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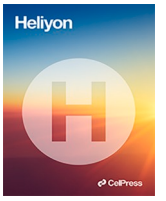

Research article

Is there a LINKAGE between credit access, land use, and crop diversification in achieving food security? Evidence from cocoa-producing households in Nigeria

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ABSTRACT

Cocoa farmers in Nigeria adopt crop diversification to safeguard the food security of their households. Although credit and land are thought to play a vital role in crop diversification, they continue to have limited access to credit and land. This study investigated the linkages between access to credit, land use, crop diversification, and food security with a focus on cocoa farming households. A multistage sampling procedure was used to obtain data for the study. Data were analyzed with the aid of descriptive statistics, the Heifindahl index, the Tobit regression model, the food consumption score, and the ordered Logit regression model. The results for the entire respondents showed mean values of 55 years for age, 31 years for farming experience, 6 people for household size, and 5 ha for farm size. Heifindahl index shows 38.67 % of the respondents had low crop diversification in the study area. Tobit regression model reveals that access to credit, farming experience, cooperative organization, access to extension service, farm size, distance to farms, and labour are the main albeit significant factors that determine crop diversification among cocoa farming households. Food consumption score revealed that 46.67 % were poor, 30.67 % were at the borderline and about 27.67 % were within the acceptable threshold. The ordered logit model revealed that crop diversification index, formal education, access to credit, farm size, land use, and farming experience have a significant influence on the food security of households. The study concluded that there is a positive relationship between access to credit, land use, crop diversification, and food security. Therefore, the government and financial institutions should make credit facilities accessible to cocoa farmers to improve their livelihood.

1. Introduction

Food is a fundamental right and basic human necessity as without food, the survival of human beings is impossible. Food security has become a global challenge with many dimensions. Ensuring the production of adequate food supplies, maximizing stability in the flow of supplies, and ensuring access of households to available supplies have been critical in many parts of the world [1]. Food security exists when all people always have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life [2]. Nevertheless, food insecurity remains a challenge in all developing countries of the world. The most recent report on the State of Food Security in the World. Studies such as [1,3] revealed very

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worrying statistics: nearly 690 million people are hungry. In reality, in 2019, nearly 750 million people, or about one in ten people worldwide, were at risk of severe levels of food insecurity. Further, the number of people facing chronic and persistent food insecurity and malnutrition has been steadily increasing in the past decade [1,4]. Thus, the world is not on track to achieve Sustainable Development Goal (SDG) 2: Zero Hunger by 2030 [5]. If recent trends continue unabated, the number of hungry people will exceed 840 million by 2030. Unsurprisingly, many of these people live and work in sub-Saharan Africa (SSA) [5]. SSA is home to more than one-third of the malnourished people in the World [1]. About 17 million people are currently food insecure in Nigeria alone [5]; this could be due to a series of challenges that hamper people's ability to ensure their household's food security. Of course, many of these people live in rural areas of Nigeria, where cocoa is the primary source of income [6,7].

Cocoa is essential to the lives of farmers in Nigeria [8–10]; therefore, the farm area planted with cocoa, the cocoa yield, and the price farmers receive for their cocoa beans all have a significant impact on overall household income. Cocoa farming households often rely heavily on cocoa sales revenue, which accounts for 66 % of the total household income [11,10]. Despite high export values, cocoa producers frequently earn less than a liveable wage [12], receiving just 40–50 % of the global market price and 6 % of the chocolate price paid by final customers. Nevertheless, many cocoa farmers struggle to earn a living wage and, as a result, are locked in a cycle of food insecurity. Cocoa growing in Nigeria is plagued by structural hurdles, making it extremely difficult for farmers to provide a stable living wage for themselves and their families [13,14]. For example, their farms are often small and have low production; also, their income base is minimal. This, in turn, reduces agricultural investment, trapping these farmers in a cycle of poor productivity and low income [15]. Therefore, almost all cocoa in Nigeria is produced by smallholder farmers, many of whom are poor [16,17]. Cocoa has sometimes been described as a 'poor man's crop', as some recent studies have calculated that a large proportion of cocoa farmers live in extreme poverty [16,18,19]. For cocoa farmers to get out of the poverty cycle, one narrative that has been gathering pace is that farmers should diversify further into other crop options. Proponents of this narrative suggest that diversification can be useful for mitigating food insecurity, particularly outside of the main cocoa season [20], among smallholder farmers whose main livelihood is dependent on cocoa [21,22]. Owing to the various merits of diversification, some farmers have diversified away from cocoa to other crops, including vegetables.

Crop diversification refers to a mix of farming systems rather than the shift from one given enterprise to another [23,24,25,26,27]. It is a veritable strategy for mitigating risks in small-scale subsistence agriculture as farmers allocate their resources to diverse sub-units of production areas for sustainable food supply among farm families [28,29,30]. In other words, crop diversification gives a broader choice in the production of different varieties of crops in each area of land to boost household food production [31]. Farmers practice crop diversification to maximize the use of land and other resources [32], by planting varieties of crops on their farmland to avoid the risk of monoculture and to minimize the uncertainty of climatic and biological vagaries [33,34,35]. Land use intensification refers to the extent to which land is used and how available resources have been used to achieve the desired goal. Literature substantiates the role of diversification with food crops in the improvement of incomes and food which provides two capital dimensions of food security: the availability and accessibility of food [28,1,36,37,38,39]. Chiefly, crop diversification provides farmers with different crops that they cannot access either because of the cost or because of poor infrastructure constraints [18,40,41,42]. This is because studies have shown that food availability in the household increases with crop diversity [43,44,45,27]. In line with this, crop diversification has been promoted by different food security interventions [46,47]. Despite the growing importance of crop diversification, very little is known in Nigeria about the role it plays in improving the food security status of farming households.

The tendency for cocoa farming households to engage in crop diversification is often noticeable, but few attempts have been made to investigate crop diversification and the food security status of farming households in Nigeria. Notable ones include [7], who concluded that there exists no relationship between farm diversity and household dietary diversity among subsistence farmers. Much empirical evidence suggests a relationship between crop diversification and food security [48,49,50,51,52,53]. Nevertheless, the findings highlighted above seem contradictory regarding the impact of crop diversification on food security. Some studies suggest a positive relationship between crop diversification and food security while others suggest a negative relationship. This current study therefore tries to establish a link between crop diversification and food security. Furthermore, less emphasis has been given to access to credit as a determinant of crop diversification strategies among households. Credit access may facilitate the household's capacity to acquire more inputs for crop diversification. Studies such as [54,55] acknowledged that when credit is made available to farmers, they are given the chance to make better use of it to acquire the right input mix for production. Nevertheless, access to credit by smallholder farmers is still hugely hindered [56]. Poor access to credit prevents farmers from expanding their farms and lowers their ability to bear the cost of recommended agronomic practices [57]. However, until now, many cocoa farmers continue to lack access to credit in their quest to diversify. Though issues on access to credit have received considerable research attention, it remains inconclusive and unclear to which extent access to credit influences crop diversification. Thus, studies that relate access to credit and crop diversification strategies are scarce despite the potential relationship between the two concepts.

Considering the foregoing, the paper is prompted by the need to resolve the following questions: How does farmers' access to credit contribute to crop diversification among cocoa farming households? Does land use and crop diversification ensure the food security of cocoa farming households? Thus, an important goal of this study is to evaluate the linkages between access to credit, land use, crop diversification, and food security with a focus on cocoa farming households. This study hypothesizes a positive relationship between access to credit, land use, crop diversification, and food security. This paper presents policy implications for addressing challenges associated with credit access, crop diversification, and food security in cocoa-producing households. The failure of many food security interventions in Nigeria has been because they ignored the great diversity in the range of crop mix in which they engage to generate income. It thus becomes important for policymakers to understand the cropping systems that rural households engage in to generate incomes and how these cropping systems affect their food security status. The outcome of this study is of benefit to firms granting credits, policymakers, and other agricultural stakeholders to realize the dynamics in accessing credit by cocoa farmers and their quest

Table 1
Distribution of food items by group and weight.

No	Food groups	Weight
1	Cereals *(bread, rice, maize, barley)* and tubers *(potatoes, sweet potatoes)*	2
2	Pulses and nuts (*beans, lentils, peas, peanuts, etc.)*	3
3	Vegetables	1
4	Fruits	1
5	Meat and fish (*all types*)	4
6	Dairy products *(milk, yogurt, cheese, other milk products)*	4
7	Sugar, honey	0.5
8	Oil, fat, butter	0.5
9	Condiments/Spices *(tea, coffee/cocoa, salt, garlic, spices, yeast/baking powder, tomato/sauce, meat or fish as a condiment, condiments including a small amount of milk/tea coffee.)*	0.5

to diversify their crop production to ensure food security. Furthermore, this study may contribute to existing knowledge on credit accessibility and crop diversification. It will provide information for researchers for further studies.

The paper is structured into four sections. Section two presents the literature review. Section three presents the data and the methods. Section four presents and discusses the empirical findings, while section five concludes.

2. Literature review

Food security can be ensured by meeting three conditions: food stock at every level from family to nation, stable food stocks for households, and inexpensive food availability for families at all times [58]. Food insecurity is defined as a lack of access to nutritional food in households or countries. It manifests itself in two ways: chronic and transitory food insecurity [59]. Chronic food insecurity arises when food supply is consistently insufficient to provide essential nourishment for all people. However, transitory food insecurity arises when there is a temporary lack of access owing to hardship, such as food production instability, price changes, or decreased income [60,61]. Food security, in whatever shape it takes, is one of the most pressing challenges in developing countries. One of the major issues faced by cocoa farming households is establishing food security, and one approach to do so is to diversify their crop production systems on a sustainable basis. Crop diversification is the growing of two or more crops on a piece of land or different land and at different locations by a farmer or in a group farming system. It is a strategy that is used to maximize the use of land, water, and other resources, thus providing farmers with feasible options to grow different crops on their available land [62]. The factors that lead to farmers' decisions to diversify are many but include reducing the risk of crop failure, responding to changing consumer demands, changing government policy, and, more recently, as a consequence of climate change, among others. Crop diversification practices can include higher crop diversity [45], more diverse crop rotations [63], mixed cropping [64,34], cultivation of grain legumes in otherwise cereal-dominated systems [65], perennially or grassland [66,67,68] and regionally adapted varieties or variety mixtures [69,70]. It can be a measure to develop more sustainable production systems, develop value chains for minor crops [71], and contribute to socio-economic benefits [72].

Crop diversification of any region is linked to the food security of the people of that region. The tendency of farmers to depend on just one crop can have serious consequences thereby leaving farmers in a more vulnerable situation [73]. For example, the income of the monoculture farmer can be reduced as a result of a slump in the market value of a particular crop thus leaving the farmer in ruins. On the other hand, if farmers diversify, they can reduce over-dependency on one crop and they can avoid the risks associated with it. The reviewed literature categorically explains the determinants of crop diversification in three ways [74,75,76,63]. *Economic factors* consist of all economic and financial side factors. *Social factors* consist of social factors that make a farmer decide on diversification depending on the condition of risk aversion, income enhancement, and increase in productivity or subsistence. *Biological factors* have all those factors that come into natural factors for crop production. A farmer can go towards crop diversification depending on the absence or availability of any factor mentioned above. Literature has provided us with several benefits of crop diversification ranging from short run to long run. The short-run benefits are: improvements in food security, shifts in consumption patterns, increase and assurance in the availability of sustainable income, risk mitigation, employment generation, poverty alleviation, improvements in productivity and efficiency in scarce resources use (e.g, drip irrigation or vertical gardening), export promotion, conservation of

Table 2
Food consumption thresholds.

Food consumption groups	Food Consumption Score	Description
Poor	1–28	An expected consumption of staples 7 days, vegetables 5–6 days, sugar 3–4 days, oil/fat 1 day a week, while animal proteins are absent
Borderline	28.1–42	An expected consumption of staples 7 days, vegetables 6–7 days, sugar 3–4 days, oil/fat 3 days, meat/fish/egg/ pulses 1–2 days a week, while dairy products are absent
Acceptable	>42	As defined for the borderline group with a greater number of days a week eating meat, fish, egg, oil, and complemented by other foods such as pulses, fruits, milk

Table 3
Socio-economic characteristics of cocoa farmers.

Variables	Cocoa Farmers
Male (%)	98.7 %
Age (years)	55.15(±13.40)
Married (%)	91.3
Formal education (%)	97.3
Household size (#)	6.35 (±2.88)
Primary Occupation (%)	97.3
Years of farming experience	31.86(±13.20)
Commercial type of farming	82.0
Farm size (ha)	4.8(±3.9)
Cooperative membership (%)	14.7
Credit access	84.7
Extension Agent (%)	44.0

Source: Field survey, 2021,

natural resources (particularly land and water), switch of farmers from illegal narcotic-producing crops (like cocaine) to alternative crop production for their livelihood. These short-run benefits of crop diversification ensure long-run benefits such as regional equity, growth prospects in agriculture, and sustainable farming systems.

To sum up, the literature underscores the linkages between access to credit, crop diversification, and food security. From the reviewed works of literature, it is understood that crop diversity ensures two dimensions of food security, namely: food accessibility and food absorption/utilization. It is clear from the works of literature that farming households with more than one crop are more secure in terms of food supplies and income. As much as crop diversification improves food security, knowing the impact of credit access on crop diversification is vital so that they can be addressed appropriately. As far as literature is concerned and to our knowledge, no study has been conducted to explore the linkages between access to credit, crop diversification, and food security. The theory underpinning this study is sustainable livelihood framework (SLF) which builds on identifying assets and capabilities, seeking to address the barriers and vulnerabilities to improving food security. The core of SLF is the assessment of the finance capital (credit access) that is deemed to affect livelihood diversification strategies (crop diversification) to improve livelihood outcomes (Food security). The theoretical framework emphasizes that access to credit by farmers forms the basis for the development of strategies such as crop diversification against food insecurity situations. That is, households can diversify their livelihood using strategies, for instance, crop diversification [77], in their struggle for survival and to improve their way of life and standard of living [78]. By establishing this theoretical groundwork, the study aims to empirically investigate the relationship between access to credit, crop diversification, and food security. This will provide a better understanding of how access to credit could help to enhance crop diversification to ensure food security in Nigeria.

3. Material and methods

3.1. Study area

This study was carried out in Osun State, Nigeria. The State is located in South-Western Nigeria and lies within latitude 7.0° and 9.0° N and longitude 2.8° and 6.8° E above the sea level with a large gentle and undulating landscape. Farming is the major occupation of the people, particularly those living in the study areas. The State experiences two seasons annually (rainy and dry seasons) usually from November to March and the average rainfall ranges from 1125 mm in the derived savannah to 1475 mm in the rainforest belt. The mean annual rain temperature ranges from 27.2 °C in the month of June to 39.0 °C in December. The soil types are arid, but most contain a high proportion of clay and sand and are mainly dominated by laterite. The area is mainly agrarian. Cash crops and food crops are predominant in the area; these include cocoa, maize, vegetables, etc. There exists mono-cropping, the mixed or intercropping system of farming. There are thirty local government areas in the State. The study area for this research covered only two local governments which are Ife East and Ife North Local Governments selected purposively.

Table 4
Crop diversification profile of the respondents.

Level	*Number of crops grown*	*Frequency*	*Percentage %*
Low	1–4	58	38.67
Moderate	5–8	83	55.33
High	9–12	9	6.00
Total	**12**	**150**	**100**

Source: Field survey, 2021, Crop Diversification Index (CDI) = 0.53

Table 5
Land use for crop production.

Farm size (ha)	Mean	Std. Deviation
Cocoa production	7.67	±6.593
Tree crops production	0.74	±0.82
Arable crop production	0.84	±0.72
Vegetable Production	0.48	±0.54

Source: Field survey, 2021

3.2. Sampling procedures

This study was carried out in Osun State, Nigeria between August and November 2021 through personal interviews. Multi-stage sampling procedure was used to select the respondents for this study. The rationale behind the selection of the procedure is that it can reduce the possibility of systematic errors in the selection of respondents. In the first stage, there was a purposive selection of the Ife-Ijesa Agricultural Development Programme Zone based on the concentration of cocoa farming households in the zone. In the second stage, Ife East and Ife North Local Government Areas (LGAs) were purposively sampled based on the concentration of cocoa farming households in the LGAs. In the third stage, a list of about 186 villages under each local government was obtained from the local government secretariats and a total number of 5 cocoa-producing villages was randomly selected out of the existing cocoa-producing villages from each LGA making a total of 10 villages. In the final stage, 15 households were randomly sampled from each selected village using a simple random sampling technique. This study used a total of 150 respondents. This study utilized primary data. The study collected the primary data using a pretested and well-structured questionnaire. The data collected from the cocoa-farming households include their socio-economic characteristics such as age, level of education, gender, size of the house members, and farming experience, among others. The respondents included in the household survey were a person in charge of food/meal preparation and/or household heads in respective sample households [79]. Enumerators who live in the area, fluent speakers of the local language (Yoruba), well acquainted with local and cultural contexts, and working within the selected LGA were recruited for the data collection. They were trained on the contents of the interview schedule and data collection techniques. A pre-test on non-sample respondents was also made under the supervision of the researchers. Finally, the formal data collection was conducted on sample respondents after necessary modifications and adjustments were accommodated as per the result obtained from the pre-test.

3.3. Analytical techniques

Data were analyzed with the aid of descriptive statistics, the crop diversification index, the Ordered Logit regression model, the food consumption score, and the Tobit regression model.

3.4. Descriptive statistics

Descriptive statistical tools such as mean, standard deviation, frequency, and percentages were used to describe the socio-economic characteristics of the households and the level of crop diversification among the households.

3.5. Crop diversification index

The crop diversification index was used to describe the level of crop diversification in cocoa farming households. The extent of crop diversification can be determined by using several indices such as Simpson's index (SI), Margalef index (MI), Entropy index (EI),

Table 6
Effect of access to credit on crop diversification among cocoa farming households.

Variables	Coefficient	Std. Error	T	P > t	Marginal Effect	
Age	0.000	0.002	−0.09	0.926	0.000	0.002
Formal Education	−0.004	0.005	−0.95	0.346	−0.004	0.005
Household size	−0.009	0.007	−1.23	0.220	−0.009	0.007
Farming Experience	0.005	0.002	2.55	0.012**	0.005	0.002
Cooperative Organization	0.083	0.041	2.02	0.045**	0.083	0.041
Access to credit	0.032	0.046	2.69	0.003***	0.032	0.046
Extension service	0.057	0.034	1.70	0.092*	0.057	0.034
Labour	0.076	0.041	1.87	0.064*	0.076	0.041
Farm Size	0.022	0.006	3.47	0.001***	0.022	0.006
Distance	−0.005	0.001	−3.43	0.001***	−0.005	0.001
Off-farm income	−0.030	0.029	−1.05	0.295	−0.030	0.029

LR chi2(11) = 42.56, Prob > chi2 = 0.0000, Log likelihood = 43.484158, Pseudo R2 = 0.6583 ***Significant at 1 % **Significant at 5 % *Significant at 10 %.
Source: Data analysis, 2021

Table 7
Food consumption score.

Food Consumption Threshold	Score	Frequency	Percentage (%)	Cumulative %
Poor	1.0–28.0	70	46.67	46.7
Borderline	28.1–42.0	46	30.67	77.3
Acceptable	>42	34	22.67	100.0
	Total	**150**	**100**	
Cereal			39.7	
Pulses			22.5	
Vegetables			69.5	
Fruits			29.0	
Meat/Fish			31.4	
Dairy products			7.5	
Sugar/Honey			26.5	
Oil/Fat/Butter			39.3	

Source: Data analysis, 2021

Modified entropy index (MEI), Ogive index (OI), Composite entropy index (CEI), and Berger-Parker index (BPI) [80,81,82,25,83,84]. However, this study used the crop diversification index because it is the most used index in many kinds of literature on crop diversification and it addresses the degree of crop diversification [85,86,87,88,84]. The crop diversification index (CDI) was computed from the Herfindahl index to measure the extent of crop diversification for all diversified farmers using a method developed by Ref. [89]. The CDI values were obtained by subtracting the HI from 1 to 0. Moreover, a 0 value of the crop diversification index indicates perfect specialization and a movement toward 1 shows an increase in the extent of crop diversification [90]. Generally, the value of CDI increases with the increase in diversification and assumes 0 value when farmers grow and cultivate only one crop.

To compute the Herfindahl index, the study used the total cropped land (ha) of diversifiers and the proportion of land allocated for growing each crop (ha) in the year 2021 harvest[ed] season. HI (the sum of squares of all n proportions) and CDI (1-HI) were computed using the formula developed by Ref. [89] (Equations (1)–(3))

$$\mathrm{Pi} = \frac{Ai}{\sum_{i=1}^{n} Pi^2} \tag{1}$$

$\sum_{i=1}^{n} Ai$ = Total cropped areas, (ha), and i = 1, 2, 3 … …. …. …. … n (number of crop).

$$\text{Heifindahl Index (HI)} = \sum_{i=1}^{n} Pi^2 \tag{2}$$

$$\text{Crop diversification index} = \text{CDI} = 1 - \text{HI} \tag{3}$$

3.6. Tobit regression model

A Tobit model was used to determine the effect of access to credit and land use on crop diversification. Tobit model is the most suitable because it uses all observations, both those at the limit, usually zero (e.g., who chose a particular crop), and those above the limit (e.g., who did not choose a particular crop) to estimate a regression line as opposed to other techniques that use only observations

Table 8
The effect of crop diversification and land use on food security among cocoa farming households.

Variables	Coefficients	Z	Marginal effects		
			Poor	Borderline	Acceptable
CDI	2.866***	3.12	0.262	0.265	0.248
Formal education	2.358***	3.32	0.197	0.192	0.179
Access to credit	1.272*	1.78	0.208	0.218	0.136
Extension service	0.224	0.99	0.078	0.158	0.140
Household size	−0.779	−1.47	−0.589	−0.649	−0.308
Marital status	1.832	0.31	0.304	0.241	0.113
Farm size	0.799***	4.15	0.243	0.443	0.541
Land use	0.198**	2.12	0.169	0.160	0.182
Cooperative organization	2.531	1.54	0.369	0.460	0.379
Farming Experience	1.591**	2.49	0.406	0.410	0.381
Off-farm income	1.506	1.49	0.278	0.427	0.729
_cons	1.103***	3.93			

LR chi2(11) = 134.26, Prob > chi2 = 0.0000, Log likelihood = −371.63646, Pseudo R-Squared = 0.0396 ***Significant at 1 % **Significant at 5 % *Significant at 10 %.
Source: Data Analysis, 2021

that are above the limit value [91]. The procedure also captures the latent level of intensity of potential farmers who decide not to choose a particular crop. Another feature of the Tobit model is that it is a truncated regression model where the values above the threshold can be continuous. For example, in our case, the threshold is 0 (i.e. lower limit) and all values above that limit are continuous, i.e. the actual level of profit derived from growing the chosen crop with no upper limit set [92]. Therefore, in cases where zero observations are a norm (e.g. when a farmer does not choose a certain crop), the use of a truncated regression model is more appropriate than the Ordinary Least Square model. The justification for selecting the analytical model is obvious: because not all households diversified despite having the opportunity to do so, employing OLS would result in selectivity bias. To reduce this bias, a limited dependent variable regression model (Tobit) was used to quantify the impact of credit availability and land use on crop diversification among cocoa farming households. According to Refs. [93,94], the Tobit model is the most appropriate because some farmers who were highly diversified in a specific period may not diversify during the survey period due to a variety of factors such as current crop prices, pressure from farm work, and health, among others. Also, conventional regression methods fail to consider the qualitative difference between zero and continuous observation. Therefore, the Tobit model assumes that all zeros are attributable to standard corner solutions. As such, zero observations are accounted for, and the censored regression provides a more accurate estimation.

Hence, the Tobit model takes the following specifications in equation (4):

$$Y_i^* = \beta X_i + \mu_i \tag{4}$$

$$Y_i = Y_i^*, \text{if } Y_i^* > 0$$

$$Y_i = 0, \text{if } Y_i^* < 0$$

Y_i is observable and Y_i^* is the latent dependent variable. A latent variable can be observable whenever it is positive. Once the latent variable is negative, the observation becomes censored, and one can simply observe, $Y_i^* = 0$. In this study, the data are left-censored. The subscript i run from 1 to n which was used to index the observations of a sample. The total number of observations is denoted by n. X_i is the vector of independent variables, β is a vector of unknown coefficient, and μ_i is an independent distributed error term or unobservable variable that affects Y_i^* assumed to be normal with a mean zero and constant variance. However, Y_i^* is observed if $Y_i^* > 0$ and is not observed if $Y_i^* < 0$.

Then, the observed Y_i is defined as in equation (5):

$$Y_i = Y_i^* = \beta X_i + \mu_i; \text{ if } Y_i^* > 0 \quad i = 1, 2, 3 \tag{5}$$

$$Y_i = 0, \text{if } Y_i^* < 0$$

where Y_i is observed dependent variable, in this case, the value of crop diversity; X_i is the independent variable affecting the dependent variable and its intensity; β is the coefficient[s], and μ_i are residuals that are independently and normally distributed with mean zero and a common variance. The model parameters were estimated by maximizing the Tobit likelihood function (equation (6)).

$$L = \Pi_{Y>0} f \frac{1}{\sigma}\left(\frac{Y_i - \beta X_i}{\sigma}\right) \Pi_{Y\leq 0} F\left(\frac{\beta X}{\sigma}\right) \tag{6}$$

where f and F are the distribution and density function of Y_i^*, respectively; $\Pi_{Y\leq 0}$ is product over those i for which $Y_i^* < 0$ and $\Pi_{Y>0}$ is the product over those i for which $Y_i^* > 0$.

The empirical model is specified as follows:

$$Y^* = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \ldots + \beta_{11} X_{11} + \varepsilon_i \tag{7}$$

The definitions of independent variables are X_1 = Education (years of education); X_2 = Off-farm income (₦); X_3 = Farm experience (years of farming experience), X_4 = Access to extension service (Yes = 1, No = 0), X_5 = Age (age of household head in Years), X_6 = Farm size (hectare), X_7 = Household size(number of people), X_8 = Distance (Average distance between land parcel in Km), X_9 = Labour (man-day); X_{10} = Access to credit (Yes = 1, No = 0), X_{11} = Cooperative organization (member = 1, otherwise = 0).

The inclusion of these independent variables in the model was based on a previous expectation of the variable used and a review of the literature. The literature argues that farmers' socioeconomic traits are major predictors of crop diversification [26,95]. Farming experience is thought to improve crop variety. It is assumed that experienced farmers are more knowledgeable about farming procedures and agricultural difficulties [96]. Household size serves as a proxy for agricultural labour availability in the household. Household size can have a mixed impact on diversification. In some circumstances, crop diversification can be increased due to differences in preferences and labour availability [97]. In contrast, several studies have found that household size has a detrimental effect on crop diversification [97,98]. Farmers' ages are commonly used as proxies for their agricultural experience and play a major role in determining their output decisions. On the one hand, older farmers are more likely to diversify since they have better access to productive resources and information [85]. Younger farmers, on the other hand, may be more educated and have access to a broader range of information on agricultural breakthroughs, making them more eager to experiment with novel crop varieties. Thus, the impact of age on diversity might be favourable or negative. In addition, access to off-farm revenue is used as a control. Off-farm income provides the farmer with additional funds to support production activities. However, significant off-farm income may reduce farmers'

desire to grow agricultural investment (Rahman, 2008). Thus, this variable's impact on diversification could be good or negative. The distance to the farm is used as a proxy for transport costs, which may have a negative impact on crop diversification. The farther the parcel is from the farmer's residence, the higher the transaction or marketing costs. Furthermore, a longer distance to a farm increases the danger of postharvest loss. Furthermore [97], discovered that proximity to the road and market has a good impact on diversification. Farmers who live far from roads and markets, on the other hand, may diversify their production to fulfill their food requirements [97,99]. Crop diversification improves with farm size [97]. Farmers with large farms have greater flexibility in assigning acreage to different crops [85]. Crop diversification may be influenced by education, either positively or negatively. Education can have a good impact on diversification if it improves farmers' access to agricultural information and managerial capacity [62,100,101,102,98,103]. However [97], discovered that education has a negative impact on crop diversification. Crop diversification is linked to greater utilization of both family and hired labour. When farming households do not have enough domestic work, hired labour is recruited to supplement their efforts. In most situations, hired labour is sought from within the community, with wages provided in kind or cash. As a result, this variable is projected to boost crop diversification. Farmers who belong to cooperative groups have a better and greater chance of getting credit than farmers who do not belong to any. The reason given for this conclusion is that farmers can obtain credible information by joining a farmer association to engage in crop diversification. Cooperative organizations can also guarantee that members receive loans to diversify.

3.7. Food consumption score (FCS)

The FCS is considered a proxy indicator of the food security of households, and it was used to estimate the status of food security among cocoa farming households. FCS is a good measure of household food security because it gives a general overview of the amount of food consumed by the household. This indicator is useful for categorizing and tracking households' food security across time, specifically as a proxy for the quantity dimension (i.e. household caloric sufficiency) of food security. The FCS is a more complex indicator of the food security status of a household, as it considers not only dietary diversity and food frequency but also the relative nutritional importance of different food groups. On the other hand, its use of a relatively long period (i.e. 7 7-day recall period) might make the data less precise.

Dietary diversity is the number of individual foods or food groups consumed over the past seven days. *Food frequency* is the number of days (in the past 7 days) that a specific food item has been consumed by a household. Household food consumption is the consumption pattern (*frequency * weight*) of households over the past seven days Table 1.

3.8. Calculation of FCS and household food consumption groups (Table 1)

1. Using standard 7-day food frequency data, group all the food items into nine specific food groups.
1. Sum all the consumption frequencies of food items of the same group and recode the value of each group above 7 as 7.
2. Multiply the value obtained for each food group by its weight and create new weighted food group scores.
3. Sum the weighed food group scores, thus creating the food consumption score (FCS). The most diversified and best consumption with maximal FCS at 112 means that all food groups are eaten 7 days a week.
4. Using the appropriate thresholds, recode the variable food consumption score, from a continuous variable to a categorical variable, to calculate the percentage of households of poor, borderline and acceptable food consumption.

The FCS is calculated based on the past 7-day food consumption recall for the household and classified into three categories: poor consumption (FCS = 1.0 to 28); borderline (FCS = 28.1 to 42); and acceptable consumption (FCS = > 42.0). The FCS is a weighted sum of food groups. The score for each food group is calculated by multiplying the number of days the commodity was consumed and its relative weight.

The following thresholds of FSC are used to categorize households into three food consumption groups – Poor, Borderline, and Acceptable (Table 2).

3.9. Ordered logit regression model

The ordered logistic regression model is used to analyze ordinal dependent variables. The ordinal regression model is a preferred modeling tool that does not assume normality or constant variance but requires the assumption of parallel lines across all levels of the outcome variable. It is rooted in the general framework of generalized linear models meant for the analysis of ordinal dependent variables. The ordinal regression model describes the relationship between an ordered response variable and a set of explanatory variables which may be continuous or discrete. Similarly, the ordinal logistic regression procedure empowers one to select the predictive model for ordered dependent variables. In the current study, the ordinal regression method of analysis was used to meet the objectives set since the response variable has four ordered categories and the value of each category has meaningful sequential order. The study also used the logit link function which is generally suitable for analyzing the ordered categorical data when all categories are evenly distributed [104].

The ordered logit regression model was used to assess the effect of land use and crop diversification on the food security status of cocoa farming households based on the results of the FCS. The rationale for selecting the model is that an ordered logit model could be used to model relationships between a polytomous response variable which has an ordered structure and a set of regressor variables. In this study, the variable of interest takes integer values ranging from 0 to 3, and thus, an ordered logit model is used. The formulation of

the model is such that the responses are represented by a variable Yi which denotes an average FCS. The average FCS score presents the level of the food consumption gap and food insecurity among cocoa farming households. In this case, the explained variable is grouped and ranked based on the level of the FCS. The FCS denotes that the higher its value, the higher the level of food security, and the other way round. The FCS rank will be applied for all households i, and it takes the following four (4) ordered values (j = 0, 1, 2, 3). However, these observed values are assumed to derive from some unobservable latent variable Yi*, which is expressed in this equation as follows:

$$Y_i = \beta X_i + \varepsilon_i \tag{8}$$

Y_i is the hypothesized predictor of food insecurity, βs is a vector of parameters to be estimated and is an error term that is assumed to be normally distributed (Greene, 2003).

The probability of choice for category i:

$$PrPr\left(Outcome_{j=i}\right) = Pr\left(K_{i-1} < \beta_1 X_{1j} + \beta_2 X_{2j} + \ldots + \beta_k X_{kj} + \mu_j \leq K_i \right. \tag{9}$$

It is assumed to be distributed logistically in ordered logistics, where: βi = parameters coefficient i = 1, …k K_i = cut points/limits-i, i = 1, …k X_{1j} = dependent variable category-i observations-j k = the number of categories As pointed out earlier, category i = 1 is defined as the lowest value, i = 0 as the next level, and so forth. The probability of an individual to choose category i is:

$$P_{ij} = PrPr\left(y_j = i\right) Pr\left(K_{i-1} < X_j\beta + \mu \leq K_i \right.$$

$$= \frac{1}{1 + exp\left(-K_i + X_j\beta\right)} - \frac{1}{1 + exp\left(-K_{i-1} + X_j\beta\right)} \tag{10}$$

where K_0 is defined as very small (-∞) and K_k very big (+∞)

$$\text{Log-likelihood is } L = \sum wj \sum Ii(y_i) ln\, P_{ij}\Big) \tag{11}$$

$$i = 1 \quad j = 1$$

$$i = 1 \quad j = 1$$

where w_j is an optional weighting, and

$$I_i\left(y_j\right) = \left\{1, if y_j = 1\ 0, other\right.$$

The values for the observed variable Yi are assumed to be related to the latent variable Yi* in the following manner:

$$Y = 0 = foodinsecure, if Y^* < \mu_0 where \mu = 0$$

$$Y = 1 = poorconsumptionif\ 0 \leq Y^* \leq \mu_1$$

$$Y = 2 = borderlineif \mu_1 \leq Y^* \leq \mu_2$$

$$Y = 3 = Acceptableif \mu_2 \leq Y^* \leq \mu_3$$

μ means the unknown threshold parameters. For the estimated cut-off points, μ follows the order $\mu_1 < \mu_2 < \mu_3$. Using the maximum likelihood estimate technique, the values for the βs parameters can be estimated.

The empirical model is specified as follows:

$$Y^* = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \ldots + \beta_{11} X_{11} + \varepsilon_i \tag{12}$$

The dependent variable is the FCS of the cocoa farming households (1 = Poor consumption; 2 = Borderline; 3 = Acceptable).

The definitions of independent variables are: X_1 = Off farm income (₦); X_2 = Marital status (1 = married; 0 = single); X_3 = Education (years of education); X_4 = Household size(number of person); X_5 = Farm experience (years of farming experience); X_6 = Cooperative organization (member = 1, otherwise = 0); X_7 = Access to credit (Yes = 1, No = 0); X_8 = Access to extension service (Yes = 1, No = 0); X_9 = CDI (index generated from Heifindahl index); X_{10} = farm size (hectare); X_{11} = land use (1 = mixed crop; 0 = monocrop).

The inclusion of these independent variables in the model was based on a prior anticipation of the variable and a review of the literature. Access to finance has a significant impact on rural households' food security. Access to finance allows farmers to buy or afford inputs such as fertilizer, insecticides, herbicides, machinery, livestock, and so on, which boosts output levels and raises the likelihood of a household being food secure [105]. Off-farm income refers to money earned by households from sources other than their principal occupation, farming. Money from a household's off-farm activities can have an impact on food security, but whether the consequences are negative or positive is determined by the quantity of profits from the other activity. This is because increased participation in off-farm activities can generate more money, improving household food security. On the other hand, engaging in other

off-farm activities can have a negative impact on household food security status, particularly when households spend more of their time in non-farm labour at the expense of working on their farm, resulting in revenue that is insufficient to meet the household's food needs. Farm size correlates positively with household food security. According to a review of selected literature, large farm sizes increase household food production, which not only increases food availability but also provides income for the purchase of food items, thereby positively affecting households' food security situations [105]. The vast area of farmed land results in higher production, increasing the possibilities of household food security. A household head's educational level improves, increasing the likelihood that the home will be more food secure [106]. supported these findings, reporting that families with heads who had at least an intermediate level of education were more food secure than those who were illiterate or had a low level of education. Another study conducted in Nepal supported these findings, reporting that the educational level of the household head improves working efficiency, competency, income diversification, and technological adoption, all of which have a positive impact on better living conditions and food security [107]. Land usage has a favourable and considerable impact on household food security. Access to land is an important tool for alleviating rural poverty and ensuring food security [107]. Households' access to extension agents has a favourable and significant impact on food security. Extension services are intended to increase a household's access to better agricultural production techniques, improved inputs, and production incentives that boost farm productivity and output [108,109]. Farming experience significantly improves a household's food security. An experienced home manager is expected to have more knowledge and the ability to diversify his or her production to reduce the risk of food shortage. He is more likely to understand pests, disease management, and weather [110]. Household size is an important factor in food accessibility, and it is typically a negative predictor. A large household puts pressure on households for food, increasing food insecurity [111]. Larger households are more likely to be food insecure than smaller households, and when there are more dependents, more food is required, like in Nigeria [105]. [112] predict that participation in cooperatives will improve household food security. This experience also prepares farmers to better manage diverse crop enterprises and achieve high yields. Crop diversification which entails growing multiple crops, including both food and cash crops, will help improve food security. Farmers who diversify their crops will increase their revenue through cash crop sales, as well as their food security through personal consumption and the purchase of food crops with cash crop sales proceeds. Marital status is likely to have either a positive or negative effect on household food security since weddings provide an opportunity to expand the support base for managing the family farm. There is also a view that marriage increases the load on household heads because there are more mouths to feed. The duty to provide for a family forces households to try a variety of businesses to meet their responsibility of caring for their entire family.

4. Results and discussion

4.1. Socio-economic characteristics of the respondents

The socio-economic characteristics of the respondents are presented in Table 3. The majority of the farmers (98.7 %) are male. This shows that cocoa production is dominated by men. This could be because farming activities, especially the cultivation of permanent crops such as cocoa, in rural areas are mainly carried out by male farmers who mostly have title to land and have access to productive assets as compared to their female counterparts who are mostly involved in processing and marketing of agricultural products. This encourages crop diversification to cater to the food security level of the households. This finding corroborates the expression of [16,113,114] that men dominate cocoa production. The mean age of the respondents was 55.15 ± 13.4 years. This indicates that most of the respondents are in their old age but still productive to engage in agricultural production to ensure the food security of their family members. This finding corroborates the expression of [115,116,117] that an average cocoa farmer in the Southwest is old. The majority of the cocoa farmers (91.3 %) are married. The fact that most of the cocoa farmers are married shows that they will be more concerned with the issue of food security of their family members as well as other substantial household responsibilities such as family upkeep, education, and healthcare. Meeting these household needs might necessitate the cocoa farmers to engage in crop diversification as well as putting their farmlands to different uses in the study area. This finding corroborates the expression of [9,118–120]. This study revealed that the majority (97 %) of the respondents have a formal education. This implies that literate farmers are involved in cocoa production in the study area. Education of the cocoa farmers may play an important role in their decision to seek information on what crop to diversify into and also on the most productive use to put their farmland to enhance the food security of family members. This finding agrees with [121,122] who revealed a high literacy rate among cocoa farming households. The average household size of the respondents is 6.35 ± 2.88 members. From the result in Table 3, the household size is fairly large, suggesting that there may be the availability of family labour for their occupations. However, large family sizes may come with the extra costs of high family expenses on food and other consumables. Hence, a household with more family members needs to be crop diversified, engage in intensified use of land for production, and also get the possibility of having various streams of income-generating activities to meet family needs and to stay food secure. This finding agrees with [8; 81; 70]. Cocoa farming is the main occupation of the respondents (97.3 %). This showed that cocoa farming is the predominant source of income among rural cocoa farmers. This is in line with the findings of [123,124] who posited that farming is the main occupation of the rural dwellers in Southwest Nigeria. The mean farming experience of the respondents is 31.86 ± 13.21 years in the study area. This shows that the respondents have been engaged in farming activities for more than 5 decades. This is in line with the findings of [125,16,2] stating that an increase in the number of years of farming experience could lead to a productive increase in their farming output which could be attributed to the fact that years of farming experience may lead to a better chance of mastery of farming methods and seasons by farmers. The majority (82 %) of the cocoa farmers were into commercial farming systems. This explains that the farmers in the study area are not into food production for self-consumption only but majorly for-profit maximization. The average farm size in the study area was 4.8 ± 3.9 ha. This implies that

the farmers in the study area operated on a small scale. This could be attributed to the land tenure system in the study area. This makes them operate at a subsistent level. This supports the findings of [116,126] who posited that in Southwest Nigeria, the farmers operated on a small scale and farmed on land between 0.1 and 5.99 ha. The majority (85.3 %) of the respondents were members of farmer's associations or cooperative societies. This implies that farmers would have access to information on various farming methods, and income-generating opportunities as well as training programs provided for farmers by or through the cooperative societies. This supports the findings of [122,123]. The majority (84.7 %) of the respondents had no access to credit. This implies that there was limited access to credit among the respondents which may reduce the opportunities of diversifying into various agricultural activities and engaging in other activities capable as measures to stay food secure. This supports the findings of [2,127]. About 56 % of the respondents have never been visited by any extension agent. Thus, based on the percentages, cocoa farming households have limited relevant information on farm business to increase their output and, hence, their income.

4.2. Crop diversification profile of the respondents

The crop diversification profile of the respondents is presented in Table 4. The CDI value of 0.53 implies that a larger percentage of the cocoa farmers were moderately diversified. Furthermore, the results of the Table show that 38.67 % of the respondents had low crop diversification, 55.33 % had moderate crop diversification, and 6.00 % had high crop diversification in the study area. This implies that the majority (55.30 %) of cocoa farmers cultivate between 5 and 8 crops in their farms in a planting season. This finding suggests that there is a need to assist cocoa farming households in improving their livelihood activities and revenue production in the study area. Furthermore, these households may be provided with skills to generate additional revenue from different sorts of food crops. This practice could enable cocoa farming households to smoothen their sources of income all year round. This result is in line with the findings of [128] who reported that food crop farmers in the South-western part of Nigeria were more diversified in their cropping pattern and contrary to Ref. [32] who stated that variation in weather conditions of zones led to specialization on the growth of crops that thrive well in the prevailing weather condition in the North-central zone of Nigeria.

4.3. Land use for crop production

From Table 5, the average land use for Cocoa production is 7.67 $\pm$ 6.593 ha. This result proves that a larger percentage of the farmers used their land for cocoa production. For this reason, they tended to direct their focus and resources more into cocoa production which in turn contributed greatly to their income and well-being of the households towards achieving food security and fewer resources to others. The average land use for other tree crop production excluding cocoa is 0.74 $\pm$ 0.82 ha. This result proves that a larger percentage of farmers do not engage in tree crop production. The average land use for Arable crop production was 0.84 $\pm$ 0.72 ha. This result shows that a larger percentage of farmers do not engage in arable production. The average land use for vegetable crop production is 0.48 $\pm$ 0.54 ha. This result shows that a larger percentage of farmers do not engage in vegetable production. It is evident from the result that the farming households devote land to cocoa at the expense of growing food crops, hence heightening the risk of food insecurity among cocoa-growing households.

4.4. Effect of access to credit on crop diversification among cocoa farming households

The effect of credit access on crop diversification among cocoa farming households is shown in Table 6. Table 6 shows the results of the estimated Tobit model. The chi-square statistic is statistically significant (LR chi2(11) = 42.56, Prob > chi2 = 0.0000, Log likelihood = 43.484158). This justifies the rationale for using the Tobit model. In addition to access to credit, the results reveal that farming experience, cooperative organization, access to extension service, farm size, distance to farms, and labour are the main albeit significant factors that determine crop diversification among cocoa farming households.

The coefficient of farm size ($\beta = 0.022$, $p < 0.001$) is positive and significant. This implies that the larger the farm sizes, the higher the probability of crop diversification among the farmers. An increase in the size of the farm by 1 unit will increase the probability of crop diversification by 0.022 units. This means that an increase in the size of landholding will better enable a farmer to diversify. With the extra landholding, the farmer can decide how many crops to grow based on his or her production decisions. This corroborates the findings of [129,130] who stated that the larger the farm size, the more likely to produce more from the farmland. Furthermore, the findings of the study are consistent with those of [62] who found that the more access a farmer has to additional land, the more likely he or she is to engage in crop diversification. However [85,131], discovered that farm size does not have a statistically significant effect on crop diversity. The coefficient of farming experience ($\beta = 0.005$, $p < 0.01$) is positive and significant. This implies that as the farmer increases in years of farming by 1 unit, this tends to improve his level of diversification by 0.005 units. This suggests that those respondents who have been into farming for many years have a higher probability of diversifying their income than their inexperienced counterparts. The most plausible explanation is that farmers with many years of farming experience are more aware of income diversification opportunities in the farming sector. Furthermore, cocoa farmers with greater agricultural expertise are more naturally attracted to numerous income sources as a result of their previous experience with a single income-generating activity. This is also corroborated by the work of [132]. The coefficient of cooperative organization ($\beta = 0.082$, $p < 0.05$) is positive and significant. The result implies that as farmers become members of cooperative societies by 1 unit, it increases his or her crop diversification by 0.082 units. This implies that farmers who are members of cooperative societies are more likely to engage in crop diversification as compared to their counterparts who are non-members. The most obvious reason for this result is that most cooperative societies provide farmers with access to credible information and opportunities, as well as other benefits, to support and improve their crop diversification

prospects. The report of [133] supports this as well.

The coefficient of labour is ($\beta = 0.076$, $p < 0.01$) positive and significant. This implies that the higher the number of labour available for use, the higher the level of crop diversification. An increase in the labour input by 1 unit would increase the possibility of being crop diversified by 0.076 units. The idea could be that households with more labour would provide greater assistance in improving household resources to engage in various farming operations. The finding is also consistent with the conclusion of [102] that several factors, including household labour, have a significant influence on the ability of farmers to produce various crops. This study, however, contradicts the findings of [43] who found that labour size has a negative impact on crop diversification. The coefficient of Distance ($\beta = -0.005$, $p < 0.001$) was negative and significant. A one-unit increase in the distance would reduce the chance of being diversified by 0.005 units. This suggests that the greater the distance between the farm location and the household, the less likely crop diversification is, as this incurs a high cost of transportation as well as a higher cost in the mobility of labour and other resources required for successful and efficient production. As a result, a farm that is adjacent to a homestead offers more advantages in terms of crop diversification and food security for the farmer. This explains why, in terms of time, labour, safety, and management, households may choose to vary their produce on the neighbouring farm. This finding is consistent with those of [85,88] who found that households living far away from their farms manage less crop diversity. The coefficient of access to credit ($\beta = 0.032$, $p < 0.001$) is positive and significant. The result implies that as farmers have access to credit by 1 unit, it increases his or her crop diversification by 0.032 units. This means that farmers who have access to loans are more likely to diversify their crops than those who do not. The possible argument could be that access to credit increases the ability of farmers to obtain additional inputs for crop diversification. Access to trustworthy sources of finance to purchase inputs is required to continue in the new production activities will undoubtedly increase the tendency to embrace crop diversification farming systems. Thus, the more a farmer has access to credit facilities with more reasonable terms, the more he or she will invest in diverse productive crop enterprises. These findings are consistent with a report by Ref. [134].

The coefficient of access to extension services ($\beta = 0.057$, $p < 0.01$) is positive and significant. The result implies that as farmers have access to extension services by 1 unit, it increases their crop diversification by 0.057 units. This means that farmers who have access to extension services are more likely to diversify their crops than those who do not. This could be linked to the extension system which aims to increase farmer productivity and profitability. Crop diversification is favoured by extension service providers since they are generally aware of its function in risk minimization. The findings are comparable with those of [43] who discovered a positive link between household crop diversification and access to extension services.

4.5. Food consumption score

The food consumption score for the past seven (7) days based on each category of food is presented in Table 7. The Table shows that 39.7 % of the respondents consumed Cereals (including root and tubers). The food consumption score for other categories are as follows: Pulses (22.5 %), Vegetables (69.5 %), Fruits (29.0 %), Meat/Fish (31.4 %), Dairy products (7.5 %), Sugar/Honey (26.5 %), and Oil (including Fat and Butter) (39.3 %). From this, the thresholds for estimating and scoring the households based on their participation or nonparticipation in the food groups were calculated. It was discovered that 46.67 % were poor, 30.67 % were at the borderline and about 27.67 % were within the acceptable threshold. This suggests that many cocoa-producing households in the study area are food secure. This is comparable to the findings of [135]. Furthermore, this suggests that food insecurity remains prevalent among farming households in the study area.

4.6. Effect of crop diversification and land use on food security among cocoa farming households

Table 8 shows the results of the estimated ordered logit model. The chi-square statistic is statistically significant (Wald Chi2 (11) = 134.26; Prob > Chi2 = 0.000). This justifies the rationale for using the ordered logit model. According to all the diagnostics measures, we are confident to infer that the model is a good fit. The result of the model estimation also shows that 5 of the 10 explanatory variables have a significant influence on the food security of households. These variables include crop diversification index, formal education, access to credit, farm size, and farming experience.

The coefficient of the crop diversification index ($\beta = 2.866$, $p < 0.001$) has a positive and significant influence on the food security of cocoa-producing households. This means that people who produce multiple crops on a given area of land are more likely to be food secure than those who specialize in only one or a few crops. Households with high crop diversity are more food secure than those with low crop diversity. This result could be explained by the fact that households that engage in multiple cropping diversify their risk of a specific crop failure in a given season and have more access to food than those who practice monocropping. For example, if one crop does not produce well in a given season, other crops may fare better, and farmers may rely on them for survival. Multiple crop farmers may also produce cash crops alongside food crops, allowing the cash crops to be utilized to generate revenue for the household to cover other food needs that cannot be met on their farm, as well as other non-food needs. This result is in agreement with the findings of [95, 32,35]. The result of this study however departs from the findings of [136]. The coefficient of farm size ($\beta = 0.799$, $p < 0.001$) has a positive and significant influence on the food security of cocoa-producing households. Households with larger farms have a better chance of planting more crops than those with smaller farms. This is because the ability to cultivate larger areas allows farmers to grow a wider variety of crops, ensuring that the household has enough food to avoid food insecurity. This finding is also consistent with that of [137] who stated that food security increases as the area under cultivation grows. Also [130,138], concluded that increasing farming size is one strategy to achieve food security.

The coefficient of education ($\beta = 2.358$, $p < 0.001$) has a positive and significant influence on the food security of cocoa-producing households. This means that as the level of education of household heads rises, so does the food security of the household. A higher

level of educational attainment in a household allows the household to learn more about how to make agriculture a viable business to ensure food security in their households. The ability of a farmer to read and write boosts his chances of becoming food secure since he can embrace timely and new ways of doing things to maximize productivity. This finding is consistent with the findings of [136] who discovered that educated individuals are more likely to want to learn about farming and other ways to make money, as well as to use agricultural extension services and experiment with approaches to ensure they have enough food to eat. This finding agrees with that of [139,140,141] who stated that the level of education has a significant and positive association with the food security status of the household, and also agrees with the study of [142]. The coefficient of access to credit ($\beta = 1.272$, $p < 0.01$) has a positive and significant influence on the food security of cocoa-producing households. This is consistent with a priori expectations that as access to credit increases, households will be more likely to obtain resources to finance farming activities and other off-farm income-generating activities that will allow them to diversify their crops and improve their level of food security, particularly in situations where many other household members are unable to generate any income and rely solely on the household head. Furthermore, access to credit increases household purchasing power and company investments, hence improving household financial capacity in Nigeria [143]. Thus, access to credit reduces the likelihood of food insecurity in rural households. This is consistent with recent findings by Refs. [135, 2,144] who found that farmers' access to finance improves their food security status.

The coefficient of farming experience ($\beta = 1.591$, $p < 0.05$) has a positive and significant influence on the food security of cocoa-producing households. This is because an experienced household head is believed to have greater awareness and ability to diversify his or her production to reduce the risk of a food shortage. An experienced household head is more likely to have a sufficient understanding of pests, disease control, and weather to maintain food security in their household [145]. However, these results contradict that of [125] who indicated that increasing years of farming experience of respondents could result in a productive rise in their farming production, hence ensuring food security. The coefficient of land use ($\beta = 0.198$, $p < 0.05$) has a positive and significant influence on the food security of cocoa-producing households. This suggests that as the farmer uses more area for agricultural output, his food security increases. This is attributed to the possibility that land usage may guard against household food insecurity and access to land is a critical method for alleviating rural poverty and ensuring food security [107].

5. Conclusion

This study investigated the linkages between access to credit, land use, crop diversification, and food security with a focus on cocoa farming households. A multistage sampling procedure was used to obtain data for the study. Data were analyzed with the aid of descriptive statistics, the Crop diversification index, the Tobit regression model, the food consumption score, and the ordered Logit regression model. The results for the entire respondents showed mean values of 55 years for age, 31 years for farming experience, 6 people for household size, and 5 ha for farm size. The study concluded that the majority of the cocoa farmers were male, small-scale, and at the peak of their productive age. The CDI value of 0.53 implies that a larger percentage of the cocoa farmers were moderately diversified. About 38.67 % of the respondents had low crop diversification, 55.33 % had moderate crop diversification and 6.00 % had high crop diversification in the study area. The average land use for Cocoa production is 7.67 ± 6.593 ha. This result proved that a larger percentage of the farmers used their land for cocoa production. Tobit regression model reveals that access to credit, farming experience, cooperative organization, access to extension service, farm size, distance to farms, and labour are the main albeit significant factors that determine crop diversification among cocoa farming households. Food consumption score revealed that 46.67 % were poor, 30.67 % were at the borderline and about 27.67 % were within the acceptable threshold. The ordered logit model revealed that crop diversification index, formal education, access to credit, farm size, land use, and farming experience have a significant influence on the food security of households. This study concluded that food insecurity remains prevalent among the farming households in the study area. Also, there is a positive relationship between access to credit, land use, crop diversification, and food security. Consequently, access to credit in no small measure improves crop diversification of the cocoa farming households. This will in turn improve their household's food security.

6. Policy implications

Given the above conclusion, the following are recommended.

i. Extension agents should raise awareness about crop diversity and its impact on farmer productivity. This will motivate farmers to enhance their crop choices and cultivation practices on their farms, resulting in increased crop output and food security.
ii. Encourage households to combine crop enterprises for increased income and improved food security. Policies should be implemented to educate farmers on how to diversify into high-value crops such as fruits and vegetables, as well as traditional crops such as arable and cash crops. This unique encouragement has the potential to increase farm households' income and improve their nutrition/diet intake.
iii. Household education levels impact food security status. Raising awareness of the importance of food components, nutrition and health can help more families achieve food security. In addition, ideal conditions should be established to encourage educated people to choose farming careers.
iv. Smallholder farmers can benefit from social networking and collaboration to increase crop variety and food security. Household members' participation in cooperative groups will also serve to encourage crop diversification and food security through efficient resource management (capital and production inputs), as well as the marketing of their product through collaborative efforts based on mutual interest. Such engagement will help increase access to credit facilities, hence improving household food

security. Smallholder farmers must also engage in social networking and teamwork to generate social capital for crop diversification and food security.

7. Limitation of the study

The main limitation of this study is its reliance on cross-sectional household data; thus, a study based on regional-level data may provide clearer and consolidated conclusions, particularly for an extended national image. The limitation of the study is also that the sample size is rather small in comparison to the population under consideration in this study, which could pose a problem with data representativeness. In general, this study attempted to generate the results of the analysis within a specific scope, but there are still many questions to be answered. Future researchers must focus on providing fundamental knowledge on the social, political, natural, and environmental dimensions that influence food security status and livelihood strategy selection, as well as descriptive data on food insecure purchasing patterns and specific characteristics that make rural poor people more vulnerable to food insecurity.

Ethical declaration

All participants (or their proxies/legal guardians) provided informed consent to participate in the study. All participants/patients (or their proxies/legal guardians) provided informed consent for the publication of their anonymized case details and images. The respondents' participation was voluntary, and the data analysis does not reflect specific personal sensitive information. Review and/or approval by an ethics committee was exempted.

Data availability

Data are available with the corresponding author at (kehindeayodeji8@gmail.com): upon reasonable request.

CRediT authorship contribution statement

Adewumi Titus Adesiyan: Writing – review & editing, Writing – original draft, Supervision, Investigation, Conceptualization. **Ayodeji Damilola Kehinde:** Writing – original draft, Methodology, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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