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Assessing the Potential Benefits and Challenges of Cocoa Agroforestry Adoption in Ghana’s Western-North Region

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Abstract

This study explores the potential benefits and challenges of cocoa agroforestry adoption in five Theobroma cacao-growing communities in Ghana’s Western-north region. Cocoa agroforestry is a farming practice that combines cocoa cultivation with tree planting. It is an essential approach to mitigate the effects of climate change, reduce forest loss, and alleviate poverty; however, its adoption is not widespread within Ghanaian farming communities. The study used a mixed-method approach, including a semi-structured questionnaire (n = 150), interviews, and focus group discussions to gather data. The results of the study suggest that farmers’ willingness to integrate tree species on their cocoa farms is not significantly influenced by factors such as gender, age, level of education, or land ownership. *Terminalia superba*, *Khaya spp.,* and *Milicia excelsa* were the more common non-cocoa trees found, and farmers demonstrated good knowledge and understanding of cocoa agroforestry. The main motivation for farmers to plant trees was to build climate resilience, supplement their income, improve food security, and restore degraded lands. However, the main barriers to adopting cocoa agroforestry, as identified by farmers, were a lack of financial support, high transportation costs for seedlings, and insufficient technical support and awareness. The study recommends that farmers raise cocoa seedlings on their farms and receive incentives such as cash, inputs, and a pension scheme to encourage greater adoption of cocoa agroforestry as a REDD+ strategy at Ghana’s cocoa-growing communities.

Keywords: cocoa agroforestry, cocoa farmers, indigenous knowledge

1. Introduction

Climate change has negative impacts on several socioeconomic sectors, particularly agriculture (Nyong et al., 2020), which is critical to the global food supply and the economy. At Ghana, agriculture is an important economic sector, accounting for 21.3% of the nation’s GDP and providing the primary means of subsistence for nearly 60% of the working population (ISSER, 2014; Denkyirah et al., 2016). Theobroma cacao is the main export crop and according to the Bank of Ghana (2021), total cocoa exports were US$ 2.9 billion for 2021. However, the decline of the world’s forest cover is largely caused by forest-risk commodities (timber, cocoa) (Norris et al., 2010; Gockowski & Sonwa, 2011; Tondoh et al., 2015; Wessel & Quist Wessel, 2015). Due to the rise in cocoa production worldwide, nearly 2 to 3 million acres of forest were destroyed between 1988 to 2008 (; Gockowski & Sonwa, 2011; Kroeger et al., 2017).

In Ghana, between 1990 and 2008 (18 years), agricultural production was responsible for 80% of all deforestation (European Commission, 2013; Kroeger et al., 2017), which was the most significant contributor to the agricultural expansion during this time. Due to farm development in forest areas, the production of cocoa contributed to 27% of forest loss (Hosonuma et al., 2012; European Commission, 2013; Kroeger et al., 2017). Efforts by the UNFCCC to stop forest destruction led to the adoption of the REDD+ program (which aims to reduce emissions from deforestation and forest degradation while conserving, sustaining, and Managing forests to enhance carbon stocks). REDD+ aims to solve climate problems by giving developing countries money as compensation or incentive payments to reduce deforestation and increase the amount of carbon stored in their forests (Angelson, 2008; Vatn & Angelson, 2009; Pistorius, 2012).

Concerns about deforestation have led to the idea that cocoa agroforestry could be an excellent way to increase cocoa yields in Ghana and other countries, where marginal lands are cultivated to stop forest loss (Boateng, 2008;

Asare, 2015). Cocoa agroforestry is the practice of planting wood trees, fruits, food crops on cocoa (Asare et al., 2014; Essouma et al., 2020). The practice increases farmers' resilience and better positions them cope with climate change effects (Vaast et al., 2016; Blaser et al., 2018; Isaac et al., 2020). Gockowski et al. (2008) mentioned that shade trees on cocoa farms offer agronomic, economic, cultural, and ecological benefits to farmers livelihood. These benefits help farmers keep or increase farm income and the well-being of their families. In the context of REDD+, agroforestry can prevent deforestation and forest degradation by providing timber and fuelwood that would otherwise come from the nearby forest. Moreover, cocoa agroforestry is classified as a forest and hence qualifies for forest carbon payment systems. This can generate additional revenue, which could greatly incentivize farmers. Although the potential of carbon sequestration in cocoa agroforests has not yet been fulfilled, the notion that these systems can readily be classified as forests underlines the huge potential that can be realized, particularly if the price of cocoa falls on the global market. Income from carbon money could be helpful in reducing farm losses caused by bad weather, and other potentially harmful factors such as market price fall.

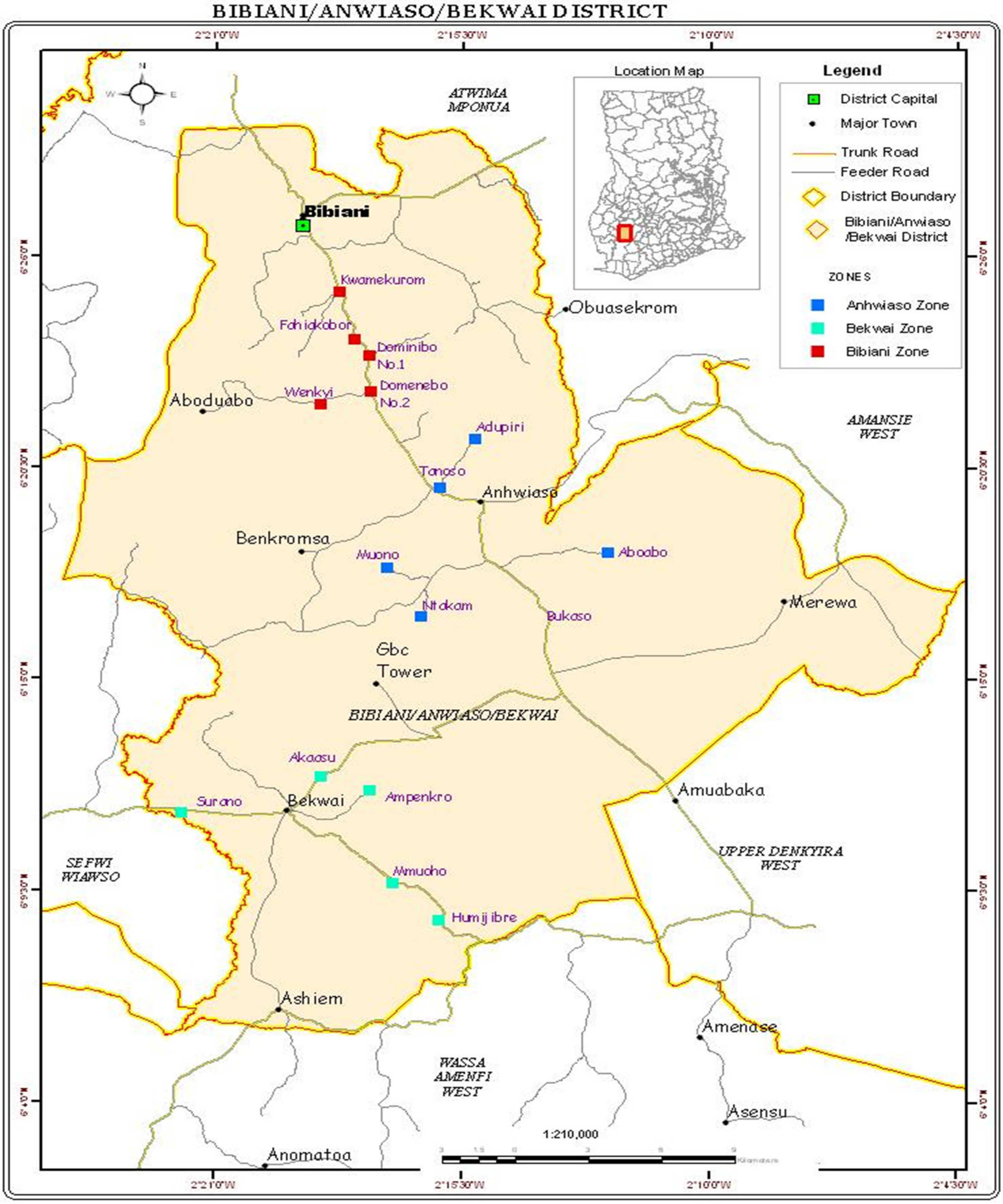
However, in recent times, cocoa farmers at Ghana and other cocoa-producing nations, have switched to low or no shade cocoa (full sun) systems (Yamoah et al., 2021) Studies have shown that this system reduces the productivity of cocoa plants in the long term. The full-sun system which is cocoa without trees exposes cocoa trees to ecological stresses, and in ways that make them more prone to pests and diseases attack and to ultimately lead to low crop yield in a few years. Such situations compel farmers to move into nearby forests for new land and to cause deforestation with significant ramifications for forest conservation, biodiversity, carbon sequestration and the resilience of cocoa plants to climate change impacts (Anim-Kwapong & Frimpong, 2005; Nunoo et al., 2014).

To address this problem, this study focuses on five cocoa-growing communities at Ghana's Western-North region to examine the prospects and challenges of adopting cocoa agroforestry as a REDD+ strategy. The study investigates farmers' knowledge and motivations for adopting cocoa agroforestry, as well as the challenges hindering its adoption. The study also identifies the most desirable tree species for cocoa agroforestry.

2. Study Context

This research was carried out at Ghana's Western-North region, specifically at the Bibiani Anhwiaso Bekwai Municipality (BABM), one of Ghana's main cocoa-producing areas. The municipality was selected purposively due to its location within the High Forest Zone (HFZ), a cocoa-forest mosaic landscape in Ghana, within the Sefwi Wiawso/Bibiani Hotspot Intervention Area (HIA). Sefwi Bibiani Anhwiaso Bekwai is situated between latitudes 6˚N, 3˚N and longitudes 2˚W, 3˚W (GSS, 2021). The district is bounded to the north by the Ashanti region's Atwima Mponua district, to the south by the Western region's Wassa Amenfi district, to the west by the western north's Sefwi Wiawso district, and the East by the central regions' Upper Denkyira West and the West by Ashanti's Amansie districts. Agriculture employs 74.9% of the municipality's households. Crop (cocoa) farming is practiced by most of the municipality's agriculture households (98.2%) (GSS 2021).

BABM is located the Equatorial Rainforest zone (GSS, 2021). In its natural state, the area is covered with a moist deciduous forest. The area is located within the Equatorial Climate Zone, which receives an average annual rainfall of between 1200 and 1500 mm (GSS, 2021).



Source: Kumi & Daymond (2015).

Rainfall pattern is bimodal, with the majority occurring between March and August and the remainder between September and October. Humidity levels are relatively high, ranging from 75% in the afternoon to 95% at night and in the morning. The favourable climatic conditions, coupled with the high fertility of forest ochrosols soils, support cocoa production and make cocoa the most crucial cash crop in the region.

3. Methodology

3.1 Study Design

This study employed the concurrent triangulation mixed-method approach. According to Creswell (2009), a mixed design allows the two methods to complement one another, making it appropriate for the presentation of research results. Data collection started from September to November 2022. Data collection activities, including conducting key informant interviews, administering household questionnaires, and focus group discussions were conducted concurrently to cross-validate the challenges and prospects of cocoa agroforestry adoption in the study area.

3.2 Sampling

Stakeholders (153) directly or indirectly involved in the cocoa sector were sampled to represent the study's target population. These include cocoa farmers, officials from the Ghana Cocoa Board and Forestry Commission. The study employed a multi-stage strategy for selecting farmers and study communities. First, the study area was selected purposively because the area is one of the country's cocoa-growing districts. Cluster sampling was also employed to divide the district into three geographical areas: Bibiani, Anhwiaso, and Bekwai geographical areas because of the district's expansive nature. Next, five cocoa-producing communities (*Domenebo No. 1, Ntakam, Muano, Humjibre, and Asempaney*e) within the municipality were selected (purposively) to represent a wide geographical spread in the study area. These communities were selected purposively based on the extent of their cocoa farming and their track record of planting trees on cocoa farms. Study participants, including cocoa farmers from all the selected communities, were sampled using convenient sampling methods. A convenient sampling technique was used because it fast, and easy to use participants who were readily available during the data collection process. The same procedure was used to select officials from the Ghana Cocoa Board and Forestry Commission in the study area.

3.3 Data Collection

Focus group discussions, household questionnaire surveys, interviews, and field observation were employed in the data collection process. An individual field survey was conducted by administering semi-structured questionnaires to 150 sampled cocoa farmers. The questionnaire consisted of both open-ended and closed-ended quantitative and qualitative questions. The questionnaire consisted of five different parts. Respondents were requested to provide sociodemographic information about themselves in the first part. The second part examined farmers' knowledge and perceptions of cocoa agroforestry. The third section also explored farmers' motivations for adopting cocoa agroforestry. The fourth section assessed challenges that hinder farmers' decisions to adopt cocoa agroforestry. Lastly, the preferred tree species farmers plant on their cocoa farms were established by asking the farmers to mention the local or traditional names of the desirable trees. Extension officers with the municipal Agriculture Department and COCOBOD double-checked the names to validate the tree species. Key informant interviews and focus group discussions among other participatory and exploratory research methods, were used to understand how cocoa farmers and resource persons perceived the cocoa-based agroforestry system. These methods helped confirm what the survey and field observations found. These methods were critical because they provided deeper insights into areas that the survey would not have been able to cover. The questionnaire was written in English; however, it was explained to farmers in twi or sefwi, which are local vernacular languages of the farmers. Farmers who could speak and understand English were engaged accordingly in the English language.

3.4 Data Management and Analysis

Qualitative data were transcribed, grouped, and evaluated in accordance with the themes linked to the study's objectives. Descriptive statistics form of percentages, and means were conducted on all the variables examined to obtain an accurate distribution and representation of the respondents' responses on the numerous variables analyzed. Two different statistical analyses were also used to explore the data collected from the field. A non-parametric chi-square test was used to assess whether farmers' migration status and education level influence their decisions to incorporate tree species in their farms. The logit model was employed to examine the factors affecting farmers' decisions to adopt cocoa agroforestry. The model is shown below where individual predictors, x_1 to x_5, influencing adoption are incorporated.

$$Logit\ [P] = 1n\left[\frac{p}{1-p}\right] = B_0 + B_1x_1 + B_2x_2 + \ \dots\ + B_5x_5$$

P= the likelihood of adopting cocoa agroforestry

1-P= the likelihood of not adopting cocoa agroforestry

Y= Cocoa farmers (coded as 1= decision to adopt cocoa agroforestry, 2= decision not to adopt cocoa agroforestry

X1= gender of farmers (coded as 1= Male, 2= Female);

X2= age of farmers (in years);

X3= ownership of land (coded as 1= Yes/ own land, 2= No/ rent land);

X4= migration status (coded as 1= indigenes, 2= Migrant);

X5= farmers' education (coded as 1= educated, 2= non- educated/ illiterate);

β0= intercept term

4. Result

The result of the data analyses is presented chronologically. Demographic characteristics of participants are presented in the first set of results. The subsequent aspect of the findings explores farmers' knowledge and understanding of cocoa agroforestry. The study also explores farmers' motivation for adopting cocoa agroforestry and assesses challenges that impede agroforestry adoption. The final set of results establishes farmers' most desirable tree species for cocoa agroforestry.

4.1 Socio- Demographic Characteristics of Farmers

From table 1, more of the respondents 62.7% (94) of the farmers were males whiles 37.3% (56) were females. The average age was 49 years. A large proportion of the farmers interviewed in the study sites were indigenes 86.7% (130) whereas 13.3% (20) were migrant of different ethnic background. Regarding education, most of the farmers (54%) reported Junior High/Middle School to be their highest form of education, followed by those with no formal education (20.7%).

Table 1. Socio- Demographic characteristics of farmers

Socio-Demographic Variables	Frequency	(%)
Gender		
Male	94	62.7
Female	56	37.3
Age Group		
18-29	2	1.3
30-44	51	34
45-59	67	44.7
Above 60	30	20
Residential Status		
Indigenes	130	86.7
Migrants	20	13.3
Level of Education		
No Formal Education	31	20.7
Primary Education	18	12
Junior High/ Middle Education	81	54
Senior High Education	12	8
Tertiary Education	8	5.3

Source: Field Data, (2022)

4.2 Effects of Socio-Demographic Factors on the Adoption of Cocoa Agroforestry

A chi-square test of independence was performed to examine the relation between residential status (RS) and integration of tree species on cocoa farms. The relation between these variables was not significant, $X^2(1, N = 150) = 1.1, p = .35$). With regards to the educational level, a chi-square test of independence showed that there was a significant association between level of education and integration of tree species on cocoa farm, $X^2(4, N = 150) = 24.1, p < .01$).

Table 2 shows the logit model results for analyzing factors that influencing the decisions of farmers adopting cocoa agroforestry or integrating tree species in their cocoa farms in the study area. Several factors have been incorporated into this model. These variables were: gender of farmer, farmer's age, farmer's residential status, level of education of farmer, and status of the land.

The test of respondents' gender (GR) did not influence the integration of tree species on cocoa farms (ITS). The dependent variable ITS was regressed on the predictor GR to test hypothesis H_1. GR did not significantly predict ITS, F (5, 144) = 1.586, p = .445, indicating that GR cannot significantly influence ITS (b = -.020, p = .445). These results do not positively impact GR. Moreover, the R^2 = .052 d that the model explains 5.2% of the variance in ITS.

The test of the age of respondents (AR) has no significant impact on ITS. The measured variable ITS was regressed on the predictor AR to test hypothesis H_2. AR did not significantly predict ITS, F (5, 144) = 1.586, p = .217, showing that AR cannot significantly influence ITS (b = -.020, p = .217). These results do not positively impact GR. Moreover, the R^2 = .052 indicates that the model explains 5.2% of the variance in ITS.

The test of the residential status of respondents (RS) has no significant impact on ITS. The measured variable ITS was regressed on the predictor RS to test hypothesis H_3. RS did not significantly predict ITS, F (5, 144) = 1.586, p = .311, which shows that RS cannot significantly affect ITS (b = .035, p = .311). These results do not positively impact GR. Moreover, the R^2 = .052 indicates that the model explains 5.2% of the variance in ITS.

Table 2. Logistic regression analysis on socio-economic determinants of respondents' willingness to integrate tree species in their cocoa farms

Hypothesis	Regression Weights	Beta Coefficient	R^2	F	p-value	t-value	Hypothesis Supported
H_1	GR → ITS	-.020	.052	1.586	.445	-.766	No
H_2	AR → ITS	-.020	.052	1.586	.217	-1.239	No
H_3	RS → ITS	.035	.052	1.586	.311	1.017	No
H_4	LE → ITS	.013	.052	1.586	.280	1.084	No
H_5	SL → ITS	-.014	.052	1.586	.129	-1.527	No

Note *p <0.05, GR: Gender of respondents, AR: Age of respondents, RS: Residential status of respondents, LE: Level of education of respondents, SL: Status of land to respondents, ITS: Integration of tree species on cocoa farms.

The test of the level of education of respondents (LE) has no significant impact on ITS. The dependent variable ITS was regressed on the predicting variable LE to test hypothesis H_4. LE did not significantly predict ITS, F (5, 144) = 1.586, p = .280, which indicates that the LE cannot significantly influence ITS (b = .013, p = .280). These results do not positively influence the LE. Moreover, the R^2 = .052 indicates that the model explains 5.2% of the variance in ITS.

The test of status of the land of respondents (SL) has no significant impact on ITS. The measured variable ITS was regressed on the predictor SL to test hypothesis H_5. SL did not significantly predict ITS, F (5, 144) = 1.586, p = .129, which shows that the SL cannot significantly impact ITS (b = -.014, p = .129). These results do not positively impact SL. Moreover, the R^2 = .052 indicates that the model explains 5.2% of the variance in ITS.

4.3 Knowledge and Perceptions of Farmers about Value of Cocoa Agroforestry

The findings revealed that most farmers have heard of cocoa agroforestry. The overwhelming majority of farmers, 99.3% indicated that they knew and understood what cocoa agroforestry was. This is because terminology (s) related to cocoa agroforestry is deeply rooted in their local dialect for the people to understand through a radio sensitization drive. There are also educational programmes (Farmer business school activities, farmer rallies, and stakeholder engagements) rolled out in the districts to enhance farmers' knowledge of cocoa agroforestry. Farmers who said they knew about cocoa agroforestry were then asked where they had heard about it. The results showed that the farmers had heard about cocoa agroforestry from different sources. Approximately, 47.3% indicated COCOBOD as their source of knowledge about cocoa agroforestry. According to 28% of the farmers also said they heard of cocoa agroforestry on the radio or television. Lastly, 37 (24.7%) said they heard about cocoa agroforestry from non-governmental organizations (NGOs) operating in the study communities.

The results revealed that farmers got most of their information about cocoa agroforestry from COCOBOD and radio or TV. They can be valuable avenues for advocacy campaigns and communication about cocoa agroforestry to increase awareness and adoption. Most of the farmers appeared to know of the positive and negative effects of shade trees. Cocoa farmers enunciated diverse views on the advantages and disadvantages of shade trees in their farms (Table 3).

Table 3. Summary of farmers perceived key advantages and disadvantages of integrating shade trees in cocoa farms at Bibiani Anhwiaso Bekwai Municipal

Advantages	**Frequency**	**(%)**
Provide protection and protect cocoa plant	149	99.3
Provide additional income	108	72
Good growth and health of cocoa	91	60.7
Protect soil and improve soil fertility	53	35.3
Increases output	48	32
Food, medicinal products, firewood	101	67.3
Serve as wind break	33	22
Disadvantages	**Frequency**	**(%)**
Too much shade	109	72.7
Damage cocoa trees	87	58
Attract diseases	66	44
Occupy much space	61	40.6
Compete for soil water and nutrient	60	40

Source: Field Data (2022)

Suggestions are summarized quotes directly cited by farmers (farmers offered multiple suggestions on the benefits and disadvantages of integrating tree species on cocoa farms).

4.4 Motivation for Adoption of Cocoa Agroforestry

The study's results indicated that the main reason cocoa farmers were willing to plant or keep tree species on their farms was climate resilience (to provide shade and protect cocoa plants from excessive sunlight), as mentioned by 96% (145) of the respondents. 81.3% (122) of the farmers said the desire to supplement one's income was also a motivating factor. 49% (71) of the farmers revealed that the need to improve food security is one of the reasons they plant or retain tree species on their farms, and 16% (24) of the farmers mentioned that they would grow more trees because trees can restore degraded lands. Technical support was identified as the least significant justification for planting trees after the analysis. Moreso, cocoa farmers expressed varied suggestions on what could motivate them to plant trees in their cocoa farms.

Table 4. Summary of farmers perceived factors that motivate them to integrate or keep shade trees in cocoa farms at Bibiani Anhwiaso Bekwai Municipal

Factors that motivate farmers to integrate tree species in their farms	Number of farmers
For climate resilience	145
For alternative income	122
To improve food security	71
To restore degraded land	24
Technical support	14

Source: Field Data, (2022). Suggestions are summarized quotes directly cited by farmers (farmers provided multiple factors that motivate them to integrate or keep tree species on cocoa farms)

Table 5. Farmers recommendations on how to enhance the adoption of cocoa agroforestry at Bibiani Anhwiaso Bekwai Municipal

Suggestion from cocoa farmers on how to improve the adoption of cocoa agroforestry	**Number of farmers**
Financial support	143
Incentives (cash, inputs, pension scheme)	116
Technical support	47
Financial assistance to cater for cost of transporting seedlings	116
Awareness creation and training	29

Source: Field Data, (2022) Suggestions are summarized quotes directly cited by farmers (farmers provided multiple recommendations on how to enhance cocoa agroforestry adoption).

4.5 Barriers to Adoption of Cocoa Agroforestry

The results showed that the principal barrier preventing farmers from adopting cocoa agroforestry was a lack of financial support, which was mentioned by 95% (143) of the farmers. In addition, 77% (116) of the cocoa farmers said they had difficulty transporting the six-month-old, raised seedlings supplied to them to their farms. Farmers cited other challenges, including a lack of technical support 31.3% (47), a lack of awareness and training 19% (29), and increased competition with cocoa plants for water and nutrients 10% (16). Additionally, focus group discussions and interviews indicated that farmers had naturally regenerating shade trees on their farms and wanted to include only a few due to a lack of space. They were concerned about the fact that incorporating more trees might create too much shade, as well as occupy too much space. It was also surprising to know that most farmers harboured plans to convert old cocoa farms into other perennial crops such as oil palm, which is gaining market momentum in the study sites.

4.6 Desirable Trees Farmers Incorporate in Their Cocoa Farms

From the survey results, all the farmers interviewed (100%) seem to know the tree species on their farms. Farmers expressed various opinions concerning the benefits and drawbacks of having tree species on their cocoa farms and their attributes and uses. The results indicated that farmers used different tree species to provide temporary and permanent shade to their cocoa trees (Table 6). All the farmers interviewed indicated they grow cassava, plantains, maize, and cocoyam to protect the cocoa plants in the early stages of cocoa growth. The crops are mostly planted to give extra revenue and food to the farmers. Farmers introduced permanent shade trees at various stages of cocoa seedling growth. Some farmers already had permanent shade trees when they started their farms, and they also planted new shade trees. Farmers kept already-existing tree species on farms based on knowledge they have acquired from parents, grandparents, and other family members. Some of the most desired tree species were fruit trees and timber trees. The top 15 most common shade trees were six (6) fruit tree species and nine (9) timber trees. In all the study communities, 94% (141) of farmers grew *Terminalia superba*, the most popular tree species. Farmers answered positively in a focus group discussion that *Terminalia superba* is compatible with cocoa and can serve as good timber for sale or personal use.

Table 6. Types of shade species used by farmers to provide permanent shade in cocoa farms at Bibiani Anhwiaso Bekwai Municipal

Types of shade trees present on farms	**Frequency (%)**
Terminalia superba (Ofram)	141 94
Khaya spp. (Mahogany)	94 62.7
Milicia excelsa (Odum)	53 35.3
Newbouldia laevis (Sesemasa)	17 11.3
Ceiba pentandra (Onyina)	33 22
Alstonei boonei (Nyamedua)	27 18
Triplochiton scleroxylon (Wawa)	46 30.7
Celtis milbraaedii (Esa)	36 24
Citrus sinensis (Orange)	91 60.7
Magnicifera indica (Mango)	47 31.3
Cocos nucifera (Coconut)	46 30.7
Psidium guajava (Guava)	2 1.3
Elaeis guineensis (Oil palm)	51 34
Persea americana (Pear)	17 11.3
Terminalia ivorensis (Emire)	46 30.7

Source: Field Data, (2022). Multiple trees in one cocoa farm.

Local vernacular or English name of tree species in bracket

The results showed that cocoa agroforestry would be challenging to implement, even though farmers seem to have adequate knowledge and a general understanding of the benefits of shade trees. When asked whether they would participate, or continue including other tree species in their farms, 82% (123) of the farmers interviewed indicated their willingness to incorporate non- cocoa trees in their farms, whereas 12% (18) were unsure. However, 6% (9), however indicated their unwillingness to adopt cocoa agroforestry.

5. Discussion

From the survey findings, it is clear that age influence decisions around agroforestry adoption because of experience and also differences in risk-taking behaviours between young and old farmers. The study's results indicated the farmers interviewed in the selected communities were 51 years on average, a little above the country's average age of cocoa farmers (CRIG & WCF, 2017). Cocoa is generally grown by aged farmers, which is very common in other cocoa-growing countries in the sub-region. The result confirms what Abdullai et al. (2018) and Gyau et al. (2014) observed when they reported that the average age of cocoa farmers in Ghana and the Ivory Coast is about 49. The age gap has implications for the sustainability of cocoa production. It also reflects concerns about how cocoa farming is dominated by considerably older farmers who may not have the strength to continue any longer.

Available research has shown that gender influences farmers' decisions in new technology uptake. Results from the study showed that most of the farmers were males compared to females. This result is in line with a study by Danso-Abbeam et al. (2012), which found that males predominate in the cocoa farming sector in the municipality. Some existing studies for example Owusu & Frimpong (2014) at Ghana and Nkamleu & Manyong (2005) in Cameroon have reported that migration status influences the adoption of cocoa agroforestry. The findings of this study found no linkage between migration status and agroforestry adoption. The level of education of farmers has a significant impact on their ability to access and use information, leading to adoption of technology, according to MoFA (2011). Mwangi & Samuel Kariuki (2015) have further reported that a farmer's level of education positively influences their decisions to use new technology. This study has contributed to this body of knowledge by highlighting a positive effect of education on cocoa agroforestry adoption. However, an effective radio campaign and awareness raising by COCOBOD and NGOs using the local dialect has yielded positive results. Like the findings of Nyasimi et al. (2017) at East Africa, Government institutions, NGOs, and Community-Based Organizations working in agriculture collaborated to disseminate information that affected the adoption of the farm-based practice.

Analysis of data from the study also revealed most of the cocoa farmers, 82% (123), were motivated to plant trees on their farms due to several benefits. These benefits are (1) personal and (2) farm-supportive. On the personal benefits, farmers mentioned that they were willing to adopt cocoa agroforestry because of the direct benefits it provides to them. Through interviews and focus group discussions, it came to light that farmers prefer to integrate or retain tree species in their cocoa farms to get food (fruits), medicinal products and additional income through sales of fruits. As a respondent emphasized,

"*I have more ofram in my farms, they do not just protect my cocoa, but sometimes I can cut some to roof my house"* (Cocoa farmer, Muano).

Thus, the trees incorporated into farms of these farmers at the study sites serve as a critical means for farmers to earn extra income and for personal use. Moreover, on the farm-supportive benefits, farmers mentioned that the trees provide great services to the cocoa plants. One of the farmers through interview explained:

"The trees in my farms provide shade and protect the cocoa from the sun during the dry season." I have another cocoa farm; some officers told me to cut the trees, and afterwards, the sun obliterated the cocoa trees. I saw that the trees looked new and fresh on the farm I did not cut the trees. I have learned my lesson; I will not listen to any officer again. "I will go by what my indigenous knowledge" (cocoa farmer, Domenebo No.1).

The farmers' opinions are consistent with a related study by Wartenberg et al. (2018), which found that shade trees provide shade and protection to cocoa plants, as perceived by 67% of farmers in Indonesia.

During focus group discussions, farmers, on the other hand, pointed out some disadvantages of planting non-cocoa trees on cocoa farms. The most significant drawback of trees on cocoa farms was that they could create too much shade. Through a focus group discussion, a farmer pointed out:

"Some of the trees can create too much shade, so if you don't do regular pruning, the whole of the cocoa farm could be dark, and air cannot circulate in the farm well." This situation could cause "black pods" (Cocoa farmer, Humjibre).

Again, more farmers mentioned that some shade trees could cause physical damage to cocoa (especially *Ceiba pentandra*). Farmers agreed during a focus group discussion that keeping Ceiba petanda on farms destroys cocoa plants. As a result, they no longer keep them on their farms. An informant with the Cocoa Extension and Health Division of COCOBOD at Anhwiaso said:

"*Though Ceiba pentandra has good shade, its branches are soft, so with the slightest wind, the branches break and fall on the cocoa plants and destroy them. The situation is worrying; therefore, we have advised farmers to remove them from their farms and declare them undesirable"* (Technical Officer, COCOBOD, Anhwiaso).

His statement confirms and corroborates the assertions made by the farmers. In addition, farmers claimed that shade trees could occupy much space and attract disease (the swollen shoot virus). Through interviews, some farmers also mentioned that the shade trees could compete with the cocoa plant for water and nutrients. However, only 0.7% (1) of the farmers mentioned planting trees on cocoa farms had no disadvantages. Through the interviews, a farmer said,

"I attend meetings and training, so I observe planting distance and plant the recommended trees and do what I need to do." "I have not seen any problem with the trees found in my cocoa farms" (cocoa farmer, Muano).

This statement by the farmer shows how crucial training and field demonstrations are for better planting practices. The findings of this study revealed that 98% (147) of farmers in the study sites valued the presence of trees and kept or grew new species (*Terminalia superba (Ofram)*) on their farms. The study indicated that farmers had a positive attitude towards keeping naturally regenerated tree species on their farms and were willing to integrate other tree species. However, some farmers have observed *Ceiba pentandra* causing physical damage to cocoa plants and removed them. This claim by the farmers is consistent with Kaba et al. (2020) and Dormon et al. (2004), who reported that farmers cut *Ceiba pentandra* in the early stages of farming due to its branches falling to destroy cocoa plants.

The results revealed that farmers in the study communities are motivated to adopt cocoa agroforestry for the following reasons: climate resilience, the desire to supplement their income, improve food security, and the need to restore degraded lands. Again, 94% (141) of the farmers thought they could be encouraged to plant more shade trees on their cocoa farms if given cash, inputs, and a pension scheme. The farmer's opinion shows that the government should expedite its plans to enroll cocoa farmers in the farmers' pension scheme, which aims to guarantee a decent pension for cocoa farmers in Ghana.

An informant with the Cocoa Extension and Health Division of COCOBOD at Anhwiaso, when asked about the steps taken to implement the scheme, pointed out:

"There is a national exercise to collate data of all farmers in the country, and as I talk to you right now, the officials are issuing identity cards to the farmers, and when the exercise ends, the pension scheme will kick off." (Technical Officer, COCOBOD, Anhwiaso).

Farmers (94%) call for the government to offer incentives for farmers who plant shade trees, a demand that is very common in the literature and aims to motivate farmers to plant trees on their farms (Somarriba & Lopez-Sampson) Overall, these farmers' perspectives give the impression that adopting cocoa agroforestry is feasible but lies in the ability to tackle barriers to adoption.

The findings indicated that the principal barrier to adoption of cocoa agroforestry as mentioned by farmers were lack of financial support 95% (143), high cost of transporting seedlings 77% (116), lack of technical support and awareness creation 31.3% (47). The difficulty and high cost of transporting seedlings confirm the reasons why some farmers, 60.7% (91), source tree species and incorporate in their farms by themselves. Through focus group discussion farmers revealed that the cost of labour, illegal logging by chainsaw operators disincentivize them to plant or retain tree species in their cocoa farms. This quote from the farmer is in keeping with Asare and Raebild (2016), who reported Ghana's tree tenure policies prevent farmers from owning naturally occurring timber trees because the timber industry could receive concessions to cut down those trees. Due to the ambivalence surrounding timber ownership on farmlands, farmers are doubtful and even decide not to plant timber species. However, a key informant from the Cocoa Extension and Health Division of COCOBOD at Anhwiaso pointed out:

"Farmers have been educated and encouraged to report illegal loggers." "The Forestry Commission has liaised with the Ghana Police Service and the Traditional Authorities to enact a friendly intervention to take on illegal loggers squarely, regardless of who is affected" (Technical Officer, COCOBOD, Anhwiaso).

The findings revealed that farmers integrated or kept trees on their cocoa farms that were primarily timber and fruit trees (Table 6). *Terminalia superba, Khaya spp., and Citrus sinensis* were the most popular non-cocoa trees grown on cocoa farms across the study sites. Earlier studies by Asare et al. (2017) and Dormon et al. (2004)

corroborate that Terminalia superba and Terminalia ivorensis are commonly found on cocoa farms in Ghana. It is not surprising that fruit trees were grown on cocoa farms. Previous research by (Koko et al., 2013; Atangana et al., 2021) found that fruit trees predominate on cocoa farms. During the lean season, these fruit species help cocoa farmers get additional income by selling the fruits and providing nutritional benefits to the household (; Asare, 2005; Koko et al., 2013; Sonwa et al., 2014; Kenkhuis, 2016). This statement, however, favours only some of the farmers in the study sites because they rely on fruits for their household's dietary needs.

Despite most farmers' desire to plant or keep trees on their farms, cocoa agroforestry adoption will not be straightforward. Challenges such as lack of financial support, the high cost of transporting seedlings, a lack of technical support and awareness creation, labour costs, and illegal logging by chainsaw operators could limit the practice of cocoa agroforestry. Jerneck and Olson (2014) claimed that poor small-scale farmers sometimes fail to adopt agroforestry because they primarily focus on food and are not ready to take a risk by investing time and labour in new technology. The study's findings augment our understanding that there are more reasons than poverty hindering cocoa agroforestry adoption. The study's results indicated that tree ownership, illegal logging, scarce land, a lack of incentives, and difficulty transporting seedlings identified at the study communities influence farmers' decisions to plant trees on their farms. These barriers send a signal to various agroforestry proponents to tackle adoption obstacles cited in this work.

6. Conclusions

Based on the findings of this study, even though farmers possess adequate knowledge about the advantages and disadvantages of incorporating trees on their farms, the adoption of cocoa agroforestry continue to face several obstacles such as insufficient financial assistance, high expenses associated with seedling transportation, a lack of technical support, labour expenses, and illegal logging activities carried out by chainsaw operators. As a result, the study suggests the following policy recommendations to enhance and promote cocoa agroforestry adoption in the study area and beyond.

First, COCOBOD and NGOs should make conscious effort to facilitate access to desirable seedlings by training farmers to raise seedlings on their farms. Extension officers can provide proactive management practices to raise seedlings, which will reduce the cost of transporting seedlings to farms. Additionally, COCOBOD and NGOs can collaborate to create incentives such as cash and inputs to encourage farmers to invest time in planting trees on cocoa farms. The government should also prioritize enrolling cocoa farmers in the pension scheme and fast-tracking this process. Finally, the government can link data of farmers with trees on their farms with GPS and also to the Agricultural Development Bank to access low-interest loans that farmers can repay through timely deductions by designated cocoa-buying companies during the cocoa season.

Secondly, to encourage cocoa farmers to integrate shade trees on their farms, COCOBOD and NGOs need to prioritize weed control, shade management, and pest and disease management. Early weed control is crucial, and providing free weedicides to farmers can be helpful. Conducting interviews in the farmers' native language proved to be crucial for gaining their trust and sharing their ideas. The study showed that a radio campaign in the local dialect was an effective way to raise awareness about cocoa agroforestry. Therefore, future research in the study area or elsewhere should be carried out in the local language and/ or mother tongue. The study also revealed that many cocoa farmers view cocoa farming income as unsustainable and are venturing into other crops like oil palm plantations. It is necessary to conduct further research to understand the extent of this trend and its potential impact on the sustainability of the cocoa industry in the future.

Declaration of interest

We the authors Clement Baidoo, Bob Offei Manteaw, and Yaw Agyeman Boafo, wish to declare no conflict of interest concerning the publication of the manuscript in the journal of Sustainable Environment

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