., & Ali, E. B. (2020). Climate change coping and adaptation strategies: how do cocoa farmers in Ghana diversify farm income?. *Forest Policy and Economics*, *119*, 102265. https://doi.org/10.1016/j.forpol.2020.102265

[40] "A Way Towards a Living Income for Ghanaian Cocoa Farmers." Rikolto (International), https://international-rikolto.wieni.work/en/project/way-towards-living-income-ghanaian-cocoa-farmers

[41] Adams, M. A., & Carodenuto, S. (2023). Stakeholder perspectives on cocoa's living income differential and sustainability trade-offs in Ghana. *World Development*, *165*, 106201. https://doi.org/10.1016/j.worlddev.2023.106201; Boysen, O., Ferrari, E., Nechifor, V., & Tillie, P. (2023). Earn a living? What the Côte d'Ivoire–Ghana cocoa living income differential might deliver on its promise. *Food Policy*, *114*, 102389. https://doi.org/10.1016/j.foodpol.2022.102389;



Source: [Waarts & Kiewisch (2021)] based on [Living Income Community of Practice (2020).]

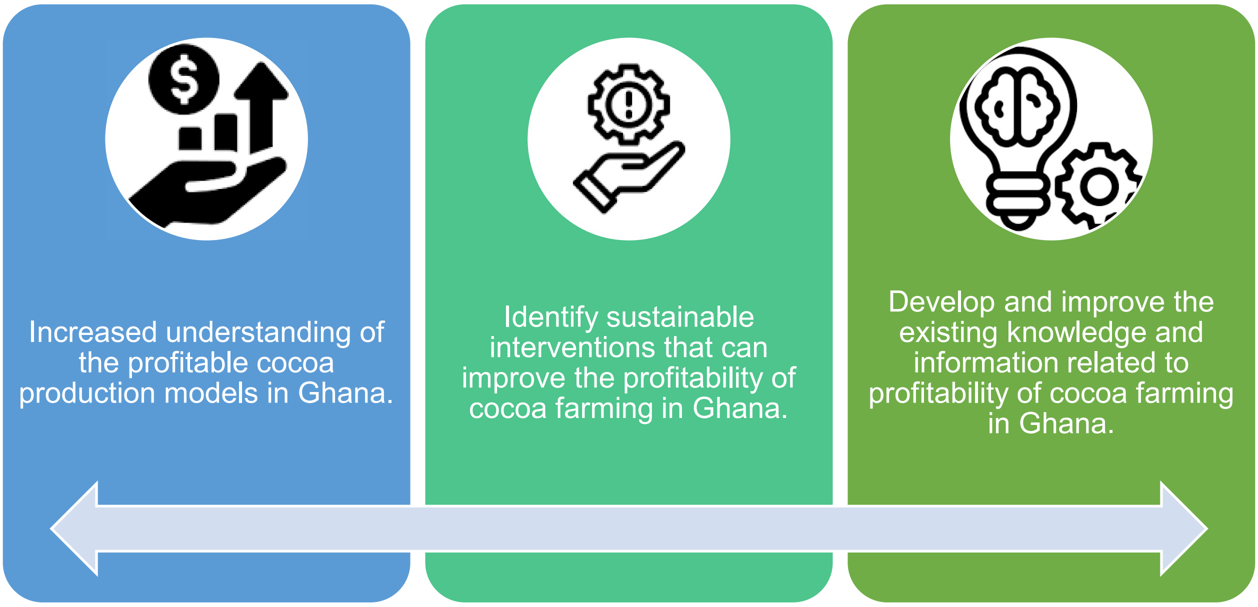
1.3 Purpose and scope of the report

This report aims to understand Ghana's most profitable cocoa production model on a comparative basis, the drivers of profitability, and the sector's environmental sustainability (Figure 1-2). With the benefit of a comprehensive survey encompassing 353 respondents, the report highlights the dynamics involved in implementing three common cocoa farming models in Ghana, the comparative profitability indices of these models, and the innovative pathways to make cocoa a profitable business in Ghana.

The report also makes recommendations on sustainable interventions that can improve the profitability of cocoa farming in Ghana. The report intends to contribute to improving the existing knowledge and information on how best to ensure sustained profitability of the cocoa industry in Ghana.

van Vliet, J. A., Slingerland, M. A., Waarts, Y. R., & Giller, K. E. (2021). A Living Income for Cocoa Producers in Côte d'Ivoire and Ghana?. *Frontiers in Sustainable Food Systems*, *5*, 732831. https://doi.org/10.3389/fsufs.2021.732831; Boysen, O., Ferrari, E., Nechifor Vostinaru, V. and Tillie, P., Impacts of the Cocoa Living Income Differential Policy in Ghana and Côte d'Ivoire, EUR 30812 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-41091-1, doi:10.2760/984346, JRC125754.

Fig 1-2 Objectives of the project



Source: Authors' construct

1.4 Key framing issues and research questions

In the past, government and private interventions made into the cocoa industry to ensure sustainability have mostly concentrated on providing direct inputs and technical assistance or services to cocoa farms across the country. However, any analysis of factors that account for the industry's profitability must go beyond these interventions. A primary investigation into the correlation between farm models and their comparative advantage for profitability is required to understand which cocoa farming model is worth investing in in the future. This report contributes to deepening our understanding of these dynamics by providing answers to the following questions:

1. What are the **common cocoa farming models** used by farmers in the major cocoa-growing areas in Ghana?

2. What are the **linkages** between productivity, income, and profitability of the current cocoa farming models in Ghana?

3. What are the **linkages** between cocoa farming and environmental sustainability in Ghana?

4. What are the **available policy entry points** to promote the profitable cocoa farming models, and what is the role of the private sector and development partners in promoting profitable cocoa farming?

1.5 Methodology: Survey design, data collection and analysis

1.5.1 Survey design

To answer the above questions, we surveyed the top three cocoa-producing regions: Western, Ashanti, and Eastern Region. Working with the COCOBOD technical team, a mapping of top-producing districts was done to undertake the survey. In addition, selection criteria were used to select the type of farms (tree age) suitable for such analysis. The data for the project was sourced from both primary and secondary sources.

This study adopts a quantitative design. Objective questions are coded to allow respondents to provide their responses while the researchers can model them quantitatively to draw insights.[42] This specific research design is chosen as it is the most appropriate for large-scale research that primarily relies on closed questions formed as ordinal, dichotomous or multiple choice. This approach is also most appropriate for establishing trends across a population of interest, and the data can be analysed or presented using statistical tools and techniques. This approach is also very useful when there is the need to collect the data on a future date to compare as and when policies are implemented.

To ascertain which model provides the most benefits, **a cost-benefit analysis was conducted to ascertain the cash flow associated with each model**.

The relevance of this type of study to help shape policy cannot be underestimated as it provides an avenue for researchers to reveal farmers' opinions, which is relevant in exploring ways to shape further, change, withdraw or implement sustainable cocoa farming methods.

1.5.2 Data collection, survey instrument and framework

The study used a survey instrument designed based on the review of the extant literature, which included policy documents on cocoa farming in Ghana and other countries and expert advice. Several close-ended questions were developed after a review of the documents. This is followed by a consultation of agricultural sector exports from academia, COCOBOD and practitioners with many years of experience and expertise in the issues above.

A team of seasoned enumerators administered the questionnaire in the top three cocoa-producing regions. In the Ashanti Region, this included New Edubiasi, Antoakrom and Tepa. In the Brong-Ahafo Region, we surveyed farmers in Goaso, Kasapin and Nkrankwanta. Finally, cocoa farmers from Juaboso, Sefwi-Wiawso, Akontombra/Bodi were surveyed in the Western Region. Three hundred ninety farmers were surveyed, of which 353 provided adequate responses. The latter number is what is used in our subsequent analysis.

On the whole, respondents were willing and open to answering questions. This ensures a wide variability; thus, insights and inferences will be relevant for shaping national policy. The enumerators were drawn from the communities.

The questionnaire was **administered within a two-and-a-half-week window in September 2023.**

The survey questions and the main themes are presented in the **Appendix**. These reveal the areas of focus of the study in line with the three main objectives of the study. The demographic information also provides some detailed characteristics about the respondents, which can be used for a richer and more detailed analysis of the results.

1.5.3 Sample population, frame and size

The sample frame consists of all cocoa farmers in the three regions with the highest cocoa production levels in Ghana, concentrating on the highest-producing districts (Table 1-3 and Figure 1-3).

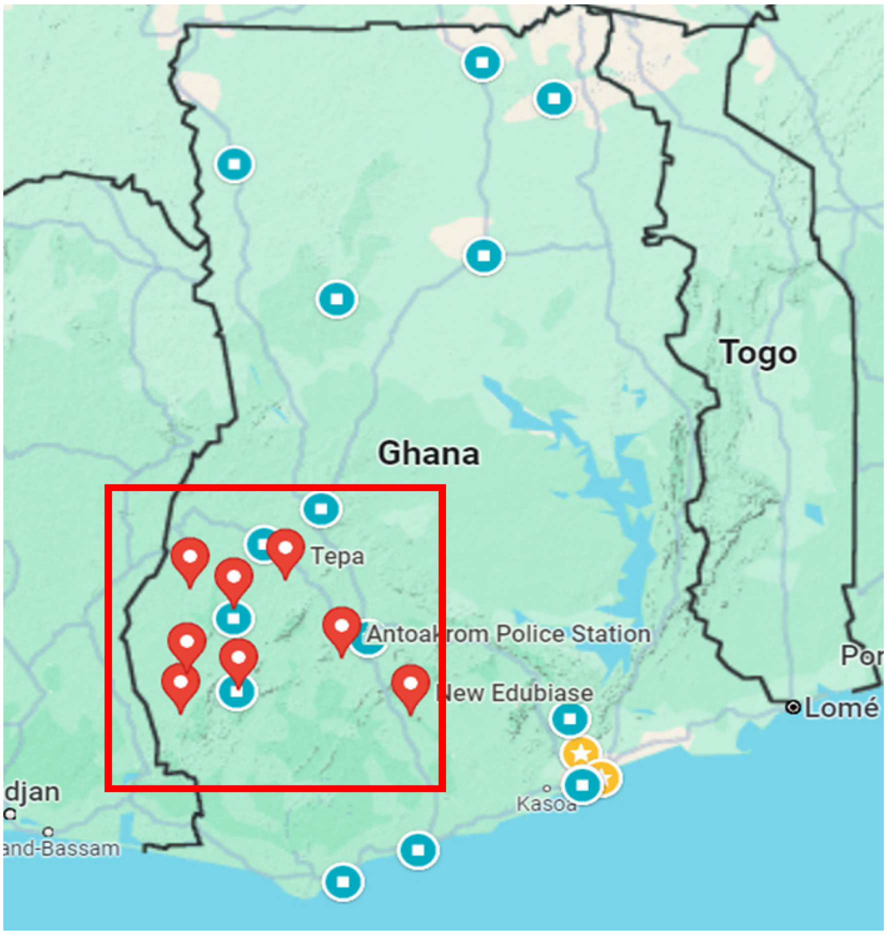
Table 1-3 Sample Frame

ASHANTI REGION		**WESTERN REGION**		**BRONG-AHAFO REGION**	
Districts	**Farmers**	**Districts**	**Farmers**	**Districts**	**Farmers**
Tepa	11,000	Juaboso	19,000	Kasapin	11,000
New Edubiase	10,000	Sefwi Wiawso	15,000	Goaso	14,000
Antoakrom	19,000	Akontombra/Bodi	11,000	Ankrankwanta	9,000
Total number of farmers (sample frame)				**119,000**	

Source: Author's construct

[42] Larossi, G. (2006). *The power of survey design: A user's guide for managing surveys, interpreting results, and influencing respondents*. Washington, DC: World Bank. https://openknowledge.worldbank.org/handle/10986/6975

Fig 1-3 Map of sampled districts in red box and pin



Source: Google Maps

The sample size[43] is calculated based on the formula:

$$n = \frac{N}{1 + N\,(\alpha^2)} \dots\dots\dots\dots\dots\dots\dots\dots (1)$$

where

- n is the sample size
- N is the sample frame
- α is the margin of error (the confidence level used in this calculation is 95%, making the margin of error 5%).

This gives:

$$n = \frac{119{,}000}{1 + 119{,}000\,(0.05^2)} = 399.996 \cong 400 \dots\dots\dots\dots\dots..(2)$$

[43] Singh, A. S., & Masuku, M. B. (2014). Sampling techniques & determination of sample size in applied statistics research: An overview. *International Journal of economics, commerce and management*, *2*(11), 1-22.

The sample size for this survey is, therefore, 400 farmers. This number is distributed proportionally among the nine districts in the three regions, as shown in Table 1-4. The formulae adopted is:

$$\frac{no\ of\ farmers\ per\ district}{Total\ number\ of\ farmers\ in\ the\ nine\ districts}\ x\ 400 \ldots\ldots\ldots\ldots\ldots..(3)$$

Table 1-4 Proportional Distribution of the sample size

Districts	Formulae	Sample size
	ASHANTI REGION	
Tepa	$11000/119000\, x\ 400$	37
New Edubiase	$10000\ /119000\, x\ 400$	34
Antoakrom	$19000/119000\, x\ 400$	64
	WESTERN REGION	
Juaboso	$19000\ /119000\, x\ 400$	64
Sefwi Wiawso	$15000\ /119000\, x\ 400$	50
Akontombra/Bodi	$11000\ /119000\, x\ 400$	37
	BRONG-AHAFO REGION	
Kasapin	$11000\ /119000\, x\ 400$	37
Goaso	$14000\ /119000\, x\ 400$	47
Ankrankwanta	$9000/119000\, x\ 400$	30
Total		**400**

Source: Author's construct

1.6 Structure of the report

- **Section 2:** Addresses some salient issues in the context of cocoa production in Ghana-sharing brief highlights on how the sector has been of immense benefit to rural development and how it has provided employment for women and the youth. The section further touches on the industry's environmental and social sustainability issues while noting the policy responses from the Government of Ghana meant to tackle these issues.

- **Section 3**: Looks at the three types of farm models employed by cocoa producers in Ghana-the full-sun, shaded and high-tech cocoa production, assessing the strengths and weaknesses of each model and how each helps sustain cocoa production overtime.

- **Section 4**: With the complement of secondary data, this section assesses and reviews the results from the survey conducted in three regions (the Western Region, the Ashanti Region, and the Eastern Region) in order to contextualise the variations in benefits and weaknesses of each of these models in terms of profitability.

- **Section 5**: Highlights some recommendations for the benefit of stakeholders concerning the most appropriate model to opt for to guarantee the profitability and sustainability of the cocoa industry in Ghana. It draws broad-based conclusions about the report and addresses issues.

2 Review of Ghana's Cocoa Industry

2.1 Impact of the cocoa industry on rural infrastructure development and social services

Ghana's rural development has benefited significantly from the production of cocoa.[44] The Ghanaian government gains immensely from cocoa production through taxes and duties on cocoa exports. These profits help fund government spending on necessities, including infrastructure improvements, healthcare, and education. In turn, this has aided rural towns' economic development. Due to the necessity of transporting cocoa beans from outlying locations to processing facilities and ports, many cocoa-producing regions have seen enhanced infrastructure development in transportation, including roads and bridges.[45] Concerning processing facilities and warehousing, cocoa processing facilities have been established due to the cocoa industry.[46] By creating goods like cocoa butter and powder, these facilities increase the value of cocoa, create jobs, and boost regional economies.[47]

There have been similar improvements as far as export infrastructure and port facilities are concerned. The ports of Tema and Takoradi are the main gateways for the export of cocoa from Ghana. The upgrading and extension of these ports due to the demand for cocoa exports has benefited the cocoa industry and other economic sectors.

Regarding social services, schools and educational resources have been made available due to infrastructure investments in education funded by profits made from the cocoa sector. Similarly, the development and upkeep of healthcare facilities, such as hospitals and clinics, have been funded by proceeds from cocoa.[48] As a result, farmers and residents from nearby communities of cocoa-growing areas now have access to some level of healthcare services.

As the cocoa industry expanded, the utility infrastructure had to be improved. This includes expanding electricity and water supply networks to remote cocoa-growing areas. The availability of these services has improved the standard of living for locals and facilitated agricultural output. With regard to the development of community and housing accommodations for employees, cocoa firms occasionally offer accommodation to their workers, including farmworkers and those working at processing plants. The living conditions of persons engaged to work in the industry have improved as a result. In cocoa-producing regions, certain cocoa firms and industry associations have started community development programs, building community centres, schools, and sanitary facilities as part of these projects.[49]

This report takes the view that whilst there is little doubt that Ghana's infrastructure and social services have benefited from the cocoa sector and that these benefits have been favourable to the country, they are by no measure adequate to the required needs of several people who are directly or indirectly impacted by the cocoa industry across the country. Issues of equitable benefit distribution, environmental sustainability, and ongoing investment in these areas still need to be addressed. This ensures that the cocoa industry has a long-term beneficial impact on Ghana's development.

[44]Kolavalli, S. and Vigneri, M. ''Cocoa in Ghana: Shaping the Success of an Economy'' In: Chuhan-Pole, P. and Manka, A., Eds., Yes, Africa Can: Success Stories from a Dynamic Continent, World Bank, Washington DC, (2011) pp 4-5 https://documents1.worldbank.org/curated/ru/304221468001788072/930107812_201408252033945/additional/634310PUB0Yes0061512B09780821387450.pdf

[45]*ibid* p.2

[46]*ibid* p.207

[47]*ibid* p.206

[48] ''Cocobod Considering Building Clinics in Cocoa-Growing Communities'' Cocobod News Article (August 2023). https://cocobod.gh/news/cocobod-considering-building-clinics-in-cocoa-growing-communities

[49] ''West Africa Community Development Implementation Manual'' CocoaActionWorld Cocoa Foundation (May 2016 Version 1.0) pp 6-7https://www.worldcocoafoundation.org/wp-content/uploads/CocoaAction-Community-Development-Manual_v1.0_May-2016.pdf

2.2 Employment generation

Cocoa farming and its associated activities provide employment opportunities for most Ghanaians. It is estimated that millions of people are directly or indirectly engaged in the cocoa industry, from cocoa farmers and labourers to traders, transporters, and processing workers. The cocoa sector directly employs 800,000[50] people (including 620,000 farmholders) at the production end of the value chain.[51] The availability of employment in this sector helps to reduce poverty and provide revenue.

2.3 Gender aspects in the cocoa industry

Women run about a quarter of cocoa farms in Ghana and are fully engaged in the production, pre-harvest, and marketing activities in the value chain. [52] However, most of the high-risk households of poverty in Ghana's cocoa sector are female-headed due to existing structural barriers and cultural limitations such as access to land and limited access to finance. This implies that women in the cocoa sector in Ghana are exposed to more risk and poverty than men, and the activities of women who are not farmholders may never be registered and remunerated because their husbands are the main focal persons in production.

2.4 Environmental and social sustainability challenges

In Ghana, the development of the cocoa industry has contributed to the clearing of forests to make way for cocoa farms. Serious ecological effects result from this practice: disturbance of the water cycle and loss of wildlife habitats, among others. Historically, Ghana has achieved increased cocoa production through increased land cultivation, a driver of deforestation. For instance, cocoa production in Ghana increased from about 730 hectares to about 1.69 million hectares over three decades (1987-2017) and recorded a tree cover of about 1.09 million hectares between 2001 and 2018.[53] These increments have naturally taken a toll on forest covers in cocoa-producing areas.

Illegal mining (also known as 'galamsey') continues to take place in Ghana's cocoa-growing regions, further increasing the potential to degrade the soil, pollute the water supply, and destroy cocoa fields. Activities related to galamsey can potentially contribute to biodiversity loss and deforestation.[54] The improper use of pesticides and chemicals can harm the environment, taint water supplies, and impair the health of farmers and their communities. Promoting sensible and sustainable pesticide use in cocoa growing areas has often proven difficult in the Ghanaian experience.

Intensive cocoa farming methods can also pose a risk to sustainability. Intensive cocoa farming methods can cause soil erosion, which lowers soil fertility and long-term sustainability.[55] Often, these methods include poor land management and the removal of shade trees.

Child labour is still a significant problem in Ghana's cocoa industry, with children under eighteen (18) frequently doing dangerous jobs on cocoa farms. Although there are obstacles, efforts to end child labour and guarantee fair working conditions for farmers and labourers are underway.

Land tenure and access also present risks for sustainability in the cocoa sector. [56] Problems with land tenure and disagreements over who owns what can upend benefits to communities that grow

[50]''Supply Chain Risk Assessment- Cocoa Sector in Ghana'' World Bank (2013).. World Bank Document

[51]''Ghana Census of Agriculture (GCA) 2017/18'' Ghana Statistical Service. (2020).. *Final Report 11 11 2020 printed version.pdf (statsghana.gov.gh)

[52] ''Towards a Living Income for Cocoa Framers in Ghana; Assessing Companies Efforts to Date'' OXFAM (2023). Towards a Living Income for Cocoa Farmers in Ghana: Assessing companies' efforts to date (openrepository.com)

[53]FAOSTAT

[54] Taylor, M. S., & Taylor, K. ''Illegal Gold Mining Boom Threatens Cocoa Farmers (And Your Chocolate)'' National Geographic (2018) https://www.nationalgeographic.com/science/article/ghana-gold-mining-cocoa-environment

[55] ''Soil management'' - CSA Cocoa. (2019, May 19) https://climatesmartcocoa.guide/entry-points/soil-management/

[56] Roth, M., Antwi, Y., & O'Sullivan, R. ''Land and Natural Resource Governance and Tenure for Enabling Sustainable Cocoa Cultivation in Ghana'' USAID Tenure and Global Climate Change Program -Washington, DC: (2017) p.18 https://www.land-links.org/wp-content/uploads/2017/02/TGCC-Cocoa-tenure-deforestation-assessment_Feb-2019.pdf

cocoa and restrict access to land for young farmers or newcomers to the industry. The problem worsens when gender becomes a factor—women frequently have limited access to land, resources, and decision-making authority in the cocoa industry. It is often difficult to advance gender equality and give women more authority in cocoa communities.

Furthermore, although the cocoa industry has made access to education and healthcare possible for some farmers, access to high-quality education and healthcare services is hugely restricted in some cocoa-growing regions. The social sustainability of cocoa-producing communities depends on access to these fundamental services. In terms of community development, many cocoa settlements need basic infrastructure and social amenities, including electricity, access to clean water, and sanitary facilities beyond what they already have access to.[57] Closing these infrastructure gaps is crucial for enhancing community members' wellbeing.

The risk of sustaining Ghana's cocoa production is further heightened by climate change—one of the key highlights the report deals with below. Increased temperatures, extended dry seasons, and unpredictable weather patterns are a few of the effects of climate change to which Ghana's cocoa industry is vulnerable. These changes may affect the yield and quality of cocoa overtime. The fact that this important risk factor is highly unpredictable emphasises the need for stakeholders to take immediate action to reduce its potential adverse effects on the cocoa industry in the future.

Addressing these sustainability challenges requires concerted efforts from various stakeholders, including the government, cocoa organisations, international buyers, and civil society. To encourage sustainable cocoa production, alleviate child labour, and enhance living circumstances in cocoa-producing communities, several initiatives and programs, including certification systems (e.g., Fair Trade, Rainforest Alliance), have already been implemented, as noted earlier. However, due to the complex nature of these systems, finding genuine and lasting answers calls for constant dedication and cooperation among stakeholders over related commitments.

2.5 Government policies and cocoa sustainability

Over the years, the government's policy responses to make cocoa a sustainable business have focused on productivity enhancement programs that increase access to high-yield seedlings, mass spraying and hi-tech fertiliser applications, cocoa rehabilitation, and artificial pollination approaches.[58] However, the recent Cocoa Barometer report suggests that productivity enhancement programs have been less optimal in raising the net income of cocoa farming households because they are accompanied by high investment inputs and labour costs, which increase the overall cost of production.[59] Given the low financing opportunities and the risk of declining prices, productivity enhancement methods alone are ineffective in making cocoa profitable. There is an urgent need for a more diversified and economically resilient approach, including diversification of crops, diversification of products, a diversified market, the employment of sustainable techniques, and the construction of infrastructure. Others include financial innovation, research and development, targeted governmental actions and assistance, proper risk management administration, and encouraging alternative incomes.

2.6 Summary

Cocoa production in Ghana has immensely benefited the government in terms of export earnings. Over the years, this trend has equally had a trickle-down impact on infrastructure development—including transportation and warehousing needs in both rural and urban communities; and on the country's existing healthcare system while helping to expand access to education. The cocoa industry

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[57] ''West Africa Community Development Implementation Manual'' Cocoa Action World Cocoa Foundation (May 2016 Version 1.0) pp 6-7https://www.worldcocoafoundation.org/wp-content/uploads/CocoaAction-Community-Development-Manual_v1.0_May-2016.pdf

[58] Jebuni-Dotsey, S. and Senadza, B. ''Supply-Side Interventions in Cocoa Production in Ghana: A Regional Decomposition of Technical Efficiency and Technological Gaps'' Sustainable Agriculture Research (2023)

[59] Fountain, A.C. and Huetz-Adams, F. ''2022 Cocoa Barometer''- The Cocoa Barometer Consortium and Voice Network https://voicenetwork.cc/wp-content/uploads/2022/12/Cocoa-Barometer-2022.pdf

has also significantly impacted job creation- guaranteeing income for both males and females engaged in production. These significant feats have improved the lives of actors engaged in the industry.

However, issues of equitable benefit distribution, environmental sustainability, and the need for ongoing investment in these areas still require urgent attention from stakeholders and the government to improve the industry further. The fight against Illegal mining and the impact of climate change are essential areas to commit resources to ensure the industry's sustainability. Additionally, gender-specific issues need to be resolved since women in the cocoa sector in Ghana are exposed to diverse risks and poverty. Their important contributions to the industry are yet to be duly recognised. Government policies to enhance and sustain the industry have been limited to interventions addressing productivity challenges. A lot more needs to be done. There is an urgent need for a diversified and economically resilient approach that will serve as a key driver to ensuring sustainability in the cocoa industry.

3 Cocoa Farming Models in Ghana

3.1 Introduction

The model of cocoa production could be a key predictor of productivity and profitability, which arguably has implications for forest conservation and sustainability.[60] There are three common systems of cocoa production in Ghana based on our review of the extant literature and consultations with stakeholders.[61] **Cocoa production favours a choice between either full-sun, shaded (agroforestry) or high-tech cocoa production –** see Figure 3-1**.** The choice of either is based on several variables, including the regional climate, the size of the farm, and the farmer's preference. The choice between full-sun and shaded cocoa production, for example, is not always binary and exclusive of each other. Cocoa farms could employ a mix of these models. Ghana's cocoa industry is dynamic and still developing, with continual efforts to balance the need for higher yields and social and environmental sustainability. This makes the choice of a profitable model important for the industry.

Fig 3-1 Main types of farming models

Full-sun cocoa | **Shaded cocoa** | **High-tech cocoa**

The **full-sun model**[62] refers to cocoa farms with less than 13 shade trees per hectare intercropped with food crops such as plantains and bananas. In contrast to shaded or agroforestry systems, where cocoa trees are grown beneath the canopies of larger shade trees, full-sun cocoa production refers to the growth of cocoa trees in direct sunlight conditions. Full-sun cocoa production is widespread in Ghana. The model has traditionally been preferred in some cocoa-growing areas of Ghana, particularly in the Western Region, while other regions may employ other models.

The **shaded cocoa production model**[63] has gained more attention in recent years because of its positive effects on the environment and overall sustainability. It refers to a cocoa plantation model where over 50% of the tree canopy is above the planted cocoa. Cocoa plants are planted under the canopies of shade trees or in mixed cropping systems. The production of shaded cocoa is in line with sustainability certification programs like Rainforest Alliance and Fair Trade, which emphasise ethical and sustainable farming methods. Farmers may need to balance these trade-offs to maximise their output and income. Ongoing studies and farmer education initiatives in Ghana promote the best

[60] Amponsah, Owusu. "Ghana's Cocoa Production Relies on the Environment, Which Needs Better Protection." The Conversation, https://theconversation.com/ghanas-cocoa-production-relies-on-the-environment-which-needs-better-protection-134557

[61] Wainaina, P.; Minang, P.A.; Duguma, L.; Muthee, K. ''A Review of the Trade-Offs across Different Cocoa Production Systems in Ghana'' Sustainability (2021) https://www.mdpi.com/2071-1050/13/19/10945

[62] Tondoh,J.E. François N'guessan Kouamé,F.N. et al ''Ecological changes induced by full-sun cocoa farming in Côte d'Ivoire'' Global Ecology and Conservation, Volume 3, 2015, pp.575-595 https://www.sciencedirect.com/science/article/pii/S2351989415000219

[63] ''Shading and agroforestry'' - CSA Cocoa. (2019, May 20) https://climatesmartcocoa.guide/entry-points/shading-and-agroforestry/

methods for growing shaded cocoa. These programs assist farmers in comprehending the advantages of agroforestry and properly implementing sustainable shade systems.

High-tech cocoa production[64] often has highly intensified production systems that require high inputs and are primarily maintained without shade. Modern techniques and technology are used during production to guarantee high cocoa yields, bean quality, and sustainability. Modern cocoa farms employing this model also emphasise sustainable farming methods such as organic farming, soil protection, and environmentally friendly inputs. They also place a priority on conserving natural ecosystems through appropriate land management. To ensure that farmers and plantation employees properly utilise and maintain the high-tech systems, they often receive training on technology and current farming techniques. Although traditional cocoa farming practices are still widely used in Ghana, high-tech cocoa production is gaining recognition in Ghana due to the high level of farming precision it assures. This is especially important as the sector tries to overcome challenges and meet the demand for cocoa on a global scale.

3.2 Comparative strengths and weaknesses of the three cocoa production models

This study draws important distinctions between the models based on an assembled list of possible strengths and weaknesses per the diverse literature on cocoa production models. Tables 3-1 and 3-2 show the strengths and weaknesses, detailing unique attributes evident through past farmers' experiences implementing the three cocoa production models.

[64] M Bosompem, JA Kwarteng and E Ntifo-Siaw (2011): Towards the Implementation of Precision Agriculture in Cocoa Production in Ghana: Evidence from the Cocoa High Technology Programme in the Eastern Region of Ghana- Journal of Agricultural Research and Development -- Vol. 10 No. 1. https://www.ajol.info/index.php/jard/article/view/74026

Table 3-1 Comparative strengths of the three cocoa production models

Indicators	Full-sun cocoa production	Shaded cocoa (agroforestry) production	High-tech cocoa production
Increased Yield/ Profitability	A sufficient amount of sunshine exposure, helps boost photosynthesis, which in turn encourages healthier and more fruitful cocoa plants, leading to increased yields of cocoa.	Yields from shaded cocoa cultivation- often dependent on several factors other than sunlight- and may not always be as great as those from full-sun production.	High-tech cocoa production can boost the total profitability of cocoa farming operations by increasing productivity, yields, and quality of cocoa beans.
Better Quality Cocoa Beans	Sunlight can contribute to the development of quality cocoa beans. Adequate sunlight exposure during the growing season can positively impact the flavour profile, aroma, and overall quality of the cocoa beans. Quality beans are often associated with premium cocoa production.	Good beans are frequently linked to the manufacturing of high-quality cocoa under agroforestry systems.	Better-quality cocoa beans may result from high-tech cocoa production, but this will rely on a number of variables, including the particular technology employed, the management strategies put in place, and the general farming environment. It is critical to remember that technology by itself cannot ensure success.
Disease and Pest Management	Better air circulation and drier conditions are two benefits of full-sun cultivation that may help lower the prevalence of some fungal infections.	In agroforestry systems, a variety of plants can serve as a natural defence against specific pests and illnesses. More robust and healthier cocoa plants can result from the ecosystem's ability to upset pest life cycles and lower the frequency of cocoa illnesses.	Modern technologies like satellite tracking and remote sensing enable real-time cocoa plantation monitoring. This makes it possible for farmers to identify early indicators of illnesses, pest infestations, or other problems. Second, integrated pest management systems manages insect and disease challenges on cocoa plantations while reducing the need for pesticides.
Faster Growth and Development:	In general, cocoa plants do best in warm, sunny regions. Cocoa trees grown in full sun tend to grow and develop more quickly, which might result in early fruiting and therefore faster profits for farmers.	In the production of shaded cocoa (agroforestry), the growth and development of cocoa trees are influenced by a number of variables, such as the particular agroforestry system, the kind of shade trees, the local climate, the state of the soil, and the management techniques used. Though generally speaking, cocoa	Precision farming, effective resource management, monitoring, and other areas of cocoa farming can all be optimized with the help of high-tech cocoa production. However, a variety of factors affect the growth and development of cocoa trees, and although technology can improve some elements of cultivation, it is not

		trees may develop more slowly in shaded areas than in full sun, the advantages of shade overshadow any possible slowdown in growth rate in terms of ecological sustainability and long-term crop resilience.	the only factor that determines how quickly a tree grows.
Precision in Farm Management	Precision management is the application of technology and data-driven methods to maximize many facets of farming. Farmers may find it simpler to run their farms in full-sun cocoa production because there are fewer complicated agroforestry systems or shade trees to worry about. This can lessen the possibility of competition for resources and nutrients and simplify farming techniques.	Agroforestry systems retain the possibility of a customized precision management strategy.	Precision agriculture methods, such as the utilization of sensors, drones, and satellite imaging, are used in high-tech cocoa production. This makes it possible for farmers to precisely monitor and oversee their cocoa plantations, making the best use of resources like water, fertilizer, and pesticides.
Efficient Resource Management	In order to maximize productivity while reducing environmental effect, full-sun cocoa production requires efficient resource management. An approach which may require careful thought and in some instances additional investment.	The production of shaded cocoa is able to accommodate more effective resource management techniques when traditional knowledge is combined with contemporary practices and technologies.	The efficient use of water, fertilizers, and other resources is made possible by precision agricultural technology such as automated nutrient delivery, smart irrigation systems, and others under this model. By doing this, waste is decreased and it is guaranteed that cocoa plants receive the proper quantity of nutrients for healthy growth.
Ease of Harvesting	Plantations growing cocoa under full sun are frequently easier to harvest and maintain. The harvesting procedure is made simpler and more efficient for farmers when there are no overhanging shade trees.	Many elements pertaining to the design of the agroecosystem, the choice of shade trees, and management techniques affect how simple it is to harvest cocoa in shaded cocoa (agroforestry) production.	Improved Post-Harvest management: Controlled fermentation and drying systems are two examples of technologies that help with better post-harvest management under this model. Through lowering the possibility of contamination and guaranteeing consistency in flavor and aroma, these technologies aid in

			maintaining the quality of cocoa beans.
Biodiversity Conservation	Because it supports the overall sustainability of the cocoa farming system and helps to maintain the ecological balance of the surrounding environment, biodiversity protection is an important factor in full-sun cocoa cultivation.	The preservation of biodiversity is one of agroforestry's main advantages. Because shade trees provide habitat for a variety of plants, animals, and beneficial insects, their presence contributes to a more diversified ecosystem. An agricultural environment that is healthier and more robust is facilitated by this biodiversity.	High-tech cocoa production can improve resilience, contribute to the preservation of natural ecosystems, and guarantee the long-term viability of cocoa farming by fusing technology with biodiversity-friendly methods.
Reduced Soil Erosion	In full-sun cocoa production, soil erosion is a major concern, especially in regions where natural vegetation has been destroyed to create plantations.	By lessening the effect of rainfall on the ground, shade trees aid in the protection of the soil from erosion. Additionally, the stabilizing effect of their roots stops soil degradation and nutrient runoff. Better soil fertility and long-term sustainability of cocoa production may arise from this.	High-tech cocoa production may address soil erosion issues and support ecologically friendly and sustainable farming systems by combining cutting-edge technologies with precision farming methods but this naturally comes at a cost.
Climate Resilience	Full-sun cocoa production is especially susceptible to fluctuations in the environment and severe weather.	In general, agroforestry systems are more resistant to changes in the climate. Cocoa plants may better adapt to varied climate conditions when they have shade from trees, which can also protect against rapid weather changes, lessen water stress, and alleviate temperature extremes.	Climate modelling- which may come at a cost under this model- can assist in forecasting modifications to weather patterns, enabling farmers to put plans in place to lessen the effects of catastrophic weather occurrences.
Income Diversification	It is feasible to achieve income diversification in full-sun cocoa production, but it might need for careful planning and the adoption of alternative agricultural or non-agricultural pursuits.	Farmers are able to diversify their sources of revenue through agroforestry. Shade trees can yield important goods including fruits, nuts, and lumber in addition to cocoa. By reducing reliance on a single crop, this diversification can help farmers become more financially stable.	Profiting from innovations, sustainable practices, and technical improvements is one way to diversify revenue streams in high-tech cocoa production.

Long-Term Sustainability:	Although it is a difficult task, full-sun cocoa production may be made sustainable over the long term with careful planning, the adoption of sustainable techniques, and constant adaptability to changing circumstances could help.	A farming system that is more robust and sustainable is encouraged by the agroforestry concept. It contributes to soil health, ecological balance, and the long-term sustainability of cocoa farming by imitating natural ecosystems.	High-tech cocoa production can achieve long-term sustainability through strategic planning, adoption of sustainable practices, and a dedication to continuous innovation.

Table 3-2 Comparative weaknesses of the three (3) cocoa production models

Indicators	**Full-sun cocoa production**	**Shaded cocoa (agroforestry) production**	**High-tech cocoa production**
Vulnerability to Climate Stress	Production of cocoa under full sun is more vulnerable to adverse weather conditions like droughts and intense heat. This strategy could raise the risk of crop failure and lower output in areas where weather patterns are erratic.	In the face of climate stress, shaded cocoa production in agroforestry systems can show both benefits and drawbacks. Agroforestry has some resilience to some climate concerns because of its shade trees, but there are also possible weaknesses.	When it comes to some aspects of climate stress, high-tech cocoa production may be more resilient than conventional or less technologically sophisticated approaches.
Increased Risk of Pest and Disease Outbreaks	Full sun can lessen the chance of developing some fungal diseases, but it can also make cocoa plants more susceptible to pests. Cocoa plants could become more vulnerable to insect infestations if shade trees are not around to provide a protective cover.	Agroforestry may have some benefits for naturally controlling pests and diseases, but the variety of plants may also give some pests and illnesses a place to live.	In high-tech cocoa production, the danger of pest and disease outbreaks varies based on a number of factors, including as the particular technologies used, management strategies, and environmental circumstances.
Soil Erosion	Increased soil erosion may result from the removal of shade trees, particularly in regions that receive much rain. In agroforestry systems, shade trees aid in soil stabilization and erosion reduction; but, in full-sun plantations, this natural defense is	Under shaded cocoa (agroforestry) production, soil erosion can happen, but it can vary in degree and severity depending on a number of factors, such as the particular agroforestry techniques used, the local	In order to maximize growing conditions, high-tech cocoa production uses regulated settings and cutting-edge technologies.

	absent, which may result in soil degradation.	environmental circumstances, and management approaches.	
Loss of Biodiversity	Removal of shade trees is a common practice in full-sun cocoa farming, and this may lead to a decline in biodiversity.	Cultivation of cocoa under shade is typically thought to be more beneficial to biodiversity than cultivation under full sun. Production of shaded cocoa has the potential to promote biodiversity, particularly if it is planned and executed with protection of biodiversity in mind.	Precision farming and controlled settings found in high-tech cocoa production may mitigate some of the environmental drawbacks of conventional farming practices.
Limited Carbon Sequestration	Shade tree agroforestry systems contribute to carbon sequestration, which slows down global warming. This advantage is absent from full-sun cocoa cultivation, which makes it less useful in the fight against greenhouse gas emissions.	In agroforestry systems, trees help sequester carbon, which slows down global warming. Beyond the immediate agricultural context, the varied vegetation on shaded cocoa farms stores and absorbs carbon dioxide, benefiting the ecosystem.	In high-tech cocoa production, carbon sequestration is feasible, and the use of cutting-edge technologies can even increase the efficiency of carbon sequestration techniques.
Long-Term Soil Health Concerns	In full-sun cocoa plantations, a lack of varied vegetation can cause imbalances in soil nutrients and organic matter. This may lead to long-term issues with soil health, which may eventually affect how sustainably cocoa is produced.	Even while producing cocoa under shade has several advantages, such as improving biodiversity and conserving soil, it still needs to be carefully managed to address long-term issues with soil health.	High-tech cocoa production can have both beneficial and possibly detrimental effects on the long-term health of the land. It is typified by the application of cutting-edge technologies like precision agriculture, controlled settings, and creative farming techniques.
Reduced Cocoa Yield in the Short Term	While there may be difficulties in the beginning with full-sun cocoa cultivation, which could result in lower yields, these problems can eventually be resolved by putting in place suitable mitigating techniques.	Initially, cocoa yields on shaded plantations might be lower than those on full-sun farms. Cocoa plants may receive less sunlight due to the shadow that trees produce, which could temporarily slow down their growth and lower production.	The adoption of an advanced technology-based cocoa production strategy does not ensure lower cocoa yields in the near future.
Complex Management	Compared to certain agroforestry or shade-grown systems, full sun cocoa production can be easier to handle.	Managing agroforestry systems is more complicated than full-sun cocoa crops. To maintain ideal circumstances for both cocoa plants and shade trees, the diversity of plant types	Due to the integration of complicated equipment and procedures, high-tech cocoa production models can be challenging to manage.

		necessitates careful planning and maintenance. Some farmers may find this complexity difficult to understand.	
Competition for Resources	Cocoa production systems that receive full light may have issues related to competition for resources, especially nutrients. Nutrient competition is exacerbated in full sun conditions, where cocoa plants are exposed to direct sunlight without the protection of trees or other crops.	Cocoa plants and shade trees compete with one another for sunlight, water, and nutrients in agroforestry systems. This competition may hinder the growth and productivity of shade and cocoa plants if it is not well controlled.	Cocoa production under this model provide prospects for accurate management of nutrients. Using cutting-edge technologies and tailoring nutrient treatments based on real-time data can optimize the advantages of high-tech cocoa production while also maximizing resource efficiency.
Delayed Cocoa Maturity	The quick maturity of cocoa pods may be impacted by the full sun cocoa production strategy, which grows cocoa plants in direct sunshine free from the shade of other crops or trees.	Cocoa pod maturation may be slowed down by the presence of shade trees. This may cause a delay in the cocoa bean harvest, which could have an impact on when farmers receive their money.	The effects of sophisticated cocoa production models on cocoa maturity can differ based on the particular technology and management techniques used, as well as on the local environment and degree of adaption.
Limited Space for Expansion	The size of the current plantation, the ownership of the land, the environment, and local land use regulations are some of the variables that can affect the amount of space available for expansion on full sun cocoa production farms.	Because shade trees provide shade, there may not be as much room for expansion on shaded cocoa estates. This could provide a barrier for growers trying to boost cocoa output to keep up with demand.	The potential for expansion on high-tech cocoa production farms depends on a number of factors. A thorough analysis and a well-thought-out plan are essential for the high-tech cocoa farming business to be successful and sustainable.
Tree Maintenance Challenges	There may be a few tree maintenance issues in full sun cocoa production models, when cocoa plants are grown in direct sunlight without the protection of other crops or trees. The dynamics of the ecosystem, the health of the trees, and the soil can all be impacted by the lack of shade trees, which are common in conventional agroforestry systems.	In agroforestry systems, shade tree management and upkeep demand extra work. It can take much effort to prune and maintain the trees to keep them from overshadowing the cocoa plants or creating other problems.	The difficulties in maintaining trees may be different from those in full-sun or conventional agroforestry systems. High-tech cocoa production frequently uses hydroponics, vertical farming, and controlled climates.

Variability in Cocoa Quality	There may be differences in the quality of cocoa produced under the full sun cocoa production paradigm. Numerous factors affect the quality of cocoa beans; full sun farming has advantages but also has drawbacks that may affect the quality of the cocoa.	Although cocoa that has been shaded is frequently linked to superior beans, the quality of cocoa can also be impacted by variations in shade circumstances. Different cocoa beans on the plantation may have different flavours and degrees of quality due to uneven shadow levels.	Utilizing cutting-edge technologies and controlled settings can present chances to maximize cocoa quality in high-tech cocoa production models.
Knowledge and Training Requirements	Because successful cultivation necessitates an awareness of agricultural practices, environmental conditions, pest and disease management, and other pertinent issues, knowledge and training are essential in the development of full sun cocoa.	Farmers under this model must comprehend how shade trees and cocoa interact and how to manage these systems efficiently. Poor understanding can result in less than ideal outcomes.	In high-tech cocoa production, where cutting-edge technologies and regulated settings are used, knowledge and training are crucial. A workforce with the necessary skills to carry out high-tech approaches successfully must be knowledgeable about data-driven decision-making, precision agriculture, and technology.
Market Perception and Premiums	Market perceptions of full sun cocoa producing farms can differ, and factors including cocoa quality, environmental standards, and demand from consumers all play a role in determining premiums.	Full-sun plantations' cocoa may still be valued more in some markets because of the possibility for bigger yields and distinct flavor profiles. Farmers that grow shaded cocoa may obtain different prices for their crop depending on how the market perceives them.	Numerous elements, such as the quality of the cocoa beans, sustainability practices, technical innovation, and customer tastes, might affect how the market perceives high-tech cocoa production farms and the possibility of larger premiums.
High Initial Investment	The initial outlay needed for full sun cocoa production might differ depending on the farm's size, the climate in the area, the infrastructure that is already in place, the amount of technology being used, and the inputs used.	The amount of initial capital needed for the production of shaded cocoa (agroforestry) can vary depending on a number of variables, such as the operation's scale, the infrastructure already in place, the agroforestry techniques used, and the local environment.	The adoption of advanced technology in cocoa production frequently necessitates a substantial upfront financial outlay. The majority of cocoa producers are smallholder farmers, who may find it difficult to get and afford these technologies.
Limited Access to Technology and its Integration	The amount of technology needed for full sun cocoa production can vary based on a number of variables,	The size of the farm, the resources available, and the farmer's objectives will all affect how much technology is	It is possible that farmers in isolated or poor areas do not have easy access to the internet connectivity and other

	including farm size, location, and the farmer's individual objectives.	used in the production of shaded cocoa.	technological infrastructure that they need to use cutting-edge agricultural technologies. It can be challenging to incorporate several high-tech solutions into a productive farming system. Farmers may find it difficult to handle and troubleshoot a variety of technologies, which could result in inefficiencies and possible production process disruptions.
Dependency on External Inputs	It is possible for the management of a full sun cocoa production model to rely on outside inputs. Different external inputs can be employed to assist and enhance the growing of cocoa plants in full sun cocoa farming.	External inputs may also be necessary for the management of cocoa production in shade (agroforestry), albeit the precise inputs and their relative importance may vary from full-sun cocoa cultivation.	Certain advanced techniques could necessitate reliance on outside resources, including specialized equipment, sensors, or exclusive software. Farmers might grow dependent on these inputs, which could provide problems if the supply chain is disrupted.
Environmental Concerns	The production of cocoa under full sun might give rise to several environmental issues. Full sun cocoa production raises several environmental challenges, such as deforestation, biodiversity loss, soil erosion, water management problems, chemical inputs, climate change effects, and low resilience.	The environmental effect under this model is typically less than that of full sun systems.	Some high-tech components' manufacture and disposal may have an impact on the environment. Ecological issues could be exacerbated, for instance, by electronic waste from obsolete equipment and the environmental effects of producing specific technology.
Rural Infrastructure Challenges	Issues with rural infrastructure can have a big impact on full sun cocoa output in several ways. Transportation, linking farmers to markets, and supporting agricultural activities all depend heavily on infrastructure. The effectiveness and sustainability of full sun cocoa production might be hampered when	Problems with rural infrastructure can have a big impact on the production of shaded cocoa (agroforestry), affecting several parts of farm management and sustainability in general.	Many cocoa-producing regions lack the rural infrastructure necessary to facilitate the implementation of high-tech solutions, particularly in emerging nations. This covers problems like unstable power supplies and inadequate road systems.

	rural areas have difficulties in the development of infrastructure.		

3.3 Summary

Increased productivity, sustainability, and the long-term viability of cocoa production may benefit from a wider use of high-tech approaches as Ghana's cocoa sector continues to develop. However, there are several trade-offs between the three models of cocoa production, including yield, extra food products, input use, labour cost, and environmental effects. These trade-offs drive a farmer's choice of a production model. Existing studies have focused on comparative analysis of the advantages and disadvantages between the three common models but often isolate profitability analysis due to a lack of accurate data on the profitability of these models in the cocoa industry. For policies and business initiatives to be meaningful in addressing the livelihood challenges of farmers, it is imperative to understand which model is profitable and environmentally sustainable using primary data. In the next section, we present the survey findings.

4 Findings

4.1 Participant characteristics

Table 4-1 shows the summary breakdown of the unweighted demographic profile for the 353 respondents who fully completed the survey. A few noticeable trends are highlighted within the larger context of cocoa farming trends in Ghana.[65]

Sex

A relatively higher proportion of the sample size are males (71%) compared to females (29%). The respective proportions largely reflect the gender disparity in cocoa farming in Ghana, where there are more male cocoa farmers than female ones. This can be attributed to several historical, social, and economic factors. Some reasons include land ownership and inheritance, whereby some traditional Ghanaian societies generally pass land on through a patrilineal succession, which means that male family members are often the inheritors. Historically, male farmers have had easier access to resources, including loans, agricultural extension services, and contemporary farming equipment. It is more difficult for women to become involved in cocoa farming due to the unequal allocation of resources. Women's inability to actively participate in cocoa farming has also been hampered by their lack of education and training, which can give them valuable knowledge and skills for agricultural activities.

The Age Group of Farmers

The majority of those who completed the survey were relatively old (above the 45-year category): this breaks down into 45-54 years (37%), followed by 55-64 years (25%) and 65 years and above (12%). Very few youth below the age of 35 years are involved in cocoa farming (4%). The declining involvement of youth in cocoa farming in Ghana can be attributed to several factors: the younger generation frequently views farming as labour-intensive, low-paying, and difficulties with bad weather (climate change related), pests, and diseases. Some also believe alternative employment options, such as artisanal and small-scale mining (ASM), are more alluring and lucrative. Rather than staying in rural areas to pursue cocoa farming, many young people are lured to urban areas for better career possibilities, educational opportunities, and improved living conditions. Due to a lack of access to contemporary farming methods and technology, older farmers are not only getting older but also becoming less productive. Also, due to land inheritance patterns, cocoa estates in Ghana have grown more dispersed over time. This might make it more difficult for younger farmers to buy and maintain sparsely spaced-out tiny plots of land. Furthermore, due to their perceived higher risk profile, younger farmers may have difficulties obtaining loans, contemporary farming tools, and inputs like fertilisers and better cocoa types.

Educational Qualification

Regarding educational attainment, about 62% of the respondents had only basic education up to the JSS/JHS/MSLC level. Specifically, 36% had JSS/JHS/MSLC education, 26% had primary education, and 18% had no education. A further 16% had secondary education, while only 3% had tertiary or postgraduate education. In Ghana, cocoa farming is often passed down through generations, and many cocoa farmers have limited formal education. Many cocoa farmers in Ghana only have an elementary (basic) education, if any, or even less formal education. The lower educational attainment of cocoa growers may be attributed to the lack of access to quality education in some rural areas, affecting their adoption of agronomic practices that can improve cocoa yields. Access to education and training for cocoa farmers can lead to better livelihoods, more productive and sustainable cocoa farming techniques, and the general growth of the cocoa business in Ghana.

Cocoa farm ownership

As expected, 58% of our respondents had inherited their cocoa farms, 24% were involved in sharecropping, 15% purchased their farms outright, and another 3% were leaseholds.

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[65] The data was further analysed, after processing and computer entry, with STATA software package (version 17) using quantitative analytical techniques such as frequencies, percentages and cross tabulations, among others.

Table 4-1 Distribution of demographic and farm characteristics of respondents in the study

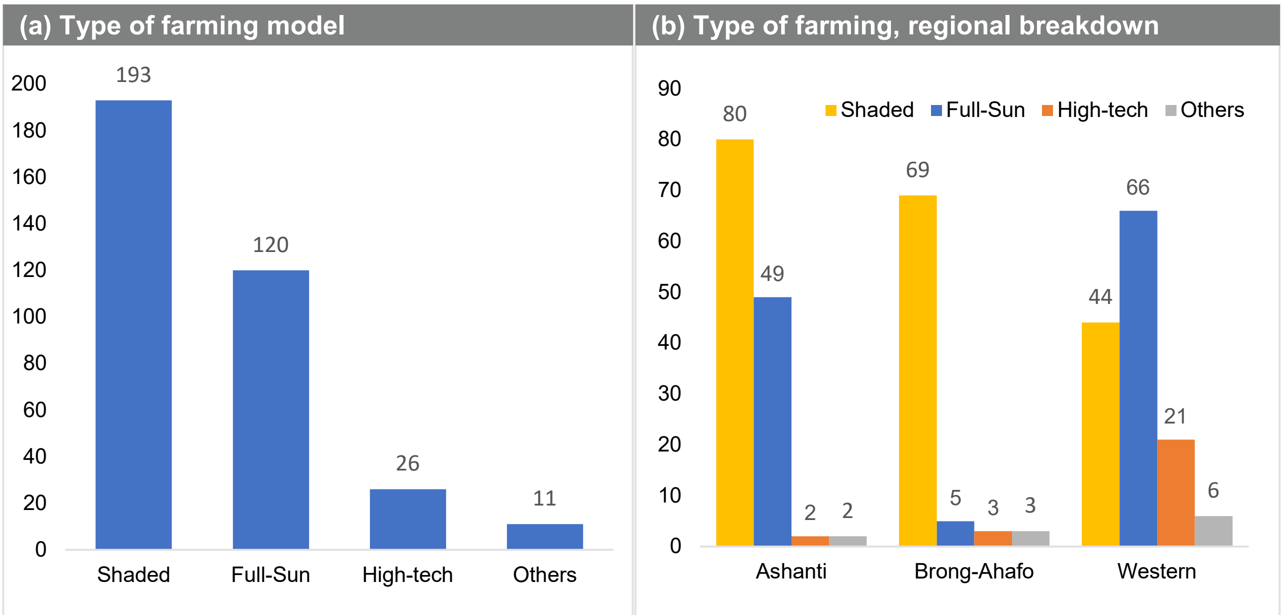
Sex	Freq.	Percent	Cum.
Female	100	28.65	28.65
Male	249	71.35	100.00
Age group of farmers (years)	**Freq.**	**Percent**	**Cum.**
18-24	1	0.28	0.28
25-34	14	3.98	4.26
35-44	79	22.44	26.70
45-54	130	36.93	63.64
55-64	87	24.72	88.35
65 and above	41	11.65	100.00
Highest educational qualification	**Freq.**	**Percent**	**Cum.**
JSS/JHS/MSLC	128	36.26	36.26
No education	63	17.85	54.11
Postgraduate	1	0.28	54.39
Primary	93	26.35	80.74
Secondary/O/A Level	57	16.15	96.88
Tertiary	11	3.12	100.00
Cocoa farming years	**Freq.**	**Percent**	**Cum.**
11-15 years	102	30.36	30.36
16 years and above	163	48.51	78.87
5 years and below	7	2.08	80.95
6-10 years	64	19.05	100.00
Cocoa farm ownership	**Freq.**	**Percent**	**Cum.**
Inheritance	203	58.00	58.00
Leasehold	9	2.57	60.57
Purchased	54	15.43	76.00
Sharecropping	84	24.00	100.00
Farm size	**Freq.**	**Percent**	**Cum.**
Above 5 acres	151	42.78	42.78
Between 3 to 5 acres	145	41.08	83.85
Less than 3 acres	57	16.15	100.00
Region	**Freq.**	**Percent**	**Cum.**
Ashanti	133	37.68	37.68
Brong-Ahafo	81	22.95	60.62
Western	139	39.38	100.00
District	**Freq.**	**Percent**	**Cum.**
Adansi South	33	9.38	9.38
Ahafo Ano North	40	11.36	20.74
Amansie West	59	16.76	37.50
Asunafo North	62	17.61	55.11
Bodi	38	10.80	65.91
Dormaa West	20	5.68	71.59
Juaboso	62	17.61	89.20
Sefwi-Wiawso	38	10.80	100.00
Main occupation	**Freq.**	**Percent**	**Cum.**
Driver	1	0.28	0.28
Farming	318	90.08	90.37
Labourer (Agric/Non-Agric)	1	0.28	90.65
Manufacturing	6	1.70	92.35
Petty trading	2	0.57	92.92
Public Servant	22	6.23	99.15
Trading/Entrepreneur	3	0.85	100.00
Main religion	**Freq.**	**Percent**	**Cum.**
Christianity	292	83.43	83.43
Muslim	49	14.00	97.43

None of the above	1	0.29	97.71
Traditionalist	8	2.29	100.00
Children below 18-years engaged in cocoa farming	**Freq.**	**Percent**	**Cum.**
No	282	79.89	79.89
Yes	71	20.11	100.00

4.2 Common cocoa farming models used by farmers in the major cocoa-growing areas in Ghana

According to the survey data, the shaded and full sun models are the dominant cocoa farming models in the three high-producing regions (Figure 4-1). More than half (55%) of the farmers use the shaded cocoa farming model, and more than a third (34%) use the full sun model. About 7% of the farmers use the high-tech model, and the remaining 3% combine the three farming models (others).

Fig 4-1 Farming model breakdown



At the regional level, shaded farming is most dominant in Ashanti and Brong Ahafo, while the full sun was more dominant in the Western Region. Typically, cocoa trees thrive under the canopy of other trees.[66] This implies that farmers do not typically need to clear an entire forest to undertake cocoa farming. Also, the shaded trees are mostly tree crops like avocado, oil palm and commercial timber trees that provide extra revenue for the farmer.[67] The shaded model supports forest conservation and environmental protection compared to other tree crops. In addition, shaded trees help to reduce damage to the cocoa trees caused by insects and pests[68].

Another benefit of the shaded cocoa farming model is that the shaded trees serve as alternative hosts to parasitic plants such as mistletoes, which otherwise would attack the cocoa trees and deprive them

[66] Ruf F, Zadi H (1998) Cocoa: from deforestation to reforestation. In first international workshop on sustainable cocoa growing, 1998, Smithsonian Institute, Panama.

[67] Osei-Bonsu K, Opoku Ameyaw K, Amoah F. M, Oppong F. K (2002) Cocoa-coconut intercropping in Ghana: agronomic and economic perspectives. Agroforest Syst 55:1–8

[68] Obiri, B.D., Bright, G.A., McDonald, M.A. *et al.* Financial analysis of shaded cocoa in Ghana. *Agroforest Syst* **71**, 139–149 (2007). https://doi.org/10.1007/s10457-007-9058-5

of the needed nutrients[69]. This makes the shaded cocoa tree a more beneficial model for farmers because of the alternative revenue generation opportunities it offers and explains the high utilisation of the shaded cocoa farming model.

This finding is consistent with our discussion in Section 3, where the shaded cocoa model has gained traction in recent years due to its positive effects on the environment and overall sustainability: biodiversity, soil fertility and carbon absorption. The shade of taller canopy trees helps regulate extreme temperatures and keep the microclimate at a level that fosters the growth of cocoa trees. This means that diseases spread less quickly while temperature fluctuations are regulated through the natural shade offered by the trees, creating more stable yields.[70]

Nevertheless, the full sun model also offers farmers opportunities to diversify their income by planting other food crops that support the household food needs and supplement the farmers' income, especially during periods of low prices. However, research has established that ecological, agronomic and other policy issues account for the rise in the full sun model despite the benefits of the shaded cocoa model[71]. The full sun model is beneficial in areas with high rainfall patterns because the shade increases humidity, making farms easily susceptible to black pod disease[72]. Additionally, farmers have identified that the hybrid cocoa seeds did not do well with the shaded cocoa farming model[73].

Furthermore, illegal logging destroys cocoa farms, discouraging farmers from planting shaded trees in their cocoa farms. Obiri et al. (2007)[74] identified that the effect of illegal logging, limited understanding of the timber market by farmers, and the weak regulation of the timber sector were key reasons farmers cited for reducing shaded trees and the high preference for the full sun model. Boni (2006)[75] established that, by planting shaded trees, farmers had to deal with legal and illegal loggers, and the damages it has on the cocoa tree disincentives farmers from using the shaded model.

The high-tech model is less utilised because of its high input cost. Most farmers are low-income earners, so they are less likely to use the high-tech model despite its low labour cost and high productivity. **Thus, the choice of farming model is based on a trade-off between income, cost, and weather conditions.**

Figure 4-2 shows the cocoa farming models and their distribution by farm size. **The results show an even split of farm sizes between 3 (1.2 hectares) and 5 acres (2 hectares) and those above 5 acres.** In all, 43% of farms had acreage above 5 acres, 41% had between 3 and 5 acres, and 16% had less than 3 acres. Within the full-sun model, 50 farmers (42%) cultivated on land above 5 acres, 49 farmers (41%) cultivated between 3 and 5 acres, and 21 farmers (17%) cultivated less than 3 acres. Under high-tech farming, 12 farmers (46%) cultivated land above 5 acres, nine farmers (35%) cultivated between 3 and 5 acres, and five farmers (19%) were on land less than 3 acres. Likewise, shaded farming encompassed 83 farmers (43%) cultivating land above 5 acres, 82 farmers (43%) between 3 to 5 acres, and 28 farmers (14%) on less than 3 acres.

These findings also reflect the 2017/18 Ghana Agricultural Census[76], where most cocoa farmers operated on farms below or up to 5 acres (2 hectares). Farm size affects productivity by determining the number of cocoa trees, spacing, and other practices influencing high yield.

[69]Obiri BD (2004) Improving fallow productivity in the forest and forest-savannah transition of Ghana: a socio-economic analysis of livelihoods and technologies. Unpublished Ph.D. thesis. University of Wales, Bangor, UK, 358 pp

[70] Blaser, W. J., Oppong, J., Hart, S. P., Landolt, J., Yeboah, E., & Six, J. (2018). Climate-smart sustainable agriculture in low-to-intermediate shade agroforests. *Nature Sustainability*, *1*(5), 234-239. https://doi.org/10.1038/s41893-018-0062-8

[71] Ruf, F.O. The Myth of Complex Cocoa Agroforests: The Case of Ghana. *Hum Ecol* **39**, 373–388 (2011). https://doi.org/10.1007/s10745-011-9392-0

[72] ibid

[73] ibid

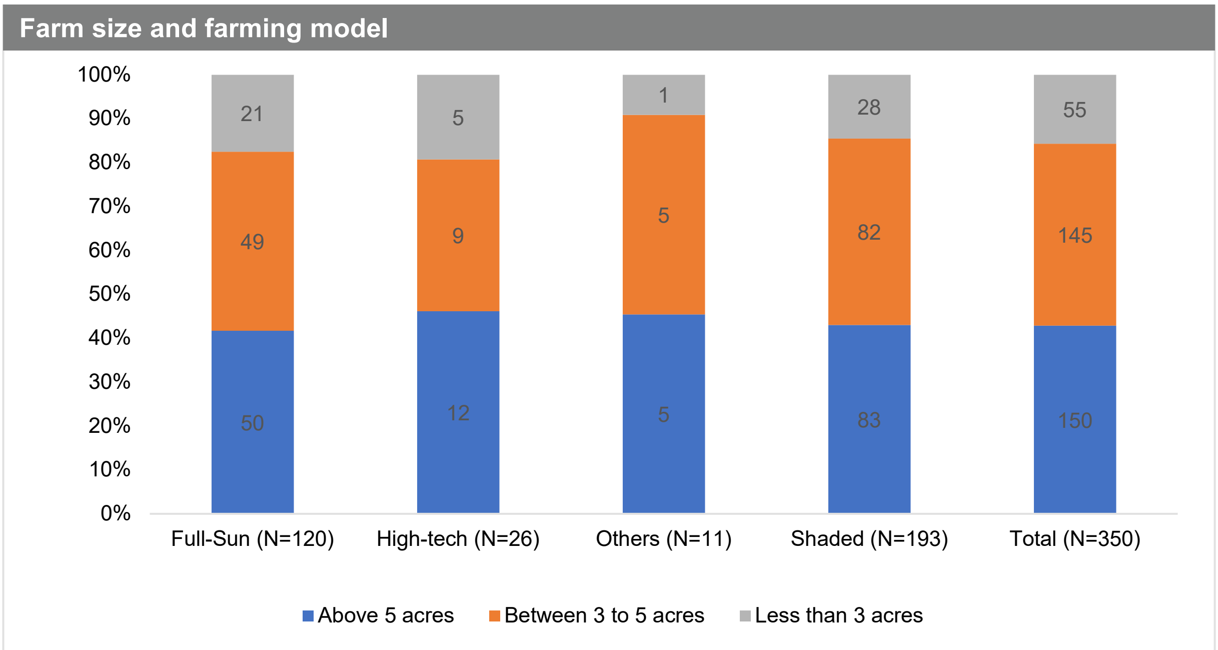
[74] Obiri, B.D., Bright, G.A., McDonald, M.A. *et al.* Financial analysis of shaded cocoa in Ghana. *Agroforest Syst* **71**, 139–149 (2007). https://doi.org/10.1007/s10457-007-9058-5

[75] Boni, S. (2006). Ghanaian Farmers' Lukewarm Reforestation: Environmental Degradation, The Timber Option and Ambiguous Legislation. Contributed Paper to the International Conference "At the Frontier of Land Issues", IRD, Montpellier.

[76] https://statsghana.gov.gh/gssmain/fileUpload/pressrelease/Final%20Report%2011%2011%202020%20printed%20version.pdf

Additionally, during periods of high prices, farmers with large farm sizes can benefit compared to small farms. Regarding income diversification, the farm size can influence the type of crops farmers can grow and the acreage it can cover to ensure high output.

Fig 4-2 Farm size and farming model



This pattern is also repeated mainly at the regional level, albeit with minor differences (Table 4-2). The regional breakdown of acreage and farming model also supports the analysis that the **shaded and full sun models are the most preferred cocoa farming models in the three regions**. However, the choice depends on several factors, including weather patterns. The shaded cocoa model is highly utilised in the Ashanti and Brong Ahafo regions, while the full sun model is more utilised in the Western region. The Ashanti and Brong Ahafo regions are located in the middle belt of Ghana, where most of Ghana's forest zones are. As a result, the shaded cocoa farming model seems to be the most economical method for most of the cocoa farmers sample.

Even though the Western region forms part of the high forest zones of Ghana, the rainfall patterns make the full sun reduce their exposure to black pod disease[77]. Between 2000 and 2022, the average annual mean rainfall in Western and Western North regions was 1,471 millimetres (mm) and 1,561mm, respectively, compared to 1,277mm, 1,180mm, and 1,352mm of the Ahafo, Brong Ahafo and Ashanti regions (see Figure 4-3). In a study conducted in 2011[78], farmers in the Western region preferred the full sun model to the shaded due to the high humidity and potential risk of black pod disease associated with the shaded trees.

[77]Ruf, F.O. The Myth of Complex Cocoa Agroforests: The Case of Ghana. *Hum Ecol* **39**, 373–388 (2011). https://doi.org/10.1007/s10745-011-9392-0
[78] ibid

Table 4-2 Tabulation of farm size, farming model and region

Ashanti

Type of cocoa farming model	Size of farm			
	Above 5 acres	Between 3 to 5 acres	Above 5 acres	Total
Full-Sun	23	21	5	49
	46.94	42.86	10.20	100.00
High-tech	2	0	0	2
	100.00	0.00	0.00	100.00
Others	2	0	0	2
	100.00	0.00	0.00	100.00
Shaded	32	40	8	80
	40.00	50.00	10.00	100.00
Total	59	61	13	133
	44.36	45.86	9.77	100.00

The first row has *frequencies,* and the second row has *row percentages.*

Brong-Ahafo

Type of cocoa farming model	Size of farm			
	Above 5 acres	Between 3 to 5 acres	Above 5 acres	Total
Full-Sun	2	2	1	5
	40.00	40.00	20.00	100.00
High-tech	0	3	0	3
	0.00	100.00	0.00	100.00
Others	0	3	0	3
	0.00	100.00	0.00	100.00
Shaded	28	33	8	69
	40.58	47.83	11.59	100.00
Total	30	41	9	80
	37.50	51.25	11.25	100.00

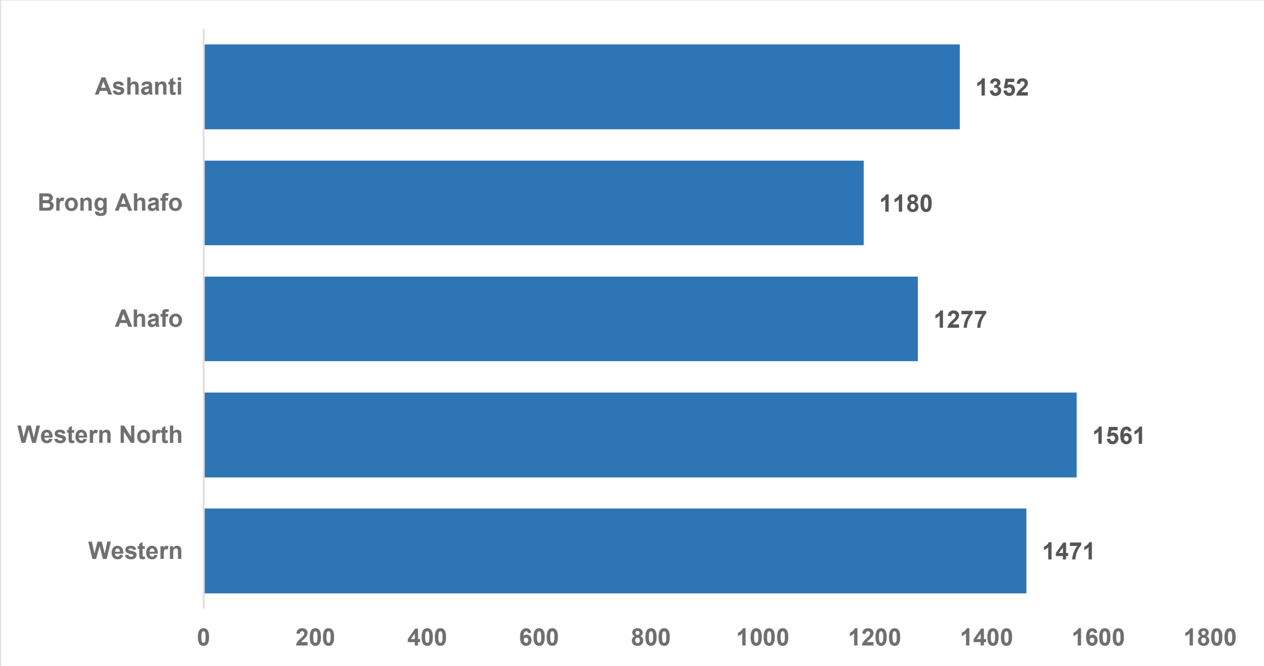
The first row has *frequencies,* and the second row has *row percentages.*

Western

Type of cocoa farming model	Size of farm			
	Above 5 acres	Between 3 to 5 acres	Less than 3 acres	Total
Full-Sun	25	26	15	66
	37.88	39.39	22.73	100.00
High-tech	10	6	5	21
	47.62	28.57	23.81	100.00
Others	3	2	1	6
	50.00	33.33	16.67	100.00
Shaded	23	9	12	44
	52.27	20.45	27.27	100.00
Total	61	43	33	137
	44.53	31.39	24.09	100.00

The first row has *frequencies,* and the second row has *row percentages.*

Fig 4-3 Rainfall Patterns in the Western, Ashanti and Brong Ahafo Regions (2000-2022)



Data Source: World Bank[79]

Farm, farmer characteristics and statistical relationship to cocoa farming models

Table 4-3 shows the farm and farmer characteristics and their statistical relationship to the type of cocoa farming model.[80] **We find some notable statistical differences across farm-level and household (farmer) characteristics.** For example, the educational attainment of the farmers, region and district were significant predictors of the type of farming and, eventually, the yield. These are subsequently thoroughly tested in a full regression model discussed in the next section.

Over the years, the government has embarked on several rehabilitation programmes to remove aged trees and improve farm productivity. The survey data shows that most cocoa trees are below 20 years old (Figures 4-4 and 4-5). In addition, a greater number of the trees were about five years old, indicating relatively new trees. Essentially, about 99% of the trees on the farms engaged in this survey were below 40 years old. The shaded farms have most trees spread up to 40 years, while most full-sun farms have trees below 30 years.

Given that the high-tech model is relatively new, most farms under this model were below ten years old and had a similar pattern to those that combined the models. This suggests that the cocoa trees are not aged, which is a necessary factor for high productivity. Binam et al. (2008)[81], assessing the impact of age trees on the technical efficiency and productivity of cocoa farms, argue that the high yield peaks at about 18 years of cocoa trees. Given that most of the trees were below 20 years old, they are in their productive years, and thus, the correct agronomic and farm management practices could potentially lead to higher yields.

[79] Ghana - Climatology | Climate Change Knowledge Portal (worldbank.org)

[80] We used svyset command in STATA to specify other design characteristics, such as the number of sampling stages and the sampling method, and analysis defaults, such as the method for variance estimation. See https://www.stata.com/manuals/svysvyset.pdf

[81] Binam J, Gockowski J, Nkamleu G (2008). Technical efficiency and productivity potential of cocoa farmers in West African countries. Dev Econ 46(3):242–263. doi:10.1111/j. 1746-1049.2008.00065.x

Table 4-3 Farm and farmer characteristics and cocoa farming model

	Cocoa farming model					
Sex	**Full-sun**	**High tech**	**Others**	**Shaded**	**Total N**	**p-value**
Female	41	6	3	50	100	0.4283
Male	78	19	8	141	246	
Age group of farmers (years)	**Full-sun**	**High tech**	**Others**	**Shaded**	**Total N**	**p-value**
18-24	0	0	0	1	1	0.1367
25-34	6	0	0	8	14	
35-44	28	7	2	42	79	
45-54	35	9	5	80	129	
55-64	32	3	4	46	85	
65 and above	19	7	0	15	41	
Highest educational qualification	**Full-sun**	**High tech**	**Others**	**Shaded**	**Total N**	**p-value**
JSS/JHS/MSLC	49	5	4	69	127	0.0005***
No education	17	10	2	34	63	
Postgraduate	0	1	0	0	1	
Primary	33	6	4	50	93	
Secondary/O/A Level	14	2	0	39	55	
Tertiary	7	2	1	1	11	
Cocoa farming years	**Full-sun**	**High tech**	**Others**	**Shaded**	**Total N**	**p-value**
11-15 years	28	8	2	63	101	0.7456
16 years and above	57	13	5	87	162	
5 years and below	2	0	0	5	7	
6-10 years	27	4	2	30	63	
Cocoa farm ownership	**Full-sun**	**High tech**	**Others**	**Shaded**	**Total N**	**p-value**
Inheritance	80	12	7	104	203	0.5206
Leasehold	3	1	0	5	9	
Purchased	12	6	2	33	53	
Sharecropping	24	7	2	49	82	
Farm size	**Full-sun**	**High tech**	**Others**	**Shaded**	**Total N**	**p-value**
Above 5 acres	50	12	5	83	150	0.9627
Between 3 to 5 acres	49	9	5	82	145	
Less than 3 acres	21	5	1	28	55	
Region	**Full-sun**	**High tech**	**Others**	**Shaded**	**Total N**	**p-value**
Ashanti	49	2	2	80	133	0.0000***
Brong-Ahafo	5	3	3	69	80	
Western	66	21	6	44	137	
District	**Full-sun**	**High tech**	**Others**	**Shaded**	**Total N**	**p-value**
Adansi South	8	2	1	22	33	0.0000***
Ahafo Ano North	5	0	1	34	40	
Amansie West	36	0	0	23	59	
Asunafo North	3	0	3	55	61	
Bodi	17	2	1	18	38	
Dormaa West	2	3	0	15	20	
Juaboso	33	10	4	13	60	
Sefwi-Wiawso	15	9	1	13	38	
Main occupation	**Full-sun**	**High tech**	**Others**	**Shaded**	**Total N**	**p-value**
Driver	0	0	0	1	1	0.1882
Farming	100	23	10	182	315	
Labourer	0	0	0	1	1	
Manufacturing	4	1	0	1	6	
Petty trading	3	0	0	2	5	
Public Servant	13	2	1	6	22	
Main religion	**Full-sun**	**High tech**	**Others**	**Shaded**	**Total N**	**p-value**
Christianity	106	21	10	154	291	0.6992

Muslim	11	5	1	30	47	
None of the above	0	0	0	0	1	
Traditionalist	3	0	0	0	5	

Significance thresholds: p <.1 or significant at a 10% level, p < .05** or significant at a 5% level, p < .01*** or significant at a 1% level or less.*

Fig 4-4 Cocoa tree years and farming model

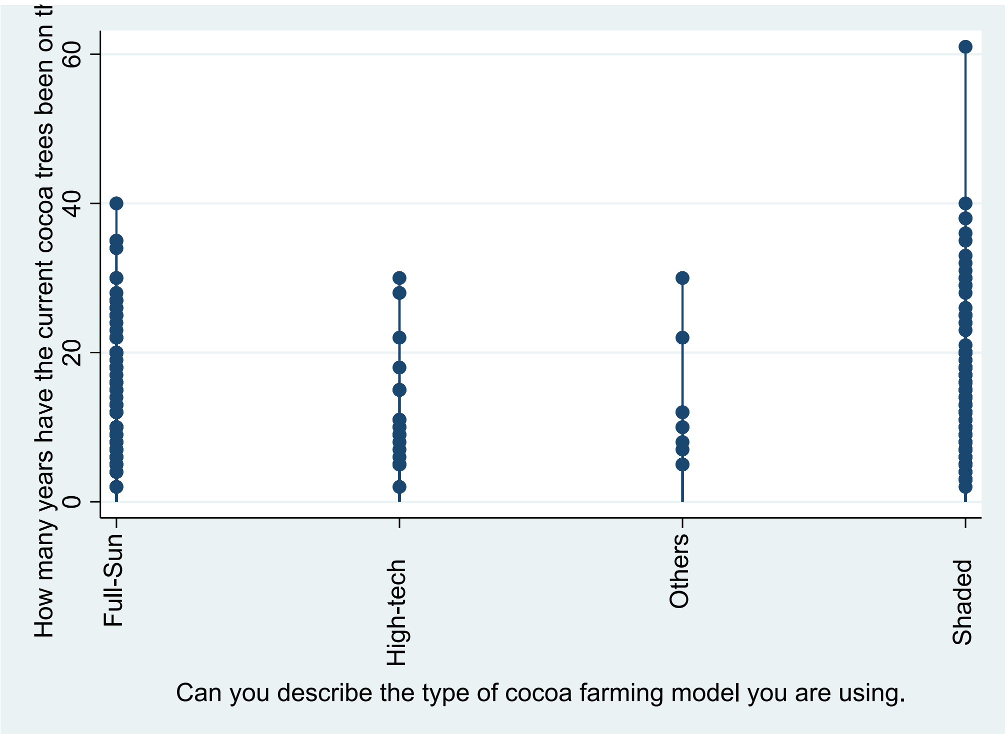
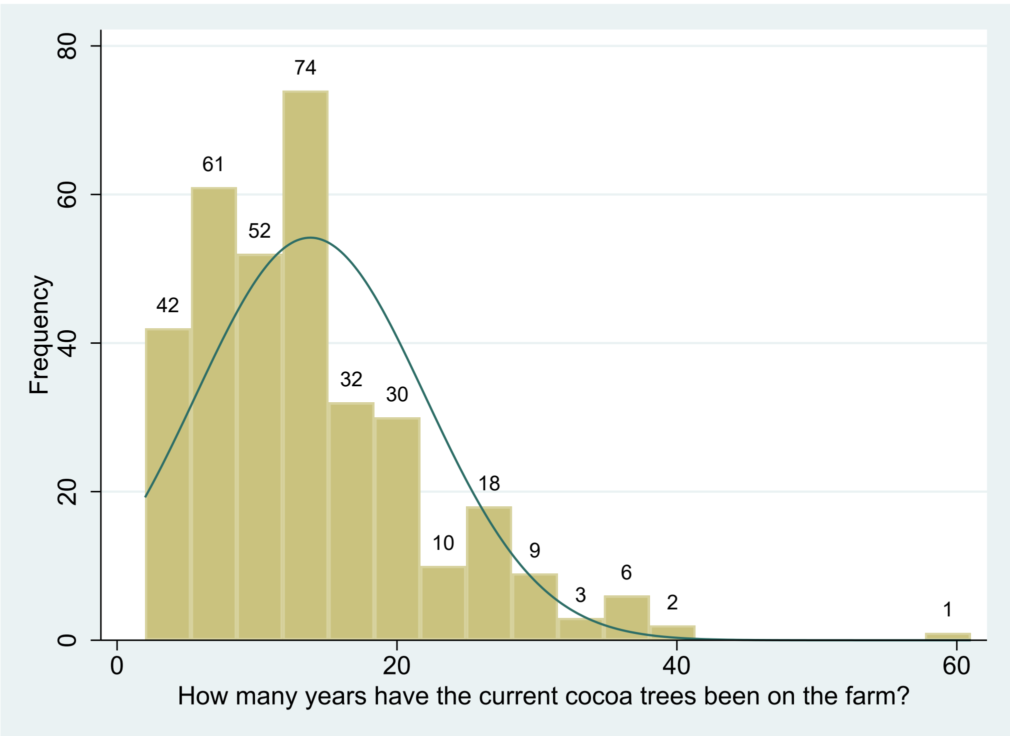


Fig 4-5 Histogram plot showing the distribution of cocoa tree years overlaid with a normal density curve



4.3 Productivity, income, and profitability of cocoa farming models in Ghana

4.3.1 Productivity analysis

The key indicator of farm productivity used in this report is the cocoa yield, measured in kilogrammes (kg) per hectare of land farmed. This metric is consistent with several other published studies in the field.[82]

To enhance data quality and accuracy, respondents were asked to answer the question of how many bags of cocoa they produced and sold over from 2017-2022 in bags. For land size, they were given a range to choose from in acres, although some also provided the actual size off-head in acres, poles or hectares. The data was then re-calculated into kilogrammes per hectare. Before the analysis, we cleaned the data to remove some right-hand side outlier values that were more than four standard deviations (4 S.D.) from the mean, as is consistent with other published literature.[83]

Lastly, instead of using average bags harvested over the past six years, we focussed on the bags produced in 2022 as our key outcome variable. This allows us to capture the cross-sectional dimension, and which is important for the subsequent profitability analysis, given that farmers provided the most recent input costs. In other words, choosing a single year as the unit of analysis allows a like-for-like comparison.

The cocoa bags harvested by each farmer i in year t is converted into a productivity metric as follows:

$$Productivity_{i,t} = \frac{Cocoa\ bags_{i,t}\ \times 64\ kg\ average\ net\ weight\ per\ bag}{Average\ farm\ size\ in\ each\ category} \ldots\ldots\ldots\ldots\ldots..(4)$$

Average farm size in each category: based on an extensive literature review and as highlighted earlier in Section 1.2, we use an average size of **2.5 acres (1.01 hectares)** for farms less than 3 acres. Also, for those between 3-5 acres, we use an average size of **4 acres (1.62 hectares),** and for those above 5 acres, we use an average size of **7 acres (2.83 hectares).**

Overall productivity

The average productivity, as shown in the histogram overlaid with a normal density curve of the sampled farmers, is estimated at 457 kg/ha with a range of 20-1333 kg/ha and a median of 395 kg/ha (Figure 4-6). This finding is consistent with about 400 kg/ha reported in several studies cited earlier in Section 1.2 such as Barrientos & Akyere (2012), Asamoah et al. (2013), Lambert et al. (2014), Wessel & Quist-Wessel (2015), Oomes et al. (2016), Donovan et al. (2016), Vigneri and Serra, Bymolt et al. (2018) and Kalischek et al. (2023).

In other words, **most (61%) of the sampled cocoa farmers of the country's three top-most cocoa-producing regions have yields below 500 kg/ha (actual average of 262 kg/ha)**. On the other hand, a few others (33%) in our sample have cocoa operations at medium productivity of 500-999 kg/ha (actual average of 709 kg/ha). **Only 5% operate at high production level above 1,000kg/ha** (actual average of 1,145 kg/ha)—see Figure 4-7.

[82] See Section 1.2 for a summary of these studies.

[83] See https://www.kit.nl/wp-content/uploads/2018/11/Demystifying-cocoa-sector-chapter10-production-and-yield.pdf

Fig 4-6 Histogram plot showing the productivity of the sampled farmers [N=353], kg/ha

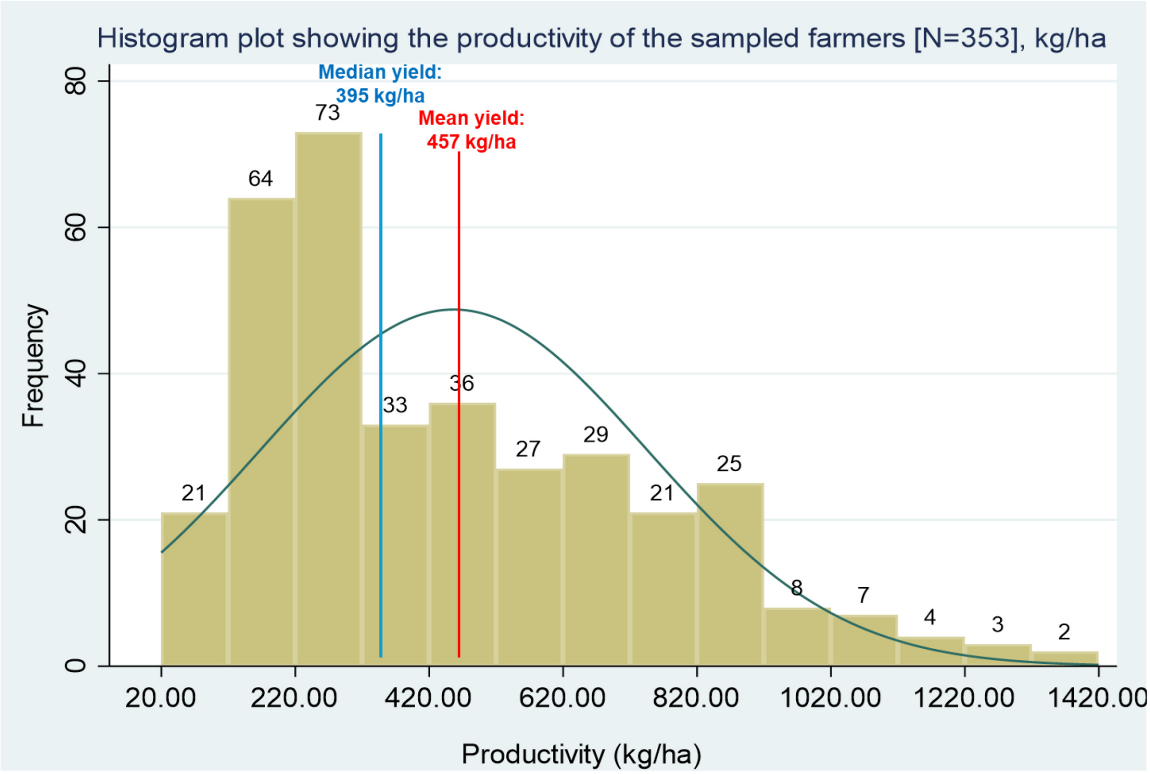
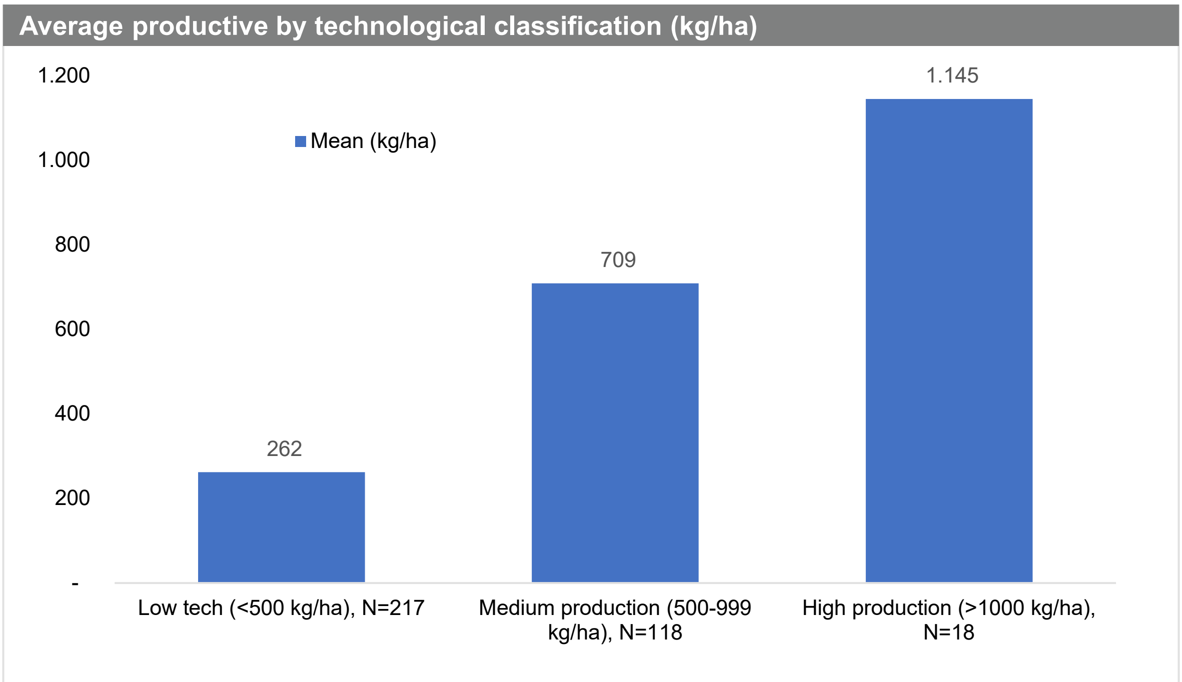


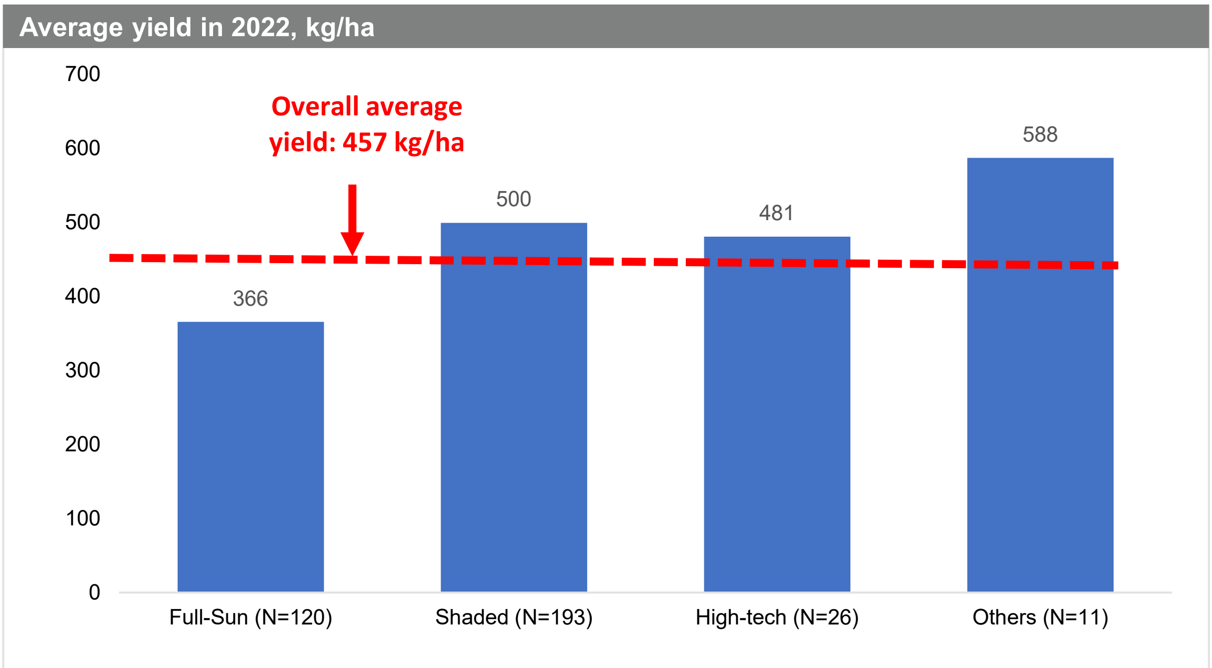
Fig 4-7 Average productivity by technological classification [N=353], kg/ha



Productivity by farming model

The analysis of mean yields also shows shaded and high-tech farming models with the most productivity outcome for farmers compared to full-sun cocoa (Figure 4-8). Based on the respondent data, the full-sun cocoa farming model yielded an average of 366 kg/ha in 2022. In contrast, the shaded and high-tech cocoa models produced an average of 500 kg/ha and 481 kg/ha output. **The findings confirm the higher yield performance of the shaded and high-tech models without considering production costs.**[84]

Fig 4-8 Average yields in 2022 by type of farming model, kg/ha



Productivity by region

The regional productivity also reveals some interesting results, as Table 4-4 shows. Respondent cocoa farmers in the Brong-Ahafo region had the highest average yield of 628 kg/ha, followed by Western at 450 kg/ha and Ashanti at 360 kg/ha.

Table 4-4 Summary statistics of average regional yield

Region	N	Mean [kg/ha]	std dev	min	max
Ashanti	133	360	226	20	1,067
Brong-Ahafo	81	628	248	59	1,333
Western	139	450	319	45	1,328

4.3.2 Regression analysis of yield

Figure 4-9 shows our conceptualisation of the determinants of farm productivity and environmental sustainability based on the review of the extant literature. This is primarily grouped into two thematic areas: farmer and farm characteristics.

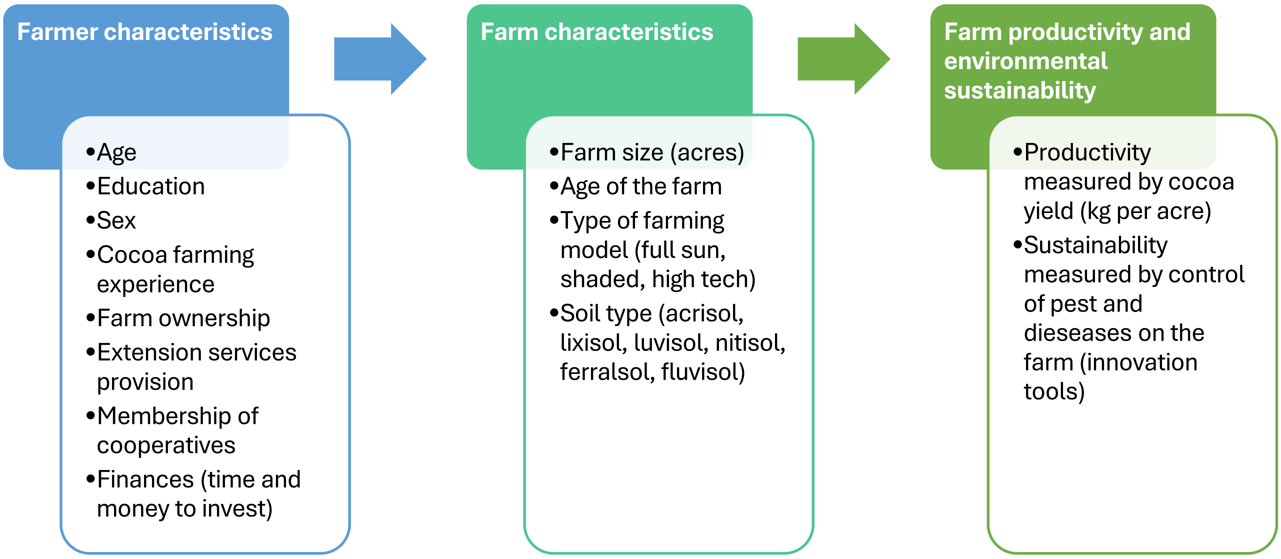
Farmer characteristics include demographic information such as age, education, sex, cocoa farming experience, farm ownership type, extension services provision and membership in cooperatives.

[84] A cost benefit analysis is carried out in later sections of this report

Farm characteristics, on the other hand, include attributes such as farm size (acres), age of the farm, type of farming model (full sun, shaded, high tech) and soil type (acrisol, lixisol, luvisol, nitisol, ferralsol, fluvisol)[85]. Farm productivity is measured by the cocoa yield (kg per hectare).

In contrast, environmental sustainability is measured by controlling pests and diseases on the farm (innovation tools) and knowledge of climate change and corrective measures or farm practices undertaken to mitigate its impact.

Fig 4-9 Determinants of farm productivity and environmental sustainability



Source: Authors' construct

The specification of the general form of multiple regression requires that the variable to be explained (dependent variable Y) be hypothesised as a function of independent variables. $x_1, x_2, x_3, \dots, x_n$. The general form of the multiple regression model is given as follows:

$$General\ form: Y = f(x_1, x_2, x_3, \dots, x_n, \varepsilon_t) \dots \dots (5)$$

$$Linear\ form: Y = \beta_o + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 +, \dots, \beta_n x_n + \varepsilon_t \dots \dots (6)$$

where

$$Y = profitability\ indicator\ (\ kilogrammes\ per\ hectare\ [kg/ha]\ of\ cocoa\ harvested\ in\ 2022.)$$

$$x_n = set\ of\ farmer\ and\ farm\ charateristics$$

$$\varepsilon_t = error\ term$$

Relevant data from the field were fitted into three functional linear model forms, namely:

- **only farm characteristics—**farm size, farming model, age of cocoa trees, and soil type;
- **only farmer characteristics**—age, sex, education, region, district, religion, land ownership, farming years, and
- **both farm and farmer characteristics**.

[85] Cocoa adjusts to a wide range of soil classes and types, but good yield depends on the soil's quality. See Amponsah-Doku, B., Daymond, A., Robinson, S., Atuah, L., & Sizmur, T. (2022). Improving soil health and closing the yield gap of cocoa production in Ghana–a review. *Scientific African*, *15*, e01075. https://doi.org/10.1016/j.sciaf.2021.e01075

The reported model outcome parameters include goodness of fit for regression (R^2), t-test and F-values, as well as the signs and statistical significance of estimated regression parameters. Table 4-5 shows the descriptive statistics while Table 4-6 shows the results from an ordinary least squares linear regression (OLS) on a set of the farm and farmer characteristics.

Table 4-5 Descriptive statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
age	352	4.168	1.047	1	6
sex	349	1.713	0.453	1	2
Education	353	2.776	1.666	1	6
Occupation	353	2.351	1.144	1	8
Region	353	2.017	0.879	1	3
District	352	4.506	2.207	1	8
Religion	350	1.214	0.559	1	4
Farm Size	353	1.734	0.721	1	3
Productivity	353	456.664	288.744	19.768	1332.957
Farming Model	350	2.791	1.4	1	4
Tree Years	340	2.75	1.301	1	5
Soil type	350	3.249	2.368	1	7
Land Ownership	350	2.054	1.302	1	4

Discussion

The models' F-values of 8.1 to 4.20 were all statistically significant ($p<0.01$), indicating a combined influence of all significant variables on productivity. Also, the R2 of 0.28 to 0.38 suggests that we can explain about 28% to 38% of the variability in cocoa productivity by the factors investigated.

At the **farm level (Model 1),** some farm sizes, farming models, and soil types significantly influence cocoa productivity. Regarding the farming model, full-sun cocoa had a statistically negative coefficient on cocoa yield compared to the other farming categories. Furthermore, acrisols, ferralsols, nitisols, lixisols and luvisols also significantly impacted cocoa yields at the 5% significance level.

Regarding only the **farmer characteristics (Model 2),** most variables, including region, education, age and other farmer characteristics, were insignificant.

With the **combined farm and farmer characteristics (Model 3),** the relevant statistically significant variables were the soil type, sex, and region. For example, gender differences were highly significant at the 5% level, with male farmers having better cocoa yields than females—a difference of 76kg/ha. Also, compared with the Ashanti region, farmers from Brong-Ahafo had better statistically significant average yields.

Table 4-6 OLS regression results

Variable	(1) Farm Characteristics	(2) Farmer Characteristics	(3) Farm and Farmer Characteristics
Farm Size (Ref: less than 3 acres)			
Above 5 acres	-219.084***	—	-266.219***
	(43.081)	—	(50.529)
Between 3 to 5 acres	-79.49*	—	-105.254**
	(42.322)	—	(48.062)
Farming Model (Ref: Others)		—	
Full-Sun	-158.198*	—	-105.768
	(85.576)	—	(91.454)
High-tech	8.281	—	48.478
	(96.709)	—	(105.915)
Shaded	-16.682	—	-31.866
	(83.798)	—	(90.257)
Cocoa Tree Years (Ref: Up to 5 years)		—	
11-15 years	-77.845	—	-44.173
	(51.246)	—	(60.343)
16-20 years	-110.506**	—	-20.018
	(52.071)	—	(66.417)
6-10 years	-47.122	—	-27.408
	(46.595)	—	(50.824)
More than 20 years	-58.711	—	18.377
	(55.267)	—	(67.253)
Soil type (Ref: Others)		—	
Acrisols	248.173***	—	236.655***
	(48.105)	—	(53.963)
Ferralsols	263.129***	—	207.613**
	(81.67)	—	(91.451)
Fluvisols	57.445	—	132.762
	(72.573)	—	(81.045)
Lixisols	202.925***	—	186.404**
	(69.467)	—	(72.247)
Luvisols	338.657***	—	268.127***
	(64.286)	—	(69.848)
Nitisols	191.181***	—	186.422***
	(58.06)	—	(60.618)
Age (Ref: 18-24)			
25-34	—	142.278	37.65
	—	(248.383)	(251.116)
35-44	—	264.5	216.532
	—	(241.374)	(241.415)
45-54	—	262.072	245.203
	—	(240.98)	(241.06)
55-64	—	317.016	286.32
	—	(242.807)	(242.3)
65 and above	—	411.849*	291.885
		(245.49)	(245.492)
Sex (Ref: Female)			
Male	—	-0.128	75.939**
	—	(32.367)	(33.843)
Education (Ref: No education)			
JSS/JHS/MSLC	—	13.291	-22.168
	—	(42.766)	(44.463)
Postgraduate	—	133.808	150.22
	—	(241.798)	(248.944)
Primary	—	46.429	32.561

	—	(42.956)	(45.317)
Secondary/O/A Level	—	145.456***	67.436
	—	(49.91)	(52.515)
Tertiary	—	133.579	110.685
		(87.707)	(95.462)
Region (Ref: Ashanti)	—		
Brong-Ahafo	—	-201.316	157.69***
	—	(239.296)	(50.952)
Western	—	23.684	-10.984
	—	(64.684)	(39.87)
Intercept	505.44***	-19.816	297.069
	(108.822)	(358.366)	(391.13)
Observations	334	325	306
R-squared	0.276	0.346	0.381
F-statistic	8.10	5.60	4.20
Prob > F	0.000	0 0.000	0.0000
District Dummy	No	Yes	Yes
Farming Years Dummy	No	Yes	Yes
Land Ownership Dummy	No	Yes	Yes
Religion Dummy	No	Yes	Yes

Standard errors are in parentheses
**** p<.01, ** p<.05, * p<.1*

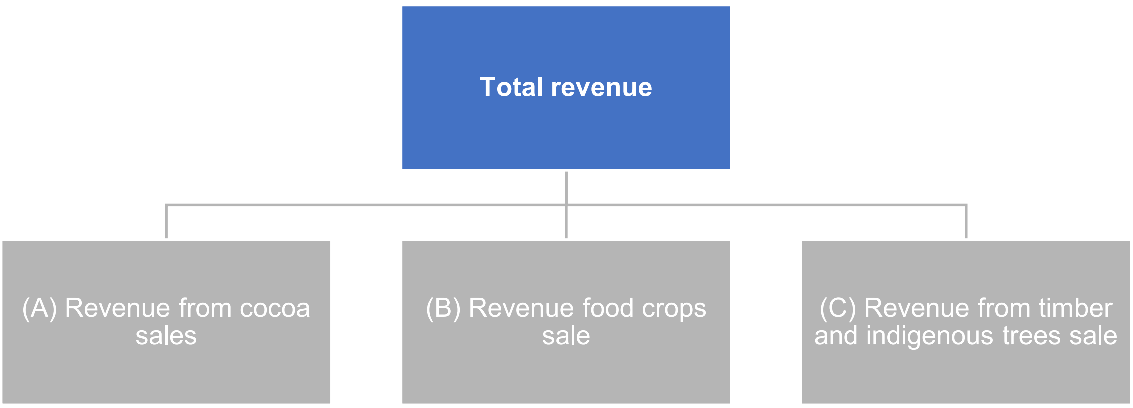
Source: IMANI CPE

4.3.3 Revenue analysis

Three broad income sources were considered for this analysis: ***(i) the revenue from cocoa, (ii) revenue from food crops, and (iii) income from timber and indigenous trees*** (Figure 4-10). Farmers were asked to provide the income for the four revenue sources in 2022. The gross revenue was computed by analysing the average revenue from the farmer's three income sources. In addition, the average revenue was also assessed based on a per-hectare basis to ascertain the model that generates the highest revenue per hectare.

Given that cocoa is sold in a regulated market, the average cocoa revenues are computed based on the annual (2022-23 season) farm-gate price of US$1,248.78 per MT (GHS 12,800 per MT) and the productivity (metric tonnes) by model. This is then standardised by the farm size. This approach was adopted to control for the errors associated with the farmers' under-reporting and over-reporting of cocoa revenues, especially given that cocoa production typically makes about 70-80% of household revenues. Data from the revenues on food crops and timber was based on the average reported revenues by the farmers mainly because these two revenue streams are obtained from unregulated markets. Thus, we rely on the self-reported figures by the farmers.

Fig 4-10 Revenue profile of cocoa farmers



Source: IMANI CPE

Cocoa revenue analysis

Tables 4-7 and 4-8 show the assumptions and results from the cocoa income analysis. A typical household of five farming under the farming models would be expected to harvest and sell between 688 kgs under the full sun, 930 kgs under the high-tech, and 959 kgs of cocoa beans under the shaded model in 2022. The overall sample average production is 871 kgs of cocoa beans. Likewise, in terms of acreage, output ranges from 623 kgs for those with farms less than 3 acres (average of 2.5 acres or 1.01 hectares), 785 kgs doing between 3-5 acres (average of 4 acres or 1.62 hectares), and 1,046 kgs for those with farms over 5 acres (average of 7 acres or 2.83 hectares).

Using the US$1,249 (GHS12,800) per metric tonne farm gate price to farmers announced by the Ghanaian government[86] for the 2022-23 season and the output from farming models abovementioned generates estimated yearly revenue of GHS8,806 (US$859), GHS12,277 (US$1,198), and GHS11,910 (US$1,162) for the full sun, shaded, and hi-tech models respectively. On a per hectare basis, the shaded model generated the highest revenue of GHS5,981 (US$583), which is followed by the Hi-Tech model with an annual revenue per hectare of GHC5,775 (US$563), and the full sun with the lowest revenue per hectare of GHC4,363 (US$426). This indicates that the shaded model provides high cocoa revenues, which can be attributed to the relatively high productivity compared to other models.

Assuming that the cocoa revenues are the only source of revenue for the farming household (with an average size of five), the revenues translate to an average daily living income between US$0.47 (US$0.23 per hectare), US$0.66 (US$0.32 per hectare), and US$0.64 (US$0.31 per hectare) per person for the full sun, shaded, and hi-tech model, which is below the Living Income Community of Practice (LICOP) benchmark of US$1.96 as the amount required per person per day in Ghana in 2022 to afford a decent living. Living income is "sufficient income generated by a household to afford a decent standard of living for the household members".[87] LICOP estimated **US$1.96 as the amount required per person per day (US$298/GHS 2,324 per month or US$3,576/GHS27,893 per annum) in Ghana in 2022 to afford a decent living**.[88] The Fairtrade Living Income Reference Price methodology[89] defines feasible yield levels and minimum viable farm size; this is used as a reference to benchmark the income analysis.

As the analysis shows, **none of the three models in this study provided a sustainable living income for the farmer's household**. Farmers would have almost to triple their output to over 2,000 kgs annually, or there has to be an extreme windfall from cocoa prices in the international market from the 2022-23 farmgate price of US$1,249 per MT to have a decent living based on LICOP standards. **In other words, cocoa farming households sampled, which represent the major cocoa growing areas in the country, cannot afford a decent living**; they have average annual incomes of about US$1,087 versus household needs of US$3,576 per year—see Figure 4-11.

Similarly, the analysis of cocoa revenues by farm size and daily living income also indicates that the farmers with large farm sizes above five (5) acres or 2.83 hectares could not meet the daily living income benchmark per household member. These indicate that irrespective of farm sizes, the farmers were living below the expected daily income benchmark. However, **given that more than two-thirds of Ghanaian cocoa farmers operate below five (5) acres, it is unlikely that most of them would reach the daily living income even if prices doubled at the farm gate**.

[86] https://www.reuters.com/markets/commodities/ghana-hikes-20232024-cocoa-farmgate-price-supplies-tighten-2023-09-09/

[87] See 2023 Fairtrade Living Income Reference Prices for Cocoa - https://files.fairtrade.net/Fairtrade-Living-Income-Reference-Price-for-Cocoa-update-1-Oct-2023.pdf and 2019 Explanatory Note- https://files.fairtrade.net/2019_RevisedExplanatoryNote_FairtradeLivingIncomeReferencePriceCocoa.pdf ibid

[88] ibid

[89] ibid

Table 4-7 Cocoa income analysis, by farming model

Farming model	Estimated mean production (MT) [A]	Farm gate price to farmers (2022/2023 season) US$/MT [B]	Annual income (US$) [C=AxB]	Monthly income (US$) [D=C/12]	Daily income (US$) [E=C/365]	Estimated daily living income for a 5-person household (US$ per person per day) [F=E/5]	LICOP living income benchmark for a 5-person household (US$ per person per day)
Full-Sun (N=120)	0.688	1,249	859	71.60	2.35	0.47	1.96
Shaded (N=193)	0.959	1,249	1,198	99.82	3.28	0.66	1.96
High-tech (N=26)	0.930	1,249	1,162	96.83	3.18	0.64	1.96
Others (N=11)	1.152	1,249	1,439	119.88	3.94	0.79	1.96
Overall (N=353)	0.871	1,249	1,087	90.61	2.98	0.60	1.96
Farming model	**Estimated mean production (MT) [A]**	**Farm gate price to farmers (2022/2023 season) GHS/MT [B]**	**Annual income (GHS) [C=AxB]**	**Monthly income (GHS) [D=C/12]**	**Daily income (GHS) [E=C/365]**	**Estimated daily living income for a 5-person household (GHS per person per day) [F=E/5]**	**LICOP living income benchmark for a 5-person household (GHS per person per day)**
Full-Sun (N=120)	0.688	12,800	8,806	733.87	24.13	4.83	20.09
Shaded (N=193)	0.959	12,800	12,277	1,023.12	33.64	6.73	20.09
High-tech (N=26)	0.930	12,800	11,910	992.49	32.63	6.53	20.09
Others (N=11)	1.152	12,800	14,746	1,228.80	40.40	8.08	20.09
Overall (N=353)	0.871	12,800	11,145	928.76	30.53	6.11	20.09

Source: IMANI CPE *GHC1=US$10.25

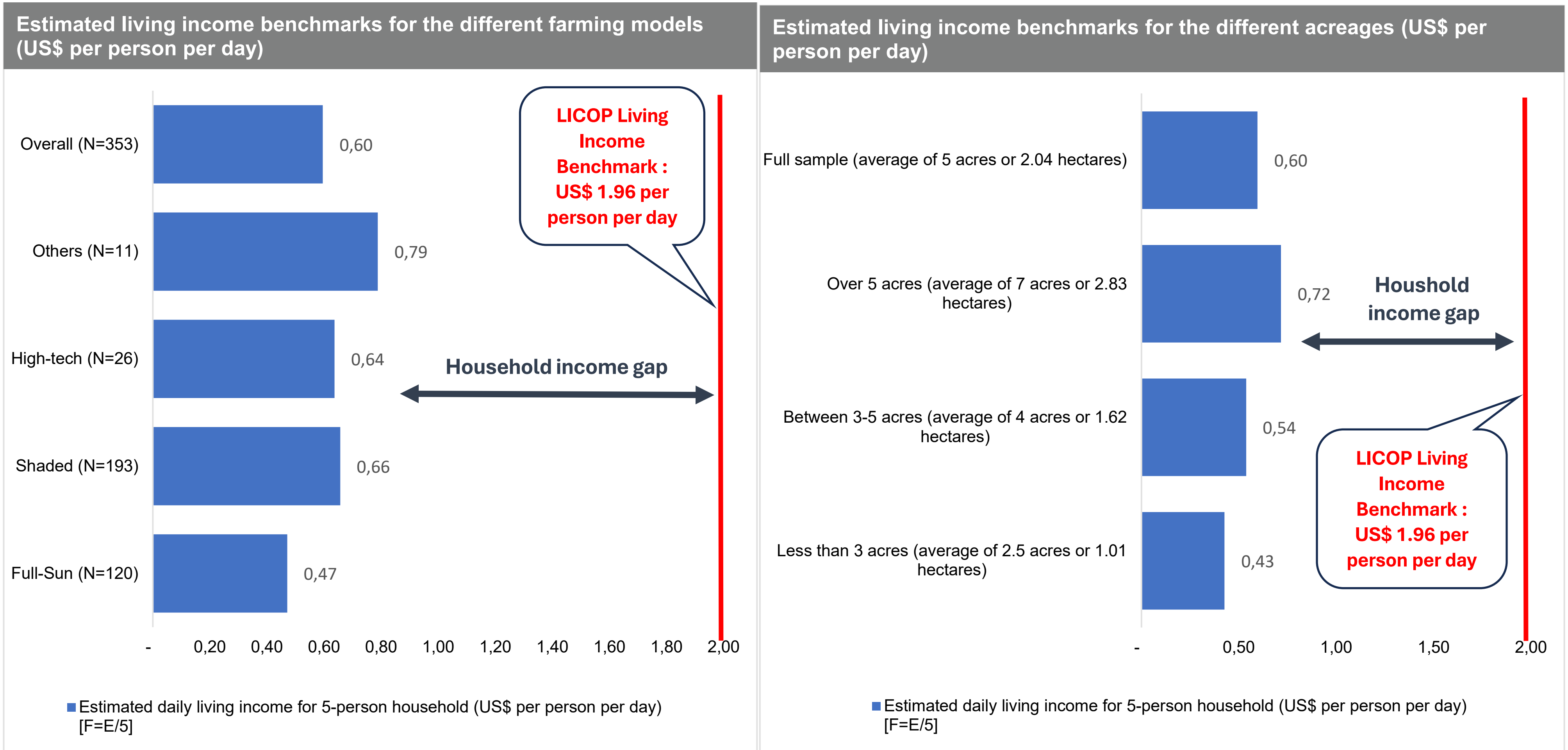
Table 4-8 Cocoa income analysis, by farming acreage

Acreage	Estimated mean production (MT) [A]	Farm gate price to farmers (2022/2023 season) US$/MT [B]	Annual income (US$) [C=AxB]	Monthly income (US$) [D=C/12]	Daily income (US$) [E=C/365]	Estimated daily living income for a 5-person household (US$ per person per day) [F=E/5]	LICOP living income benchmark for a 5-person household (US$ per person per day)
Less than 3 acres (average of 2.5 acres or 1.01 hectares)	0.623	1,249	778	64.83	2.13	0.43	1.96
Between 3-5 acres (average of 4 acres or 1.62 hectares)	0.785	1,249	980	81.69	2.69	0.54	1.96
Over 5 acres (average of 7 acres or 2.83 hectares)	1.046	1,249	1,306	108.85	3.58	0.72	1.96
Full sample (average of 5 acres or 2.04 hectares)	0.871	1,249	1,088	90.64	2.98	0.60	1.96

Acreage	Estimated mean production (MT) [A]	Farm gate price to farmers (2022/2023 season) GHS/MT [B]	Annual income (GHS) [C=AxB]	Monthly income (GHS) [D=C/12]	Daily income (GHS) [E=C/365]	Estimated daily living income for a 5-person household (GHS per person per day) [F=E/5]	LICOP living income benchmark for a 5-person household (GHS per person per day)
Less than 3 acres (average of 2.5 acres or 1.01 hectares)	0.623	12,800	7,974	664.53	21.85	4.37	20.09
Between 3-5 acres (average of 4 acres or 1.62 hectares)	0.785	12,800	10,048	837.33	27.53	5.51	20.09
Over 5 acres (average of 7 acres or 2.83 hectares)	1.046	12,800	13,389	1,115.73	36.68	7.34	20.09
Full sample (average of 5 acres or 2.04 hectares)	0.871	12,800	11,149	929.07	30.54	6.11	20.09

Source: IMANI CPE *GHC1=US$10.25

Fig 4-11 Estimated living income benchmarks for the different farming models and acreages



Source: IMANI CPE

Overall revenue profile per hectare by model

The findings indicate that the income from cocoa is the primary source of revenue for cocoa farmers across all the models, accounting for an average of 78% of reported household income (see Figure 4-12)**.** The share of cocoa revenues per hectare was between 78% and 81% across all three farming models. In addition, revenues from food crops per hectare represent up to about a fifth of the farmer's overall revenue per hectare, indicating some attempts to diversify incomes. This corroborates existing research where cocoa farmers in Ghana identified food crop investment as their second strategy for enhancing resilience.[90]

Table 4-9 Revenue profile, GHS and GHS per hectare

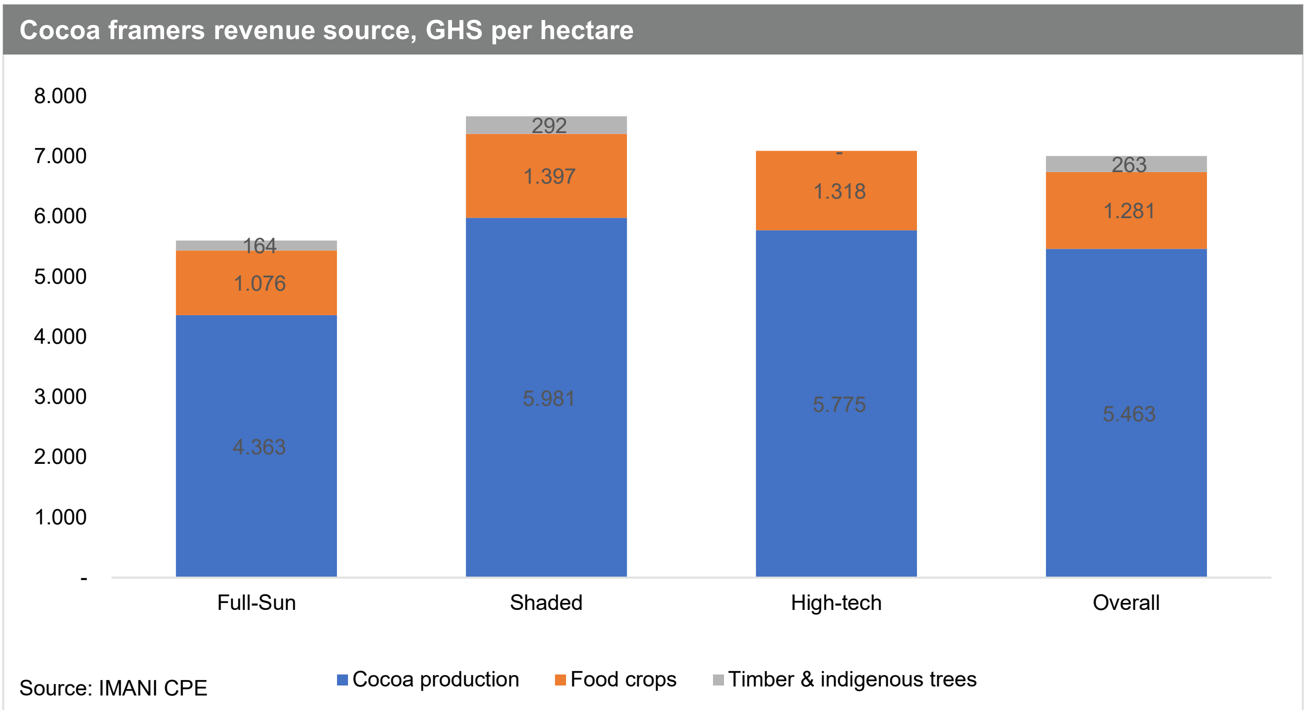
	Full-Sun	Shaded	High-tech	Overall
Average farm size, ha	2.018	2.053	2.062	2.040

Average revenues, GHS	**Full-Sun**	**Shaded**	**High-tech**	**Overall**
Cocoa production (estimated from average production X farm gate price)	8,806	12,277	11,910	11,145
Food crops [self-reported by farmers]	2,171	2,867	2,719	2,613
Timber and indigenous trees [self-reported by farmers]	331	598	-	536
Total revenues	**11,309**	**15,743**	**14,629**	**14,295**

Average revenues, GHS per ha	**Full-Sun**	**Shaded**	**High-tech**	**Overall**
Cocoa production	4,363	5,981	5,775	5,463
Food crops	1,076	1,397	1,318	1,281
Timber and indigenous trees	164	292	-	263
Total revenue, GHS per ha	**5,603**	**7,669**	**7,093**	**7,007**

Source: IMANI CPE

Fig 4-12 Cocoa framers revenue source, GHS per hectare



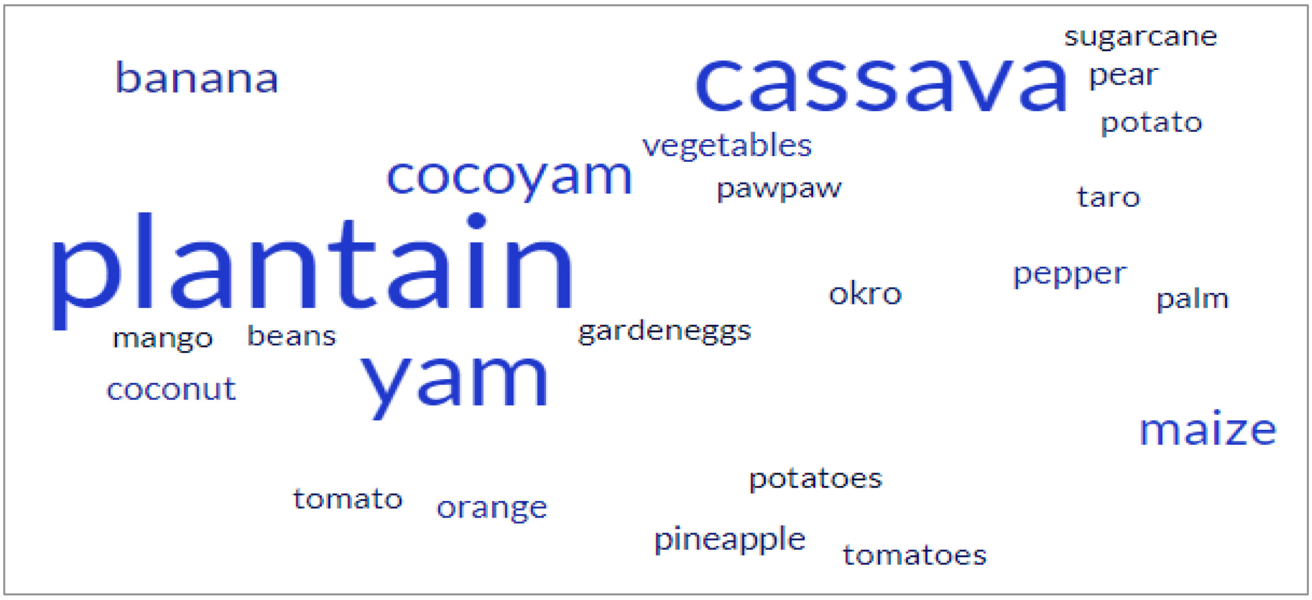
[90] Bymolt R., Laven A., and Tyszler M. (2018). Demystifying the cocoa sector in Ghana and Côte d'Ivoire. https://www.kit.nl/wp-content/ uploads/2020/05/Demystifying-complete-file.pdf

The findings in Table 4-9 indicate that the shaded model generates the highest revenue per hectare. This is primarily attributed to the relatively high productivity compared to the other models. The hi-tech model follows this, while the full sun generates the lowest revenue per hectare. In addition, the additional income earned from the food crops and timber significantly influences the farmers' revenues, which makes diversification important.

Income diversification in commodities in unregulated markets tends to affect income predictability (Figure 4-13). While the findings suggest the incidence of diversification of income sources, the main food crops do not have guaranteed prices in the market. As a result, expected incomes are unpredictable, which implies that the diversification areas may not significantly impact the farmer's income. Furthermore, the farmer's income significantly shapes the size and nature of food crops they can invest. Farmers are responsible for all the food crop production costs, mainly financed with the income from cocoa farms. As a result, small-size and low-income farmers are less likely to diversify their income on a large scale, even if the food crops have high market prices.

The indigenous trees and timber offered the least income to the farmers. This does not provide enough incentives for the farmers to maintain agroforestry practices. Recent reports and research[91] have found farmers increasingly shifting away from planting indigenous trees and timber in their farms because of the difficulties involved in trading timber, and the activities of tree loggers tend to destroy cocoa trees. Cocoa farmers are not well integrated into the timber market and thus are unable to appreciate the value of the timber and mechanisms to benefit from the market. They interface with legal and illegal loggers, further complicating the timber trading activities. If farmers consistently receive low values from the timber and indigenous trees, this could potentially hurt agroforestry cocoa farming, which tends to support environmental conservation.

Fig 4-13 Common food crops for income diversification by cocoa farmers



Source: IMANI CPE

4.3.4 Cost analysis

There are three main components of cost:

i. **Cost of labour:** The cost of labour focuses on the total cost incurred by the farmer when they hire labourers to undertake any of the five (5) main activities (land preparation, spraying chemicals and weeding, harvesting, pod breaking, drying the cocoa beans, and other activities (cocoa and other unrelated activities). In analysing the average cost of labour per activity, we assume that the farmer hired the services of the labourers once in the entire farming season.

[91] Ruf, F.O. The Myth of Complex Cocoa Agroforests: The Case of Ghana. *Hum Ecol* **39**, 373–388 (2011). https://doi.org/10.1007/s10745-011-9392-0

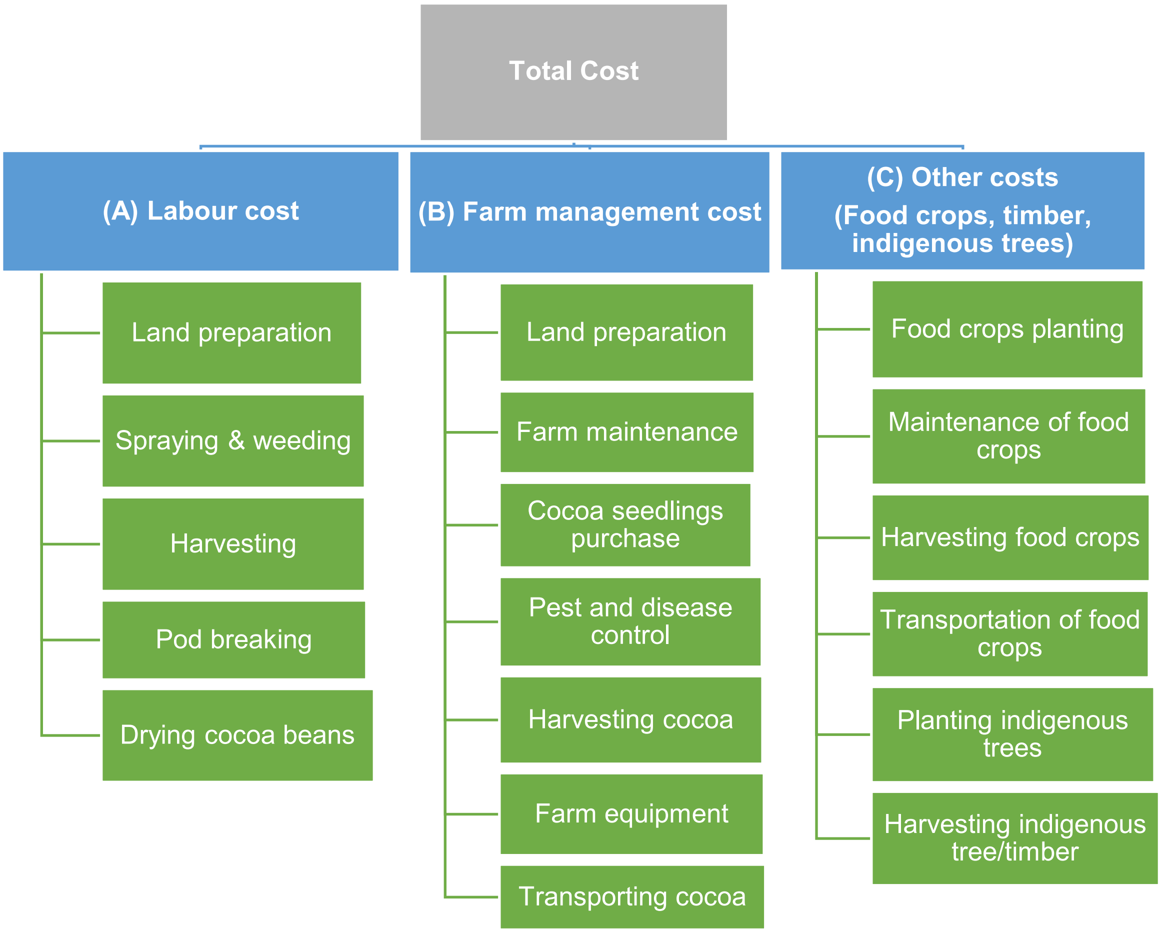
We estimate the average cost of the labourer per activity per day. This helps to understand how much it is likely to have cost a farmer if they hired the services of labourers for each of the activities per day in the season. We compute the total average labour cost by multiplying it by the number of labourers they employ for each activity. It is important to note that the actual labour cost may be higher than estimated as the number of days increases. The daily wages of labourers also depend on factors such as experience.

ii. **Farm management and maintenance costs** relate to non-labour costs associated with cocoa farming. It includes costs for land preparation, farm maintenance, purchase of cocoa seedlings, planting of seedlings, pest and disease control [e.g. herbicides], harvesting cocoa, farm equipment, transportation of cocoa, and other non-labour costs.

iii. **Other costs:** These are costs related to food crops, maintenance of food crops, harvesting food crops, transportation of food crops, planting indigenous trees, and harvesting indigenous trees/timber.

Figure 4-14 shows an overview of the entire cost profile of cocoa farmers. All costs are computed per hectare by computing the average farm size in hectares and computing a ratio of the farm size to the cost indicators expressed below. We use an estimated average farm size of ***2.06 hectares, 2.05 hectares, and 2.02 hectares*** for hi-tech, shaded, and full sun models, respectively.

Fig 4-14 Cost profile of cocoa farmers



The findings suggest that farm management is the largest cost component for cocoa farmers, representing more than two-thirds of the total cost across the three models (Table 4-10). Comparatively, the farm management cost is relatively higher under the hi-tech model. Also, the average labour cost per hectare was almost the same for all the models. In addition, there were minimal differences between the models regarding the cost of planting food crops, indigenous trees and timber on a per-hectare basis. This implies that farm management activities are the main cost drivers for cocoa farmers. Overall, the hi-tech model is associated with a relatively high cost per hectare. This can be attributed to the intensive use of fertilizer, pesticides, and other farm management practices that can increase the cost of farming under the hi-tech model.

The findings also indicate that spraying of chemicals and weeding, land preparation, and pod breaking were the activities with high labour costs across all the farming models. In addition, these activities were also labour-intensive, requiring an average of more than four (4) people across the models. Across all the models, spraying of chemicals and weeding were the activities with high labour costs (Table 4-10). Thus, interventions such as free mass spraying could reduce the labour cost for farmers. However, the current programme implemented by the COCOBOD is only available to some selected districts and farms.

Lastly, across all the models, land preparation, farm maintenance, and farm equipment are the main farm management and other cost items for cocoa farmers. **On a per-hectare basis, there is a relatively low difference between cost items across models.**

Table 4-10 Cost analysis by farm model, GHS per hectare

Cost Indicators	Model		
	Shaded	**Full Sun**	**Hi-Tech**
(A) Labour cost			
Land preparation	141.75	143.63	143.92
Spraying of chemicals and weeding	293.34	270.60	277.26
Harvesting	109.71	111.06	110.54
Pod breaking	176.03	177.58	178.47
Drying of cocoa	102.02	100.56	101.55
Total (A)	**822.85**	**803.43**	**811.73**
(B) Farm management cost			
Land preparation	696.92	610.05	613.33
Farm maintenance	491.11	490.84	490.12
Cocoa seedlings	171.66	169.42	168.12
Planting cocoa seedlings	174.33	189.28	178.64
Pest and disease control	356.55	356.50	354.45
Harvesting cocoa	341.20	353.66	344.34
Transporting cocoa	183.33	187.78	183.73
Farm equipment	537.52	523.66	525.94
Renting farm equipment	120.36	124.50	122.30
Total (B)	**3,072.98**	**3,005.69**	**2,980.97**
(C) Other cost (food crops, timber and indigenous trees			
Food crops	359.83	360.32	356.43
Maintenance of food crops	206.16	208.05	205.70
Harvesting food crops	251.28	260.23	252.69
Transportation of food crops	277.03	278.76	277.92
Planting of timber or indigenous trees	110.73	103.45	105.69
Harvesting indigenous tree/timber	62.66	60.41	60.16
Total (C)	**1,267.69**	**1,271.22**	**1,258.59**
Overall Cost (A+B+C)	**5,163.52**	**5,080.34**	**5,051.31**

Source: IMANI CPE

4.3.5 Cocoa model profitability: Cost-benefit analysis

To ascertain which model provides the most benefits per hectare basis, a cost-benefit analysis was conducted to ascertain the net income of each model. This is presented in Table 4-11.

The shaded model provides the highest net income per hectare. This can be attributed to the relatively higher yield than the other models. Other studies, such as Obiri et al. (2007), also identified the shaded model as the most profitable cocoa farming model compared to the traditional full sun and the hybrid[92]. Given that revenue from cocoa production forms more than 70% of the farmer's income, increased yields can significantly influence the farmer's income. The hi-tech model also recorded a relatively high net income per hectare, making it another profitable cocoa farming model to pursue. The results of this study is also corroborated by the work of Gockowski et al. (2013)[93], which analysed the financial profitability of different cocoa farming models over 24 years, where the hi-tech model was identified to be financially profitable and recorded high average yields. **The main difference in profitability between the hi-tech and shaded can largely be attributed to productivity and the complementary income from the timber and indigenous trees.** This implies that if cocoa farmers are effectively integrated into the timber sub-sector and information asymmetry and illegal logging are addressed, the shaded trees could add more revenue to the farmer's earnings. **Overall, the shaded model is profitable compared to the hi-tech and the full sun.**

Table 4-11 Cashflow statement per hectare of the cocoa farming models

Revenue/Cost	Model		
	Shaded	**Full Sun**	**Hi-Tech**
Revenue (per hectare)			
Cocoa	5,980.85	4,363.12	5,774.95
Food crops	1,396.57	1,075.67	1,318.28
Timber and indigenous trees	291.53	164.05	-
Total revenue per hectare (A)	**7,668.95**	**5,602.84**	**7,093.23**
Cost (per hectare)			
Labour cost	822.85	803.43	811.73
Farm management cost (cocoa)	3,072.98	3,005.69	2,980.97
Other cost (food crops, timber, indigenous trees)	1,267.69	1,271.22	1,258.59
Total cost per hectare (B)	**5,163.52**	**5,080.34**	**5,051.31**
Net income per hectare (A-B)	**2,505.43**	**522.50**	**2,041.92**

Source: IMANI CPE

4.4 Cocoa farming and environmental sustainability

4.4.1 Illegal mining practices

Table 4-12 shows the results of farmers who have been approached by people involved in galamsey to sell their cocoa farm to them for mining activities, while Table 4-13 indicates the extent to which farms are actually being used for any mining activity, including galamsey. As can be seen, **about 14% or 1 in 10 cocoa farmers have been approached by people involved in galamsey to buy their farms and use them for mining activities.** While we could not find any baseline statistic to compare

[92]Obiri, B.D., Bright, G.A., McDonald, M.A. *et al.* Financial analysis of shaded cocoa in Ghana. *Agroforest Syst* **71**, 139–149 (2007). https://doi.org/10.1007/s10457-007-9058-5

[93] Gockowski, J., Afari-Sefa, V., Sarpong, D. B., Osei-Asare, Y. B., & Agyeman, N. F. (2013). Improving the productivity and income of Ghanaian cocoa farmers while maintaining environmental services: what role for certification?. *International Journal of Agricultural Sustainability*, *11*(4), 331-346. https://doi.org/10.1080/14735903.2013.772714

this to in terms of whether this is a rising or declining trend, various anecdotal and news reports highlight the growing prevalence of the practice of more cocoa farmers being willing to sell their land to illegal miners or engaging in galamsey themselves to supplement or replace their incomes.[94] A recent study by Siaw et al. (2023) found evidence of what they call 'coerced to sell' strategies deployed by miners in the acquisition of farmlands.[95]

Data from COCOBOD shows that between 2019 and 2020, over 19,000 hectares of productive cocoa farms in key cocoa-growing regions—Ashanti, Western and Western North— were destroyed by illegal gold miners.[96] The factors driving this phenomenon include "farmer poverty, youth unemployment and sheer impunity by the illegal gold miners"[97] and also "uncompetitive cocoa prices on the international market"[98], which impact farmer livelihoods. Lastly, as Table 4-11 shows, farmers in the Western Region (almost 20% or 2 in 10 farmers as compared to 14% in the full sample) faced more pressure to sell their cocoa farms for galamsey activities, while those in the Brong-Ahafo faced less pressure. Ghana's western region is home to some of the richest deposits of gold in the country and hosts some of the biggest multinational miners.[99] A 2021 NASA Earth Observatory report highlights the following: *"although individual galamsey sites cover less area than an industrial mine, their cumulative effect on the landscape outweighs those of larger mines. In the **southwestern forests** of Ghana, for instance, **the footprint of small-scale mines is nearly seven times greater** than that of industrial mines*."

Table 4-12 Responses on cocoa farmers being approached by galamseyers to sell their farms

Approached by people involved in galamsey to sell cocoa farm	**Region**			
	Ashanti	**Brong-Ahafo**	**Western**	**Total**
No	122	78	116	316
	88.41	91.76	80.56	86.10
Yes	16	7	28	51
	11.59	8.24	19.44	13.90
Total	138	85	144	367
	100.00	100.00	100.00	100.00

The first row has *frequencies*, and the second row has *row percentages.*

Table 4-13 Farm use for mining activity

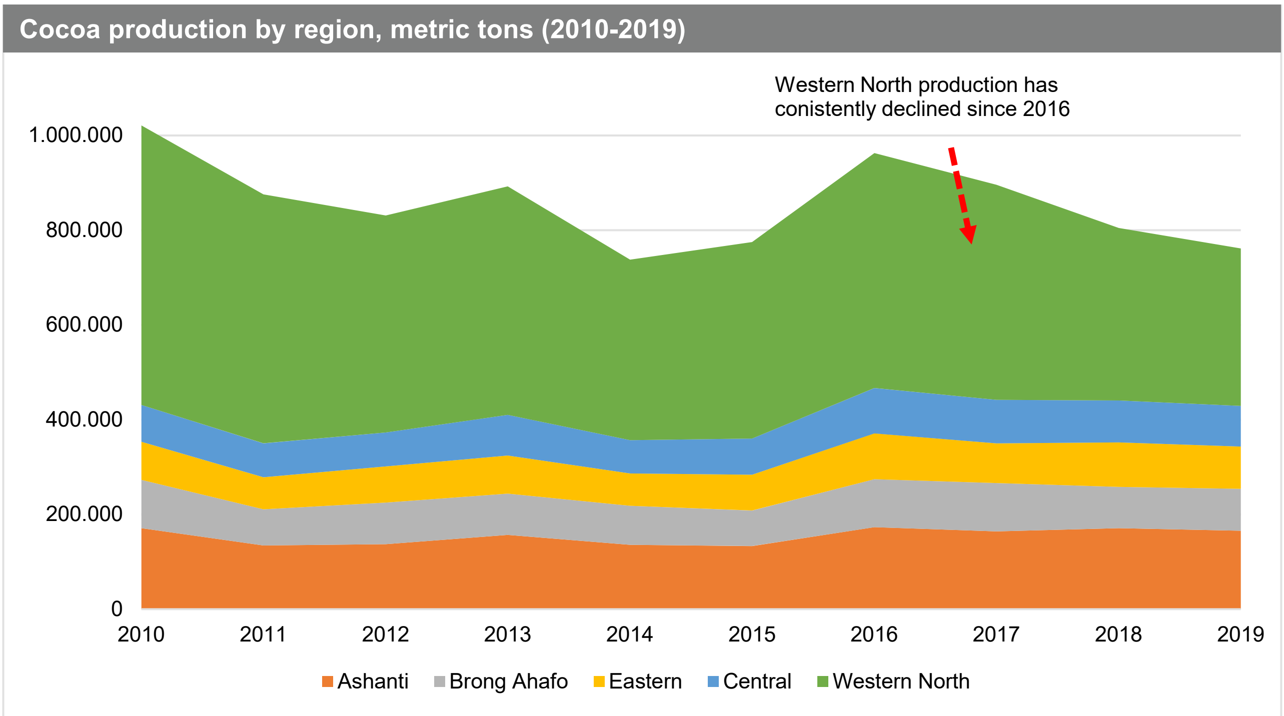
Part of farm being used for any mining activity	**Region**			
	Ashanti	**Brong-Ahafo**	**Western**	**Total**
No	137	88	142	367
	99.28	100.00	98.61	99.19
Yes	1	0	2	3
	0.72	0.00	1.39	0.81
Total	138	88	144	370
	100.00	100.00	100.00	100.00

[94] See https://www.oxfam.org/en/press-releases/chocolate-giants-reap-huge-profits-promises-improve-farmers-incomes-ring-hollow
[95] Siaw, D., Ofosu, G., & Sarpong, D. (2023). Cocoa production, farmlands, and the galamsey: Examining current and emerging trends in the ASM-agriculture nexus. *Journal of Rural Studies*, *101*, 103044. https://doi.org/10.1016/j.jrurstud.2023.103044
[96] See https://thecocoapost.com/can-ghanas-cocoa-sector-survive-the-illegal-gold-mining-invasion/ and https://thecocoapost.com/galamsey-is-robbing-cocoa-farmers-of-future-pensions/
[97] ibid
[98] https://thebftonline.com/2022/10/03/farmers-surrender-cocoa-farms-for-galamsey/
[99] Eshun, P. A. (2005). Sustainable small-scale gold mining in Ghana: setting and strategies for sustainability. *Geological Society, London, Special Publications*, *250*(1), 61-72. https://doi.org/10.1144/gsl.sp.2005.250.01.07
Arthur, F., Agyemang-Duah, W., Gyasi, R. M., Yeboah, J. Y., & Otieku, E. (2016). Nexus between artisanal and small-scale gold mining and livelihood in Prestea mining region, Ghana. *Geography Journal*, *2016*, 1-18. https://doi.org/10.1155/2016/1605427

The first row has *frequencies,* and the second row has *row percentages.*

Galamsey activities have increased in scale and scope since 2016, while data on cocoa production by region shows that the total production from the Western North (the same as the Western Region) has consistently declined since 2016—see Figure 4-15. The Western Region, Ghana's highest-producing region, has consistently recorded a decline in production partly due to galamsey; sustaining the production levels is at an even higher risk.

Fig 4-15 Cocoa production by region (2010-2019)



Data source: Ghana Cocoa Board[100]

4.4.2 Climate change awareness

Table 4-14 shows the awareness of climate change while Table 4-15 lists the causes of climate change described by the farmers. **Overwhelmingly, almost all the farmers (97%) indicated that they know about climate change—which refers to changing weather patterns indicated by excessive rainfall and extremely hot temperatures**. Many farmers indicated that cocoa production on their farms is affected by conditions such as too little rainfall, delay in the onset of rain starting, extremely high temperature, or delay in rain stopping, among others.

Regarding the causes of climate change, a little over half of the respondents (52%) indicated that it was caused by human activities such as illegal logging, excessive wood fuel usage, and slash-and-burn agriculture. This was more pronounced among farmers in the Western Region (59%). Likewise, another 48% of the farmers surveyed indicated that climate change was due to natural phenomena, with those from the Ashanti region (54%) believing more in this relative to the sample average. Finally, practices that farmers are using to boost the production of cocoa to mitigate the impact of climate change include more fertilizer application, afforestation, pegging of plants, hand pollination and manure application, among others.

[100] https://thecocoapost.com/statistical-data-on-cocoa-production-in-ghana-since-1948/

Table 4-14 Awareness of climate change

Know about climate change	Region			
	Ashanti	Brong-Ahafo	Western	Total
No	4	2	5	11
	3.03	2.30	3.50	3.04
Yes	128	85	138	351
	96.97	97.70	96.50	96.96
Total	132	87	143	362
	100.00	100.00	100.00	100.00

The first row has *frequencies,* and the second row has *row percentages.*

Table 4-15 Causes of climate change

Causes of the unusual/rapidly changing rainfall patterns	Region			
	Ashanti	Brong-Ahafo	Western	Total
Human activities	61	42	84	187
	45.86	48.28	58.74	51.52
Natural phenomena	72	45	56	173
	54.14	51.72	39.16	47.66
Superstition	0	0	3	3
	0.00	0.00	2.10	0.83
Total	133	87	143	363
	100.00	100.00	100.00	100.00

The first row has *frequencies,* and the second row has *row percentages.*

5 Conclusions

The cocoa sector remains critical to Ghana's economic transformation: almost a million of Ghana's population are actively engaged in cocoa farming and the sector generates the second-largest foreign exchange after mining. However, despite several decades of political, economic, and administrative reforms to make cocoa a meaningful business for rural farmers, the country is yet to find a just solution to the triple problem in the sector: ***low living incomes, environmental degradation, and child and human rights issues.*** While these factors are detached, the common thread of poverty intertwines them. Addressing the triple problem in part depends on identifying farming models that provide sustainable incomes for farmers to afford a decent living, and support them to pursue alternative farming approaches that are environmentally sustainable.

This study set out to understand the common cocoa farming models that are profitable and support environmental protection. The analysis shows that the shaded model (also referred to as the agroforestry model) is the most profitable. The shaded model was found to deliver more output and revenue per hectare and was associated with a similar cost profile to other less profitable models. In addition, the shaded model was identified to possess characteristics such as about half of the farm canopy covered by shaded trees, which predisposed it to be more environmentally supportive. These qualities made the shaded model more supportive of biodiversity, soil erosion, and climate resilience. The shaded model has characteristics that make it a feasible farming approach to address deforestation. Furthermore, promoting the shaded model can contribute significantly to Ghana's efforts to meet the upcoming EU Deforestation Regulation.

Over the last two decades, successive governments have pursued several strategies, including the Cocoa Pest and Disease Control (CODAPEC) and Hi-Tech programme, to promote the adoption of the hi-tech model in Ghana. The study also found the hi-tech model to be profitable and productive, compared to the traditional full sun cocoa farming approaches, which were found to be less profitable and productive. While it is encouraging that the three common farming models practiced in the top three cocoa-producing regions are generally profitable, the study finds that the majority of the farmers are living below the expected living income threshold. The results indicate that farmers must at least double their current production before they can attain the living income threshold. Given that more than two-thirds of cocoa farmers operate less than two hectares, a greater number of farmers are less likely to achieve the expected living income threshold, leaving them vulnerable.

In view of the foregoing, the following policy recommendations are proposed:

1. **Government should collaborate with development partners to accelerate the re-adoption of the agroforestry models in major cocoa-growing areas.** Cocoa is typically cultivated under forestry systems, however, several practices have led to the conversion of forest for cocoa farming, largely because of limited understanding and lack of support to maintain agroforestry systems. Currently, there is a National Implementation Plan, which is intended to promote forest conservation and promote agroforestry cocoa farming. Ongoing initiatives such as the Cocoa and Forest Initiative (CFI) must be expanded to increase farmers' access to shaded trees for new and existing farmers. Stronger government support is needed to intensify the education and adoption of the shaded model.
2. **Government and stakeholders should intensify work with farmers to encourage more commercial scale cocoa farming, improve productivity and total output to make cocoa farming a viable business:** there is a need to encourage more commercial scale cocoa farming beyond the current subsistence level being practised by most farmers. As the analysis shows, most farm sizes (average of about 5 acres or 2 hectares) and yields (average of 457 kg/ha of cocoa output) are too small in order for cocoa farming alone to generate living incomes for farming households. None of the farming models meets the LICOP standard of US$1.96 per person per day (US$298/GHS 2,324 per month or US$3,576/GHS27,893 per annum) in Ghana in 2022 to afford a decent living. Subsistence level farmers must be supported through new agronomic practices that can double or triple farm yields to 1,000–1,900 kg/ha. New commercial scale cocoa farms could be based on the shaded model as this supports increased yields and better agroforestry practices that are more environmentally friendly.

3. **Expand the coverage of the Cocoa Pest and Disease Control (CODAPEC), and Cocoa Rehabilitation and Intensification Programmes (CRIP):** Initiatives such as CODAPEC and CRIP must be expanded with subsidised inputs and mass spraying as these help reduce farm management costs and ultimately improve yields.
4. **Deepen education and training offered through extension services to farmers:** The findings also show specific soil types [and agronomic practices] support productivity. The central government and related agencies such as COCOBOD should increase the scope and coverage of ongoing farmer engagements and education on sustainable agricultural techniques, such as environmental preservation and responsible input usage.
5. **Increase income diversification activities of cocoa farmers.** The findings indicate food crops as the second highest income source of farmers, but most government and donor programmes tend to only focus on cocoa production. Stakeholders (DPs, licensed buying companies and other industry players) could introduce initiatives that allows farmers to expand their income diversification activities. Along with investing in the shaded or high-tech production model, encouraging farmers to grow other food and tree crops might help lessen the industry's sensitivity to price changes, pests, and diseases. Intercropping with fruit trees, oil palms, and rubber can give farmers alternate sources of income. In addition, the diversification of products through manufacture of specialised chocolates, cocoa beverages, or cosmetics utilising cocoa derivatives can create new markets and sources of income for farmers through small-scale or cottage industries.

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