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Original Research Article

Determinants of Approved Pesticides Use and Its Effect on Farm Performance among Cocoa Farmers in *Osun* State, Nigeria

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Abstract

This study examined the effects of approved pesticide use on cocoa output and farm income in Osun State, Nigeria, given cocoa's importance as a major cash crop. A multi-stage sampling technique was used to select 120 cocoa farmers, and data were analysed using descriptive statistics, logit regression, farm budgeting, and multiple regression models. The average farmer was 49 years old, had 24 years of farming experience, a household size of seven, and cultivated about 2.7 hectares. Logit regression results indicated that age, marital status, farmers' association membership, access to credit, and pesticide costs significantly influenced the likelihood of using approved pesticides. Budgetary analysis showed that average costs and returns per hectare were $150.22 and $290.54, respectively, with total revenue of $440.76, a gross margin of $326.21, and net income of $290.54, yielding a profit margin of 65.92%. Ordinary least squares estimates revealed that gender, education, quantity of pesticide used, and pesticide cost significantly affected cocoa output, while farm size, age, education, quantity of pesticide, and household size significantly influenced income. The findings suggest that the use of approved pesticides is associated with higher cocoa output among farmers. The results also indicate that the use of approved pesticides is linked to improved farm income. The study recommends policies that enhance farmers' access to credit, promote youth participation in cocoa production, and encourage membership in farmer associations to increase adoption of approved pesticides and improve livelihoods in the cocoa sector.

Keywords: Cocoa production; Agrochemical adoption; Farm productivity; Smallholder farmers; Agricultural income; Pest management practices;Yield determinants; Rural livelihoods; Technology adoption

INTRODUCTION

Nigeria is one of Africa's leading cocoa (*Theobroma cacao*) producers, ranking behind Côte d'Ivoire and Ghana in production volume (Oyenpemi et al., 2023). At the global level, FAO statistics indicate that Nigeria ranked third by cocoa output in 2023 but fourth by value, suggesting that production rankings alone do not fully capture countries' economic performance in international cocoa markets (FAO, 2023). Consistent with this pattern, FAO trade data show that Nigeria was the world's second-largest exporter of cocoa beans by both volume and value in 2024, underscoring the country's strong position in global cocoa commerce despite producing less than some competitors (FAO, 2024). Nonetheless, cocoa does not rank among Nigeria's leading crops nationally by value (32nd) or volume (36th). Even so, it remains economically strategic because of its contributions to export earnings, rural employment, agro-industrial raw material supply, and revenue generation in major producing states (Kehinde, 2022; Kehinde et al., 2024; FAO, 2024). Despite recent production gains, Nigeria has not regained its historical prominence in global cocoa output, with production estimated at 340,163 tons in the 2023/2024 season (Olutuyi, 2020; World Atlas, 2022; Kehinde et al., 2024). Although government policies targeted an expansion to 500,000 tonnes, actual output has remained between 280,000 and 320,000 tonnes, reflecting structural constraints such as aging tree stocks, limited replanting, and slow uptake of productivity-enhancing technologies (FAO, 2025). Consequently, while Côte d'Ivoire (about 1.8 million tons), Indonesia (642,000 tons), and Ghana (530,873 tons) continue to dominate global production, Nigeria is still striving to expand both output volumes and domestic value addition along the cocoa value chain (World Atlas, 2022; Adesiyan et al., 2023).

In response to this performance gap, recent policy and industry initiatives sought to accelerate cocoa production growth, with the Cocoa Farmers' Association of Nigeria (CFAN) projecting an output target of 500,000 tons by 2024 as part of broader efforts to strengthen export earnings and diversify national revenue sources in the post–COVID-19 recovery period (Ibirogba, 2022). However, FAO production data indicate that this target was not achieved, as actual output remained substantially below expectations, pointing to persistent agronomic, institutional, and structural bottlenecks within the sector. Among the most binding of these constraints are insect pests and diseases, which continue to undermine farm performance across Nigeria's major cocoa-growing regions (Cadoni, 2013). The country's humid tropical climate creates favorable ecological conditions for destructive pathogens such as vascular streak dieback, witches' broom, frosty pod rot, black pod disease, and cocoa swollen shoot virus (Etaware, 2021). These biotic stresses reduce yields and bean quality while simultaneously increasing production costs and income volatility among smallholder farmers. As a result, cocoa output remains well below its agronomic potential, constraining foreign exchange earnings and public revenue from the sector (Eta et al., 2023). The persistent gap between policy ambitions and realized production therefore highlights the urgency of strengthening pest and disease management systems, improving access to safe crop protection technologies, and reinforcing institutional capacity to support productivity growth and long-term sector resilience.

Within this context, the concept of "approved pesticides" is central to understanding crop protection practices in cocoa production. In this study, approved pesticides refer specifically to chemical crop protection products that have been evaluated, registered, and authorized for cocoa use by Nigeria's Cocoa Research Institute of Nigeria (CRIN) in accordance with national regulatory frameworks and international residue standards, particularly those of the European Union and Codex Alimentarius. These products are considered to have acceptable toxicological, environmental, and residue profiles when applied according to label recommendations. In contrast, non-approved pesticides include banned substances, obsolete formulations, or products not registered for cocoa use that may still circulate in informal markets due to weak regulatory enforcement, porous borders, limited farmer awareness, and economic incentives linked to lower prices and perceived effectiveness. Empirical evidence suggests that although approved pesticides dominate formal distribution channels, non-approved products remain accessible in some cocoa-growing communities, reflecting enforcement gaps and limited extension oversight (Babasola et al., 2017; Eta et al., 2023). Their continued availability is problematic because it heightens risks to human health, environmental sustainability, and export market access, especially under increasingly stringent international food safety standards. However, systematic evidence on the relative prevalence of approved versus non-approved pesticide use remains limited, underscoring the need for research that clarifies both adoption patterns and the economic implications of compliance with approved pesticide regimes.

Against this background, cocoa farmers rely on a range of pest management strategies, with pesticides remaining the most widely used tool for controlling insect pests and diseases that threaten cocoa productivity (Babasola et al., 2017; Faloni et al., 2022). In Nigeria, pesticide use is particularly widespread because of the intense pest pressure associated with humid tropical agroecological conditions. When properly applied, approved pesticides play a critical role in reducing crop losses, improving yields, and stabilizing farm incomes (Tham-Agyekum et al., 2025). However, inappropriate practices – including overdosing, mixing incompatible chemicals, and applying non-approved products – undermine these benefits and raise production costs (Babasola et al., 2017; Eta et al., 2023). Studies further show that limited farmer knowledge of recommended dosages, inadequate extension services, and weak enforcement of pesticide regulations contribute to misuse, resulting in elevated residue levels in cocoa beans in some producing regions (Mahmood et al., 2016; Eta et al., 2023). These outcomes pose risks to consumer health, farmer safety, and international market access, reinforcing the importance of promoting compliance with approved pesticide standards, strengthening extension education, and improving regulatory oversight to ensure that pesticide use supports, rather than undermines, sustainable cocoa production.

The public health and trade implications of pesticide misuse have attracted growing international concern. Exposure to pesticide residues has been linked to respiratory disorders, skin and eye irritation, neurological symptoms, reproductive impairments, endocrine disruption, and increased risks of chronic diseases such as cancer and renal dysfunction (Eta et al., 2023). In response, the World Health Organization (WHO) and the European Union (EU) began banning several highly hazardous pesticides in 2008, with cocoa-producing countries required to comply or face trade restrictions. More recent EU regulations extend these controls to substances classified as carcinogenic, mutagenic, toxic to reproduction, endocrine-disrupting, persistent, bioaccumulative, and toxic (PBT), or very persistent and very bioaccumulative (vPvB). The European Food Safety Authority currently sets the maximum residue limit (MRL) for cocoa beans at 0.01 mg/kg; however, cocoa samples from Nigeria have been reported to contain dichlorvos residues ranging from 0.03 to 4.6 mg/kg, suggesting continued exposure to non-approved or misused chemicals in some contexts (Gathman et al., 2025). These findings underscore that regulatory compliance is not merely a legal requirement but a critical determinant of market access, public health protection, and the long-term viability of Nigeria's cocoa sector.

In Nigeria, the Cocoa Research Institute of Nigeria (CRIN) is mandated to evaluate, register, and periodically update the list of pesticides approved for cocoa production based on efficacy, environmental impact, toxicological safety, and consistency with international residue standards (CRIN, 2019). Currently approved products include insecticides (Actara 25WG, Esiom 150 SL, Proteus 170 O-TEC), fungicides (Funguran-OH, Champ DP, Ridomil Gold 66 WP, Copper Nordox 75 WP, Ultimax Plus, Kocide 2000, Kocide 101, Cabrio Duo, Red Force, Pergado), herbicides (Touchdown, Clear Weed, Roundup), and fumigants. These products are designed to control major cocoa pests, diseases, and weeds that significantly reduce yields and compromise bean quality. Their use contributes to productivity enhancement, output stabilization, and compliance with export market residue requirements, thereby strengthening international competitiveness. Secondary benefits accrue through higher farm incomes, which may support household investments in education, health, and asset accumulation, contributing to broader human capital development and rural welfare (Macías-Montes et al., 2025). Understanding the determinants of adoption of these approved pesticides and their economic effects is therefore essential for designing policies that balance crop protection, environmental sustainability, public health safety, and farm-level profitability.

Although substantial research has examined pesticide use in cocoa production – particularly in relation to productivity, environmental risks, and farmer welfare (e.g., Popp et al., 2013; Schreinemachers and Tipraqsa, 2012; Tijani and Masuku, 2019; Kehinde and Tijani, 2021; Faloni et al., 2022; Kehinde, 2022) – empirical evidence explicitly linking the use of approved pesticides, as defined by national regulatory standards, to cocoa output and farm income in Nigeria remains limited. For instance, Kolapo et al. (2022) analyzed factors influencing the adoption of EU-approved pesticides among cocoa farmers but did not assess their productivity or income effects. While the broader literature establishes that pesticide use generally increases crop yields and farm revenue, there is still a need for context-specific evidence on whether compliance with approved pesticide regimes translates into measurable economic gains under local institutional, ecological, and market conditions. Accordingly, this study contributes to applied policy and extension practice by providing empirical evidence on the determinants and economic implications of approved pesticide use in Nigerian cocoa production. Specifically, it describes the socioeconomic characteristics of cocoa farmers, identifies factors influencing approved pesticide adoption, estimates the costs and returns associated with pesticide application, evaluates the effects of approved pesticide use on output, and evaluates the effects of approved pesticide use on farm income. The remainder of the paper is organised as follows: the next section presents the data and research methodology and reports the main findings, followed by conclusions, policy recommendations, limitations, and directions for further research.

MATERIAL AND METHODS

Sampling and Sampling Techniques

Respondents were selected using a multistage sampling design, a widely accepted probability-based approach

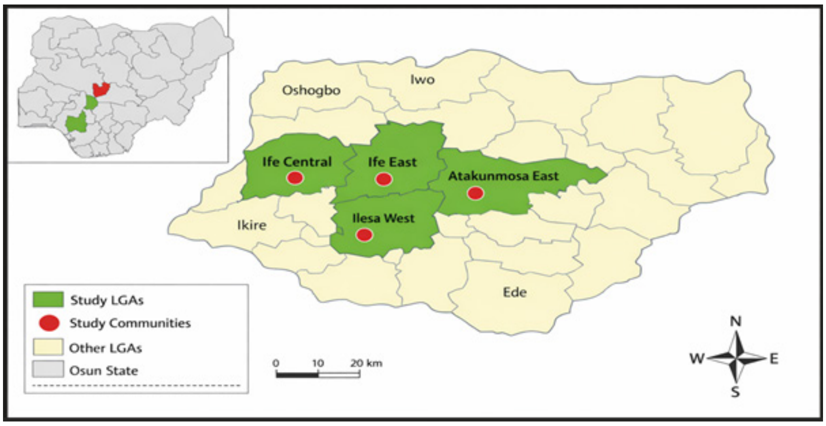

Figure 1. Map of Osun State showing Ife Central, Ife East, Atakunmosa East, and Ilesa West

commonly employed in agricultural and socioeconomic field surveys to enhance representativeness while maintaining operational feasibility and cost efficiency (Cochran, 1977; Kothari, 2004). This method involves sequential sampling across hierarchical units and is particularly appropriate for studies conducted over large and geographically dispersed populations. In the first stage, four Local Government Areas (LGAs) – Ife Central, Ife East, Atakunmosa East, and Ilesa West – were purposively chosen based on their high concentration of cocoa farmers and contribution to the state's cocoa output. In the second stage, three communities were randomly selected from each LGA, followed by the random selection of ten cocoa farmers from each community, resulting in a total of 120 respondents. Primary data were collected using a structured questionnaire, covering farmers' socio-economic characteristics, institutional factors such as extension services and access to credit, and information on pesticide use in cocoa production.

Analytical technique

The data collected were analysed using descriptive statistics, a logit regression model, farm budgetary techniques, and an ordinary least squares (OLS) regression model. Descriptive statistics (frequencies and percentages) were used to describe the socio-economic characteristics of cocoa farmers.

Logit regression model

The logistic regression statistical analysis method is used to forecast the relationship between the response and predictor variables (Hosmer and Lemeshow, 2000). On a category or interval scale, a dependent variable with two or more categories is accompanied by one or more explanatory factors (independent variables). Ordinary linear regression models using the OLS approach are unable to describe the link between response variables with qualitative or categorical features and explanatory factors with two or more categories (Hendayana 2013). If the linear regression approach is pushed to analyse data with the features indicated above, the Gauss-Markov assumption will be violated (Kutner et al., 2004). The logistic regression analysis is used to predict the association between a dichotomous response variable (outcome or dependent) and a set of predictor variables (explanatory or independent). The Response variable is dichotomous qualitative data, with 1 (one) indicating the occurrence of an event and 0 (zero) indicating the absence of an event. The general form of the logistic regression equation model is shown below:

$$\pi_{(j)} = P(Y=1|X) = \frac{e^{\beta_0+\beta_1 x_{j1}+\beta_2 x_{j2}+\ldots+\beta_p x_{jp}}}{1+e^{\beta_0+\beta_1 x_{j1}+\beta_2 x_{j2}+\ldots+\beta_p x_{jp}}} \quad (1)$$

The link function used is logit, with the logit of πIe:

$$logit(\pi) = log\left(\frac{\pi_j}{1-\pi_j}\right) = \beta_0+\beta_1 x_{j1}+\beta_2 x_{j2}+\ldots+\beta_p x_{jp} \quad (2)$$

The logistic regression model is used to predict the likelihood or occurrence of a circumstance. The logistic regression method is used to explain non-linear correlations between X and Y (Hendayana, 2013). In contrast to OLS and linear regression, logistic regression does not require a linear relationship between the dependent and independent variables. The data does not need to be consistently distributed (Sekele et al., 2020).

A logit regression model was used in this study to determine the factors affecting approved pesticide use among cocoa farmers. The model is often used when an individual makes choices between alternatives. In this case, the decision is to either use or not use approved pesticides.

The model is implicitly expressed as

$$Y = L_N \frac{P_i}{(1-P)} = \beta 0 + \beta 1X1 + \beta 2X2 +$$
$$+\beta 3X3 + \beta 4X4 + \beta 5X5 \ldots \beta 9X9 \quad (3)$$

Y = EU-approved pesticide use is a categorical variable as an adoption variable.

a. Y = 1 to use EU-approved pesticides

b. Y = 0 to not use EU-approved pesticides

The explanatory variables are:

X_1 = Age (Years);

X_2 = Farm size (hectares);

X_3 = Labor (Man Days);

X_4 = Sex (1 = Male, 0 = Female);

X_5 = Household Size (actual number);

X_6 = Educational status (years spent on education);

X_7 = Cost of unit of approved pesticide (₦);

X_8 = Access to extension service (1 = yes, 0 = no);

X_9 = Access to credit (1 = yes, 0 = no);

Ui = error term.

Farm budgetary techniques

Farm budgetary techniques were used to estimate the cost and returns to pesticide usage by cocoa farmers. The various types of inputs were used, and their costs were identified. These costs are divided into variable costs and fixed costs. The variable costs include the cost of labour, the cost of the approved pesticide, etc. Fixed costs include depreciation on fixed assets [e.g. Chemical sprayer, Hoes, Cutlass, labour (depending on the type of farm), etc], and it was charged using the straight-line method.

Profitability and efficiency ratio

The following ratios were computed to ascertain the extent of the profitability of cocoa farmers using approved pesticides

ROI (rate of return on investment) = GM / TVC (4)

$$\text{Operating expenses ratio} = \frac{Totalvariablecost}{Grossrevenue} \quad (5)$$

$$\text{Profitability Index} = \frac{NFI(₦)}{Totalrevenue(₦)} \times 100 \quad (6)$$

$$\text{Benefit cost ratio} = \frac{TotalRevenue}{Totalcost} \quad (7)$$

Ordinary least squares regression model

The impact of approved pesticide use on cocoa farmers' output and revenue was examined using the OLS regression model. Finding the best-fitting linear relationship between a dependent variable and one or more independent variables is the foundation of the OLS model's reasoning. OLS is a statistical technique for estimating parameters, or coefficients of a linear regression model, in regression analysis. One linear regression technique used to determine the unknown parameters in a model is called OLS. The sum of squared residuals, which represents the differences between the observed and predicted values of the dependent variable, is minimised by this method. The difference between the actual and anticipated values is the precise definition of the residual. "Error term" is another word for residual (Sharma et al., 2013). To investigate household income issues, previous research has used a variety of estimation techniques, such as pooled Poisson (Kafle, 2014), logistic regression, multinomial logit endogenous switching, propensity score matching, and OLS (Okello, 2025). Farm income and cocoa output were the dependent variables in the OLS model. The entire dataset is amenable to the OLS estimate technique, and the dependent variables (cocoa output and annual household income from farming) are continuous. As a result, we defined the estimating method as:

$$Y_i = \propto + \theta U_i + \gamma x_i + \varepsilon_i \quad (8)$$

where Y_i is cocoa output or farm income, U_i is approved pesticides, x_i is a vector of controlled variables consisting of socio-demographic and economic characteristics of cocoa farmers and other household income determinants.

Output model

The model is implicitly expressed as

$$Y = \beta 0 + \beta 1X1 + \beta 2X2 + \beta 3X3 + \beta 4X4 + \beta 5X5 \ldots \beta 9X9 \quad (9)$$

Y = Output of cocoa (kg)

The explanatory variables are:

X_1 = Labor (man days);

X_2 = Farm size (hectares);

X_3 = Quantity of approved pesticide used (litres);

X_4 = Quantity of fertilizer used (kg);

X_5 = Age (years);

X_6 = Gender (1 = Male, 0 = Female);

X_7 = household size;

X_8 = Education (Years);

X_9 = Cost of approved Pesticide (Naira);

Ui = error term.

Income model

$$Y = \beta 0 + \beta 1X1 + \beta 2X2 + \beta 3X3 + \beta 4X4 + \\ + \beta 5X5 \ldots \beta 9X9 \quad (10)$$

Y = Income of cocoa farmers (naira)
The explanatory variables are:
X_1 = Labor (man days);
X_2 = Farm size (hectares);
X_3 = Quantity of approved pesticide used (litres);
X_4 = Quantity of fertilizer used (kg);
X_5 = Age (years);
X_6 = Gender (1 = Male, 0 = Female);
X_7 = household size;
X_8 = Education (Years);
X_9 = Cost of approved Pesticide (Naira);
Ui = error term.
The model was run using "STATA", an econometric software. After fitting an OLS model, it is critical to verify that these assumptions hold. Thus, the validity of the regression model was rigorously checked for heteroscedasticity, multicollinearity, autocorrelation, and specification errors.

Normality, multicollinearity, heteroscedasticity, and autocorrelation tests

The Jarque-Bera test and variation inflation factor (VIF) indices were used to evaluate the normality of errors and multicollinearity (correlation of two or more independent variables in a multiple regression equation). Before fitting crucial variables into the models, it was necessary to test for multicollinearity between continuous variables and linkages between discrete variables, which have a significant impact on parameter estimates. According to Gujarati (2003), multicollinearity is a circumstance in which it is difficult to detect the independent variables' individual effects on the dependent variable due to their strong interdependence. In other words, multicollinearity occurs when the explanatory variables are highly connected. Thus, the VIF is used to assess the multicollinearity of continuous data. As R2 approaches 1, it demonstrates substantial multicollinearity of explanatory variables. The higher the value of VIF, the more bothersome or collinear the variable Xi. As a rule, a VIF greater than 10 (which occurs when R2 is greater than 0.80) indicates that the variable is very collinear. Similarly, the Breusch-Pagan, Godfrey, and Glejser tests were used to detect heteroscedasticity (when the variance of the error term in the regression model varies), whereas the Breusch-Godfrey LM and Q-statistic Ljung-Box tests investigated the assumption of no correlation (no identifiable relationship between the error term values).

Regression Specification Error Test

Functional misspecification and/or omitted variables are common problems in regression models, resulting in biased and inefficient estimators (Juodis, 2025). As a result, Ramsey's (1969) Regression Specification Error Test (RESET) was employed to determine if non-linear combinations of explanatory factors contribute to the response variable. The test compares the null hypothesis of no misspecification against the alternative, misspecification.

Box-Cox Model Specification

To further address potential functional form issues, we conducted a Box-Cox test in STATA. The test examines whether a transformation of the dependent variable improves model fit and provides additional evidence regarding the appropriateness of the linear specification. The Box-Cox procedure suggested a λ value close to 1 for both output and income models, indicating that no transformation was necessary and that the linear functional form is reasonable. The transformed model is specified as:

$$Y(\lambda) = \begin{cases} \dfrac{Y^{\lambda} - 1}{\lambda} & \text{if} \quad \lambda \neq 0 \\ \ln(Y) & \text{if} \quad \lambda = 0 \end{cases} \quad (11)$$

The Box-Cox regression can thus be written as:

$$Y(\lambda) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_9 X_9 + u_i \quad (12)$$

where $Y(\lambda)$ is the Box-Cox transformed dependent variable (either cocoa output or income), X_1 to X_9 are the explanatory variables (labor, farm size, quantity of approved pesticide, fertilizer use, age, gender, household size, education, and cost of approved pesticide), and u_i is the error term.

The Box-Cox procedure estimates the parameter λ, which identifies the most appropriate transformation of Y to improve model fit. In this study, the estimated λ values were close to 1 for both output and income models, indicating that no transformation was necessary and that the linear OLS specification is appropriate.

Description of dependent and explanatory variables

Table 1 presents a detailed description of the dependent and explanatory variables employed in the econometric analysis, including their measurements and expected

Table 1. Description of dependent and explanatory variables

Dependent variables		
Variables	**Description**	
Cocoa output	Kilogram (continuous)	
Farm income	$	
Independent variables		
Variables	**Description**	**Signs**
Labour	Manday (continuous)	+/–
Farm size	Hectares of land under cultivation (continuous)	+/–
Approved pesticide use	Litre (continuous)	+/–
Fertilizer	Kg (continuous)	+/–
Age	Number of Years (continuous)	+/–
Gender	Dummy;1 if male and 0 if otherwise	+/–
Households size	The number of people living in the household (continuous)	+/–
Years of formal education	Years spent in schooling (continuous)	+/–
Cost of approved pesticides	Naira (continuous)	+/–
Years of farming experience	Years spent in farming (continuous)	+/–

effects on cocoa output and farm income. The dependent variables consist of cocoa output, measured in kilograms, and farm income, measured in monetary units, both specified as continuous variables. Cocoa output reflects the physical productivity of cocoa farms, while farm income captures the financial returns accruing to farmers from cocoa production activities. Together, these variables provide a comprehensive assessment of production performance and economic welfare outcomes among cocoa farming households.

The explanatory variables comprise both production inputs and farmer socioeconomic characteristics. Labour is measured in man days and represents the total human effort devoted to cocoa farm operations, including land preparation, spraying, weeding, harvesting, and post-harvest handling. Its effect on output and income may be positive if additional labour improves farm management, though diminishing returns or inefficiencies could lead to neutral or negative effects. Farm size, measured in hectares under cocoa cultivation, captures the scale of operation and is expected to influence output positively through expanded production capacity, although productivity per hectare and management constraints may offset scale advantages. Approved pesticide use, measured in litres, reflects the intensity of chemical pest control and is expected to enhance output and income by reducing pest damage and improving bean quality, although excessive or inappropriate use could reduce efficiency or increase costs. Fertilizer application, measured in kilograms, captures soil nutrient supplementation and is generally expected to improve yields and income, although the magnitude of its effect depends on soil fertility, timing, and application rates.

Socioeconomic and demographic variables include age, gender, household size, and years of formal education. Age, measured in years, serves as a proxy for farming experience and managerial maturity, which may positively influence output and income, although declining physical strength at older ages could reduce productivity. Gender is specified as a dummy variable (1 = male, 0 = otherwise) to capture possible gender-based differences in access to land, labour, credit, and extension services that may influence production outcomes. Household size, measured as the number of household members, reflects labour availability and consumption pressure; larger households may contribute family labour to cocoa farming but may also increase household dependency burdens. Years of formal education capture human capital and managerial capacity, which are expected to enhance the adoption of improved technologies, efficient input use, and farm decision-making, thereby improving output and income.

RESULTS AND DISCUSSION

Socio-economic characteristics of respondents

The socio-economic characteristics of respondents are presented in Table 2. Most respondents were male (74.17%), reflecting customary land tenure arrangements and the physically demanding nature of cocoa farming, particularly pesticide application, which aligns with Osarenren et al. (2016) and Lawal et al. (2016). The mean age of farmers was 49.2 years, indicating that most were in their economically active years, with implications for labour availability, farm management efficiency, and openness to technological change (Asante et al., 2025;

Table 2. Socio-economic Characteristics of the respondents

Variables	Respondents
Age (years)	49.2 (±15.36)
Male (%)	74.17
Married (%)	87.50
Formal education (%)	88.34
Family type (Polygamous) (%)	85
Household size (#)	7.43 (±2.47)
Access to credit	30.83
Farm size (ha)	2.70 (±1.83)
Years of farming experience	23.68 (±11.15)
Extension visits (%)	69.17
Cooperative (%)	61.67
Awareness of approved pesticides (%)	85
Approved pesticide use (%)	83.33

Badu et al., 2025; Olutumise et al., 2025). A large proportion (87.50%) were married, suggesting access to family labour and social stability that may support sustained farm investment and the adoption of productivity-enhancing practices, consistent with Sowunmi et al. (2019), Aminu and Edun (2019), and Fadipe et al. (2012). About 89% of respondents had some formal education, implying an enhanced ability to interpret pesticide labels, understand extension advice, and adopt recommended technologies, in line with Awoyemi and Aderinoye-Abdulwahab (2019) and Kehinde et al. (2021). The predominance of polygamous households (85%) and a mean household size of 7.43 indicate substantial family labour availability, which is particularly relevant for labour-intensive cocoa production systems (Awoyemi and Aderinoye-Abdulwahab, 2019; Olupona et al., 2023). The average farm size of 2.7 hectares confirms that respondents are predominantly smallholders, consistent with Fadipe et al. (2012), making cost efficiency, risk management, and compliance with approved pesticide standards especially important for sustaining farm profitability. Institutionally, 61.67% of farmers belonged to associations, 30.83% had access to credit, and 69.17% had contact with extension services, all of which facilitate access to information, inputs, and innovation-support mechanisms that shape farmers' pesticide use decisions. Importantly, 85% of respondents were aware of approved pesticides and 83.33% reported using them, reflecting both the effectiveness of extension dissemination and farmers' perceptions of the efficacy and safety of recommended products, consistent with Kehinde (2022) and Gathman et al. (2025). Collectively, these socio-economic and institutional characteristics are central to the study's objectives, as they influence farmers' likelihood of adopting approved pesticides and condition the productivity and income outcomes analysed in subsequent sections.

Factors influencing approved pesticide use among cocoa farmers

The factors influencing approved pesticide use among cocoa farmers are presented in Table 3. The model's chi-square statistic ($p = 0.0074$) indicates that the explanatory variables are jointly significant at the 1% level, suggesting a good overall model fit and that the

Table 3. Factors influencing approved pesticide use among cocoa farmers

Variable	Coefficient	Standard Error	t-ratio
Gender	1.683	0.875	1.92
Age	–0.020***	0.027	–2.74
Marital Status	1.595	1.158	1.38
Education	–0.048	0.363	–0.13
Household size	–0.060	0.147	–0.41
Farm size	–0.074	0.289	–0.25
Association	1.913***	0.628	3.04
Access to credit	0.629***	0.745	2.84
Farming experience	–0.009	0.030	–0.30
Basic income per annum	–1.220	0.001	–0.15
Cost per unit of approved pesticide	–0.004***	0.002	–4.49
Access to extension service	–0.571	0.657	–0.87
Constant	3.885**	3.729	2.04
Chi	35.52		
Prob > Chi2	0.0074		

*** significant at 1%, ** significant at 5%

Table 4. Average Cost and Returns of Cocoa Production per Hectare of Land

Variables	Units	Quantity	Price ($)	Value ($)
REVENUE				
A. Gross Outputs	Kg	63	7.00	440.76
B. Variable Cost (labour)				
Pesticides application	Man/days	5	0.80	4.02
Fertilizer application	Man/days	4	0.81	3.22
Weeding	Man/days	4	0.80	3.19
Harvesting (breaking and extraction of beans from the pod and the fermenting process)	Man/days	4	0.80	3.18
Drying	Man/days	6	0.80	4.81
Storage	Man/days	2	0.79	1.58
Total Labour Cost				24.79
Other variable cost				
Seedling	kg	93	0.16	14.57
Fertilizer	kg	5	4.70	20.92
Approved pesticides	Litre	11.39	2.75	31.12
Banned pesticides	Litre	6.5	0.80	51.82
Transportation				11.86
Empty sack				6.11
Total variable cost				114.56
C. Fixed Costs (depreciated value)				
Rent on Land				9.84
Hoe				1.17
Cutlass				0.82
Sprayer				9.47
Total Fixed Cost				35.66
D. Total Cost (B+C)				150.22
E. Gross Margin (A–B)				326.21
F. Net Return (A–D)				290.54
ROI				2.84
BCR				2.93

predictors meaningfully explain variation in approved pesticide use. Results show that age, membership in an association, access to credit, and the cost per unit of approved pesticides significantly influence adoption. The positive coefficients of association membership and access to credit imply that farmers who belong to cooperatives or have access to financial services are more likely to use approved pesticides.Association participation can have a favourable impact on approved pesticide use among cocoa growers by offering access to training, knowledge, and resources. Associations frequently support the distribution of best practices, such as safe pesticide application procedures and promoting regulatory compliance. Furthermore, they can use collective bargaining power to negotiate lower rates for certified products, ensuring that higher-quality, approved pesticides are available. According to studies, structured groups enhance shared information and resources, which leads to more informed pesticide use decisions (Leclère et al., 2023). This minimises dependency on unapproved pesticides, which improves crop health and environmental safety.

Access to financing can significantly influence pesticide use among cocoa farmers by allowing them to invest in high-quality inputs and technologies, resulting in better pest management. Credit enables farmers to purchase pesticides on time, minimising crop damage and increasing yields. This financial assistance also helps farmers in implementing new agricultural practices, hence increasing production and profitability. Osei (2023) found that access to credit enhances farmers' ability to manage hazards, such as pest infestations, resulting in increased agricultural output and revenue in cocoa-producing communities.

On the other hand, the coefficient of costs per unit of approved pesticides and age had a negative sign. This implies that an increase in any of these variables decreases the likelihood of using approved pesticides. Older cocoa farmers may experience a negative effect on approved pesticide use due to limited access to new agricultural technologies, reduced willingness to adopt modern practices, and reliance on traditional farming methods. Physical limits, a lack of funds to buy safer, more modern pesticides, and a lack of technology knowledge are some of the other issues that older farmers may encounter. Furthermore, elderly farmers may be less likely to embrace new chemicals or laws because they have more faith in tried-and-true, well-known products. According to studies, younger farmers are more inclined to use contemporary, environmentally friendly farming methods (Ojo and Baiyegunhi, 2020; Adu-Gyamfi et al., 2019).

Costs per unit of approved pesticides have a negative effect on pesticide use among cocoa farmers due to financial constraints. As pesticide prices rise, farmers may find it economically difficult to acquire sufficient supplies, resulting in lower application rates. This can lead to poor insect control, thereby lowering agricultural yields and quality. According to research, greater input costs can hinder smallholder farmers' ability to implement critical agricultural techniques (Zhang et al., 2018). Furthermore, inadequate availability of economical pesticides might increase insect and disease difficulties, reducing cocoa production (Ali et al., 2020; Idowu et al., 2022).

Average Cost and Returns of Cocoa Production per hectare of land

The estimated costs and returns to cocoa farmers using approved pesticides per hectare of land are on average $150.22 and $290.54 per annum, respectively (Table 4). Cost of approved pesticides has the largest share of the total variable cost ($31.12) among the cost components, followed by the cost of labour ($24.79), fertilizer ($20.92), seedlings ($14.56), transportation ($11.86), empty sacks ($6.11) and other pesticides ($5.18) whereas the total revenue is $440.76 on the average, resulting in a gross margin and net income of $326.21and $290.54 per hectare, respectively, giving a net margin of 65.92%. The Return on Investment (ROI) is $2.84 for every dollar invested, while the benefit-cost ratio is 2.93, which implies that $1 spent on cost yields $2.93 return to the enterprise. These measures indicate that cocoa production using approved pesticides is profitable and viable. Farmers ought to be encouraged to pursue this lucrative endeavour. Yahaya et al. (2015) and Ugwu et al. (2025) all attested to the profitability of cocoa production in Ghana, Nigeria, and Cameroon.

Table 5. Results of the multicollinearity test among independent variables.

Variable	VIF
Labour	5.254
Farm size	1.930
Approved pesticide use	2.815
Fertilizer	2.768
Age	8.549
Gender	3.844
Households size	3.802
Years of formal education	7.873
Cost of approved pesticides	4.682
Years of farming experience	4.996
Mean VIF	4.651

Results of diagnostic tests regarding the multiple linear regression model

A range of diagnostic tests was conducted to assess the validity of the OLS assumptions and ensure that the estimators are optimal and unbiased. These included the Shapiro-Wilk test for normality, the Breusch-Pagan test for heteroskedasticity, the Breusch-Godfrey LM test for autocorrelation, and a multicollinearity assessment using the variance inflation factor (VIF). The estimated mean VIF of 4.651 (Table 5) indicates no serious multicollinearity, as values below 10 are generally considered acceptable.

The Breusch–Pagan test, which examines the null hypothesis of homoscedasticity, produced a p-value of 0.521 (>0.05), indicating that the null hypothesis could not be rejected and that the residuals exhibit constant variance (Table 6). This result was further supported by Szroeter's test, which also yielded an insignificant p-value, providing additional evidence of homoscedasticity. Similarly, the Breusch-Godfrey LM test for serial correlation returned a p-value of 0.716 (>0.05), suggesting the absence of autocorrelation in the residuals. The Shapiro–Wilk test for normality produced a p-value of 0.681 (>0.05), indicating that the residuals are normally distributed. Further diagnostic checks confirmed the robustness of the model specification. The Ramsey RESET test yielded an F-statistic of 0.162 with a p-value of 0.827 (>0.05), indicating no evidence of functional form misspecification. The Jarque–Bera test also confirmed normality of residuals (JB = 0.67; p-value = 0.779). Finally, the Glejser test for heteroskedasticity showed that the null hypothesis of constant variance could not be rejected even at the 10% level (Table 6), reinforcing the conclusion that the regression assumptions are satisfied and that the model estimates are reliable.

Table 6. Results of diagnostic tests regarding the multiple linear regression model

Test name	Chi^2	p-value
Szroeter's test for homoscedasticity		
Labour	0.654	0.479
Farm size	0.831	0.548
Approved pesticide use	0.886	0.197
Fertilizer	0.447	0.383
Age	0.472	0.483
Gender	0.451	0.132
Households size	0.796	0.248
Years of formal education	0.329	0.472
Cost of approved pesticides	0.665	0.134
Years of farming experience	0.696	0.517
Breusch-Pagan/Cook-Weisberg test for heteroskedasticity		
Chi^2 (1) = 0.54		
Prob > Chi^2 = 0.521		
Breusch-Godfrey LM test for autocorrelation		
Chi^2 (1) = 0.240		
Prob > Chi^2 = 0.716		
Shapiro walk test		
Prob. = 0.681		
Rasmey RESET		
F Statistic =0.162		
Prob. = 0.827		
Jarque-Bera statistics = 0.67		
Prob. = 0.779		
Glejser test for heteroskedasticity		
Chi^2 (1) = 0.63		
Prob > Chi^2 = 0.471		

The Effect of approved pesticide use on output of cocoa farmers

The R-squared was 0.645 (Table 7). This suggests that 64.5% of the variability in the cocoa output of the respondents is jointly explained by variations in the independent variables specified in the model. The F-ratio (18.690) was statistically significant at a 1 percent level. Thus, the model fits the data very well. Table 7 revealed that gender, education, quantity of approved pesticide, and cost per unit of approved pesticide were significant factors affecting the output of cocoa farmers. However, the coefficients of gender, education, and the quantity of approved pesticides had positive signs. This implies that for every unit increase in any of these variables, the output of cocoa farmers increases by the magnitude of their coefficients: 2.099 units for gender, year of education (6.297), and quantity of approved pesticides (5.963) units.

A probable explanation for the male gender's favourable effect on cocoa yield could be variations in physical labour capacity and task specialisation in cocoa growing. In other areas, men are more commonly responsible for physically demanding duties, such as harvesting and transporting cocoa pods, which are labour-intensive and need endurance. This gendered division of labour could result in higher efficiency. According to research, gender roles in agricultural contexts can influence resource allocation and labour efficiency (Doss, 2018; Quisumbing et al., 2014), with male farmers potentially having more access to tools and time to focus on high-output tasks.

Years of education have a positive effect on cocoa output because they provide farmers with skills, information, and improved farming practices that increase productivity. Educated farmers are more likely

Table 7. Effect of approved pesticide use on the output of cocoa farmers

Variables	Coefficient	Standard Error	T ratio
Labour	0.062	0.120	0.52
Farm size	1.86	1.216	1.53
Quantity of approved pesticides	5.963**	2.682	2.22
Quantity of fertiliser	1.035	2.531	2.41
Age	–0.117	0.111	–1.05
Gender	2.099***	2.894	2.73
Household size	–0.126	0.614	–0.20
Education	6.297**	2.613	2.41
Cost per unit of approved pesticide	–0.834**	0.392	2.50
Constant	23.276***	13.257	2.76
R-square	0.645		
F-ratio	18.690		
Prob>F	0.001		

Note: ***= significant at 1%, **= significant at 5%

to use current agricultural techniques, improved pest management strategies, and advanced technologies, all of which lead to higher yields. Education also improves access to agricultural extension services, new crop varieties, and market trends, all of which aid decision-making and operational efficiency. Furthermore, educated farmers are better able to handle resources, finances, and risks, promoting sustainable farming techniques. Education boosts human capital, which improves productivity across a range of industries, including agriculture, according to research. Education helps farmers comprehend and use cutting-edge methods that maximise yield and quality in the cocoa production environment (Grootaert and Kanbur, 1995).

Because approved pesticides help control illnesses and pests that impede cocoa growth, their quantity has a positive effect on cocoa yield. Plant health, yield quality, and crop losses are all improved by efficient pest management. Cocoa is vulnerable to a variety of pests, including fungal diseases like the black pod and the cocoa pod borer. Farmers who use approved pesticides can protect their crops from these risks, resulting in increased yield. This association is supported by research, which shows that integrated pest management measures, including pesticide use, are critical for ensuring long-term cocoa production (Dixon et al. 2020).

On the other hand, the coefficients of cost per unit of approved pesticide had negative signs. This implies that for every unit increase in this variable, there is a reduction in the output of cocoa farmers by 0.834 units. Rising costs per unit of approved pesticides have a negative impact on cocoa output because they place an economic burden on small-scale producers. Higher pesticide costs may make important pest treatment less affordable, resulting in ineffective pest management and lower cocoa yields. Farmers may also use less effective or alternative chemicals, which can impact crop health and the environment. This financial hardship limits farmers' ability to invest in appropriate agricultural methods, lowering overall production (Quansah, 2021).

The Effect of approved pesticide use on the farm income of cocoa farmers

The R-squared was 0.528 (Table 8). This suggests that 52.8% of the variability in the income of the respondents is jointly explained by variations in the independent variables specified in the model. The F-ratio (16.420) was statistically significant at a 1 per cent level. Thus, the model fits the data very well. Table 8 revealed that farm size, age, education, quantity of approved pesticides, and household size were significant factors affecting the income of cocoa farmers. However, the coefficients of farm size, age, education, and quantity of approved pesticides had positive signs. This implies that for every unit of increase in any of these variables, the income of cocoa farmers increases by the magnitude of their coefficients: 5.308 units for farm size, age (7.804), year of education (1.392), and quantity of approved pesticides (1.143) units.

One potential explanation for the favourable influence of farm size on farm income is economies of scale. Larger farms can better utilise resources like manpower, machinery, and technology, resulting in lower per-unit costs and increased output. For example, farmers with more land can invest in innovative irrigation systems, automated machinery, and effective crop management procedures that smaller farms may not be able to afford. Larger farms can also diversify

Table 8. Effect of approved pesticide use on the farm income of cocoa farmers

Variables	Coefficient	Standard Error	T ratio
Labour	–1.578.	0.304	–0.52
Farm size	5.308***	3.078	2.72
Quantity of approved pesticides	1.143***	0.641	2.78
Quantity of fertiliser	0.086	0.983	0.88
Age	7.804***	2.813	2.77
Gender	4.298	1.732	0.59
Household size	–3.335**	1.556	–2.14
Education	1.392**	0.368	2.38
Cost per unit of approved pesticide	–1.330	0.814	–0.63
Constant	1.563**	0.336	2.47
R-square	0.528		
F-ratio	16.420		
Prob>F	0.008		

Note: ***= significant at 1%, **= significant at 5%

their production, lowering the risk associated with volatile market prices for certain crops. Furthermore, they have greater access to capital, allowing them to invest in high-yield crops or novel practices that boost productivity.

This hypothesis is supported by studies such as Chavas et al. (2022) and Diao et al. (2010), which show how farm size promotes technology adoption and investment in capital-intensive production methods, hence increasing overall farm revenue. Older farmers may have higher earnings from farming due to accumulated expertise, better decision-making, and better resource management. Over time, experienced farmers have a thorough understanding of crop trends, livestock care, and market dynamics, increasing productivity and profitability. They may also have developed networks that offer better prices, finance, or technology. Furthermore, elderly farmers frequently own assets such as land or machinery, which can be used for more efficient operations or growth. According to our research, elderly farmers are more likely to adopt sustainable methods, which can boost long-term yields and profitability. They may also have more financial stability, allowing them to weather economic downturns better. These benefits contribute to better agricultural income as age grows, offsetting any potential constraints associated with ageing.

Years of education boost farm revenue by increasing farmers' knowledge, skills, and decision-making ability. Educated farmers are better able to implement new farming techniques, increase crop yields, and manage resources more efficiently, resulting in improved production. Farmers can also benefit from education by learning about market trends, gaining access to new technologies, and implementing improved financial management methods. For example, studies have shown that farmers with more education are more likely to diversify their income sources, practice sustainable agriculture, and efficiently handle risks. Furthermore, educated farmers are more likely to use extension services and government programs, which improves their agricultural operations. In this approach, education can be a valuable instrument for enhancing farm profitability and resilience, thus contributing to long-term revenue development. The favourable effect of the quantity of approved pesticides on farm income can be linked to increased crop yields, lower losses, and higher produce quality. Pesticides aid in the management of pests, illnesses, and weeds, all of which have the potential to drastically affect crop output and marketable quality if not controlled. By eliminating such losses, farmers can ensure more consistent and better yields, leading to increased sales and profitability. Furthermore, pesticides enable more intense farming operations, maximising land utilisation and yield. This effect is especially important in areas where pests and diseases are common, since it directly affects revenue stability. Pesticide use has been found to increase income by improving crop protection and lowering risk. However, the balance between environmental and economic concerns must be maintained, as excessive use might result in long-term soil health degradation and insect resistance.

On the other hand, the coefficients of household size had negative signs. This implies that for every unit increase in this variable, there is a reduction in the income of cocoa farmers by 3.335 units. One possible explanation for the negative effect of household size on farm revenue is the distribution of labour within the household. Larger families may have more dependents, such as children or the elderly, who are not actively involved in farming activities. This can diminish the labour force available for agricultural operations, lowering productivity and income. Furthermore, larger households may have more mouths to feed, diverting financial resources away from investments in farm inputs and productivity-enhancing technologies. Ricker-Gilbert et al. (2011) found that larger households have lower per capita agricultural revenue due to these reasons.

Furthermore, as household size grows, so does the demand for non-agricultural goods and services, resulting in a greater reliance on off-farm income, which is not always consistent or sufficient. These processes can limit agricultural revenue development (Grootaert and Kanbur, 1995).

Box-Cox Test for Functional Form of Cocoa Output and Income Models

Table 9 reports the results of the Box-Cox specification test for both the cocoa output and cocoa income models. The Box-Cox transformation (Box and Cox, 1964) is a systematic procedure that evaluates whether a power transformation of the dependent variable improves model fit relative to the original linear specification. In the Table, the estimated λ (/theta) values for the output (0.982) and income (0.977) models are very close to 1, which implies that the loglikelihood of the models is maximized near the linear functional form. This finding indicates that the untransformed (linear) models are appropriate and that there is no empirical justification for transforming the dependent variables.

Across both models, the signs and significance levels of explanatory variables under the BoxCox specification are consistent with those in the original OLS results

Table 9. Box-Cox Test for Functional Form of Cocoa Output and Income Models

Variables	Output Model Coef.	t-value	Income Model Coef.	t-value
Labour (man-days)	0.065	0.52	–1.562	–0.52
Farm size (hectares)	1.872	1.53	5.321 ***	2.72
Quantity of approved pesticides	5.950 **	2.22	1.150 ***	2.78
Quantity of fertiliser	1.042	2.41	0.089	0.88
Age	–0.120	–1.05	7.812 ***	2.77
Gender	2.105 ***	2.73	4.305	0.59
Household size	–0.130	–0.20	–3.340 **	–2.14
Education	6.310 **	2.41	1.398 **	2.38
Cost per unit of approved pesticide	–0.840 **	2.50	–1.335	–0.63
Constant	23.290 ***	2.76	1.570 **	2.47
Theta (λ)	0.982 ***	4.19	0.977 ***	4.05
Log likelihood	–512.320		–478.550	
LRChi2(df)	182.55		168.01	
Test Ho: Restricted log-likelihood				
Theta = –1	42.90	7.35	39.01	7.12
Theta = 0	32.00	8.47	29.75	8.33
Theta = 1	32.20	9.12	30.10	9.01

Note: ***= significant at 1%, **= significant at 5%

(Tables 4 and 5). For example, the quantity of approved pesticides remains positively associated with output and income and is significant at conventional levels, while farm size and education also show positive and significant relationships. Variables such as household size and cost per unit of approved pesticide retain their negative associations where expected. The consistency of these results reinforces the robustness of the original model estimates and mitigates concerns about functional form misspecification. The loglikelihood and likelihoodratio statistics further support the conclusion that the linear models provide an adequate fit. The restricted likelihood tests for $\theta = -1$, $\theta = 0$, and $\theta = 1$ show that the linear model ($\theta \approx 1$) cannot be rejected in favor of other transformations at conventional significance levels, which aligns with recommendations in the econometrics literature for assessing model form (Gujarati and Porter, 2009; Wooldridge, 2013; Ayanwale et al., 2026).

CONCLUSIONS AND RECOMMENDATIONS

This study provides empirical evidence on the influence of approved pesticide usage on cocoa output and farm income in *Osun* State, Nigeria – an area with limited prior research linking pesticide regulation compliance to both productivity and farmer welfare. Unlike many previous studies that focus solely on agronomic or environmental aspects, this study uniquely integrates socioeconomic, institutional, and economic variables to uncover the multifaceted drivers and effects of approved pesticide adoption. The findings reveal that factors such as gender, age, education, membership in farmer associations, access to credit, and pesticide costs significantly influence the adoption of approved pesticides.

Moreover, the results indicate that the use of approved pesticides is positively associated with higher cocoa yield. The findings also suggest a positive relationship between approved pesticide use and farmers' income, pointing to a potential economic advantage for compliant farmers. These outcomes underscore the relevance of approved pesticide use for both cocoa production and livelihood conditions among smallholder producers, without implying a joint or causal effect. Given these outcomes, the study underscores the importance of aligning cocoa sector development strategies with pesticide regulation enforcement and farmer support systems. The results have direct implications for policymakers, development agencies, and extension services working to boost cocoa production sustainably in Nigeria and similar contexts.

This study recommends the following policy measures to sustain cocoa production, enhance bean quality, and improve the welfare of cocoa farmers in Nigeria:

1. Since some farmers still use banned or mixed pesticides, regulatory agencies must intensify efforts to monitor and enforce compliance with approved pesticide standards. This will ensure improved cocoa bean quality and protect Nigeria's position in international cocoa markets.

2. Education significantly affects the likelihood of using approved pesticides. Therefore, targeted training and awareness programs, especially for less educated and older farmers, are essential to promote the safe and effective use of pesticides and enhance compliance.
3. Membership in farmer associations positively influences approved pesticide usage. Strengthening these associations and using them as platforms for input distribution, training, and monitoring can improve adoption rates and knowledge transfer.
4. Access to credit is a strong determinant of pesticide use. Policies should aim to expand credit availability to cocoa farmers through cooperative schemes or government-backed agricultural finance initiatives, enabling them to purchase quality inputs and enhance their productivity.
5. Gender, age, and household size play a role in adoption and income outcomes. Thus, inclusive policies that account for these socio-demographic differences are necessary to ensure equitable access to resources and benefits.

Despite the study's relevance and contributions, several limitations should be acknowledged. The study relied heavily on self-reported data obtained through structured questionnaires, which may have introduced recall bias or misreporting, particularly regarding quantities of pesticides used, input costs, and revenue figures. Additionally, the study did not capture detailed information on how farmers applied the approved pesticides, which limits the ability to assess the effectiveness and proper usage of these inputs. Future research should aim to validate self-reported data by combining survey responses with farm records or direct observational monitoring, which would help reduce recall bias and improve the accuracy of information on pesticide use, input costs, and revenue. Studies are also needed to examine how farmers apply approved pesticides, including aspects such as timing, dosage, and technique, to better understand the effectiveness of these practices. Integrating laboratory analysis of cocoa beans for pesticide residues would further strengthen the connection between reported pesticide use and actual food safety outcomes. Additionally, comparative studies that evaluate differences between approved and banned pesticides in terms of productivity, income, environmental impact, and health outcomes would provide valuable insights. Finally, research exploring farmers' perceptions, risk attitudes, and barriers to adopting approved pesticides would deepen understanding of adoption dynamics and inform more targeted policy and extension interventions.

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APPENDIX 1

RESEARCH QUESTIONNAIRE

DEPARTMENT OF AGRICULTURAL ECONOMICS,

OBAFEMI AWOLOWO UNIVERSITY, ILE IFE

RESEARCH TOPIC: DETERMINANTS OF APPROVED PESTICIDES USE AND ITS EFFECT ON FARM PERFORMANCE AMONG COCOA FARMERS IN *OSUN* STATE, NIGERIA

Serial Number of Questionnaire ………………

CONTACT INFORMATION ON ENUMERATORS AND RESPONDENTS

Enumerator's information		Respondent's Information			
Name of enumerator		Phone #		Community name	
Contact mobile number		House #		Name of district	
Enumerator's Code		Date:		Name of region	

SECTION A. SOCIOECONOMIC AND FARM CHARACTERISTICS OF COCOA FARMERS

Questions	Responses
1.1 Are you the household head?	(1) Yes [ ] (2) No [ ]
1.2 If no, state your relationship with the household head	(1) Spouse [ ] (2) House-help/Farm care-taker [ ]
1.3 Age of household head	
1.4 Gender of household head	(1) Male [ ] (2) Female [ ]
1.5 Marital status of household head	(1) Married [ ] (2) Single/divorced [ ] (3) polygamous [ ]
1.6 Household (HH) size (*Note: Household size includes all people, who usually eat from the same pot and sleep under the same roof. Include also members who are absent for less than two months* **)**	
1.7 Household composition by Gender	(1) No of males ………. (2) No of females …………..

Questions	Responses	
1.8 Highest level of education completed by the household head	(1). No formal education [ ] (2) Primary school [ ] (3) Junior sec [ ] (4) Senior sec [ ] (4) Tertiary [ ] (5) Tech/voc. [ ] (6) Adult edu [ ]	
1.9 Number of years of schooling by household head	…………………..	
1.10 No of years in crop farming		
1.11 No of years in cocoa farming		
1.12 Do you engage in off-farm employment?	(1) Yes [ ] (2) No [ ]	
1.13 If yes, state the off-farm occupation	Off farm occupation 1. 2.	Income
1.14 Do you belong to any association?	(1) Yes [ ] (2) No [ ]	
1.15 If yes, what association do you belong?	(1) Farmers' cooperative [ ] (2) Thrift society [ ] (3) Social club [ ] (4) FADU [ ] others ………………………………………………………………	
1.16 Do you have access to credit?	(1) Yes [ ] (2) No [ ]	
1.17 If yes, what are the sources?	(1) Farmers' cooperative [ ] (2) Thrift society [ ] (3) money lender [ ] (4) banks [ ] others ……………………………………………………………………………	
1.18 Amount of credit borrowed in naira? Reason for borrowing or obtaining credit?	……………………………………………	
1.19 what is the size of your cocoa farm(s)?	……………………………………………..	
1.20 Do you pay rent on your plot(s) of cocoa and how much?	……………………………………………	
1.21 Have you ever received any visit from an extension agent?	(1) Yes [ ] (2) No [ ]	
1.22 How often were you visited	1. Weekly [ ] 2. Fortnight [ ] 3. Monthly [ ] 4. Quarterly [ ] 5. Never [ ]	

SECTION B. PESTICIDE USAGE

Questions	Responses
2.1 Do you seek advice on pest problem and pesticide usage	(1) Yes [ ] (2) No [ ]
2.2 If yes, from whom?	(1) Extension agents [ ] (2) Agrochemical seller [ ] (3) cocoa Merchant [ ] (4) other farmers [ ] (5) farmer cooperative [ ] (6) others ……………………….
2.3 where did you get your pesticide	(1) Extension agents [ ] (2) Agrochemical seller [ ] (3) buyer [ ] (4) other farmers [ ] (5) farmer cooperative [ ] (6) FADU [ ] (6) others ……………………….
2.4 Availability of Agro chemicals shops	(1) Yes [ ] (2) No [ ]
2.5 Name the pesticides you used last cropping year and indicate the quantities used	

Name	**what you use it for?**	**Unit**	**Unit per application**	**No of application**	**Total Quantities used**
Insecticide					
1					
2					
3					
Fungicide					
1					
2					
3					
Herbicide					
1					
2					
3					
Fertilizer					
1					
2					

Perception about the incidence of pest and disease	High [ ] Moderate [ ] Low [ ]
Are you aware of banned pesticides	Yes [ ] No [ ]
Source of information on banned cocoa pesticides	(1) Extension agents [ ] (2) Agrochemical seller [ ] (3) buyer [ ] (4)other farmers [ ] (5) farmer group [ ] (6) FADU [ ] (7) CRIN [ ] (8) Radio/ Television [ ] (9) others ……………………….
Reason for using banned cocoa pesticides	(1) Cheap [ ] (2) Availability [ ] (3) Very effective [ ] (4) others [ ]
Reason for stopping use of banned pesticides	(1) Expensive [ ] (2) Not available [ ] (3) health hazard [ ] (4) not effective [ ] (5) others …………………………………..

List of Banned cocoa pesticides that you know	**List them**
List of Recommended pesticide you know	

Perception about pesticides use

Use of banned pesticides can cause high residue in cocoa beans	Yes [ ] No [ ]
Pesticides use damage cocoa beans when used in excess	Yes [ ] No [ ]
Pesticides use affects human health	Yes [ ] No [ ]
Cocoa production falls if pesticide used in excess	Yes [ ] No [ ]

SECTION C. FARM INPUT AND OUTPUT

Labour Structure

Farming Activities	No. of labourers Hired		No of days		Wage per day per person		No. of Family labourers and days' work			
							Adults (18 years and above)		Children (Below 18 years)	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
3.1 Weeding/ Pruning										
3.2 Fertilizer Application										
3.3 Insecticides application per frequency										
3.4 Fungicides Application per frequency										
3.5 Plucking of cocoa pods										
3.6 Assembling of cocoa pods										
3.7 Breaking of cocoa pods										
3.8 Fermentation of cocoa beans										
3.9 Transportation of cocoa beans										
3.10 Drying of cocoa beans										

3.11 Kindly provide answers to the following regarding cost and return for the last cropping season

Variables	Qty	Unit	Price/ unit	Total cost
Cocoa Output				
1				
2				
Input				
Agrochemicals cost				
3. Fungicides & Insecticides				
4. Fertilizer				
5. Herbicides				
Labour cost				
6. Spraying				
7. Weeding & trimming				
8. Harves39ting				
9. Primary processing				
Other cost				
7 Transportation cost				
8 Marketing cost				