

Food security and livelihood diversification among cassava-based farming households in ido local government area, Oyo State, Nigeria

Abstract

Food insecurity remains a critical development challenge among rural cassava-farming households in southwestern Nigeria, where livelihood strategies remain predominantly subsistence-oriented and vulnerable to climatic and economic shocks. This study examines food security status and the role of livelihood diversification among cassava-based farming households in the Ido Local Government Area (LGA) of Oyo State, Nigeria. Using a three-stage sampling procedure, primary data were collected from 150 cassava-farming households through structured questionnaires. Descriptive statistics, the Herfindahl-Hirschman Index (HHI), the Foster-Greer-Thorbecke (FGT) poverty indices, and an ordered probit regression model were employed for data analysis. Endogeneity was tested using the Durbin-Wu-Hausman test, and multicollinearity was assessed using Variance Inflation Factors (VIFs). Results show that 47.33% of households were core food-insecure, 19.33% were moderately food-poor, and only 33.33% were food-secure. The FGT indices confirmed a food insecurity incidence of 30.5%, a depth of 10.8%, and a severity of 4.7%. A majority (71.33%) of respondents recorded a low livelihood diversification index, while 28.67% achieved a high index. The ordered probit regression revealed that age ($p < 0.01$), household size ($p < 0.01$), farming experience ($p < 0.05$), years of education ($p < 0.10$), and access to farm training ($p < 0.10$) significantly influenced household food security status. Policy interventions should implement household-size-sensitive social protection measures, promote education and vocational skills development, and prioritise integrated agricultural capacity and vocational training to strengthen diversification capacity and reduce food insecurity among rural farming households.

Keywords: cassava farming households, food insecurity, Foster-Greer-Thorbecke indices, livelihood diversification, Nigeria, ordered probit model

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Introduction

Agriculture remains the backbone of most economies in sub-Saharan Africa (SSA), contributing substantially to gross domestic product (GDP), employment, food production, and rural livelihoods. The sector accounts for approximately one-quarter of SSA's GDP and provides employment for a large proportion of the rural population.^{1,2} Despite this strategic importance, agriculture in many African countries is characterized by low productivity, limited commercialization, and high vulnerability to environmental and socioeconomic shocks. Consequently, a significant proportion of rural farming households remain trapped in persistent poverty and food insecurity, notwithstanding their dependence on agriculture as a primary livelihood.

Food security has become an increasingly urgent development concern, particularly in developing economies where agricultural production is closely tied to household welfare. The Food and Agriculture Organization of the United Nations (FAO) defines food security as a state in which all people, at all times, 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.³ This concept encompasses four interrelated dimensions: availability, accessibility, utilization, and stability.

Nigeria is the world's largest producer of cassava (*Manihot esculenta* Crantz), a crop that plays a strategic role in national food security, income generation, and rural economic development. Cassava serves multiple functions as a staple food, industrial raw material, livestock feed, and source of household income. Its adaptability to

diverse agroecological conditions and resilience to adverse weather events have made it a critical crop for smallholder farmers across the country. However, cassava production is constrained by pests and diseases, declining farm sizes, inadequate processing infrastructure, poor market access, and increasing production risks associated with climate variability.^{4,5} These challenges undermine farm profitability and erode households' capacity to achieve food security.

In response to growing livelihood pressures, rural households increasingly adopt diversification strategies to reduce vulnerability and improve welfare. Livelihood diversification refers to the process by which households construct diverse portfolios of activities and assets to survive and improve their living standards.⁶ Such strategies encompass intra-sectoral diversification, expansion of crop and livestock enterprises, and engagement in off-farm and non-farm activities such as trading, wage employment, processing, and artisanship. The growing body of evidence from Africa suggests that diversified livelihood portfolios can improve household welfare by stabilising income, spreading risk, and enhancing resilience to shocks.^{7,8}

Despite the growing literature on these themes, empirical findings remain mixed on the extent to which diversification improves food security among smallholder farmers. Moreover, few studies have explicitly examined this relationship among cassava-producing households in Oyo State, Nigeria—a major cassava-producing zone whose households face a unique combination of agrarian, institutional, and market challenges. This study addresses that gap. Specifically, it investigates the socioeconomic and institutional determinants of

livelihood diversification, characterizes household food security status using established poverty indices, and estimates the effects of diversification on food security outcomes using an ordered probit model. The findings provide context-specific evidence for policy design aimed at promoting sustainable livelihoods and reducing food insecurity among smallholder farming communities.

Theoretical and empirical framework

Theoretical framework

This study is anchored in the Sustainable Livelihoods Framework (SLF), developed by the UK Department for International Development,⁹ which conceptualizes rural livelihoods as a composite of assets, human, social, financial, physical, and natural capital that households mobilize under a prevailing vulnerability context and institutional environment to achieve livelihood outcomes. Within this framework, livelihood diversification is understood as a household-level adaptive strategy that draws on multiple asset bases to generate diverse income streams, thereby reducing risk exposure and improving food access.^{6,10}

Complementing the SLF is the Economic Dependency Theory, which highlights the structural constraints that perpetuate food insecurity in developing economies. Originating in the work of Frank¹¹ and the Prebisch-Singer hypothesis,¹² this theoretical strand argues that the persistent underdevelopment and food vulnerability of Global South countries are rooted in historically unequal trade relations and post-colonial economic structures that prioritised export-commodity production over domestic food systems. In the Nigerian context, these structural legacies—including weak infrastructure, limited access to credit, poor market integration, and governance deficits—constrain smallholder farmers' ability to invest in productive activities, compelling them to diversify their livelihoods as a coping mechanism.^{13,14}

Empirical literature review

A substantial body of empirical literature has examined the relationship between livelihood diversification and food security across sub-Saharan Africa, with largely positive yet context-specific findings. Using panel data from Ethiopia, Minyiwab et al.¹⁵ found that household size, female headship, and market access positively influenced livelihood diversification, while age, rural residence, road distance, and exposure to shocks reduced it; critically, households experiencing shocks remained food-insecure despite diversification. In Ghana, Salifu¹⁶ identified remittances, technical education, and mobile phone ownership as significant promoters of livelihood diversification.

Studies examining the food security impacts of diversification have produced broadly positive results. Adjimoti and Mensah¹⁷ demonstrated that crop diversification significantly improved household food security in rural Benin, while Getinet and Lorato¹⁸ found similar outcomes among rural households in Ethiopia. In Nigeria, Oke and Akerele¹⁹ reported that income diversification through agricultural and non-agricultural activities significantly improved food security among cassava farmers in Southwest Nigeria, a finding corroborated by Olutumise et al.²⁰ However, Arigbo and Agbo²¹ found no significant relationship between diversification and food security in Enugu State, suggesting that the food security benefits of diversification are conditional on the quality and productivity of available income-generating opportunities.

With respect to the determinants of household food security, Obayelu and Oyekola²² identified education, household size, income,

and duration of residence as significant predictors among urban slum dwellers in Ibadan.

Agboola et al.²³ and Akukwe²⁴ similarly reported that education, income, gender, and market access were key determinants. The consensus in the literature is that households with higher levels of education, stable incomes, and smaller dependency ratios are systematically more food-secure. Akintunde et al.²⁵ further identified limited farm income, large household size, and poverty as the principal drivers of livelihood diversification in Osun State, Nigeria, with trading, artisanship, and transportation services constituting the most prevalent diversification activities.

Methodology

Study area

The study was conducted in the Ido Local Government Area (LGA) of Oyo State, southwestern Nigeria, at approximately 7.49°N latitude and 3.86°E longitude. The LGA covers approximately 986 km² and shares boundaries with Akinyele LGA to the north, Ibadan Northwest LGA to the northeast, Ibadan Southwest LGA to the east, Oluoye LGA to the south, and Ibarapa Central LGA to the west.²⁶ Based on the 2006 National Population Census, Ido LGA had a population of 103,261, projected to approximately 123,549 by 2012 at an annual growth rate of 3.4%.²⁷ Ido LGA lies within the derived savanna agroecological zone of Oyo State, which is characterized by a mosaic of grasslands and scattered trees transitional between the rainforest and Guinea Savanna.^{28,29} The area receives approximately 1,200–1,500 mm of annual rainfall in a bimodal pattern, with the main rainy season from April to October and a short dry season from November to March.^{30,31} Mean annual temperatures range between 25°C and 34°C, with relative humidity of 70–90% during the wet season and 40–60% in the dry season.²⁹ The derived savanna zone supports the cultivation of cassava, maize, yams, cashew, soybeans, and pepper, making it one of the most agriculturally productive areas in Oyo State.^{32,33}

Data collection

Primary data were collected through a cross-sectional survey of cassava-farming households in Ido LGA using a pre-tested structured questionnaire. The instrument captured information on respondents' socioeconomic and demographic characteristics, household income sources, monthly food and non-food expenditures, land use, access to credit and extension services, and participation in livelihood activities.

Sampling technique and sample size

A three-stage sampling procedure was employed. In the first stage, six wards actively engaged in cassava production were purposively selected from the LGA: Alako, Akufo, Akinware, Camp, Idi-Iya, and Omi-Adio. In the second stage, cassava-farming households were identified from each ward using lists obtained from the Agricultural Development Program (ADP) office. In the third stage, 150 households were selected using a proportionate-to-size sampling approach, with ward-level allocations of 30, 35, 25, 22, 18, and 20 respondents, respectively. Data were collected in 2024.

Analytical techniques

Data were analyzed using descriptive statistics (frequencies, percentages, means, and standard deviations) to characterize respondents' socioeconomic profiles. Four analytical methods were then applied sequentially to address the study objectives: the Herfindahl-Hirschman Index (HHI), the Foster-Greer-Thorbecke

(FGT) class of food insecurity measures, and an ordered probit regression model. Each is described in detail below.

Herfindahl-hirschman index (HHI) for livelihood diversification: The Herfindahl-Hirschman Index (HHI) is a widely used measure of economic concentration and diversity.³⁴ Following Oni and Fashogbon,³⁵ we applied the HHI to quantify the degree of livelihood diversification at the household level. The index measures the concentration of income across sources and is calculated as the sum of the squares of the income shares from each source.³⁶ It can be formally expressed as:

$$HHI = \sum_i^n S_i^2 (1)$$

$$HDI = 1 - HHI(2)$$

where S_i is the income share of the i -th income source within the household, and $i = 1, 2, 3, \dots, N$. The HHI ranges from 0 to 1: a value near 0 indicates high diversification (the household participates in many income-generating activities with relatively equal shares), while a value near 1 indicates full income concentration or specialization in a single activity.^{37,38} The Household Diversification Index (HDI), computed as $1 - HHI$, provides a complementary measure, with higher values signifying greater diversification. Households were subsequently classified into low ($HDI \leq 0.5$) and high ($HDI > 0.5$) diversification categories for comparative analysis.

Foster-greer-thorbecke (FGT) food insecurity indices

Household food security status was assessed using per capita monthly food expenditure as a proxy for welfare, following FAO³⁹ and Omonona and Agoi.⁴⁰ We used the Foster-Greer-Thorbecke (FGT) class of poverty measures,⁴¹ adapted for food security analysis by Oni and Fashogbon,³⁵ to estimate three dimensions of food insecurity. The food poverty line (Z) was set at two-thirds of the mean monthly per capita food expenditure, consistent with Obayelu and Oyekola²² and Oke and Akerele.¹⁹ Households were classified into three food security categories: core food-insecure (per capita food expenditure below one-third of the mean), moderately food-poor (between one-third and two-thirds of the mean), and non-food-insecure (above two-thirds of the mean). The general FGT index is expressed as:

$$P = \sum_{i=1}^q \frac{(z - Y_i)\alpha}{z} (3)$$

$$G_i = (Z - Y_i) / Z (4)$$

where N is the total number of sampled households; q is the number of food-insecure households (those below the food poverty line Z); Y_i is the per capita monthly food expenditure of household i ; Z is the food security threshold line (two-thirds of the mean per capita food expenditure); G_i is the food expenditure deficiency ratio of household i ; and α is a sensitivity parameter ($\alpha = 0, 1, 2$). Setting $\alpha = 0$ yields the food insecurity headcount ratio (P_0), which measures the proportion of households below the threshold; $\alpha = 1$ yields the depth or gap index (P_1), representing the average proportional shortfall in food expenditure among food-insecure households and indicating the additional resources required, on average, to raise them to the food poverty line; and $\alpha = 2$ yields the severity index (P_2), calculated as the mean of the squared expenditure deficiencies and placing greater weight on the most severely food-insecure households.

Ordered probit regression model

The effect of livelihood diversification on household food security status was estimated using an ordered probit regression model, as proposed by Amemiya⁴² and Newey⁴³ and subsequently adopted by Maitra and Rao.⁴⁴ The model is appropriate here because the outcome variable, food security status, is measured on an ordinal scale with three ordered categories, and standard OLS or binary logit/probit approaches would fail to exploit the inherent ordering.⁴⁵ The ordered probit specification assumes the existence of a latent continuous variable Y_i^* , which is a linear function of the explanatory variables:

$$Y_i^* = X_i\beta + \varepsilon_i (5)$$

where Y_i^* is the unobserved latent food security propensity for household i ; X_i is a vector of explanatory variables; β is a vector of parameters to be estimated; and ε_i is a normally distributed error term with zero mean and unit variance. The observed ordinal outcome Y_i is linked to Y_i^* through two threshold parameters μ_1 and μ_2 (with $\mu_0 = 0$) as follows:

$$Y_i = 0 \text{ (Non-food insecure) if } Y_i^* \leq \mu_0$$

$$Y_i = 1 \text{ (Moderately food poor) if } \mu_0 < Y_i^* \leq \mu_1$$

$$Y_i = 2 \text{ (Core food insecure) if } Y_i^* > \mu_1$$

The threshold parameters μ_1 and μ_2 are estimated jointly with the coefficient vector β . Marginal effects, computed at the mean values of the explanatory variables, were reported to quantify the change in probability of falling into each food security category associated with a unit change in each predictor. The explanatory variables included in the model (X_1 – X_{14}) are defined in Table 1.

Table 1 Definition and measurement of explanatory variables in the ordered probit model

Variable	Name	Definition and measurement
X_1	Age	Age of household head (years); continuous
X_2	Sex	Sex of household head; dummy (Female = 0, Male = 1)
X_3	Education level	Years of formal education completed by household head; continuous
X_4	Household size	Number of persons in the household; continuous
X_5	Farming experience	Years of cassava farming experience; continuous
X_6	Farm training	Access to formal agricultural training; dummy (No = 0, Yes = 1)
X_7	Total income	Total annual household income from all sources (NGN); continuous
X_8	Access to credit	Access to formal credit facilities; dummy (No = 0, Yes = 1)
X_9	Source of land	Land tenure arrangement; ordinal (1 = personal, 2 = inherited, 3 = rented/leased, 4 = other)
X_{10}	Cooperative membership	Membership of a farmers' cooperative society; dummy (No = 0, Yes = 1)
X_{11}	Extension services	Access to agricultural extension services; dummy (No = 0, Yes = 1)

Table I Continued....

X ₁₂	Distance to the input market	Distance from household to nearest input market (km); continuous
X ₁₃	Distance to farm	Distance from household to farm plot (km); continuous
X ₁₄	Livelihood diversification index	Household livelihood diversification index derived from HHI (HDI = 1 – HHI); continuous, range 0–1

Source: Authors' compilation based on field survey instruments, 2024. NGN, Nigerian naira.

Before estimating the model, we tested potential endogeneity among the explanatory variables using an instrumental variable (IV) approach. The Durbin–Wu–Hausman test confirmed the absence of significant endogeneity (Durbin $\chi^2 = 0.315$, $p = 0.575$; Wu-Hausman $F = 0.282$, $p = 0.597$), supporting the use of the standard ordered probit estimator. Multicollinearity was assessed using Variance Inflation Factors (VIFs), with all individual VIFs below 10 and a mean VIF of 1.67, indicating that the explanatory variables are not problematically correlated.^{46,47}

Results and Discussion

Socioeconomic characteristics of the cassava farming households

Table 2 presents the pooled socioeconomic and institutional profile of the 150 surveyed cassava-farming households. The findings are discussed below by theme. The age distribution indicates that the majority (25.33%) of respondents fell within the 40–49 years cohort, with a mean age of 43 ± 13 years and a range of 22 to 85 years. This suggests that most cassava farmers are within their economically active years, possessing the physical capacity and experience to engage in both on-farm and off-farm livelihood activities. This finding aligns with Ogunsumi et al.⁴⁸ and Mwaura et al.,⁴⁹ who reported that middle-aged farming households tend to diversify their income more effectively than their younger or older counterparts.

Table 2 Socioeconomic and institutional characteristics of cassava-farming households in ido LGA, Oyo State, Nigeria (n = 150)

Characteristic / Category	Frequency	Percentage (%)	Cumulative (%)
Age (years)			
≤ 29	30	20.00	20.00
30–39	33	22.00	42.00
40–49	38	25.33	67.33
50–59	28	18.67	86.00
60–69	17	11.33	97.33
≥ 70	4	2.67	100.00
Mean ± SD: 43 ± 13.1 years; Min: 22; Max: 85			
Sex			
Female	52	34.67	34.67
Male	98	65.33	100.00
Marital status			
Single	32	21.33	21.33
Married	107	71.33	92.67
Divorced	5	3.33	96.00
Separated	6	4.00	100.00
Educational attainment			
No formal education	7	4.67	4.67
Primary education	21	14.00	18.67
Secondary education	58	38.67	57.33
Tertiary education	64	42.67	100.00
Household size (persons)			
1–5	104	69.33	69.33
6–10	43	28.67	98.00
11–15	2	1.33	99.33
16–20	1	0.67	100.00
Mean ± SD: 5 ± 3 ; Min: 1; Max: 20			
Years of cassava farming experience			
1–5	35	23.33	23.33
6–10	60	40.00	63.33
11–15	21	14.00	77.33

Table 2 Continued....

16–20	16	10.67	88.00
> 20	18	12.00	100.00
Mean ± SD: 12 ± 8.1 years; Min: 1; Max: 40			
Primary occupation			
Cassava farming	37	24.67	24.67
Civil servant	21	14.00	38.67
Artisan	36	24.00	62.67
General farming	48	32.00	94.67
Others (students)	8	5.33	100.00
Access to formal agricultural training			
Yes	116	77.33	77.33
No	34	22.67	100.00
Access to credit			
Yes	27	18.00	18.00
No	123	82.00	100.00
Source of land			
Personal (purchased)	36	24.00	24.00
Inherited	37	24.67	48.67
Rented / Leased	76	50.67	99.33
Other	1	0.67	100.00
Membership of cooperative society			
Yes	83	55.33	55.33
No	67	44.67	100.00
Access to extension services			
Yes	96	64.00	64.00
No	54	36.00	100.00
Distance to input market (km)			
≤ 5	74	49.33	49.33
6–10	66	44.00	93.33
11–15	6	4.00	97.33
> 15	4	2.67	100.00
Mean ± SD: 6.3 ± 4.0 km; Min: 1; Max: 30			
Distance to farm (km)			
≤ 5	13	8.67	8.67
6–10	38	25.33	34.00
11–15	57	38.00	72.00
> 15	42	28.00	100.00
Mean ± SD: 13 ± 5.2 km; Min: 1; Max: 25			
Annual income from cassava production (NGN)			
≤ 50,000	4	2.67	2.67
50,001–100,000	13	8.66	11.33
100,001–150,000	7	4.67	16.00
150,001–200,000	31	20.67	36.67
200,001–250,000	18	12.00	48.67
> 250,000	77	51.33	100.00
Mean: NGN 282,066.70; Min: 0; Max: 750,000			
Annual income from other livelihood activities (NGN)			
≤ 50,000	5	3.33	3.33
50,001–100,000	2	1.33	4.67
100,001–150,000	4	2.67	7.33
150,001–200,000	4	2.67	10.00
200,001–250,000	10	6.67	16.67
> 250,000	125	83.33	100.00
Mean: NGN 557,033; Max: 6,000,000			
Monthly food expenditure (NGN)			
≤ 25,000	9	6.00	6.00

Table 2 Continued....

26,000–50,000	80	53.33	59.33
51,000–100,000	57	38.00	97.33
> 100,000	4	2.67	100.00
Mean: NGN 54,193.33; Min: 15,000; Max: 150,000			
Monthly non-food expenditure (NGN)			
≤ 25,000	68	45.33	45.33
26,000–50,000	73	48.67	94.00
51,000–100,000	8	5.33	99.33
> 100,000	1	0.67	100.00
Mean: NGN 32,600; Min: 10,000; Max: 250,000			
Total Respondents	150	100.00	

Source: Field Survey, 2024. PCFE, per capita food expenditure; NGN, Nigerian naira.

Males constituted the majority (65.33%) of household heads in the sample, reflecting the patriarchal structure of land ownership and household resource control prevalent in Yoruba rural communities. This finding is consistent with the broader literature showing male dominance in cassava farming across southwestern Nigeria.⁵⁰ Regarding marital status, 71.33% of respondents were married, a pattern attributable to local customs, early marriage traditions, and the labour complementarities associated with marriage in smallholder farming contexts. Married household heads have been observed to engage more actively in cassava farming and diversified livelihood activities, generating higher income and achieving better food security outcomes.²⁰

The sample was relatively well-educated: 95.33% of respondents had some formal education, with 38.67% having attained the secondary level and 42.67% having attained tertiary education. Higher educational attainment is associated with improved food production decisions, better access to market information, and greater capacity to exploit non-farm income opportunities, all of which contribute positively to household food security.²² The mean household size of five persons, with 69.33% of households comprising one to five members, indicates a moderately low dependency burden relative to typical rural Nigerian households, which may support more effective resource allocation toward food and livelihood investments.

Farming experience averaged 12 ± 8.1 years, with 40% of respondents reporting 6–10 years of cassava cultivation experience. Experienced farmers typically possess greater production efficiency, risk-management capability, and technical knowledge, thereby

supporting better household welfare outcomes. A majority (77.33%) of respondents had access to formal agricultural training, and 64% had access to extension services, both of which are associated with improved farm management and diversification capacity. In contrast, 82% of respondents lacked access to formal credit, a structural constraint commonly linked to limited financial intermediation in rural Nigeria and the high collateral requirements of formal lending institutions.²³

Half (50.67%) of respondents cultivated rented or leased land, while 24% owned their farmland outright, and 24.67% farmed inherited land. The prevalence of land rental arrangements may partly motivate diversification into non-farm activities to generate income for meeting rental obligations. The mean annual income from cassava production was NGN 282,066.70, with 51.33% of respondents earning above NGN 250,000 per year. Diversified income from other livelihood activities was substantially higher, averaging NGN 557,033 annually, underscoring the economic significance of non-cassava income sources for rural household welfare. Monthly food and non-food expenditures averaged NGN 54,193.33 and NGN 32,600, respectively.

Food security status and FGT indices

Table 3 presents respondents' food security classification and the associated FGT indices. The mean monthly per capita food expenditure (PCFE) was estimated at NGN 4,208.41, calculated by dividing total household food expenditure by household size, with the food poverty line set at NGN 2,805.61 (two-thirds of the mean PCFE).

Table 3 Food security status and foster-greer-thorbecke (FGT) indices of cassava-farming households in Ido LGA (n = 150)

Food Security Status	Frequency	Percentage (%)	Cumulative (%)
Core food insecure (< 1/3 of mean PCFE)	71	47.33	47.33
Moderately food poor (1/3 to 2/3 of mean PCFE)	29	19.33	66.67
Non-food insecure (> 2/3 of mean PCFE)	50	33.33	100.00
Total monthly per capita food expenditure: NGN 631,261.50		Mean per capita food expenditure (PCFE): NGN 4,208.41	
Food poverty line (2/3 of mean PCFE): NGN 2,805.61		FGT Indices: P0 = 0.305; P1 = 0.108; P2 = 0.047	

Source: Field Survey, 2024. PCFE, per capita food expenditure. P0, incidence; P1, depth/gap; P2, severity.

The results indicate a pronounced food security deficit among the surveyed households. Nearly half (47.33%) were classified as core food-insecure, with monthly per capita food expenditures below one-third of the sample mean. An additional 19.33% were moderately

food-poor, while only 33.33% were food-secure. These figures broadly align with Oluyole et al.⁵¹ and Oke and Akerele,¹⁹ who documented higher rates of food insecurity among rural farming households than among urban counterparts in southwestern Nigeria.

The FGT food insecurity incidence ($P0 = 0.305$) indicates that 30.5% of households fell below the food security threshold. The depth index ($P1 = 0.108$) implies that, on average, food-insecure households would need an additional 10.8% in food expenditure to reach the food poverty line. The severity index ($P2 = 0.047$) suggests that although food insecurity is moderately widespread, extreme food deprivation is relatively contained, as evidenced by the low severity coefficient. Together, these indices confirm that food insecurity is significant but not uniformly extreme among cassava-farming households in the study area.

Livelihood diversification index across socioeconomic characteristics

Table 4 presents the livelihood diversification index (HHI-based) disaggregated by selected socioeconomic and institutional

characteristics. Overall, 71.33% of respondents recorded a low diversification index, while 28.67% achieved a high index, indicating that most cassava-farming households in Ido LGA remain predominantly dependent on farming with limited engagement in alternative income-generating activities. The ward-level analysis reveals notable spatial heterogeneity. Omi-Adio (50%) and Idi-Iya (44.44%) wards recorded the highest proportions of highly diversified households, while Akufo (82.86%) and Alako (76.67%) wards exhibited the most concentrated, low-diversification profiles. These spatial patterns may reflect differential access to non-farm labor markets, road infrastructure, and urban proximity, consistent with the findings of Adepoju and Oyegunle.⁵²

Table 4 Livelihood diversification index (HHI) by socioeconomic characteristics of cassava-farming households in Ido LGA (n = 150)

Characteristic / category	Low index n (%)	High index n (%)	Total n (%)
Ward			
Alako	23 (76.67)	7 (23.33)	30 (100)
Akufo	29 (82.86)	6 (17.14)	35 (100)
Akinware	18 (72.00)	7 (28.00)	25 (100)
Camp	17 (77.27)	5 (22.73)	22 (100)
Idi-Iya	10 (55.56)	8 (44.44)	18 (100)
Omi-Adio	10 (50.00)	10 (50.00)	20 (100)
Sex			
Female	30 (57.69)	22 (42.31)	52 (100)
Male	77 (78.57)	21 (21.43)	98 (100)
Marital Status			
Single	22 (68.75)	10 (31.25)	32 (100)
Married	77 (71.96)	30 (28.04)	107 (100)
Divorced	2 (40.00)	3 (60.00)	5 (100)
Separated	6 (100.00)	0 (0.00)	6 (100)
Educational Attainment			
No formal education	5 (71.43)	2 (28.57)	7 (100)
Primary	16 (76.19)	5 (23.81)	21 (100)
Secondary	40 (68.97)	18 (31.03)	58 (100)
Tertiary	46 (71.88)	18 (28.13)	64 (100)
Primary Occupation			
Cassava farming	31 (83.78)	6 (16.22)	37 (100)
Civil servant	12 (57.14)	9 (42.86)	21 (100)
Artisan	19 (52.78)	17 (47.22)	36 (100)
General farming	38 (79.17)	10 (20.83)	48 (100)
Others	7 (87.50)	1 (12.50)	8 (100)
Food Poverty Status			
Core food poor	55 (77.46)	16 (22.54)	71 (100)
Moderately food poor	16 (55.17)	13 (44.83)	29 (100)
Non-food poor	36 (72.00)	14 (28.00)	50 (100)
Total	107 (71.33)	43 (28.67)	150 (100)

Source: Field Survey, 2024. Low index = HHI closer to 1 (low diversification); High index = HHI closer to 0 (high diversification).

Female farmers showed a greater tendency toward livelihood diversification (42.31% high index) than male farmers (21.43%), suggesting that women in rural farming households more actively combine multiple income-generating strategies to compensate for restricted access to land and productive resources. This corroborates Adebayo et al.,⁵³ who found that women in rural households in Nigeria are more actively engaged in diversified livelihood portfolios.

With respect to occupation, civil servants (42.86%) and artisans (47.22%) exhibited higher diversification than those primarily engaged in cassava farming (16.22%), reflecting the inherent capacity of non-farm primary occupations to generate additional income streams. Households with access to farm training recorded a higher diversification rate (31.90%) compared to those without (17.65%), while moderately food-poor households exhibited the highest

diversification tendency (44.83%) among the three food security categories—a pattern consistent with the hypothesis that moderate food insecurity motivates proactive livelihood adjustment rather than passive coping.⁵⁴

Determinants of food security status: ordered probit regression results

Table 5 presents the ordered probit regression estimates of the determinants of household food security status. The model achieved

a good overall fit ($LR \chi^2(14) = 121.53$, $p < 0.001$; pseudo- $R^2 = 0.39$), indicating that the selected explanatory variables jointly explain approximately 39% of the variation in food security status. The Durbin-Wu-Hausman test confirmed the absence of significant endogeneity ($p = 0.575$ and $p = 0.597$ for the Durbin and Wu-Hausman statistics, respectively), and multicollinearity was ruled out (mean VIF = 1.67, all individual VIFs < 10).

Table 5 Ordered probit regression estimates of the determinants of household food security status among cassava-farming households in ido LGA (n = 150)

Variable	Coeff.	Std. Err.	P > z	dy/dx (0)	dy/dx (1)	dy/dx (2)
Age	0.046***	0.016	0.005	-0.009***	0.001*	0.009***
Sex (male=1)	0.000	0.303	0.999	-0.000	4.46e-06	0.000
Years of education	-0.056*	0.034	0.096	0.012*	-0.001	-0.011*
Household size	-0.773***	0.125	0.000	0.158***	-0.013*	-0.146***
Farming experience	-0.056**	0.025	0.025	0.011**	-0.001*	-0.011*
Farm training	0.591*	0.359	0.100	-0.121*	0.010	0.111*
Total income	6.61e-07	5.08e-07	0.193	-1.35e-07	1.07e-08	1.25e-07
Access to credit	0.287	0.362	0.428	-0.059	0.005	0.054
Source of land	-0.223	0.158	0.160	0.046	-0.004	-0.042
Cooperative membership	-0.232	0.281	0.408	0.048	-0.004	-0.044
Access to extension agents	-0.043	0.290	0.883	0.009	-0.001	-0.008
Distance to market	0.030	0.034	0.383	-0.006	0.001	0.006
Distance to farm	-0.012	0.025	0.637	0.003	-0.000	-0.002
Livelihood diversification index	-2.048	3.396	0.546	0.419	-0.033	-0.386
Lower threshold (Cut 1)	-2.819	1.013				
Upper threshold (Cut 2)	-1.864	1.001				
LR Chi2 (14) = 121.53; Prob > Chi2 = 0.000; Pseudo R ² = 0.39; Log-likelihood = -94.93; N = 150; Mean VIF = 1.67						

Source: Field Survey, 2024. dy/dx (0) = marginal effect on probability of being core food insecure; dy/dx (1) = moderately food poor; dy/dx (2) = non-food insecure. * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

Interpretation

Age was positively and significantly associated with food security status at the 1% level ($\beta = 0.046$; $p = 0.005$). The marginal effect indicates that each additional year of age reduces the probability of being core food-insecure by 0.9 percentage points and increases the probability of being food-secure by 0.9 percentage points. This suggests that older household heads, who typically have greater accumulated assets, experience, and social networks, are better positioned to ensure household food access. This finding is consistent with Muzira et al.⁵⁵ Years of education carried a significant negative coefficient ($\beta = -0.056$; $p = 0.096$), implying that higher educational attainment reduces the likelihood of food insecurity. The marginal effect indicates that each additional year of schooling increases the probability of being food secure by 1.1 percentage points. Education enhances farmers' production efficiency, nutritional knowledge, and capacity to access non-farm income opportunities, all which support food security.⁵⁶

Household size was the strongest negative predictor of food security ($\beta = -0.773$; $p < 0.001$). Each additional household member increases the probability of being core food-insecure by 15.8 percentage points and reduces the probability of being food-secure by 14.6 percentage points, reflecting the severe pressure that large household size places on food consumption and resource allocation. This finding is consistent with Hawkins et al.⁵⁷ Farming experience was significantly and negatively associated ($\beta = -0.056$; $p = 0.025$),

indicating that more years of experience reduce the probability of being in lower food security categories. Specifically, the marginal effect shows that each additional year of experience reduces the probability of core food insecurity by 1.1 percentage points, consistent with the argument that experienced farmers achieve higher productivity and more effective resource management.⁵⁸ Access to farm training was positively and significantly associated with food security ($\beta = 0.591$; $p = 0.100$). The marginal effect indicates that access to training increased the probability of being food secure by 11.1 percentage points, underscoring the role of agricultural capacity building in improving household welfare. The livelihood diversification index, while expected to be negative, was not statistically significant ($p = 0.546$), suggesting that diversification alone, without accompanying improvements in asset endowments, institutional access, and income quality, may not be sufficient to improve food security outcomes. This nuanced finding is consistent with the cautionary evidence reported by Arigbo and Agbo.²¹

The livelihood diversification index was negative but insignificant ($\beta = -2.048$; $p = 0.546$), showing diversification via the HHI index did not significantly improve household food security. Diversification isn't always linked to better welfare; it may be a deliberate income strategy or a distress-coping response. When alternative activities are low-yielding, unstable, or limited by market access and resources, diversification can increase income sources without enhancing food access. The descriptive evidence supports this interpretation. Although income from other livelihood activities was substantial,

averaging about ₦557,033 annually compared with ₦282,067 from cassava production, 71.33% of households were still classified as having low livelihood diversification. Moreover, 82% of respondents reported no access to formal credit, suggesting that many households operate under considerable financial constraints that may limit their ability to invest in more profitable non-farm or off-farm enterprises.

The insignificant coefficient likely reflects diversification quality and composition rather than a lack of diversification activities. Households engage in multiple low-return activities mainly to smooth consumption or handle seasonal income swings, not necessarily to build productive assets or increase disposable income. This aligns with the Sustainable Livelihoods Framework, which states that livelihood outcomes depend on the number of activities and access to various capitals.^{6,9} It also aligns with mixed empirical findings: Oke and Akerele¹⁹ found income diversification improved food security among Nigerian cassava farmers, while Arigbo and Agbo²¹ found no significant link, suggesting diversification benefits depend on context and the quality of livelihood options.

Thus, the insignificant effect should not mean that livelihood diversification is unimportant. Rather, it suggests that diversification alone is insufficient to overcome the structural constraints underlying food insecurity among the sampled cassava-farming households. The effectiveness of diversification likely depends on whether households can transition from low-return coping activities to more productive and sustainable livelihood opportunities.

Conclusion

This study investigated food security status and the role of livelihood diversification among cassava-based farming households in Ido Local Government Area, Oyo State, Nigeria. Drawing on a cross-sectional survey of 150 households and employing the Foster-Greer-Thorbecke poverty indices, the Herfindahl-Hirschman Index, and an ordered probit regression model with endogeneity and multicollinearity diagnostics, the study generated several important empirical findings. The food security analysis revealed a deeply concerning situation: 47.33% of households were core food-insecure, 19.33% were moderately food-poor, and only one-third had adequate food access. The FGT indices confirmed a headcount food insecurity rate of 30.5%, a depth of 10.8%, and a severity of 4.7%, collectively indicating that food insecurity is prevalent and structurally embedded rather than transient or mild. The livelihood diversification analysis showed that 71.33% of respondents had a low diversification index, with most household income remaining concentrated in cassava and general farming activities. Spatially, farmers in Omi-Adio and Idi-Iya wards exhibited higher diversification tendencies, as did female farmers, civil servants, artisans, and households with access to farm training patterns that point to the importance of occupational flexibility, human capital, and institutional access in enabling diversification.

The ordered probit regression confirmed that age, years of education, household size, farming experience, and access to farm training were statistically significant determinants of food security status. Notably, household size had the largest and most robust negative effect, while access to farm training had the strongest positive marginal effect on the probability of food security. The livelihood diversification index was not independently significant, suggesting that diversification contributes to food security through pathways mediated by asset accumulation and institutional access rather than as a direct, unconditional mechanism.

Taken together, the findings highlight the multidimensional nature of food insecurity among cassava-farming households in Ido LGA

and underscore the inadequacy of single-intervention approaches. Structural constraints, including limited access to credit, inadequate extension coverage, land tenure insecurity, and poor market connectivity, interact to perpetuate food vulnerability even among farmers who attempt to diversify their livelihoods. Effective policy must therefore address these structural determinants simultaneously.

Recommendations

Based on the study findings, the following evidence-based recommendations are proposed for policymakers, development practitioners, and agricultural institutions:

- 1. Expand agricultural training and capacity-building programmes:** Since access to farm training increased the probability of household food security by 11.1 percentage points, government ministries of agriculture, extension agencies, and development organisations should strengthen and scale up integrated farmer-training programmes. Such programmes should cover improved cassava production practices, post-harvest handling, food processing, enterprise development, and financial literacy. Training should also be gender-responsive, with deliberate efforts to improve women's access to extension and capacity-building services, given their relatively greater engagement in livelihood diversification.
- 2. Implement household-size-sensitive social protection interventions:** Household size had the strongest negative association with food security in the estimated model. Social protection interventions, including conditional cash transfers, food vouchers, and nutrition-sensitive programmes, should therefore give priority to larger and vulnerable households. Existing social protection platforms, including Nigeria's National Social Investment Programme (NSIP), could strengthen targeting mechanisms using household-level socioeconomic and geographic information to identify cassava-farming households experiencing severe food insecurity. This is particularly important given that 47.33% of the sampled households were classified as core food insecure.
- 3. Promote education and vocational skills development in rural communities:** The positive association between educational attainment and food security highlights the importance of human-capital development. Government and development partners should therefore strengthen quality primary and secondary education in rural areas while expanding adult literacy, vocational training, and entrepreneurship programmes. Such investments can improve farmers' capacity to process information, adopt improved technologies, manage farm enterprises, and access more productive non-farm employment opportunities.
- 4. Improve access to productive resources for livelihood diversification.** Although livelihood diversification was not statistically significant in explaining household food security, this finding should not be interpreted as evidence that diversification is inherently ineffective. Rather, the result suggests that diversification alone may be insufficient when households engage predominantly in low-return activities or face constraints in accessing productive assets, finance, markets, and skills. Policies should therefore focus on improving the **quality and returns of diversified livelihood activities** through affordable credit, enterprise development, market linkages, vocational skills, and access to productive assets rather than simply encouraging households to increase the number of activities they undertake.

5. Strengthen complementary institutional support for food-security improvement. The findings suggest that household characteristics and access to productive services jointly shape food-security outcomes. Agricultural institutions should therefore adopt an integrated approach that combines extension and training with credit facilitation, market access, social protection, and livelihood-support interventions. Such an approach is more likely to generate sustainable improvements in food security than interventions targeting individual constraints in isolation.

6. Prioritize longitudinal and nutrition-sensitive research. Future studies should employ panel or longitudinal data to better establish the causal relationship between livelihood diversification and food security and to distinguish strategic diversification from distress-driven diversification. Future research should also incorporate multidimensional and nutrition-sensitive measures of food security beyond expenditure-based indicators and examine whether climate variability and other agroecological factors moderate the effectiveness of livelihood diversification across different regions of Nigeria.

Conflicts of interest

The author declares no conflicts of interest.

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