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Cocoa Farmer's Use Of Approved Pesticides And Compliance With Safety Standards In Obuasi Municipality, Ghana

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***Abstract*—Amidst the agricultural landscape of Ghana lies a complex interplay of practices governing the use of approved pesticides and adherence to safety standards among farmers. By analysing data gleaned from 400 farmers through the multistage sampling technique, our aim is reveal the multifaceted influences that shape farmers' decisions in the use of approved pesticides and safety compliance. Age, education, marital status, farm ownership, experience, farm size, access to equipment and services, cooperative membership, secondary occupations, and income, significantly influence farmers' choices in the use of approved pesticides. Furthermore, compliance with safety protocols is found to be influenced by factors such as farm size, access to extension services, and the perceived relative advantage of pesticides. We advocate for policies that promote the use of approved pesticides and prioritise safety standards in agricultural practices. This may include strengthening regulatory frameworks, incentivising sustainable farming practices, and enforcing penalties for non-compliance with safety regulations.**

Keywords*—approved, compliance, cocoa farmers, pesticides, safety standards

I. Introduction

Agriculture is one of the industries with the highest global pesticide usage [1]. Each year, the global use of pesticides doubles by 50%. Pesticide usage totals 2.5 million tonnes (5 billion pounds) a year [2]. Additionally, current pesticides are 10 to 100 times more dangerous than earlier pesticides. The average quantity of pesticides used worldwide is 0.5 kg/ha. However, this number might be greater in some developed countries and industries. Taiwan uses about 17 kg, the Republic of Korea uses 14 kg, Japan uses 12 kg, the Netherlands uses 9.4 kg, and the United States uses 7 kg. Pesticide use is rising quickly in middle- and low-income countries, especially in the East [3, 49].

Regulation and registration of pesticides led to a new economic boom, resulting in an increase in the registration of pesticide products for use in Ghana. However, the use of pesticides has had adverse effects on individuals involved in the food supply chain, including farmers, merchants, and consumers [4]. Excessive and improper crop usage has had a detrimental impact on production, the environment, and human health. The use of cheap, falsified, and contaminated pesticides in Ghana has increased due to ineffective government enforcement of pesticide rules, poor farmer awareness of pesticide types, uses, and hazards, and strong financial incentives among pesticide users and merchants [5].

Given these issues, there has been a move towards the use of more environmentally friendly pesticides, which resulted in the introduction of Ghana's pesticide registration system in 2003. The Pesticide Regulation and Management Act, Act 528 of 1996, was the applicable pesticide regulation at the time. Act 490 of 1994, which established the Ghana Environmental Protection Agency [6], now includes the statute in Part II. This regulation covers the whole pesticide life cycle, as well as pesticide registration, procurement, importation, distribution to farmers, retail sales, quality control inspections, and waste disposal.

In 2009, the introduction of the Cocoa Disease and Pest Control Programme (CODAPEC), also known as mass spraying, aimed to address the issue of pest and disease management for smallholder farmers [7]. The local community assembles and trains spraying teams to spray each farm twice between August and December. However, due to climate change, the twice-yearly spraying of this pesticide is insufficient to reduce production costs. As a result, farmers must purchase chemicals to spray their farms as soon as they detect insect pests, in addition to mass spraying. This has led to some farmers purchasing unapproved pesticides from the open market. This also implies that farmers are unable to adhere to safety regulations, despite the established benefits of compliance on their income and assets [8].

Despite the efforts made by COCOBOD to provide approved pesticides such as insecticides, fungicides, fumigants, and weedicides to cocoa farmers in the country to control pest and disease incidence, reduce their effect on the cocoa trees, and maintain high product quality, cocoa farmers still use pesticides from unknown and unapproved sources. The resultant effects include numerous sick or dying cocoa trees, the emergence of pests and diseases, low productivity, the presence of poisonous substances in cocoa beans, and high toxicity, all of which pose potential health risks to farmers (Manual for Cocoa Extension in Ghana). Local markets still contain numerous banned pesticides, which pose potential risks to both the environment and human health. The abuse of pesticides is more common in rural areas of developing countries [8].

Numerous researchers [8, 9, 10] have researched pesticides. In Nigeria, [9] revealed 100.0% compliance with the pesticide's safety precautions. The use of pesticides is still high among farmers, but they do not follow the COCOBOD recommendations [10]. According to [8], most farmers knew about pesticide usage, but the majority did not use the recommended pesticide rate. Cocoa farmers are unaware of and have a bad attitude towards wearing protective equipment (PPE) when handling and applying insecticides. Additionally, farmers exhibit poor behavior when it comes to handling pesticides during application. Furthermore, [12] indicated that farmers suffer severe health concerns due to a lack of education and awareness and incorrect application procedures, such as irresponsible handling of pesticides.

Despite the numerous studies on pesticides, most of them focused on pesticides in a general sense. To ensure a more accurate analysis, this study looks at the COCOBOD-approved pesticides and their specific classifications. Again, in most of the studies, there is less or no emphasis on farmers` use and compliance with safety standards. This study contends that addressing the aforementioned policy gaps on pesticides is crucial to enable cocoa farmers to apply approved pesticides and fully adhere to the standards. Hence, the major contribution of this study to the literature on pesticides is the assessment of farmers' use of approved pesticides and compliance with safety standards on cocoa farms in Obuasi Municipality. The study specifically seeks to: assess farmers' perceptions towards the use of COCOBOD-approved pesticides; determine the factors that influence farmers' extent of use of COCOBOD-approved pesticides; determine the factors that influence farmers' compliance with safety standards; and identify and rank the constraints faced by cocoa farmers in using the approved pesticides.

II. METHODS

We conducted the study in the Obuasi Municipality in the Ashanti Region of Ghana. The Obuasi municipality is located in the southern part of the Ashanti Region of Ghana and is about 64 km from Kumasi. It lies between latitudes 5 ˚35N and 5 ˚65N and longitudes 6 ˚35W. The municipality spans a total land area of 109.5 km2, with the Upper Denkyira East Municipality of the Central Region to the south, Adansi South District to the east, and Adansi North District to the north [13]. The district population was 104,297, with an annual average growth rate of 1.1%. Out of the total population, 51,885 were males and 52,412 were females, with 69,034 and 10,299 being literate and illiterate, respectively [13].

The study employed a cross-sectional research strategy to gather data from the sample chosen to represent the larger population. Therefore, to achieve the primary objectives of the study, we employed a quantitative research methodology known as a survey, which allowed for the simultaneous collection of data from a large population. For this study, all cocoa farmers in the Obuasi district were the target population. In the Obuasi municipality, there are a total of 15,257 registered cocoa farmers who operate approximately 32959 farms. We calculated the sample size using [14]'s formula. We derived a total sample of 389. However, we adjusted it to 400 to accommodate more respondents.

The study employed a multistage sampling technique that included purposive, cluster, and simple random sampling techniques at various stages to select 390 farmer households. Okoffo [11] reported that, compared to a single sampling technique, multi-stage sampling produces a more representative sample of the population, which can lower the cost of large-scale survey research. We purposefully selected Obuasi municipality as one of the cocoa districts in the Ashanti region of Ghana. The next stage involved a cluster selection of three political districts or areas in Obuasi, namely, Obuasi East, Obuasi West, and Adansi North, each with a cocoa operational area. We used the simple random sampling technique to select five communities in each political district and farm households from each of the three site districts, thereby circumventing bias and ensuring a probability of selection for every member of the population.

The researchers designed a structured questionnaire that exclusively featured closed-ended questions. The researcher administered the questionnaire in the local language to all 400 farmers, but only a small percentage of the literate farmers filled it out themselves. The researcher did not select farmers for interviews based on their gender, religion, or political affiliation. We educated village head farmers and opinion leaders in each chosen community about the study's goals before interviewing any farmer. To enhance the accuracy of the information provided, we ensured that the interview was conducted with farmers through the appropriate chain of command in each community. We administered the questionnaire in March–April 2023.

We used the Statistical Package for Social Scientists (SPSS) to analyze the collected data. We used a variety of descriptive and inferential statistical tools, including frequencies, percentages, means, standard deviation, perception index, multivariate probit regression model, binary probit model, and Kendall's coefficient of concordance.

We used a five-point Likert scale, ranging from disagree (1) to strongly agree (5), to analyse farmers' perceptions of COCOBOD-approved pesticides. We computed the mean score for each perception to obtain the perception index.

$$Mean\ Score = \frac{\sum (Frequency_1 \text{x} code_1) + (Frequency_2 \text{x} code_2) + \cdots + (Frequency_k \text{x} code_k)}{N}$$

Were,

PI is the overall perception index,

N is the total number of respondents

N_{ps} is the number of perceptions

We used a five-point Likert scale, ranging from never (1) to always (5), to analyse farmers' use of 51 COCOBOD-approved pesticides. Following this, we classified farmers who used less than 50% as no-use (0), and those who used more than 50% as use (1). We then used the multivariate probit regression model to analyse the factors that influence farmers' use of COCOBOD-approved pesticides. We used this model due to the presence of multiple dependent variables, including insecticides, fungicides, herbicides, and fumigants. The multivariate probit regression model is generally described below:

$$Y_{im}^* = a_o + \beta X_{im} + \varepsilon_{im} \qquad m = 1,2,\ldots,M$$

$$Y_{im} = \begin{cases} 1, & if\ Y_{im}^* > 0 \quad \text{(cocoa farmer) utilizes approved pesticides)} \\ 0, & if\ Y_{im}^* \leq 0 \quad \text{(cocoa farmer) do not utilizes approved pesticides)} \end{cases}$$

The empirical model is specified as;

$$Y_{im}^* = a_o + \sum_{i=1}^{14} \beta_{mi} X_{im} + \varepsilon_{im}$$

Where Y_{im}^* represents the dependent variables (use of approved pesticides), X_{im} represents the vector of independent variables influencing cocoa farmer i^{th} use of approved pesticides, β represents the vector of unknown parameters to be estimated and ε_{im} represents random error terms.

We used a five-point Likert scale, ranging from never (1) to always (5), to analyse farmers' compliance with 28 COCOBOD compliance standards. Next, we classified farmers who comply with less than 50% as no-compliance (0), and those who comply with more than 50% as compliance (1). We then used the binary probit regression to analyse the factors that influence cocoa farmers' compliance with safety precautions. The general specification of the binary probit regression model is given below:

$$Ad_i^* = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \cdots + \beta_k X_{ki} + \mu_i$$

$$Ad_i = \begin{cases} 1 & \text{if the i (cocoa farmer) utilizes approved pesticides} \\ 0 & \text{if the i (cocoa farmer) utilizes approved pesticides} \end{cases}$$

Where;

i is the cocoa farmer (respondent),

μ is the error and

X is the independent variables (e.g. age (continuous variable: years), sex (dummy variable: Male-1, Female-0), Educational Level (continuous variable: years of formal education), Total family size (continuous variable: number of people), Farm size (continuous variable: number of farm size in hectares), Marital status (dummy: Married-1, Others-0), education (continuous: years), farm size (continuous: acres), Access to extension services (dummy: 1 if farmer had extension service, 0= otherwise) etc.

The cocoa farmers' challenges were analysed using Kendall's Coefficient of Concordance. The most severe challenge was ranked as 1 whilst the least severe challenge was ranked as 18. The coefficient of concordance was then calculated between the ranges of 0 to 1. A coefficient of 1 represents a complete agreement among respondents, and 0 indicates that there is no agreement.

Kendall's coefficient of concordance (W) is estimated as:

$$W = \frac{12 \sum Ri^{-2} - 3N(n-1)^2}{N(N-1)}$$

Where;

W represents Kendall's value,

N is the total size and

R is the means of the rank.

III. RESULTS AND DISCUSSION

A. *Sample Characteristics*

TABLE I. SOCIO-DEMOGRAPHIC CHARACTERISTICS OF THE RESPONDENTS

Variables	Mean	SD
Age	54.002 years	12.760
Years of education	6.035 years	3.517
Household size	7.302	4.254
Number of dependents	5.582	4.028
Farming experience	21.857 years	12.831
Farm size	6.921 acres	5.481
Farm age	20.735 years	12.517
Income	6483.50 GHC	15177.690
Marital status	0.770	0.500
Land ownership	0.497	0.775
Religion	0.695	0.250
Sex	0.657	0.475
Access to knapsack	0.625	0.350
Access to labour	0.675	0.150
Traceability programme	0.592	1.125
Farmer cooperative	0.857	0.355
Access to extension	0.925	0.522
Other crops	0.850	0.851
Other livestock	0.760	0.669
Secondary occupation	0.632	0.337

Source: Field Data, 2023

Table I reveals that the average age of farmers is 54 years, suggesting an older population. The findings of this study are in line with those of [16], who discovered that older farmers were less likely to adopt best management practices in cocoa farming. Cocoa farmers have an average of 6.03 years of formal education. Farmers' capacity to adopt pesticide usage and adhere to safety standards depends critically on education [17, 18]. The average cocoa farmer's household size is seven (7). This shows that respondents have relatively large households, which can serve as a source of farmhands [15].

The average number of dependents is 5.58. The number of dependents can influence farmers' investment decisions regarding sustainable practices. The average farming experience is 21 years. A farmer's experience can influence their knowledge, skills, and decision-making processes. Odongo [19] discovered a positive correlation between farming experience and adoption behaviour. This highlights how crucial it is to leverage the knowledge and expertise of experienced farmers to promote the adoption of pesticide usage and adherence to safety standards among less-experienced farmers. According to the findings, the mean farm size is 6.92. Farm size and output have a positive association, according to [20].

The average farmer is 20 years old. Farm age is a good indicator of how long and how well-established cocoa farms are. One could consider such a farm to be less productive [21]. This could contribute to the recent drop in the nation's overall cocoa production [22]. The average farmer's income was 6483.50 GHC. Income level can play a significant role in farmers' ability to invest in pesticide usage practices and comply with safety protocols. Higher-income levels provide farmers with more resources to adopt sustainable technologies and implement recommended practices [23].

Most cocoa producers are married. This outcome is consistent with the findings of [10], who claim that married people engage in agricultural activities. The majority of farmers' land. A study by [24] found that secure land ownership positively influenced farmers' purchasing power and sustainable land management practices. The findings suggest that policies and interventions that promote secure land tenure and address land ownership issues are needed to facilitate farmers' adoption of sustainable techniques such as pesticide application in cocoa production. The majority of farmers are married men who own knapsacks or motorbikes, have access to labour and extension services, participate in traceability programs and farmer cooperatives, plant other crops, rear other animals, and engage in other secondary occupations. The design of traceability programmes aimed to meet the needs of cocoa producers and set a price that allows them to earn a livelihood. Kehinde [25] claims that cooperative membership significantly affects a farmer's ability to fully adopt new technologies for improving cocoa production. Their involvement in side businesses could influence cocoa growers' ability to repay loans in terms of credit access.

B. *Perception of farmers towards the use of approved pesticides*

TABLE II. PERCEPTION TOWARDS THE USE OF APPROVED PESTICIDES

Statements	Mean	SD
Cost [Mean =3.63, SD=1.30]		
COCOBOD approved pesticides are free of charge	3.8050	1.380
COCOBOD sprays it freely for farmers through the CODAPEC mass spraying initiative	4.0275	1.067
COCOBOD approved pesticides are less costly in market/agrochemical shops	3.0450	1.458
Residue [Mean=2.56, SD=1.25]		
The approved pesticides leave residues on plants	2.5650	1.276
The approved pesticides leave residues in the cocoa beans	2.5200	1.203
The approved pesticides leave residues in the soil	2.6050	1.268
Effectiveness [Mean=3.78, SD=1.23]		
COCCOBOD approved pesticides promote plants' health and growth	3.7750	1.147
COCCOBOD approved pesticides control/kill pests as expected	3.7925	1.305
Availability [Mean=2.84, SD=1.41]		
COCOBOD approved pesticides are readily available in market/agrochemical shops	3.2350	1.483
COCOBOD approved pesticides are readily available at district offices	3.1900	1.335
You can get COCOBOD approved pesticides at anytime	2.9500	1.397
The quantity of pesticides supplied by COCOBOD is enough for the members of the community and the farm area	2.2675	1.400
The approved pesticides supplied by COCOBOD are given to farmers on time.	2.5350	1.448
Risk to the plant health [Mean=3.62, SD=1.19]		
COCCOBOD approved pesticides do not pose any risk to the cocoa plant	3.5725	1.222
COCOBOD approved pesticides do not negatively affect cocoa plant growth	3.6600	1.150
Accessibility [Mean=3.55, SD=1.15]		
COCOBOD approved pesticide is easily accessible to members of the cocoa communities.	3.6875	1.080
Farmers in remote areas do not face difficulty in accessing free COCOBOD approved pesticides from the cocoa district offices	3.4075	1.210
Health risk to applicators [Mean =3.16, SD=1.39]		
I do not get health issues when I use approved pesticides	3.2550	1.343
The high toxicity does not affect my health	3.1750	1.431
COCOBOD approved pesticides do not pose any risk to the farmer or applicators	3.0450	1.392
Environmental risk and safety [Mean = 3.24, SD = 1.31]		
COCOBOD approved pesticides are not detrimental to the environment	3.2000	1.328
The approved pesticides do not affect soil microbial activities	3.1350	1.353
The approved pesticides are polluting the air in the cocoa farmers	3.3750	1.252
Applicability [Mean=3.67, SD=1.19]		
COCOBOD approved pesticides are easy to apply	3.7225	1.130
Pesticide mixing or formulation is easy	3.8850	.956

Statements	Mean	SD
Manufacturer’s instructions on the approved pesticides are easy to follow	3.8300	1.060
I am satisfied with the application rate/dosage of the approved pesticides from COCOBOD	3.7850	1.252
I am satisfied with the number of tank fillings of spraying pesticides per acre of farm size	3.1300	1.537

Source: Field Data, 2023

The perception of the cost of COCOBOD-approved pesticides reveals that a significant proportion of farmers agree (mean = 3.63). Farmers agree that CODAPEC mass spraying provides pesticides at no cost. The study by [10], which highlighted the role of government intervention in providing subsidised or free pesticides to cocoa farmers, aligns with this finding. The availability of free or affordable pesticides can encourage farmers to adopt recommended pest control practices and ensure sustainable cocoa production.

The perception index is 2.56 for residues left by COCOBOD-approved pesticides. The implication is that farmers are neutral about the leftover residue of pesticides. This finding is not consistent with [26, 27], which rather highlighted concerns about the presence of residues and their potential impact on crop quality.

The perception of the effectiveness of COCOBOD-approved pesticides reveals that a significant proportion of farmers agree (mean = 3.78) that COCOBOD-approved pesticides are effective. This means farmers agree that cocoa-approved pesticides are effective. These findings are consistent with [28]. The effectiveness of pesticides is critical for farmers to achieve desired pest control outcomes and maintain healthy cocoa plants. The positive perception of effectiveness suggests that farmers trust the performance of these approved pesticides.

In terms of the availability of COCOBOD-approved pesticides, the data shows that a considerable number of farmers are neutral (mean = 2.84). The implication is that farmers are in a neutral position when it comes to the availability of pesticides for cocoa. This finding contradicts the findings of [10, 29], which suggest that the availability of agrochemical shops positively influences farmers' use of approved pesticides. Adequate distribution channels and timely availability are necessary to ensure that farmers can easily obtain the required pesticides when needed.

The perception towards the accessibility of COCOBOD-approved pesticides indicates that a significant proportion of farmers agree that these pesticides are easily accessible to members of cocoa communities (mean = 3.55). The implication is that farmers agree with the fact that cocoa-approved pesticides are accessible to them. This finding aligns with [29], which indicated that accessibility plays a vital role in ensuring equitable distribution and reaching farmers in remote areas.

Regarding the perception of risk to the health of plants, applicators, and the environment, a considerable number of farmers agreed and were neutral, respectively (mean = 3.62, mean = 3.16, mean = 3.24). Denkyirah [10] agrees that the frequency of pesticide applications is likely to cause health and environmental hazards through contaminated soil. Concerning the health of applicators, [30] found that pesticides pose health risks, resulting in chronic toxicity to workers. The perception regarding the applicability of COCOBOD-approved pesticides indicates that a significant number of farmers (mean = 3.67) are in agreement. The implication is that farmers agree that they do not encounter difficulties in applying cocoa-approved pesticides to their farms.

C. The Use of Approved Pesticides

TABLE III. THE USE OF APPROVED PESTICIDES

Insecticides	Mean	SD
Confidor Oteq	1.9950	1.16549
Confidiz 200 SC	1.5325	1.06149
Actara 240 SC	1.8575	1.17073
Okumakate	1.8850	1.20641
D-Lion Akate Global 4000	1.5225	1.09659
Akatiwura	1.6975	1.04342
Actaladiz 240 SC	1.5125	1.06191
Buffalo Super	1.5050	.98101
Flash Akate	1.7950	1.15165
Transform Akate	2.9000	1.18046
Akatemaster	3.1650	1.21510
Akate Star 3EC	2.8750	1.21370
Akate Asa	2.7450	1.21807
Seizer 100 EC	2.4975	1.31694
Pyrethrum 5 EW (Agropy 5 EW)	1.3200	.82420
Inspire 30 EC	1.8000	1.09224
Akate Kaptain	2.1350	1.23920
Akate Force	2.0475	1.17631
Regent 200 EC	1.3600	.80437
AF Confidence	2.1550	1.38773
Galil 300	1.5800	1.09389
Acetastar	1.7650	1.16541
Callifan Super	1.3375	.85171
Akate Commando	1.4800	.97826
Akate Brafo 40 EC	1.7150	1.09626
Viper Super 80 (formerly Aryna 80)	1.7625	1.10188
Superkill 150 SL (Formerly Esiom)	1.4850	.97321
Thodan Super	1.4200	.91141
Lufu 150	1.9925	1.12053
Voliam Flexi	1.3625	.85318
Nomax 150	1.7950	1.12967
Emastar 112EC	2.3225	1.29332
B. Fungicides		
Agro Commet 72WP	1.6558	1.81502

Insecticides	Mean	SD
Okumanonom 72 WP	1.6075	1.07998
Metalm 72WP	1.8375	1.13769
Fungikill 50WP	2.3525	1.26580
Ridomil Gold 66 WP	2.9250	1.41399
Fantic Plus 69 WP	1.5875	1.14263
Nordox 75 WG	1.4975	.99623
Funguran-OH	1.4150	.95659
Champion	1.4600	.92224
Agro Sar 70 WP	1.3025	.81095
Kocide 2000 DF	1.3975	.94431
Royal Cop 50 WP	1.5175	.94971
Kentan 40 WG	1.2825	.79642
Delco 75 WP	1.8375	1.17454
Sidalco Defender	1.6250	1.13251
Copstar 120 SC (Anonomwura)	1.4100	.93760
Qualico Cu 46 WP	1.6175	1.04591
Forum R	1.6150	1.00713
Banjo Forte 400 SC	1.4675	1.03761
Vamos 500 SC	1.3800	.95545
C. Weedicides/Herbicides		
Glyphosate (Sunphosate)	2.0200	1.37453
D. Fumigant		
ME/DEITA (Aluminium phosphide)	1.3225	.81557

Source: Field Data, 2023

Table III's results indicate that cocoa farmers widely use "Akatemaster" as an insecticide. The mean of 3.165, although showing that farmers “sometimes” use insecticides, was the highest among the listed insecticides. The study by [31] also found "Akatemaster" to be an effective insecticide for crop pest control.

The results indicate that cocoa farmers widely use "Ridomil Gold 66 WP" fungicides. The mean of 2.925, although showing that farmers “sometimes” use fungicides, was the highest among the listed fungicides. A study by [32] found that "Ridomil 66WP” demonstrated high effectiveness in managing fungal pathogens in various crops.

We found a mean of 2.020 for weedicides and herbicides, indicating a "rare" response. This finding implies that agricultural practices rarely employ glyphosate as a weed control measure.

We found a mean of 1.322 for fumigants, indicating a "never" response. Farmers never use the fumigant "ME/DEITA (aluminum phosphide)." This suggests that farmers never use aluminium phosphide, despite its common use in pest control techniques. A study by [33] confirmed the effectiveness of aluminum phosphide in controlling stored grain pests, but farmers and merchants lack education on the proper usage of the fumigant, leading to pesticide misuse.

Generally, the use of pesticides among the farmers in this study is low. It implies that farmers may be using alternative pest management techniques or unapproved pesticides. However, [34] emphasized the necessity for farmers to have better practices and understanding regarding the use of pesticides. Aidoo and Fromm [35] found that farmers often overuse pesticides in an attempt to increase yield and effectively control pests. This overreliance on pesticides can also have detrimental effects on the environment, human health, and the sustainability of the cocoa industry.

D. Factors that influence farmers’ choice of pesticides

TABLE IV. FACTORS THAT INFLUENCE FARMERS’ CHOICE OF PESTICIDES

Variables	Insecticide	Fungicide	Herbicide	Fumigants
Age	0.00243 (0.00838)	0.00966	-0.0305***	0.0169*
		(0.00740)	(0.00821)	(0.0102)
Sex	0.103	-0.305*	0.0798	0.223
	(0.184)	(0.169)	(0.173)	(0.239)
Education	0.0132	0.0673	-0.120	0.239***
	(0.0774)	(0.0694)	(0.0749)	(0.0846)
Marital status	0.0680	0.0783	0.179*	0.0732
	(0.108)	(0.0945)	(0.100)	(0.134)
Religion	0.00714	-0.0222	-0.0211	-0.00669
	(0.0191)	(0.0146)	(0.0160)	(0.0189)
Household size	0.0520*	0.00199	-0.0327	-0.156***
	(0.0315)	(0.0242)	(0.0268)	(0.0418)
Number of dependents	-0.0810**	-0.00291	-0.0380	0.144***
	(0.0337)	(0.0271)	(0.0289)	(0.0450)
Farm ownership	0.0742	0.0114	0.0512	0.428***
	(0.136)	(0.120)	(0.122)	(0.149)
Farm experience	0.0104	-0.00922	-0.0120	-0.0408***
	(0.0100)	(0.00845)	(0.00988)	(0.0146)
Farm size	0.320*	-0.278**	-0.645***	-0.0564
	(0.172)	(0.140)	(0.166)	(0.212)
Farm age	0.00595	-0.000495	0.0375***	0.0104
	(0.00990)	(0.00847)	(0.00899)	(0.0119)
Access to knapsack	0.395*	0.0931	0.388*	0.172
	(0.210)	(0.195)	(0.212)	(0.285)

Variables	Insecticide	Fungicide	Herbicide	Fumigants
Access to labour	-0.0893	0.0823	-0.0329	-0.0776
	(0.206)	(0.184)	(0.193)	(0.252)
Traceability	-0.0790	-0.139	-0.351**	-0.000561
	(0.173)	(0.155)	(0.160)	(0.199)
Membership of cooperative	-0.0643	-0.107	-0.542**	-0.409
	(0.246)	(0.227)	(0.223)	(0.252)
Access to extension service	-0.248	0.703**	0.266	-0.498
	(0.368)	(0.305)	(0.331)	(0.436)
Other crops	0.265	0.0602	0.151	0.690*
	(0.257)	(0.232)	(0.247)	(0.400)
Livestock	-0.0290	-0.350*	-0.104	-0.534**
	(0.217)	(0.195)	(0.197)	(0.255)
Secondary occupation	0.106	0.135	-0.0165	0.456*
	(0.185)	(0.163)	(0.171)	(0.260)
Income	-4.35e-06	6.86e-06	4.22e-05***	-7.14e-06
	(4.56e-06)	(6.58e-06)	(1.47e-05)	(1.91e-05)
Complexity	-0.159	-0.0485	-0.159	-0.0930
	(0.137)	(0.120)	(0.128)	(0.146)
Relative advantage	0.0227	-0.114	0.208*	0.132
	(0.135)	(0.117)	(0.120)	(0.168)
Observability	0.00798	0.202	-0.165	0.0115
	(0.141)	(0.127)	(0.123)	(0.155)
Trialability	0.143	-0.208*	0.0642	0.615***
	(0.128)	(0.123)	(0.124)	(0.200)
Compatibility	0.214*	0.329***	-0.159	-0.575***
	(0.112)	(0.108)	(0.109)	(0.149)
Constant	-1.305	-0.589	2.712***	-2.680**
	(0.913)	(0.793)	(0.845)	(1.231)

Source: Author, 2023. Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

The findings in Table IV show a complex interplay of various factors influencing farmers' choice of pesticides. The results indicate that the following variables influence insecticide use: household size, number of dependents, farm size, access to a knapsack or motor blow, and compatibility. Farmers' sex, farm size, access to extension services, trialability, and compatibility influence fungicide use. Age, marital status, farm size, farm age, knapsack access, cooperative membership, income, and relative advantage all influence the use of herbicides. Age, education, household size, number of dependents, farm ownership, farm experience, other crops, livestock, secondary occupation, trialability, and compatibility influence the use of fumigants. These results are in line with those of prior research by [10, 20], which discovered that age had a substantial impact on farmers' decisions about pesticides.

Denkyirah [10] discovered that male farmers used pesticides and herbicides more frequently than female farmers. Jallow [34] found that farmers with higher education levels were more likely to use insecticides and fungicides. The greater knowledge and understanding of pesticide usage among educated farmers may contribute to their preference for these pesticides. According to [36], farmers who had a higher number of dependents were less likely to use pesticides. Melomey [37] found that farm ownership was positively associated with the use of herbicides. Farm owners may have a greater stake in maximising productivity and controlling weed growth, leading to a higher preference for herbicide usage. Similarly, the use of fumigants may be associated with farm ownership because it prevents harvested beans from going to waste.

Lee [38] discovered a positive correlation between farm size and pesticide use. Farmers with larger farms may need to use more pesticides since the greater agricultural area may be more vulnerable to pest infestations. The potential adoption of alternative pest management strategies or the diversification of crops on larger farms may account for the negative association with fungicide and herbicide usage. Jallow [34] reported that farmers with access to knapsack sprayers were more likely to use insecticides and herbicides. The ease of application and convenience provided by knapsack sprayers may increase the preference for these pesticides among farmers with access to such equipment. The negative association between cooperative membership and fungicide usage indicates the potential benefits of collective action and cooperative farming models in promoting sustainable pest management practices. Encouraging farmers to join cooperatives and facilitating knowledge-sharing and collaboration within these organisations can contribute to reducing pesticide usage and promoting sustainable agriculture.

Traceability has a negative coefficient for herbicides, indicating that farmers participating in traceability programmes are less likely to choose herbicides. Zhao [39] also found that traceability systems were associated with reduced herbicide usage. Traceability systems can create market incentives for farmers to produce crops with reduced chemical inputs, leading to a shift towards more sustainable farming practices.

The coefficient for membership in cooperatives is negative for fungicides, indicating that farmers who are members of cooperatives are less likely to choose fungicides. These findings are consistent with the study by [20], which reported that membership in agricultural cooperatives was also negatively associated with fungicide usage. Cooperative membership may provide farmers with access to knowledge-sharing platforms and alternative pest management strategies, reducing their reliance on fungicides. Encouraging farmers to join cooperatives and facilitating knowledge-sharing and collaboration within these organisations can contribute to reducing pesticide usage and promoting sustainable agriculture.

The coefficient for access to extension services is positive for fungicides, indicating that farmers with access to extension services are more likely to choose fungicides. Zhao [39] also showed that extension services can provide farmers with information on disease management and the efficacy of fungicides, leading to a higher preference for fungicide usage among farmers with access to these services.

The livestock coefficient is negative for fungicides and fumigants, indicating that farmers with livestock are less likely to choose these types of pesticides. Chèze [40] also reported that livestock presence was negatively associated with fungicide usage. The coefficient for secondary occupation is positive for herbicides, which suggests that farmers with secondary professions are more likely to choose them. Wang [41] also discovered that farmers with secondary employment used pesticides more frequently. The involvement in secondary occupations may limit farmers' time for manual weeding or alternative pest management practices, leading to a higher preference for herbicide usage.

Income has a positive correlation with herbicides, indicating that farmers with higher income levels are more likely to choose herbicides. Staudacher [42] also reported a positive association between income and herbicide usage. Farmers with higher income levels may have more resources to invest in chemical inputs, and they may perceive herbicides as a more efficient and cost-effective method of weed control.

E. Farmer`s Compliance with Safety Standards When Using Approved Pesticides

TABLE V. FARMER`S COMPLIANCE WITH SAFETY STANDARDS WHEN USING APPROVED PESTICIDES

Compliance with COCOBOD safety standards	**Mean**	**SD**
Personal protection and safety standards (Mean = 3.99; SD = 1.31)		
I protect myself by wearing protective clothing when applying agrochemicals	4.1689	1.08116
I avoid spilling or splashing of the pesticides on my body	4.4275	.94179
I avoid eating or smoking when applying pesticides	4.4375	1.08814
I bath or at least wash my hands after applying pesticides	4.7075	.68052
I never stir insecticides with my hands	3.8725	1.65320
I never suck up liquid insecticides with a tube	3.9200	1.55391
I do not blow out clogged spraying machine nozzles or sieve with the mouth but clean them with soap and clear water, using a sponge or brush	3.3475	1.69527
I acquaint myself and follow first aid information on the labels	3.2425	1.60159
Compliance with COCOBOD safety standards	**Mean**	**SD**
I always find the direction of the wind before I spray	3.6900	1.51811
Child considerations (Mean = 4.201; SD = 1.207)		
I keep agrochemicals out of reach of children	4.3875	1.09331
I make sure the pesticides are not applied when children are around	4.2575	1.19991
Children are only introduced to the application environment after the pesticide active period	3.9600	1.32959
Compliance with manufacturers' instructions (Mean = 3.905, S.D. = 1.140)		
I read the label instructions carefully	3.7425	1.27878
I apply pesticides that are suitable for the pest, disease or weed, according to label recommendations	3.9775	1.17279
I use the prescribed dosage of approved pesticides.	3.9400	1.09517
I apply approved pesticides on time	3.8900	1.09586
I comply with the interval of application of agrochemicals as indicated on their labels	3.8525	1.14193
I plan to spray in such a way to have no or very little spray solution left	4.0300	1.05683
Compliance with storage protocols (Mean = 3.61; SD = 1.28)		
I store agrochemicals in places which are well-ventilated and light enough to ensure that product labels can easily be read	4.2225	1.02255
I sealed agrochemicals properly to prevent spillage when transporting or in storage	4.0750	1.19497
Pesticides are stored out of reach of children	2.5300	1.62811
Post-application precautions/requirements (Mean = 2.72; SD = 1.52)		
After applying pesticides, I place warning signs at the farm to indicate the time of application and recommended days until harvest.	2.2300	1.49254
I keep invoices or any other documentary of all agrochemicals used in a safe place and make them available at the time of inspection	3.3100	1.53779
I empty containers, triple rinsed, punctured and safely stored them	2.6950	1.59949

Compliance with COCOBOD safety standards	Mean	SD
I make sure all equipment that has been in contact with hazardous materials must be cleaned and stored	2.6225	1.44922
I keep records to prove the p effectiveness of the pesticides used	2.7625	1.51388
Compliance with equipment calibration requirements (Mean = 2.03; SD = 1.42)		
I calibrate at least once a year and maintain application equipment to minimize waste and excessive applications of chemicals	1.8375	1.33812
I use the right nozzle of application equipment for each chemical	2.2250	1.50999
Compliance with environmental protocols (Mean = 3.19; SD = 1.50)		
I used to wash my knapsack/spraying machines in rivers/streams close to my farm	3.9000	1.38195
I leave the pesticide containers scattered on my farm/improper disposal of chemical containers on the farm	2.4775	1.62051

Source: Field Data, 2023

While interpreting the data, it is critical to take into account earlier research that looked at pesticide use among cocoa growers in Ghana. In their study on cocoa farmers in Ghana's Ashanti and Western areas, [43] showed that while farmers had excellent awareness of pesticide use, they lacked sufficient information regarding safe application and handling techniques. This shows that although farmers may use certified pesticides, there may be variations in how well they follow safety guidelines and good practices (Table V).

Following this, the study found that the mean score for compliance with personal protection and safety standards was 3.99, implying that farmers often use personal protection and safety standards. Oyekale [44] emphasised the importance of using personal protective equipment (PPE) when applying pesticides. It is encouraging to see that the farmers reported protecting themselves, suggesting a high level of adherence to personal safety and protection norms. The mean score for compliance with child considerations was 4.20, indicating that often This result is consistent with other research that stresses how crucial it is to protect children from pesticide exposure because of their susceptibility [45].

The average level of compliance with manufacturers' instructions was 3.91, suggesting that frequently This indicates the need for further education and awareness programmes to ensure proper adherence to recommended practices. The average level of compliance with storage protocols was 3.61, indicating that often This suggests the importance of enhancing farmers' understanding of proper storage practices and child safety measures. The average level of compliance with post-application precautions and requirements was 3.72, indicating occasional occurrences. This highlights the value of educating and advising farmers to guarantee correct and effective pesticide application, minimising waste and potential environmental impact. Compliance with equipment calibration requirements had a mean of 2.03, implying that it was rare. This shows that farmers rarely comply with equipment calibrations. The mean for compliance with environmental protocols was 3.19, suggesting that farmers occasionally adhere to these protocols. This shows that farmers sometimes comply with environmental protocols.

F. *Factors affecting cocoa farmers' compliance with safety protocols*

TABLE VI. FACTORS AFFECTING COCOA FARMERS' COMPLIANCE WITH SAFETY PROTOCOLS

Variables	Marginal effects
Age	-0.0176
	(0.0118)
Sex	0.257
	(0.267)
Education	-0.0396***
	(0.0128)
Marital status	0.171
	(0.153)
Religion	-0.336
	(0.229)
Household size	0.0264
	(0.0406)
Number of dependents	-0.0867**
	(0.0431)
Farm ownership	-0.0995**
	(0.0417)
Farm experience	-0.00130
	(0.0132)
Farm size	0.636***
	(0.246)
Farm age	-0.0242*
	(0.0132)
Access to knapsack	0.165
	(0.311)
Access to labour	-0.304
	(0.307)
Traceability	0.473*
	(0.249)
Membership of cooperative	-0.450**
	(0.226)
Access to extension service	0.936*
	(0.494)
Other crops	-0.396
	(0.385)

Variables	Marginal effects
Livestock	0.0223
	(0.305)
Secondary occupation	0.375
	(0.255)
Income	-1.20e-06
	(7.11e-06)
Complexity	-0.0234
	(0.189)
Relative advantage	0.427**
	(0.191)
Observability	-0.374**
	(0.189)
Trialability	0.0791
	(0.189)
Compatible	-0.223
	(0.180)
Constant	0.655
	(1.291)

Source: Author, 2023; Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table VI's findings from the binary probit regression analysis provide valuable insights into the factors influencing cocoa farmers' compliance with safety protocols. The variables that have a significant effect on compliance behavior are education, number of dependents, farm ownership, farm size, farm age, traceability, membership in a cooperative, access to extension services, relative advantage, and observability.

"Education" shows a significant negative marginal effect of -0.0396. This suggests that higher levels of education are associated with lower compliance among cocoa farmers with safety protocols. This finding is consistent with previous research highlighting the complex relationship between education and compliance behaviour in agricultural settings [26, 46]. The "Number of dependents" shows a negative marginal effect of -0.0867 (p 0.01), suggesting a link between increased dependents and decreased adherence to safety standards among cocoa growers. [44], which highlights the challenges farmers with larger families face in adhering to safety procedures, confirms this conclusion.

Farm owners are less likely to adhere to safety regulations, as shown by the negative marginal effect of -0.0995. Lack of resources, lack of expertise, or perceptions of farm owners' autonomy or absenteeism may explain this result. The marginal effect for "farm size" is positive and significant, indicating that cocoa producers on larger farms adhere to safety measures. This result is consistent with [11], which highlights the beneficial impact of farm size on farmers' ability to successfully adopt safety measures. The factor "farm age," on the other hand, exhibits a negative marginal effect, which suggests that owners of old farms have worse compliance with safety standards among cocoa growers.

The marginal effect of the variable "traceability" is significantly positive, indicating that cocoa producers who are members of traceability programmes have greater compliance rates. This finding seems to support the study of [47], which showed that traceability solutions improve accountability and transparency throughout the supply chain, which has a positive effect on compliance behaviour.

Membership in cooperatives has a significant negative marginal effect, showing that cooperative members have lower compliance rates among cocoa growers. The results of prior research on the impact of cooperative membership on compliance behaviour have been conflicting. Ansah [26] has shown that cooperatives encourage compliance, while others, such as [25], found lower compliance rates among cooperative members. The marginal effect of the variable "access to extension service" is significantly positive, indicating that cocoa farmers who have access to extension services have greater compliance rates. This shows the critical function of extension services in fostering information diffusion and supporting compliance behaviour among farmers.

The perceived "relative advantage" of adhering to pesticide safety measures has a significant positive marginal effect, indicating that cocoa farmers are more likely to comply with pesticide safety measures if they believe the safety standards offer advantageous gains. The variable "observability" has a significant negative marginal effect of -0.374 (p 0.01), showing that cocoa farmers are less likely to comply if they believe the results of compliance to be less observable.

G. *Constraints of Cocoa Farmers in the Use of Approved Pesticide*

TABLE VII. CONSTRAINTS OF COCOA FARMERS IN THE USE OF APPROVED PESTICIDE

Constraints	Mean Rank	Rank
Inadequate government support in terms of grants and inputs	13.50	1st
High cost of spraying equipment (spraying machine)	13.11	2nd
Fluctuations in the price of agrochemicals	12.81	3rd
Poor access to loans/credit facilities	11.54	4th
High cost of approved pesticides	10.70	5th
Short life span /high breakdown of spraying equipment	10.61	6th
Toxicity (poisonous nature of chemicals affecting farmers' health while spraying	9.71	7th
Unpredicted weather conditions	9.56	8th
Spare part of spraying machines not available/affordable	9.41	9th
High cost of PPEs	8.76	10th
Unavailability of PPEs in local markets and stores	8.59	11th
Unavailability of approved pesticides	8.51	12th
Not comfortable with using protective equipment in local markets and stores	8.47	13th

Constraints	Mean Rank	Rank
Unregulated importation of expired /banned pesticides	8.16	14th
Poor access to pesticide-related information	7.79	15th
Difficulty in understanding label directions	7.78	16th
The problem of pesticide resistance due to failure /ineffectiveness of pesticides	7.76	17th
Poor access to extension services	4.22	18th
N: 400; Kendall's Wa: 0.184; Chi^2: 1248.742; Df: 17; Asymp. Sig.: 0.000		

Source: Field Data, 2023

Inadequate government support in terms of grants and inputs was ranked the highest, indicating that farmers feel a lack of support from the government in terms of financial assistance and necessary inputs for pesticide use. The high cost of spraying equipment (spraying machine) and fluctuations in the price of agrochemicals were ranked second and third respectively (Table VII). These findings resonate with studies that have emphasized the financial challenges faced by farmers in purchasing pesticides and their equipment [48].

IV. CONCLUSION

Farmers' perceptions towards the use of COCOBOD-approved pesticides were based on their perceived effectiveness. In terms of the use of approved pesticides, “Akatemaster” was the most commonly used insecticide, while “Ridomil Gold 66 WP” was the most commonly used fungicide. Farmers rarely used weedicides or herbicides, and they never used "ME/DEITA (aluminium phosphide)" (fumigants). Generally, the use of pesticides among the farmers in this study is low. It implies that farmers may be using alternative pest management techniques or unapproved pesticides. The study found that various factors influenced farmers' pesticide usage choices, including age, education, marital status, farm ownership, experience, farm size, access to equipment and services, cooperative membership, secondary occupations, and income levels.

Farmers generally demonstrate a high level of compliance with child labor considerations in terms of safety standards. The findings from the binary probit regression analysis provide valuable insights into the factors influencing cocoa farmers' compliance with safety protocols. The variables that have a significant effect on compliance behavior are education, number of dependents, farm ownership, farm size, farm age, traceability, membership in a cooperative, access to extension services, relative advantage, and observability.

The findings emphasize farmers' complex decision-making processes and highlight the need for targeted interventions and support mechanisms to promote sustainable pest management practices, improve farmer education and access to resources, and mitigate the potential negative impacts of pesticide use on human health and the environment.

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