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Incentives-Adoption-Food Security: Implications for Sustainable Cocoa Production in Ghana

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Abstract

Understanding cocoa farming practices in Ghana is crucial because cocoa plays a major economic role. Smallholder producers face challenges such as the incidence of cocoa swollen shoot virus disease and limited access to improved cocoa varieties, and government programmes like the cocoa rehabilitation programme (CRP) aim to address these challenges. It is thus essential to examine how incentive-based sustainable agricultural practices impact household food security. This study, therefore, investigates the adoption of CRP, aiming to understand the factors influencing farmers' participation and assess its impact on food security. The research gathered quantitative data from 385 cocoa farmers in the Fanteakwa South District, Eastern region, Ghana. Mean, frequency, Tobit and ordered logit regression models were used to analyze the data. Results reveal that incentives like farm maintenance without a charge, extension access, monetary rewards, regular farm monitoring and free tree-cutting strongly promote CRP adoption. Gender, age, education, free access to extension services, free cutting of trees and monetary rewards positively influence adoption levels. The study revealed that practices like weedicide-free farming, zero burning, and efficient shade management play a substantial role in improving the food security of farmers. The study offers a comprehensive analysis of both monetary and non-monetary incentives, adoption patterns, and outcomes, particularly regarding food security in the context of cocoa production. The study suggests a multifaceted approach to enhance CRP efficacy and address the complex dynamics of sustainable agricultural initiatives.

Keywords: Adoption, cocoa rehabilitation programme, food security, sustainability

INTRODUCTION

Cocoa plays a significant economic function in Ghana by maintaining livelihoods in the cocoa industry and indirectly boosting the country's food security. Despite their crucial significance, smallholder cocoa production in Central and West Africa encounters several challenges (Aneani & Padi, 2017). According to Ameyaw *et al*. (2014), these challenges include the threat of cocoa swollen shoot virus disease (CSSVD), which jeopardizes the livelihoods of agricultural communities. Aging farms, limited access to improved varieties, climate change, making existing cultivars pest-prone,

and flaws in the formal production and supply systems of approved varieties, which exacerbate the effects of low-input production methods, are additional concerns. These restrictions are factors in Ghana's failure to become the leading producer of cocoa beans. To increase yearly cocoa production and crop quality, successive Ghanaian governments have carried out policies and efforts aimed at addressing these fundamental problems. These endeavors, with a common goal of enhancing productivity, encompass the cocoa disease and pests control programme (CODAPEC), often referred to as mass spraying, the cocoa high technology programme (CHTP), and the more recent cocoa rehabilitation programme (CRP) (Bockel *et al.*, 2021; Ameyaw *et al.*, 2014). With the removal of old cocoa trees, their replacement with seedlings, and the installation of irrigation systems, the cocoa rehabilitation programme (CRP), inaugurated in 2018, aims to revitalize underperforming farms damaged by the CSSVD (Bockel *et al*., 2021).

The cocoa health and extension division (CHED), as part of their mandate, is responsible for controlling cocoa diseases, assisting farmers to replant treated farms, and offering backup extension services to adopt recommended modern agronomic practices. They also offer other incentives or relief packages to entice farmers to cut down their old and diseased farms. These incentives include treating farms to replant disease-tolerant, high-yielding and early-bearing cocoa varieties, providing plantain suckers at no cost to the farmers and paying US Dollar (USD) 71.43 per hectare each to the tenant farmer and the landowner, as well as maintaining the farm for two years before handing it over to the farmer (COCOBOD, 2019). The farmers' decision to embrace sustainable farming methods such as the CRP in response to incentive packages is not a dichotomous process. Supported by Skinner's reinforcement theory of motivation (Gordon, 1987), the adoption of a programme is influenced by various elements, including the programme circumstances, incentives provided, environmental preferences, personal attitudes, and the farmers' level of experience and education (Barnes *et al*., 2019). Farmers' choices are influenced by subjective viewpoints, including their preferences for conservation measures, their perceptions about the programme, and their levels of risk aversion (Ward *et al*., 2016). Asset ownership, income, and access to other monetary prospects are just a few of the variables that can affect someone's decision to adopt. These factors impact the ability of the target community to gain from the initiative. The choice to use an innovation is influenced by the institutional and policy framework of the organization. Agricultural market movements have an impact on farmers' decisions to adopt agricultural practices. These highlight the importance of taking into account the specific context when designing policies and utilizing diverse policy instruments (Adhikari *et al*., 2017).

In the short term, the adoption of sustainable practices appears to be contingent upon the presence of direct economic benefits, such as enhanced productivity or profitability. Irrespective of the form of incentive, adoption rates are greater when programmes provide immediate economic advantages rather than focusing only on achieving a favorable ecological outcome. Regardless of the type of reward, it appears that one of the most powerfull motivations for farmers to embrace and sustain sustainable practices, in the long run, is the perceived favorable results of these practices for their farm or the environment (Himberg *et al*., 2009). Wider contextual elements are significant at every stage of the incentive-adoption-outcome chain (Bremer *et al*., 2014). Offering incentives can encourage the implementation of sustainable practices and yield beneficial outcomes. The probability

of adopting sustainable practices improves when participants perceive future advantages. Conversely, the adoption of sustainable agriculture techniques as a result of mandatory incentives is quite likely. Legal restrictions reduce ambiguity by imposing penalties for failure to comply. The implementation of regulatory measures depends on supervision, the effectiveness of law enforcement, and monitoring. Nevertheless, if institutions can implement punishments, the degree of uncertainty over adoption is minor or non-existent (Santiago *et al*., 2018). Other investigations have outlined the trajectory of incentive adoption outcomes in diverse contexts. Prokopy *et al*. (2019), Liu *et al.* (2018), and Greiner & Gregg (2011) have extensively explored farmers' acceptance of sustainable practices. Piñeiro *et al*. (2020) conducted a comprehensive review of the literature on incentives driving the adoption of sustainable agricultural practices and their resulting outcomes. Through the examination of various studies, they categorized incentives based on their types and voluntary or mandatory nature, aiming to ascertain their impact on farmers' inclination to adopt. These core tenants of incentive, adoption, and outcome, as well as the links they create, offer a cogent framework for assessing the most effective tactics in sustainable agriculture programmes. According to Garbach *et al*. (2012), supporting the adoption of sustainable agricultural practices among farmers requires the establishment of links between programmes and incentives.

While there is a considerable amount of literature addressing the impacts of incentives influencing the adoption of sustainable agricultural practices, there is a notable scarcity of comprehensive analyses that further link this relationship with household food security. This study provides information on farmers' decision-making regarding the adoption of CRP influenced by the incentives provided by COCOBOD and how the adoption of specific practices contributes to household food security. The study focuses on assessing farmers' perspectives on CRP, analyzing the incentive packages provided to encourage farmers' participation in CRP, measuring farmers' adoption of CRP, identifying how the incentive packages affected farmers' adoption of CRP, examining the effect of adoption of CRP on cocoa farmers' food security, and assessing the challenges encountered by farmers in adopting CRP.

MATERIALS AND METHODS

Study Area

The study was conducted in the Fanteakwa South District, located in the Eastern Region of Ghana. The district is situated in the central part of the Eastern Region covering a total land area of 803 square kilometers. It shares borders with the Kwahu South District to the northwest, Fanteakwa North District to the north, Atiwa East District and East Akim Municipal to the south, and Lower Manya Krobo Municipal and Yilo Krobo Municipal to the east. Additionally, it is bordered to the north by Volta Lake. According to the Ghana Statistical Service (2021), the current population of the district is 54,634 with 27,582 males and 27,052 females.

Research Design

The study used a cross-sectional descriptive approach to gather quantitative data. In this approach, data were collected at a single point in time from the respondents, providing a snapshot of the study variables and their relationships. One advantage of this approach is its efficiency in terms of time and resources, as data collection can be conducted relatively quickly compared to longitudinal studies that span over extended periods. It allowed

researchers to capture a wide range of information from a diverse sample within a specific timeframe, facilitating the examination of various factors simultaneously.

Sample and Sampling Procedure

The target population consisted of all cocoa farmers engaged in CRP. With a known population size of 8,152 farmers, the sample size of 385 participants was determined using Yamane (1973) formula, which accounted for an allowable error of 5%. This approach ensured that the sample adequately represented the larger population while minimizing potential sampling biases. The study utilized a multistage sampling technique to select a representative sample from the target population. The multi-stage sampling process provided a structured approach to sample selection, enhancing the study's efficiency and reducing costs. In the first stage, the Eastern region was purposively selected. The Eastern Region is home to Ghana's Cocoa Research Institute, implying that farmers in this region likely have easier access to scientists and technical experts from the institute to address their concerns. In the second stage, Fanteakwa South District was randomly selected from a list of cocoa-growing districts in the Eastern Region. Subsequently, ten communities were randomly selected from the cocoa farming communities within the district. By randomly selecting the communities, the researchers ensure that the sample reflects the diversity of cocoa farming communities within the district. This approach helps to minimize bias and increase the generalisability of the findings to the broader population of cocoa farmers in the district. Different communities may have varying socio-economic characteristics, access to resources, and levels of participation in CRP. By including a variety of communities in the sample, the researchers can capture this variability and better understand how it influences farmers' perceptions and experiences with the programme. Finally, cocoa farmers were randomly chosen from a list of farmers in each of the ten communities using the blindfolding method, ensuring each farmer had an equal chance of selection.

The use of the blindfolding method to randomly select cocoa farmers from each of the ten communities further enhances the fairness and rigor of the sampling process. By employing the blindfolding method, every cocoa farmer on the list has an equal chance of being selected for participation in the study. This ensures that the sample is not biased towards any particular subset of farmers within each community and that each farmer's perspective is given equal consideration. The blindfolding method involves randomly selecting farmers without any preconceived biases or preferences. This transparency in the selection process increases the credibility of the study and reduces the potential for researcher bias to influence the results. Randomly selecting farmers using the blindfolding method helps to ensure that the sample is representative of the broader population of cocoa farmers within each community. This randomisation process enhances the generalisability of the study findings and allows researchers to draw more reliable conclusions about the factors influencing farmers' perceptions and experiences with CRP.

Data Collection

The data collection process for the study utilized a semi-structured interview schedule, focusing on the household, socio-economic characteristics, adoption patterns and household food security status of cocoa farmers. The reliability of the instrument was assessed through Cronbach's alpha test, yielding a score of 0.72, indicating its reliability. Before actual data collection, a pre-test involving

20 cocoa farmers from Nkawkaw District in the Eastern region, a region with similar conditions to the study area, was conducted. The pre-test aimed to identify and address any ambiguities within the questionnaire. Four Agricultural Extension Agents (AEAs) from the Osino Cocoa district assisted the researchers in the data collection from February to April 2022. Selected communities were approached through the extension agents, obtaining prior consent from respondents before initiating data collection. The study's data collection tool underwent review by two lecturers at the Department of Agricultural Economics, Agribusiness and Extension, KNUST. Participation in the study was entirely voluntary. The thorough validation process, involvement of extension agents, and ethical considerations contribute to the robustness and reliability of the collected data.

Data Analysis and Analytical Framework

Data was analyzed using percentages, frequencies, means, and standard deviation, facilitated by Stata. Other methods for data analysis included the Tobit and ordered logistic regression model. A three-point Likert scale was used to analyze farmers' perception of the CRP, thus, disagree-1, neutral-2, and agree-3. Verbeek (2004) claims that the Tobit regression model is used to analyze data when the dependent variable is either censored or truncated. This type of regression is commonly employed when the dependent variable has values that are either not fully observed or restricted to a certain range. Tobit regression extends the ordinary least squares (OLS) regression model to account for these censoring or truncation issues. The Tobit model assumes that the observed data arise from a latent variable model where the dependent variable is linearly related to a set of independent variables, but the observed values are censored or truncated at certain thresholds. The Tobit regression model is estimated using maximum likelihood estimation (MLE), which accounts for the presence of censored or truncated data. The likelihood function is constructed based on the observed data and the assumed distribution of the error term. The model parameters are then estimated to maximize the likelihood function, taking into account the censoring or truncation mechanism. One of the key assumptions of Tobit regression is that the error term follows a normal distribution. Additionally, the model assumes homoscedasticity (constant variance of errors) and linearity of the relationship between the independent variables and the latent variable. The model allows researchers to estimate the effects of explanatory variables on censored or truncated dependent variables, providing valuable insights into the relationship between variables in the presence of such data limitations. The Tobit regression model can be represented by the following equation:

$$y^* = X\beta + u$$

where:

y^* is the latent variable, representing the unobservable continuous dependent variable.

X is the independent variable,

β is the vector of coefficients to be estimated, with dimensions $k \times 1$

u is the error term

X = all the explanatory variables [Household size (Continuous, number), Religion (Christian-1, Others-0), Gender (Dummy, Male-1, Female-0), Access to credit facilities (Dummy, Yes-1, No-0), Number of years spent in school (Continuous, years), Marital status (Married-1, Others-0), Years of cocoa farming (Continuous, years), Age (Continuous, years), Farm size (Continuous, acres), Access to extension (Dummy, Yes-1, No-0), Land acquisition (Dummy, Yes-1, No-0)].

According to Greene & Hensher (2009), the ordered logit regression model is a statistical technique that is used to analyze ordinal dependent variables. In contrast to binary logistic regression, which is used when the dependent variable is dichotomous, the ordered logit regression model is suitable for dependent variables with more than two ordered categories. We applied the ordered logit regression to determine how the adoption of CRP influences farmers' level of food security. Hence, we categorized the dependent variable as 0, 1, 2, and 3, corresponding to 'food insecure', 'mildly food insecure', 'moderately food insecure' and 'food secure'. We held the assumption that the relationship between the independent variables and the dependent variable is consistent across all levels of the dependent variable. The model, based on the latent regression function, was specified as:

$$\text{logit}Y_i = \beta_o + \beta_i X_i + \ldots\ldots + \varepsilon_i$$

Where Y_i= level of food security; β_o = when the arguments take a value of zero; β_i: vector of independent variables; X_i= explanatory variables [Shade management (Dummy, No-0, Yes-1), Weedicide free farm (Dummy, No-0, Yes-1), Zero burning (Dummy, No-0, Yes-1), Involvement of farmers in farm maintenance (Dummy, No-0, Yes-1), Bottle irrigation (Dummy, No-0, Yes-1), Budding/Grafting (Dummy, No-0, Yes-1); ε = error.

Household food insecurity score (HFIAS) was calculated based on levels such as 'food insecure', 'mildly food insecure', 'moderately food insecure', and 'food secure'. The HFIAS assesses food insecurity based on experiences related to insufficient food quantity, quality, and access over the past month. In the questionnaire, each response to the HFIAS questions was assigned a numerical score based on the severity of food insecurity it represents. For example, responses indicating severe food insecurity might be assigned a higher score, while responses indicating food security might be assigned a lower score. We added up the scores for all the responses to obtain a total score for each respondent. This total score reflects the level of food insecurity experienced by the household over the past month. Based on the total score, households were classified into four different food security levels ('food insecure', 'mildly food insecure', 'moderately food insecure', 'food secure'). We then established cutoff points for each level based on the range of total scores observed in the sample (Ballard *et al*., 2013).

RESULTS AND DISCUSSION

Demographic Features of the Farmers

From Table 1, 78% of the respondents are males. This distribution is largely influenced by the prevailing condition where males typically have greater access to land, resulting in their increased participation in farming activities. The results also show that 45% of the farmers inherited their land, while 55% acquired it through other means such as outright purchase, leasing and sharecropping. According to Dei Antwi *et al.* (2018), household activities and their results are significantly influenced by the mode of land acquisition. The results show that 91% of respondents are married. Married farmers may have access to additional labor resources because they can depend on their spouses and children for assistance in farming activities (Ankuyi *et al.*, 2023). This can serve as an enabler in adopting sustainable agricultural practices such as CRP. From Table 1, 93% of the respondents have access to credit. Shita *et al.* (2018) argue that for farmers to afford the labor costs associated with implementing better agricultural practices, access to financing is essential. Additionally, 93% of the farmers received extension assistance. This shows

that extension agents are easily accessible to the majority of farmers. Implementing novel agricultural practices is more likely when extension agents and farmers are regularly contacted.

The demographic characteristics presented in Table 2 offer valuable insights into the profile of the surveyed farmers and their potential receptiveness to agricultural innovations and interventions. The average age of 49 years suggests that the surveyed farmers are likely to have accumulated substantial experience and knowledge in farming practices over the years. However, it also indicates that they may be at a stage where they are less inclined to adopt new techniques unless they perceive clear benefits or incentives. With an average farming experience of 20 years, the surveyed farmers are likely to have a deep understanding of local agricultural practices, including crop management, pest control, and soil fertility management. This experience can influence their willingness to adopt innovations, with more experienced farmers potentially being more conservative in their approach to change (Ayanlade *et al.,* 2017). The average family size of six suggests that farming activities may be a significant source of livelihood for these households, with family members likely involved in various aspects of farm work. The average farm size of 6 acres indicates that the surveyed farmers operate relatively small-scale farms, which could affect their access to resources and their capacity to adopt certain technologies or practices that may require larger land holdings. The average of 10 years of formal education indicates that the surveyed farmers have attained a moderate level of education. This suggests that they may have basic literacy and numeracy skills, which could facilitate their engagement with extension services, training programs, and

Table 1. Demographic characteristics of farmers (discrete variables)

Variables	Frequency	Percentage
Sex		
Female	85	22.1
Male	300	77.9
Religion		
Christian	326	84.7
Others	59	15.3
Marital status		
Married	351	91.2
Others	34	8.8
Acquisition of land		
Inheritance	174	45.2
Others	211	54.8
Extension access		
No	28	7.3
Yes	357	92.7
Credit access		
No	297	77.1
Yes	88	22.9

Table 2. Demographic characteristics of farmers (continuous variables)

Demographic characteristics	Mean	Standard deviation
Years of cocoa farming experience	19.98	12.67
Age of farmers (years)	48.55	12.91
Household size (number of people in a housing unit)	6.46	3.57
Years spent in school	9.62	7.35
Cocoa farm size (acres)	6.32	4.85

educational materials aimed at promoting agricultural innovation and best practices.

Perception of Farmers on CRP

Table 3 presents farmers' perceptions about CRP. From the table, the statement with the highest mean rank is related to farms receiving irrigation support for seedling survival (mean = 3.00). This indicates that transplanted seedlings are provided with irrigation to increase their chances of survival. The mean value that ranks second-highest is the belief that "all rehab farms are maintained for two years before handing over to farmers" (mean = 2.55). This indicates that COCOBOD oversees the management of newly established farms for two years, ensuring their robust establishment before being transferred to the farmers' responsibility. The lowest mean perceptions (mean = 1.00) are associated with statements "all beneficiary farmers are allowed to plant their choice of cocoa varieties", "COCOBOD automatically cuts very old farms without farmers' consent", "all farmers supply their plantain suckers for the cut farms", and "all farmers are allowed to choose their type of economic trees to be planted in the cut farms". These low mean values suggest that farmers disagree with these statements. With an overall mean of 1.74, it is evident that farmers expressed a neutral stance toward CRP. This indicates that while the initiative aids in revitalizing their unproductive farms, farmers maintained a neutral position about the cocoa rehabilitation program. This neutral response suggests that farmers may not have a strong inclination toward the program.

Incentives for Adoption CRP

Various financial and non-financial incentives have been added to the cocoa rehabilitation scheme to assist growers. Table 4 presents the incentives provided on rehabi litated farms, indicating the number and percentage of respondents who reported receiving each incentive. All respondents (100.0%) reported receiving free tree-cutting services, indicating the universal availability of this incentive. All respondents (100.0%) reported receiving monetary incentives, indicating that this incentive was provided to all surveyed farmers. Similarly, almost all respondents (99.0%) reported receiving cost-free lining and pegging services, suggesting that this incentive was nearly universal among the respondents. The majority of respondents (99.2%) reported receiving plantain suckers at no charge, indicating widespread availability of this incentive. Almost all respondents (99.7%)

Table 3. Farmers' perceptions of CRP

Perceptions	Mean	Standard deviation
Irrigation is provided to all the cut farms to ensure a high survival rate for the seedlings	3.00	0.11
A period of two years is dedicated to maintaining all rehabilitation farms before transferring them to the farmers	2.55	0.80
Appropriate compensation is provided for all rehabilitation farms	2.26	0.78
All farmers have the liberty to employ their laborers to support the COCOBOD labor force	2.11	0.83
Every farmer who benefits from the program is given the freedom to plant the cocoa varieties of their preference	1.00	0.00
COCOBOD initiates the automatic removal of extremely aged farms without requiring input from the farmers	1.00	0.00
Each farmer is responsible for providing their plantain suckers for the farms that are being cleared	1.00	0.00
Every farmer is granted the choice to select the type of economic trees they wish to cultivate within the cleared farms	1.00	0.00
Overall mean:	1.74	

Note: Disagree-1; Neutral-2; Agree-3

Table 4. Incentives on rehabilitated farms

Incentives	Yes	No
	Freq. (%)	Freq. (%)
Cost-free lining and pegging services	381 (99.0)	4 (1.0)
Cost-free land preparation before planting	370 (96.1)	15 (3.9)
Supply of hybrid cocoa seedlings without cost	384 (99.7)	1 (0.3)
Provision of plantain suckers at no charge	382 (99.2)	3 (0.8)
Free distribution and application of sulfate of ammonia to planted plots	371 (96.4)	14 (3.6)
Free tree-cutting services	385 (100.0)	-
Unrestricted access to extension services without charge	340 (88.3)	45 (11.7)
Farm maintenance over two years without a cost	377 (97.9)	8 (2.1)
Monetary incentives	385 (100.0)	-
Weeding of affected farms before treatment, at no expense	384 (99.7)	1 (0.3)
Gratis provision and planting of economic shade trees on rehabilitation farms	380 (98.7)	5 (1.3)
Regular monitoring conducted by a specialized team at no cost	374 (97.1)	11 (2.9)

reported receiving hybrid cocoa seedlings without cost, indicating the high availability of this incentive among the surveyed farmers.

A significant majority of respondents (88.3%) reported receiving unrestricted access to extension services without charge, suggesting that this incentive was widely available. This is a positive indication suggesting that a significant portion of the respondents are aware of and has access to agricultural extension services. Farmers who receive visits from extension agents are generally more empowered to advocate for their interests and actively participate in attempts to revive the cocoa sector (Xiao *et al.,* 2019).

Adoption of Cocoa Rehabilitation Techniques

Table 5 provides valuable insights into the adoption of cocoa rehabilitation techniques among the surveyed farmers, shedding light on their practices and preferences regarding sustainable farming methods in cocoa cultivation. The data presented in the table indicate high levels of adoption across various techniques, reflecting a positive trend towards environmentally friendly and efficient agricultural practices within the cocoa farming community.

The high percentage of adopters (95.3%) of the zero-burning technique signifies a widespread recognition of the environmental benefits associated with avoiding the practice of burning vegetation before planting. This adoption indicates a commitment to preserving soil health, biodiversity, and air quality, aligning with sustainable farming principles. The substantial proportion of respondents (93.8%) reporting the adoption of weedicide-free farming practices highlights a growing awareness of the adverse effects of chemical herbicides on soil health, water quality, and ecosystem resilience. Farmers' willingness to adopt alternative weed management strategies under-scores their proactive approach to sustainable agriculture. This also shows that farmers are cognisant of the potential harm that weedicides can inflict on their soil and, by extension, on the overall ecosystem. As noted by Singh *et al.* (2020) and Rose *et al.* (2016), the use of weedicide affects various carbon and nitrogen mineralisation, soil respiration, nutrient cycling, organic matter decomposition, and enzyme activity.

The near-universal adoption (97.4%) of bottle irrigation methods indicates farmers' acknowledgement of the importance of efficient water use in cocoa cultivation. By implementing water-saving techniques such as bottled irrigation, farmers can mitigate water scarcity risks, improve crop yields, and reduce

Table 5. Adoption of cocoa rehabilitation techniques

Responses	Adopters	Non-adopters
	Freq. (%)	Freq. (%)
Shade management	365 (94.8)	20 (5.2)
Involvement of farmers in farm maintenance	373 (96.9)	12 (3.1)
Grafting/budding	366 (95.1)	19 (4.9)
Zero burning	367 (95.3)	18 (4.7)
Bottle irrigation	375 (97.4)	10 (2.6)
Weedicide free farm	361 (93.8)	24 (6.2)

environmental impacts associated with irrigation practices. This method's popularity can be attributed to the unpredictable nature of rainfall patterns, particularly as newly transplanted seedlings require ample water for survival. The significant adoption rate (95.1%) of grafting or budding techniques underscores farmers' efforts to propagate high-quality cocoa plants and improve varietal diversity within their farms. By adopting these propagation methods, farmers can enhance crop resilience, productivity, and profitability. This agrees with Adebiyi & Okunlola's (2013) findings on slow adoption in Nigeria, attributing it to farmers' limited understanding.

Drivers of the Extent of CRP Adoption

The optimal model that closely aligns with the data from the study was identified through the utilization of the likelihood ratio test. Table 6 demonstrates that the adoption of CRP was affected by socio-economic factors, including sex, household size, age, and level of education and incentive packages, including, free constant access to extension services, free farm maintenance for two years, monetary reward, free cutting of trees, and free periodic monitoring by a special team.

The significant coefficient of 2.13* indicates that male farmers are more likely to adopt CRP compared to their female counterparts. This gender disparity in adoption rates could be attributed to various factors, such as differential access to resources, cultural norms, or specific preferences and priorities regarding agricultural practices. To promote gender equity in programme participation and maximize its effectiveness, targeted interventions and outreach efforts may be needed to engage female farmers and address any underlying barriers they face. The outcome is supported by the research conducted by Gebregziabher *et al*. (2014), which revealed that households in Ethiopia with male members have a higher propensity to adopt technology compared to households with female members.

The negative coefficient of -0.07* suggests that older farmers are less likely to adopt CRP. This finding highlights the importance of generational differences in agricultural decision-making and the willingness to embrace new practices. Older farmers may be more entrenched in traditional farming methods or less receptive to change, whereas younger farmers may be more open to innovation and technology adoption. To overcome age-related barriers to adoption, tailored extension services, training programmes, and incentives could be designed to cater to the diverse needs and preferences of different age groups within the farming community. Older farmers may lack the physical capacity to engage in cocoa rehabilitation due to the demanding labor requirements (Wongnaa *et al*., 2021). This finding aligns with the study conducted by Akinwale & Folarin (2018), which revealed a substantial correlation between the age of farmers and the adoption of hybrid cocoa.

The coefficient of 0.49*** indicates that larger household sizes are associated with a higher extent of adoption of CRP. This positive relationship suggests that house-

holds with more members are more inclined to engage in the programme, possibly due to greater labor availability, collective decision-making processes, or shared benefits and responsibilities. Leveraging the social dynamics and resources within larger households could be an effective strategy for promoting widespread adoption and implementation of the programme across farming communities. The household size is used solely as an indicator of labor availability (Mwangi & Kariuki, 2015; Mignouna *et al*., 2011). A larger household can alleviate the work constraints that are required when introducing new technology, hence influencing the process of adoption. The findings of Wongnaa *et al*. (2018) and Wongnaa *et al*. (2021), which revealed a positive correlation between household size and the use of agricultural technologies, align with this conclusion. Tedla (2011) found that the correlation between the acceptance of fertilizer by peasant farmers and their household size was attributed to the expected rise in household labor.

The positive coefficient of 0.04** implies that higher levels of education are positively correlated with the extent of adoption of the cocoa rehabilitation program. This finding highlights the role of education in enhancing farmers' capacity to understand, evaluate, and adopt new agricultural practices. Educated farmers may possess better analytical skills, access to information, and awareness of the benefits associated with programme participation, thereby facilitating their decision to adopt. Investing in educational initiatives, vocational training, and extension services tailored to farmers' educational backgrounds could enhance programme uptake and effectiveness. The findings are consistent with the study conducted by Holden *et al*. (2008), which established a correlation between an individual's inclination to embrace novel technologies and education. Schooling is believed to significantly enhance the capacity for critical thinking and the appropriate utilization of information sources. Producers with greater education possess superior capabilities in accessing and

Table 6. Determinants of the extent of adoption of the cocoa rehabilitation programme

Parameters	Coefficient	Standard error
Socio-economic variables		
Gender	2.13 *	1.21
Age	-0.07 *	0.04
Marital status	1.00	1.51
Household size	0.49 ***	0.19
Religion	0.10	1.16
Land acquisition	0.24	1.38
Years of cocoa farming	0.06	0.05
Farm size	-0.05	0.09
Number of years spent in school	0.04 **	0.06
Access to credit facilities	0.31	1.03
Incentive packages		
Free land preparation before planting	-0.05	0.25
Free lining and pegging	-0.17	0.49
Free supply of plantain suckers	-0.25	0.54
Free supply of hybrid cocoa seedlings	-0.25	0.93
Free supply and application of sulfate of ammonia to planted farms	-0.38	0.28
Free constant access to extension services	0.44 ***	0.19
Free weeding of affected farms before treatment	-0.99	1.19
Free cutting of trees	0.32 *	0.68
Free farm maintenance for two years	-0.01 *	0.36
Free supply and planting of economic shade trees on rehab farms	0.47	0.43
Free periodic monitoring by a special team	-0.57 *	0.33
Monetary reward	3.31 ***	0.82

Notes: Number of Obs. = 385; Log-likelihood = -195.55; LR $chi^2(10)$ = 16.58; Prob > chi^2 = 0.06; Pseudo R^2 = 0.40

being aware of a wider range of knowledge sources, and are more proficient in using and assessing innovations, in comparison to their less educated counterparts.

The findings suggest that some incentives play a significant role in influencing farmers' decisions to adopt cocoa rehabilitation practices. Among these factors, change to free tree cutting, two years of change to free farm maintenance, uninterrupted access to extension services at no cost, regular farm monitoring, and monetary compensation emerge as crucial incentives that positively impact farmers' inclination towards adopting cocoa rehabilitation. The provision of change to free tree-cutting services strong motivator. This incentive likely addresses a key barrier to adoption by alleviating the cost and labor associated with tree cutting, thereby making the rehabilitation process more accessible and attractive to farmers. Similarly, the offer of two years of change to free farm maintenance is perceived as a significant incentive. This incentive not only reduces the financial burden on farmers but also ensures the sustainability and success of the rehabilitation efforts by providing ongoing support and assistance.

The availability of free extension services without interruption is highlighted as a crucial factor influencing the farmers. Access to expert guidance, training, and technical assistance through extension services is essential for farmers to adopt and effectively implement cocoa rehabilitation practices. It is essential to distribute information about agricultural technology that improves production to farmers through extension visits. Wongnaa & Babu (2020) support the findings by arguing that having more interactions with extension staff increases the chances of adopting agricultural technologies. Regular monitoring of farm activities is identified as a significant incentive. This suggests that farmers value feedback, oversight, and accountability in the implementation of rehabilitation efforts, which can help optimize performance, address challenges, and ensure compliance with best practices. Financial compensation emerges as a less influential factor, impacting only 1% of farmers. While monetary rewards may not be the primary driver of adoption, they still play a role in incentivising participation and offsetting costs or losses associated with rehabilitation activities.

Household Food Insecurity Status

Table 7 provides insights into farmers' household food insecurity status based on their responses to specific statements related to food access and availability over the past 4 weeks or 30 days. In terms of "no food to eat because of lack of resources from the past 4 weeks/30 days," 71.9% of respondents answered "yes," indicating that a significant majority of farmers experienced situations where they had no food to eat due to lack of resources during the specified period. The high prevalence of affirmative responses highlights the vulnerability of farmers to food insecurity, which can be attributed to various factors such as limited income, insufficient agricultural productivity, unpredictable weather conditions, and inadequate access to markets and social support systems. For many farmers, particularly those in low-income settings or regions prone to environmental challenges, ensuring consistent access to an adequate and nutritious diet can be a persistent struggle. Conversely, the finding that 28.1% of respondents answered "no" to the same statement suggests that a notable minority of farmers did not face issues of food insecurity during the specified period. While this may indicate relative stability or resilience within this subset of the farming population, it's essential to consider the context in which these responses were provided. Factors such as household wealth, access to alternative sources of income,

and social support networks may have influenced the ability of these farmers to maintain food security.

The finding that 71.9% of respondents answered "yes" to the statement "sleep at night hungry because there was not enough food from the past 4 weeks/30 days" highlights a significant level of food insecurity among farmers. This statistic indicates that a substantial majority of farmers or household members experienced instances where they went to sleep hungry due to insufficient food during the specified period. Such experiences can have detrimental effects on physical health, well-being, and overall quality of life for individuals and families. The high prevalence of affirmative responses underscores the severity of food insecurity within the surveyed population. It suggests that many farmers struggle to access an adequate and nutritious diet consistently, potentially leading to chronic hunger and malnutrition. Sleep deprivation due to hunger can further exacerbate health problems and impair cognitive function, productivity, and overall livelihoods. Conversely, the finding that 28.3% of respondents answered "no" to the same statement suggests that a minority of farmers did not experience situations where they or household members went to sleep hungry due to insufficient food. While this may indicate relative stability or resilience within this subset of the farming population, it's important to consider the factors that contributed to their ability to maintain food security. Factors such as higher income levels, better access to agricultural resources, social support networks, and alternative sources of food may have played a role in mitigating food insecurity for these farmers.

The finding that 73.0% of respondents answered "yes" to the statement "you or any household member go a whole day and night without food from the past 4 weeks or 30 days" highlights a critical issue of food insecurity among farmers. This statistic indicates that a significant majority of farmers or household members experienced instances where they went an entire day and night without food during the specified period. Such experiences reflect severe food deprivation and can have serious implications for physical health, well-being, and overall household stability. The high prevalence of affirmative responses underscores the severity and prevalence of food insecurity within the surveyed population. It suggests that many farmers struggle to access an adequate and consistent food supply, leading to periods of extreme hunger and deprivation. Going without food for extended periods can result in malnutrition, weakened immune systems, and increased susceptibility to diseases, further exacerbating the challenges faced by farming households. Conversely, the finding that 27.0% of respondents answered "no" to the same statement suggests that a minority of farmers did not experience situations where they or household members went a whole day and night without food. While this may indicate relative stability or resilience within this subset of the farming population, it's important to consider the factors that contributed to their ability to maintain food security. Factors such as higher income levels, better access to agricultural resources, and social support networks may have played a role in mitigating food insecurity for these farmers.

The data (Table 8) indicates that a significant proportion of households in the sample population experience food insecurity. Nearly half of the households (47.01%) are classified as "food insecure," indicating that they have limited access to an adequate and nutritious diet. This highlights a substantial challenge in ensuring food security within the community. The distribution also reveals varying levels of severity among food insecure households. While 25.97% are classified as "mildly food insecure," indicating relatively

Table 7. Food security status of farmers

Statements	Response	Frequency (%)	Statements	Response*	Frequency (%)
Experiencing insufficient resources over the past 4 weeks/30 days, leading to a lack of food for consumption	No	108 (28.1)	How did it occur over the last four weeks or thirty days?	Seldom	181 (47.0)
				A few times	96 (24.9)
				No	108 (71.9)
	Yes	277 (71.9)			
Going to bed hungry at night due to inadequate food availability for the past 4 weeks/30 days	No	109 (28.3)	How did it occur over the last four weeks or thirty days?	Seldom	154 (40.0)
				A few times	121 (31.4)
				Regularly	1 (0.3)
	Yes	276 (71.9)			
Within the last 4 weeks/30 days, either you or a member of your household has experienced a complete day and night without food	No	104 (27.0)	How did it occur over the last four weeks or thirty days?	Seldom	177 (46.0)
				A few times	103 (26.8)
				Regularly	1 (0.3)
				No	104 (27.0)
	Yes	281 (73.0)			

Notes: *Seldom (1-2); a few times (3-10); regularly (>10).

Table 8. Level of food insecurity

Levels of food insecurity	Frequency	Percentage
Food secure	35	9.09
Moderate food insecure	69	17.93
Mild food insecure	100	25.97
Food insecure	181	47.01
Total	385	100.00

less severe food access issues, 17.93% are categorized as "moderately food insecure," suggesting more pronounced challenges in accessing food. The data shows that only 9.09% of households are classified as "food secure," indicating consistent access to an adequate and nutritious diet. While this may suggest some level of resilience within the community, it also highlights the need for targeted efforts to improve food security outcomes for a larger portion of the population. The prevalence of food insecurity, particularly at varying levels of severity, highlights the importance of addressing underlying factors such as poverty, access to resources, and nutritional education. Effective interventions should aim to not only alleviate immediate food access issues but also address the root causes of food insecurity to promote long-term food security and resilience within the community. The results are corroborated by Dei Antwi *et al*. (2018) and Hashmiu *et al.* (2022), who asserted that more than 67% of households involved in cocoa production experienced food insecurity. Iddrisu *et al.* (2020) contended that 51% of households involved in cocoa cultivation achieved food security.

Adoption Practices' Impact on Food Security

Table 9 presents the coefficients and standard errors for various agricultural practices that determine farmers' food security status. These coefficients indicate the estimated effect of each practice on farmers' food security levels. Overall, the LR chi^2 test indicates that the model as a whole is statistically significant. The coefficient of 1.11

(***), indicating statistical significance at the 99% confidence level, suggests that practicing zero burning has a positive effect on food security. This means that farmers who adopt zero-burning are more likely to have higher levels of food security compared to those who do not practice zero-burning. Zero-burning practices contribute to soil fertility and organic matter, reduce land degradation, and promote ecosystem health, all of which can positively impact agricultural productivity and food security. The coefficient of 1.76 (**) denotes statistical significance at the 95% confidence level, indicating a strong positive relationship between maintaining a weedicide-free farm and food security. Farmers who refrain from using weedicides are more likely to have higher levels of food security compared to those who use weedicides. Avoiding the use of weedicides can minimize environmental contamination, protect bio-diversity, and maintain soil health, leading to improved crop yields and food security. The coefficient of 0.02 (*) denotes statistical significance at the 90% confidence level, suggesting a relatively weak positive impact of shade management on food security. Shade management practices, such as agroforestry or planting cover crops, can provide various benefits such as soil conservation, microclimate regulation, and biodiversity enhancement, contributing to overall farm resilience and potentially improving food security.

Obstacles Encountered in Implementing the CRP

From Table 10, the most commonly mentioned difficulty was the insufficient availability of plantain suckers (mean = 2.61). Plantain suckers play a crucial role as makeshift shade for the seedlings. In cases where their distribution is inadequate on newly established farms, seedlings are exposed to the sun, increasing the risk of seedling mortality. The second challenge involved delays in work caused by local village politics (mean = 2.45). Poor maintenance of farms by hired laborers (mean = 2.31) was identified as the third most prominent challenge according to the farmers. Farmers have been reluctant to adopt cocoa rehabilitation methods due to the complexity and incompatibility of certain treatments with existing practices (Adebiyi & Okunlola, 2013).

Based on the findings, it is recommended that special consideration be given to female cocoa growers due to their propensity to resist the rehabilitation plan. To effectively inform and engage farmers in the programme, it is recommended to conduct regular training sessions for farmers and launch a robust media campaign. As individuals grow older, their motivation to engage in rehabilitation diminishes. Therefore, it is crucial to encourage young people to pursue cocoa production. It is recommended that farmers receive training and authorisation to independently manage

Table 9. Practices that impact food security

Parameters	Coefficient	Standard error
Shade management	0.02 *	1.52
Weedicide free farm	1.76 **	1.23
Zero burning	1.11 ***	0.19
Involvement of farmers in farm maintenance	-0.68	0.88
Bottle irrigation	-1.02	1.16
Grafting/budding	-0.25	0.93
Food insecurity = 1	8.08	2.19
Food insecurity = 2	4.42	0.74
Food insecurity = 3	7.62	0.85

Notes: LR chi^2 = 51; Prob>chi^2 = 0.00; Log-likelihood = -881.03; Pseudo R^2 = 0.21.

Table 10. Difficulties related to the rehabilitation of cocoa

Challenges	Mean	Standard deviation
Insufficient availability of plantain suckers	2.61	0.77
Delays in work progress due to local village politics on certain farms	2.45	0.85
Subpar farm upkeep by hired labour	2.31	0.81
Shortage of hired labor for farm maintenance	2.29	0.87
delays during the transplanting of seedlings	2.11	0.93
Incompatibility with current practices	2.06	0.85
Lack of sufficient information	1.51	0.81
Technology's complexity	1.39	0.71
Financial constraints stemming from non-payment of cocoa farm cutting compensation	1.00	0.00
Diminished survival rate of seedlings due to termite infestation	1.00	0.00

Note: Disagree-1, Neutral-2, Agree-3.

their land instead of employing laborers. To reduce farmers' reliance on agriculture, it is recommended to provide them with supplementary livelihood programmes. Furthermore, it is imperative for COCOBOD extension personnel to motivate farmers to broaden the scope of their agricultural activities. This will provide them with enhanced food accessibility, especially in circumstances where cocoa plants require removal for rehabilitation purposes.

CONCLUSIONS

Even though farmers in Ghana's Fanteakwa South District in the Eastern region willingly participated in the cocoa rehabilitation programme and received the promised rewards, empirical data indicates that their perception of the programme was neutral. Gender, household size, and level of education have a beneficial impact on the adoption of cocoa rehabilitation, but age has a negative effect. The factors that had a positive impact on farmers' decisions to adopt cocoa rehabilitation included complimentary tree cutting, continued access to extension services at no cost, and financial incentives. Regarding food security, 47% of farmers indicated experiencing food insecurity, with 73% of them or a member of their household reporting not having any food for a full day or night within the past 4 weeks or 30 days. The degree of food security among farmers is defined by techniques such as shade management, weedicide-free farming, and zero burning. The programme has encountered challenges such as scarcity of plantain suckers, local village politics, and inadequate farm maintenance by hired laborers.

REFERENCES

Adebiyi, S. & J.O. Okunlola (2013). Factors affecting adoption of cocoa farm rehabilitation techniques in Oyo State of Nigeria. *World Journal of Agricultural Sciences,* 9(3), 258–265.

Adhikari, R.K.; M. Kindu; R. Pokharel; L.M. Castro & T. Knoke (2017). Financial compensation for biodiversity conservation in Ba Be National Park of Northern Vietnam. *Journal of Natural Conservation,* 35, 92–100.

Akinwale, J.A. & O.E. Folarin (2018). Factors influencing farmers' adoption of CRIN TC cocoa hybrid technology in Oyo State, Nigeria. *Pelita Perkebunan*, 34(3), 191–198.

Ameyaw, G.A.; H.K. Dzahini-Obiatey & O. Domfeh (2014). Perspectives on cocoa swollen shoot virus disease (CSSVD) management in Ghana. *Crop Protection,* 65, 64–70.

Aneani, F. & F. Padi (2017). Baseline farmer survey of smallholder cocoa farming systems in Ghana. *Sustainable Agriculture Research,* 6(526-2017-2655).

Ankuyi, F.; E.K. Tham-Agyekum; D. Ankrah; A.Y. Oduro-Owusu; J-E.A. Bakang; D. Boansi & S. Asirifi (2023). Beyond certification: Investigating the nexus between compliance with sustainable agriculture standards and livelihood assets of certified smallholder cocoa farmers in Ghana. *Cogent Food & Agriculture*, 9(1), 2256556.

Ayanlade, A.; M. Radeny & J.F. Morton (2017). Comparing smallholder farmers' perception of climate change with meteorological data: A case study from southwestern Nigeria. *Weather and Climate Extremes,* 15, 24–33.

Ballard, T. J.; A.W. Kepple & C. Cafiero (2013). *The Food Insecurity Experience Scale: Development of a* Global *Standard for Monitoring Hunger Worldwide*. Technical Paper No. 2013-02. Food and Agriculture Organization of the United Nations.

Barnes, A.P.; I. Soto; V. Eory; B. Beck; A.T. Balafoutis; B. Sánchez; J. Vangeyte; S. Fountas; T. van der Wal & M. Gómez-Barbero (2019). Influencing incentives for precision agricultural technologies within European arable farming systems. *Environmental Science & Policy*, 93, 66–74.

Bockel, L.; P. Gopal & S.A. Ouédraogo (2021). *Preliminary Impact Appraisal of Cocoa Value Chain Rehabilitation in Ghana: 2018–2028*. Food & Agriculture Organisation.

Bremer, L.L.; K.A. Farley & D. Lopez-Carr (2014). What factors influence participation in payment for ecosystem services programs? An evaluation of Ecuador's SocioPáramo program. *Land Use Policy,* 36, 122–133.

COCOBOD (2019). *Annual Reports and Consolidated Financial Statements*. Ghana Cocoa Board. Accra. Ghana.

Dei Antwi, K.; C.P. Lyford & R.Y. Nartey (2018). Analysis of food security among cocoa-producing households in Ghana. *Journal of Agriculture and Sustainability,* 11(2).

Garbach, K.; M. Lubell & F.A.J. DeClerck (2012). Payment for ecosystem services: The roles of positive incentives and information sharing in stimulating adoption of silvopastoral conservation practices. *Agriculture, Ecosystems & Environment,* 156, 27–36.

Gebregziabher, G.; M.A. Giordano; S. Langan & R.E. Namara (2014). Economic analysis of factors influencing adoption of motor pumps in Ethiopia. *Journal of Development and Agricultural Economics*, I(12), 490–500.

Gordon, R.M. (1987). *The Structure of Emotions*. Cambridge, UK: Cambridge University Press.

Greiner, R. & D. Gregg (2011). Farmers' intrinsic motivations, barriers to the adoption of conservation practices and effectiveness of policy instruments: Empirical evidence from northern Australia. *Land Use Policy*, 28(1), 257–265.

GSS (2021). *Ghana 2021 Population and Housing Census*. General Report Volume 3A. Ghana Statistical Service.

Hashmiu, I.; O. Agbenyega & E. Dawoe (2022). Cash crops and food security: Evidence from smallholder cocoa and cashew farmers in Ghana. *Agriculture & Food Security,* 11(1), 1–21.

Himberg, N.; L. Omoro; P. Pellikka & O. Luukkanen (2009). The benefits and constraints of participation in forest management. The case of Taita Hills, Kenya. *Fennia,* 187, 61–76.

Holden, R.J.; C.K. Or; S.J. Alper; A.J. Rivera & B.T. Karsh (2008). A change management framework for macro ergonomic field research. *Applied Ergonomics*, 39(4), 459–474.

Iddrisu, M.; R. Aidoo & C.A. Wongnaa (2020). Participation in UTZ-RA voluntary cocoa certification scheme and its impact on smallholder welfare: Evidence from Ghana. *World Development Perspectives,* 20, 100244.

Liu, C.; D. Ready; A. Roman; M. Van Wart; X. Wang; A. McCarthy & S. Kim (2018). E-leadership: An empirical study of organizational leaders' virtual communication adoption. *Leadership & Organization Development Journal*, 39(7), 826–843.

Mignouna, D.B.; V.M. Manyong; K.D. Mutabazi & E.M. Senkondo (2011). Determinants of adopting imazapyr-resistant maize for Striga control in Western Kenya: A double-hurdle approach. *Journal of Development and Agricultural Economics,* 3(11), 572–580

Mwangi, M. & S. Kariuki (2015). Factors determining adoption of new agricultural technology by smallholder farmers in developing countries. *Journal of Economics and Sustainable Development*, 6(5), 208 –216.

Piñeiro, V.; J. Arias; J. Dürr; P. Elverdin; A.M. Ibáñez; A. Kinengyere; C.M. Opazo; N. Owoo; J.R. Page; S.D. Prager & M. Torero (2020). A scoping review on incentives for adoption of sustainable agricultural practices and their outcomes. *Nature Sustainability*, 3(10), 809–820.

Prokopy, L.S.; K. Floress; J.G. Arbuckle; S.P. Church; F.R. Eanes; Y. Gao; B.M. Gramig; P. Ranjan & A.S. Singh (2019). Adoption of agricultural conservation practices in the United States: Evidence from 35 years of quantitative literature. *Journal of Soil and Water Conservation*, 74(5), 520–534.

Rose, M.T.; T.R. Cavagnaro; C.A. Scanlan; T.J. Rose; T. Vancov; S. Kimber; I.R. Kennedy; R.S. Kookana & L.Van Zwieten (2016). Impact of herbicides on soil biology and function. *Advances in Agronomy*, 136, 133–220.

Santiago, T.M.O.; J. Caviglia-Harris & J.L. Pereira de Rezende (2018). Carrots, sticks and the Brazilian Forest Code: The promising response of small landowners in the Amazon. *Journal of Forest Economics,* 30, 38–51.

Shita, A.; N. Kumar & S. Singh (2018). Agricultural technology adoption and its determinants in Ethiopia: A reviewed paper. *Asia Pacific Journal of Research,* 1(55), 99–104.

Singh, M.K.; N.K Singh & S.P. Singh (2020). Impact of herbicide use on soil microorganisms. pp. 179–194. ***In:*** *Plant Responses to Soil Pollution* Springer, Singapore.

Tedla, T.H. (2011). *Factors Determining Fertilizer Adoption of the Peasant Farm Sector in Northern Ethiopia, Tigray region*. Master's thesis. Norwegian University of Life Sciences.

Ward, P.S.; A.R. Bell; G.M. Parkhurst; K. Droppelmann & L. Mapemba (2016). Heterogeneous preferences and the effects of incentives in promoting conservation agriculture in Malawi. *Agriculture, Ecosystems & Environment,* 222, 67–79.

Wongnaa, C.A.; I.A. Apike; S. Babu; D. Awunyo-Vitor & A.B. Kyei (2021). The impact of adoption of artificial pollination technology in cocoa production: Evidence from Ghana. *Journal of Agriculture and Food Research*, 6, 100208.

Wongnaa, C.A. & S. Babu (2020). Building resilience to shocks of climate change in Ghana's cocoa production and its effect on productivity and incomes. *Technology in Society*, 62, 101288.

Wongnaa, C.A. & W.K. Boachie (2018). Perception and adoption of competency-based training by academics in Ghana. *International Journal of STEM Education*, 5, 1–13.

Xiao, D.; H. Niu; L. Fan; S. Zhao & H. Yan (2019). Farmers' satisfaction and its influencing factors in the policy of economic compensation for cultivated land protection: a case study in Chengdu, China. *Sustainability,* 11(20), 5787.

Yamane, T. (1973). *Statistics: An Introductory Analysis* (3rd ed.). Harper & Row. New York.

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