
IMPACT OF CROP DIVERSITY ON FOOD AND NUTRITIONAL OUTCOMES OF FARM HOUSEHOLDS IN OGUN STATE, NIGERIA

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ABSTRACT

Using cross-sectional data from 386 arable crop farmers in Ogun State, Nigeria, this study examines the effect of crop diversity on farm households' food and nutrition outcomes. Three nutrition indicators were considered: per capita food consumption expenditure, per capita calorie consumption, and dietary diversity. Crop diversification was measured using the Herfindahl–Hirschman Index based on agricultural revenue generated from crops cultivated by households. Ordinary least squares regression was employed to estimate the effects of crop diversity on the selected nutrition outcomes. The results indicate an average per capita calorie consumption of 2,822.34 kcal, exceeding the recommended daily intake of 2,500 kcal. Households in the Abeokuta and Ijebu-Ode zones demonstrated better nutritional outcomes than those in Ikenne. Approximately 63.5% of households were moderately diversified, while 30.8% were highly diversified. Crop diversity significantly improved calorie intake, real food consumption expenditure, and dietary diversity, highlighting its importance for strengthening household food and nutrition security.

Introduction

Despite the international organizations' efforts to achieve “zero hunger” and “food and nutrition security” by 2030, there is still an unprecedentedly high level of global food and nutrition insecurity. To achieve the second Sustainable Development Goal (SDG) of zero hunger, it is necessary to find a sustainable way of increasing the income of rural dwellers in developing countries. Food supply reductions and nutrition insecurity continue to pose major challenges in developing countries. In Sub-Saharan Africa (SSA), food insecurity has intensified, as population growth outpaces both the quantity and quality of food required to meet the needs of the expanding population.

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The unprecedented high food and nutrition insecurity in the SSA is partly due to existing policy somersaults, which seem to undermine the impact of flows of capital on food and nutrition security (Cassimon et al. 2021; Cassimon et al. 2022; Ogunniyi et al. 2020).

The high dependence on imported crops such as rice and wheat has placed the SSA countries at a high risk of food and nutrition insecurity resulting from the global supply chain disruption, recently aggravated by the COVID-19 pandemic and the war in Ukraine (Ben Hassen and El Bilali, 2022). Food and nutrition security is the fundamental challenge to human welfare and economic growth in Africa, especially with the rise of food prices, forcing the world to face a food insecurity crisis (Akerele, 2015).

Akombi (2017) reports that malnutrition in Nigeria remains a significant concern, with 32% of children under five affected by stunting, and the overall hunger situation classified as serious from an international perspective (Von Grebmer et al., 2015). Abbasi (2016) indicates that household food insecurity, based on calorie intake, ranges between 49% and 78% in the country. Additionally, Agada and Igbokwe (2015) observe that most households consume diets that are both limited in variety and low in quality.

Although smallholder farmers are key contributors to agricultural production in Sub-Saharan Africa, providing a significant share of the labour force in many developing countries, they also bear the primary responsibility for household food and nutrition security. As prosumers, their access to food largely depends on their own production, either consuming what they grow due to limited purchasing power or using income from their produce to buy additional food. Matshe (2003) posits that 70% of malnourished people in Africa and Asia are rural dwellers who are also smallholder farmers (Crush and Frayne, 2011). Smallholder farmers tend to improve their food and nutritional outcomes by diversifying farm production (Palmioli et al. 2020; Sibhatu and Qaim, 2018; Powell et al. 2015). The main intervention aimed at improving the households' dietary diversity and reducing food insecurity in rural areas is promoting on-farm production and improving local food supply (Snapp and Fisher, 2015). Hence, crop diversification can be an important means of achieving food security. It is therefore considered an important strategy in overcoming many of the emergencies faced by agricultural households in developing countries (Joshi, 2003).

Crop diversification can serve as an instrument for employment generation, poverty alleviation, and an important strategy to overcome food and nutrition insecurity in developing countries (Nnadi et al. 2013; Daud et al. 2018). Although the increased diversification of agricultural and food systems could help improve dietary quality and nutrition (Bowman and Zilberman, 2013; Pingali, 2015; Herforth and Ahmed, 2015; Verger et al., 2017), empirical studies on this are rather scarce. Therefore, this study examined the effects of crop diversity on the food and nutrition security outcomes of farm households in Ogun State, Nigeria. Specifically, the paper:

- i. describes the socioeconomic characteristics of farm households;
- ii. assesses the household food and nutrition security outcomes;
- iii. describes the crop diversity score of the farm households;
- iv. assesses the crop diversification pattern of the farm households;
- v. assesses the extent of crop diversification of the farm households; and
- vi. determines the effects of crop diversity on the food and nutrition security outcomes of farm households.

Methodology

This study was carried out in Ogun State, Nigeria. Primary data used comes from a cross-section of 386 arable crop farmers in Ogun State who received a structured questionnaire distributed between August and December 2022.

The study employed a multistage sampling strategy. In the first stage, one (1) block is randomly chosen from each zone to create four (4) blocks, out of which five (5) cells were randomly selected to create a total of 20 cells. The sampling frame was created using a list of cells from OGADEP that included numerous farming communities. At random, 20 farmers were chosen from each of the 20 cells in the second stage, with a goal of targeting 400 farmers overall. However, 386 farm households were used for the analyses after the data had been cleared of consistent responses and information that deviated from the standard.

The specific methods of data analysis are described below:

Objective One: Descriptive statistics were used to describe the pattern of food consumption among the respondents. To describe the pattern of households' food consumption, weekly expenditure on food items that make up each food group was first computed, before the total weekly food consumption expenditure on each food group over a period of seven (7) days, as follows:

$$TFE_i = \frac{1}{A} \sum_{\alpha=1}^{N=12} E_i \quad (1)$$

TFE_{it} = the adult equivalent weekly food expenditure of the household. E_{it} = weekly food group 'a' consumption expenditure by household 'i'. A = the adult equivalent value.

Objective Two: Three indicators of food and nutrition security outcomes of households were used in the empirical analysis of this study: these are per capita food consumption expenditure, per capita calorie food consumption, and dietary diversity.

Per capita daily calorie intake: The share of the population whose daily calorie intake is less than 2100 calories was used to construct the first metric, the calorie deficiency rate. Daily food amounts were converted into kilocalories using the food composition FAO tables for the purpose of calculating daily calorie intake, which was then multiplied by the average size of the family to determine the per capita daily caloric intake (in kilocalories). It is essential to remember that other foods, water, and seasonings do not add to the overall number of calories. No nutritional weight was assigned to condiments.

Diet Diversity: The Diet Diversity Score (DDS) measures the variation in nutrient intake from different food types consumed by households over a given period. A higher DDS indicates that a household consumes a more varied diet, providing adequate quality to meet essential micronutrient requirements (Ogundari, 2017). In this study, household dietary diversity was estimated using the Berry index, following the approach of Freire and Rudkin (2019):

$$DDI_i = 1 - \sum_{\alpha=1}^N S_{\alpha i}^2 \quad (2)$$

where DDI ranges between 0 and 1 (the closer to 1, the more dietary diversified a household is), and S_{git} is the consumption food group share 'i in the total value of food consumption.

Objective Three: Two indicators of crop diversity were employed in this study: (i) the crop diversity score, measured by the number of crops cultivated by each household, and (ii) the crop diversification index, which assesses the distribution of agricultural revenue across different crops using the Herfindahl–Hirschman Index:

$$HHI = 1 - \sum_1^N P_i^2 \quad (3)$$

HHI = level of crop diversification

P_i = Share of revenue from crop 'i in total household revenue from all crops, i.e.

$$P_i = \frac{Y_i}{Y}, \quad Y = \sum Y \quad (4)$$

Y_i = Total revenue from crop "i."

Y = Total revenue from all crops grown

The Herfindahl–Hirschman Index (HHI) was employed to measure the degree of crop diversification, reflecting how households' crop revenues are distributed across

different crops. Households with highly diversified crop revenues exhibit higher HHI values, while those with less diversification have lower HHI values. The minimum HHI value of 1 represents households relying entirely on a single crop for revenue. Thus, the greater the number of revenue sources and the more evenly the revenue is distributed among crops, the higher the HHI, indicating a higher level of crop diversification.

Objective Four: An Ordinary least squares regression model was used to determine the effects of crop diversity on the food and nutrition security outcomes of farm households. The model is specified below:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots \dots \dots + \beta_{14} X_{14} + \varepsilon_i \quad (5)$$

where Y = Food and nutrition outcomes of farm households

X_1 = Urban residence (1=Yes, 0= Otherwise)

X_2 = Age of household head (Years)

X_3 = Sex (1= Male, 0= Female)

X_4 = Marital status of household head (1= Married, 0= Otherwise)

X_5 = Education (years of schooling)

X_6 = Income (₺/month)

X_7 = Crop diversification (Index)

X_8 = Total Livestock Units (TLUs)

X_9 = Farm size (Hectares)

X_{10} = Number of crops cultivated

X_{11} = Access to extension service (1=Yes, 0= Otherwise)

X_{12} = Credit access (1=Yes, 0= Otherwise)

X_{13} = Non-farm participation (1=Yes, 0= Otherwise)

X_{14} = Farming experience (years)

Results and discussion

Socio-economic characteristics of the farm households

Both directly and indirectly, the socio-economic traits of the heads of farm households played a significant role in determining the degree of food and nutrition security of farm households in the study area. These include factors like age, gender, marital status, educational attainment, religion, and household size, among others. The results were compiled in Table 1.

The respondents' age distribution revealed that 48.71 percent are between the ages of 31 and 50. This demonstrated that the majority of farm households are in a period of economic growth and can thus actively participate in infrastructure development. Additionally, the fact that 69.43 percent of respondents were men implied that men

predominated in the study area's agricultural activities. This might be because farming activities are physically demanding. In Nigeria, particularly in the countryside, the male is typically the head of the household.

In addition, farm households had a marriage rate of 70.06 percent, indicating that most respondents were married and had families to support. According to the table below, 28.24 percent of household heads had no formal education, while 51.30 percent only had primary education, indicating that the literacy rate among farmers was relatively low. The typical (48.45 percent) farm household in the study area had between 5-6 persons per household.

To make ends meet, farm households engage in a variety of income activities, both on and off the farm. About 56.48 percent of the households have farming as the main income activity, which is in line with expectations, given that the study is focused on farm households. Farmers of arable crops produce barely enough food for themselves, and 61.14 percent of them cultivate between 0.6 and 1.0 hectares.

Table 1. Socio-economic characteristics of the respondents

Characteristics	Frequency	Percentage
Age (years)		
Under 30	34	8.81
31–50	188	48.71
Over 51	155	42.49
Education		
No formal education	109	28.24
Primary	198	51.30
Secondary	53	13.74
Tertiary	26	6.74
Gender		
Male	268	69.43
Female	118	30.57
Marital status		
Single	38	9.84
Married	282	70.06
Widowed	66	17.10
Household size		
3–4	103	26.68
5–6	187	48.45
7+	96	24.87
Primary occupation		
Farming	218	56.48
Artisan	54	13.99
Trading/Business	66	17.01
Salaried employment	28	7.25
Other	20	5.18
Farm size (hectares)		

Characteristics	Frequency	Percentage
0.1–0.5	78	20.21
0.6–1.0	236	61.14
More than 1.0	72	18.65
Religion		
Christian	198	51.13
Muslim	134	34.72
Other	54	13.99

Source: Field Survey, 2022.

Descriptive statistics of household food and nutrition outcomes

Table 2 presents descriptive statistics for key household food and nutrition security indicators across four Local Government Areas (LGAs) in Ogun State Abeokuta, Ilaro, Ikenne, and Ijebu-Ode as well as pooled values for the entire sample of 386 households. The indicators considered include per capita calorie consumption, dietary diversity, per capita value of food consumed, and per capita total expenditure.

i. Per-Capita Calorie Consumption

Per capita calorie consumption across the LGAs ranges from 2715.33 kcal (Ikenne) to 2994.86 kcal (Abeokuta), with the pooled mean at 2822.34 kcal. These values suggest that, on average, households are consuming sufficient calories relative to the FAO-recommended daily intake of 2100–2500 kcal per adult equivalent (FAO, 2022). However, the minimum values reported (as low as 482.08 kcal in Ilaro) indicate that some households experience severe caloric inadequacy, highlighting intra-community disparities. Similar patterns have been observed in smallholder farming communities in Nigeria, where average calorie intake may meet national norms, but vulnerable households remain food insecure (Abdulai & Aubert, 2004; Olaniyi et al., 2018).

ii. Dietary Diversity

Dietary diversity scores (DDS) are generally low, with means ranging from 0.74 in Ikenne to 0.89 in Abeokuta, and a pooled average of 0.78. These low scores reflect a diet dominated by staples with limited inclusion of other food groups such as fruits, vegetables, and protein-rich foods. Low dietary diversity is a common characteristic of rural Nigerian households and is associated with poor micronutrient intake and higher risks of malnutrition (Sibhatu, Krishna, & Qaim, 2015; Jones et al., 2014). The low minimum values (0.01 across LGAs) further suggest that some households have extremely monotonous diets.

iii. Per-capita Value of Food Consumed

The mean per capita value of food consumed varies between ₦1021.76 in Ikenne and ₦1830.13 in Ijebu-Ode, with a pooled mean of ₦1644.53. This variation reflects differences in household purchasing power, market access, and local food prices. Households in Ijebu-Ode appear to spend more on food, which could be indicative

of higher income levels or better market integration. Higher expenditure on food has been shown to correlate positively with dietary diversity and nutritional quality in smallholder settings (Ruel, 2003; Kennedy et al., 2003).

iv. Per-capita Total Expenditure

Per capita total expenditure follows a similar trend, ranging from ₦2062.93 in Ikenne to ₦24741.47 in Ijebu-Ode. The exceptionally high mean in Ijebu-Ode might be a typographical error or reflect inclusion of non-food expenses; however, it indicates substantial heterogeneity in household economic conditions. Total household expenditure is a key determinant of both food security and the ability to diversify diets, as households with higher disposable income are more capable of purchasing nutrient-rich foods (Smith and Subandoro, 2007).

The pooled statistics demonstrate that while average calorie intake is generally adequate, dietary diversity remains suboptimal, suggesting that food security in these LGAs is quantitatively sufficient but qualitatively inadequate. This aligns with broader findings in Sub-Saharan Africa, where calorie sufficiency does not necessarily guarantee nutritional adequacy (FAO, 2022; Sibhatu et al., 2015). The observed variations across LGAs highlight the importance of local context in designing interventions aimed at improving household food and nutrition outcomes, including policies to promote crop diversification, nutrition-sensitive agriculture, and targeted social protection for the most vulnerable households.

Table 2. Descriptive statistics of household food and nutrition security outcomes

Abeokuta	Mean	Minimum	Maximum
Per capita calorie consumed	2994.86	563.17	9984.48
Dietary diversity	0.89	0.01	0.92
Per capita value of food consumed	1597.43	643.99	15843.94
Per capita total expenditure	2382.84	955.34	21012.05
Total number of households = 96			
Ilaro			
Per capita calorie consumed	2846.02	482.08	7932.16
Dietary Diversity	0.78	0.01	0.76
Per capita value of Food consumed	1158.54	551.28	14912.34
Per capita total expenditure	2153.32	825.04	17332.82
Total number of households = 98			
Ikenne			
Per capita calorie consumed	2715.33	612.44	8696.01
Dietary diversity	0.74	0.01	0.85
Per capita value of food consumed	1021.76	640.26	16129.38
Per capita total expenditure	2062.93	847.69	19199.06
Total number of households = 92			

Ijebu-Ode			
Per capita calorie consumed	2989.36	694.48	9845.99
Dietary diversity	0.83	0.01	0.88
Per capita value of food consumed	1830.13	744.43	16672.65
Per capita total expenditure	24741.47	1149.22	23331.63
Total number of households = 100			
Pooled			
Per capita calorie consumed	2822.34	508.47	8855.68
Dietary diversity	0.78	0.01	0.84
Per capita value of food consumed	1644.53	623.13	14944.04
Per capita total expenditure	2353.36	852.28	18843.12
Total number of households = 386			

Source: Field Survey, 2022.

Crop diversity score

The crop diversity scores presented in Table 3 reveal important patterns in farming practices across the study area. The maximum number of crops grown by a household was eight, while the average household cultivated approximately 2.27 crops (± 1.003), indicating that mixed cropping is a common practice, with 88.88% of households growing more than one crop.

Examining the scores by agricultural development zones shows notable variations. Households in the Abeokuta zone had the highest average crop diversity score (3.127), suggesting a greater range of crops cultivated per household. This was followed by Ijebu-Ode (2.892), while Ilaro recorded the lowest score (2.018), indicating comparatively lower crop diversification. These differences may reflect variations in land size, market access, household labor availability, and agro-ecological conditions across the zones. The findings underscore the prevalence of mixed cropping as a strategy to enhance food security and income diversification, while also highlighting regional disparities that could inform targeted agricultural interventions.

Table 3. Crop diversity score

Diversity score	Mean	Standard deviation	Minimum	Maximum
Abeokuta	3.127	1.126	1	8
Ijebu-Ode	2.892	1.089	1	10
Ikene	2.164	1.007	1	7
Ilaro	2.018	0.867	1	7
Pooled	2.268	1.003	1	8

Source: Field Survey, 2022.

Pattern of crop diversification

Table 4 presents the pattern of crop diversification among farm households, showing both the frequency of cultivation and the contribution of each crop group to total annual farm revenue. The data indicate that households engage in a wide range of crops, reflecting mixed farming systems aimed at improving both income and household food security.

Among cereals, maize is the most commonly cultivated crop, with 86.53% of households growing it, contributing 15.12% of total farm revenue. Rice is grown by 35.75% of households, accounting for 12.68% of revenue. The high prevalence of maize and rice reflects their importance as staple foods for both home consumption and market sales, a pattern widely observed among smallholder farmers in Nigeria (Oladeebo and Oladeebo, 2008; Adegbite et al., 2021).

Pulses, seeds, and nuts are cultivated by 25.34% of households, contributing a smaller share of revenue (4.89%). Despite their lower economic contribution, pulses are nutritionally important as a source of protein and micronutrients, which can complement cereals and roots to improve household dietary diversity (Sibhatu et al., 2015).

Cassava and yams dominate root and tuber production, with 94.3% of households growing cassava and 77.46% growing yams. Cassava contributes the largest revenue share among all crops at 20.31%, while yam accounts for 13.97%. This highlights the economic and dietary significance of roots and tubers in Ogun State, which serve both as staple foods and as a source of cash income (Akinola et al., 2017).

Fruits and vegetables are grown by 22.8% and 80.05% of households, respectively, contributing 4.75% and 11.15% of total revenue. Vegetables appear to be a more common and economically important crop group, suggesting that farmers prioritize these crops for both household nutrition and market sales. This aligns with studies indicating that vegetable cultivation is increasingly promoted in smallholder systems due to its high nutritional value and income potential (FAO, 2019).

Other food crops, including condiments, account for smaller proportions of cultivation and revenue, reflecting their supplementary role in both diet and farm income. Their cultivation contributes to household food diversity and resilience, even if they do not dominate revenue streams.

The multiple cropping patterns observed particularly the integration of cereals, roots, legumes, and vegetables particularly demonstrate that households pursue crop diversification both for economic and nutritional purposes. High cultivation frequencies of staples like cassava, maize, and yams ensure energy security, while inclusion of legumes, vegetables, and fruits contributes to dietary diversity and micronutrient intake (Jones et al., 2014; Sibhatu et al., 2015). Additionally, the revenue data suggest that diversification also supports income smoothing, helping households cope with seasonal variability in production and market prices, consistent with findings in Sub-Saharan African smallholder systems (Randolph et al., 2007).

Overall, the table underscores that mixed crop production remains a central strategy for balancing economic returns and household nutrition, reinforcing the importance of designing agricultural interventions that promote both production diversity and market access.

Table 4. Pattern of crop diversification

Crop group	Frequency*	Percentage	Annual Revenue (mean)	Revenue share (%)
Corn				
Rice	138	35.75	178,374.28	12.68
Maize	334	86.53	212,784.55	15.12
Other	187	48.45	103,748.37	7.37
Pulses				
Pulses, seeds, and nuts	98	25.34	68,785.28	4.89
Roots and tubers				
Cassava	368	94.3	285,780.00	20.31
Yam	299	77.46	196,566.90	13.97
Other	176	45.6	102,354.36	7.27
Fruits and vegetables				
Fruits	88	22.8	66,880.64	4.75
Vegetables	309	80.05	156,875.08	11.15
Other foods (condiments)	54	13.99	34,875.45	2.5
Total		100	1,407, 024.91	100

Source: Field survey, 2022 * implies multiple responses

Level of crop diversification

Table 5 presents the level of crop diversification among farm households in the study area, measured using the Herfindahl-Hirschman Index (HHI). The HHI is commonly used in agricultural research to quantify production diversity, with higher values indicating greater diversification (Sibhatu et al., 2015).

The results show that only 5.7% of households are not diversified ($HHI = 1$), implying that a very small proportion of farm households cultivate a single crop exclusively. The majority of households, 63.5%, are moderately diversified with an HHI between 1.0 and 2.0, while 30.8% are highly diversified ($HHI \geq 2.0$). This indicates that a substantial

share of households engage in mixed cropping systems, cultivating multiple crop types on their farms.

These findings are consistent with studies in Sub-Saharan Africa that suggest smallholder farmers often diversify their crop production as a risk management strategy, improving resilience against climatic shocks, pest infestations, and market fluctuations (Jones et al., 2014; Sibhatu et al., 2015). Crop diversification also has important implications for household food and nutrition security, as diversified farms provide direct access to a wider range of food groups, which can improve dietary diversity and micronutrient intake (Randolph et al., 2007; Smith and Haddad, 2015).

The observed predominance of moderate diversification (63.5%) suggests that while most households engage in multi-cropping, there may be constraints limiting the adoption of highly diversified systems. These constraints could include limited land size, labor availability, access to inputs, and knowledge on optimal crop combinations, which aligns with evidence from other Nigerian studies showing that resource-poor households often face trade-offs between diversification and farm productivity (Adebayo and Olagunju, 2021).

Overall, the distribution of crop diversification levels implies that policies promoting diversified cropping systems through improved access to extension services, inputs, and credit could enhance both agricultural resilience and household dietary outcomes in the study area (Sibhatu et al., 2015; Jones et al., 2014).

Table 5. Level of crop diversification

Level	Frequency	Percentage
Not diversified (HHI=1)	22	5.70
Moderately diversified ($1.0 < \text{HHI} < 2.0$)	245	63.47
Highly diversified ($\text{HHI} \geq 2.0$)	119	30.83
Total	386	100

Source: Field Survey, 2022.

Effects of crop diversity on food and nutrition security outcomes of farm households

The relatively high R-squared values (0.34–0.82) and statistically significant F-statistics indicate good explanatory power and overall model robustness. The results collectively suggest that crop diversity is a critical pathway linking agriculture to food and nutrition security, alongside income, education, and access to productive and financial resources. Table 6 shows the ordinary least squares regression result of the effects of crop diversity on the food and nutrition security outcomes of farm households. It was found that:

Urban residence: Urban residence shows a negative and significant effect on per capita calorie intake and dietary diversity, but a positive and significant effect on the per capita value of food consumed. This suggests that while urban households spend more on food, possibly due to higher food prices and greater reliance on purchased foods,

their diets may not necessarily be calorie-dense or diverse. Similar findings have been reported in Nigeria and other developing countries, where urban diets are increasingly characterized by processed foods with lower nutritional quality despite higher food expenditure (FAO, 2022; Ruel, Garrett, and Hawkes, 2010).

Age: The age of the household head is negatively associated with calorie intake and dietary diversity but positively associated with food expenditure, indicating that older household heads may prioritize food quality or market purchases over calorie sufficiency. This could be partly attributed to the fact that older household heads are less likely to engage in diversified crop cultivation and therefore less likely to generate extra income that can be used to purchase more and diverse foods. Similar results were found by Amao (2023) and Babatunde et al. (2007).

Sex: Gender effects are also pronounced as male-headed households exhibit higher calorie intake but lower food expenditure and dietary diversity, consistent with evidence that female-headed households tend to allocate food budgets more efficiently toward diverse and nutritious diets (Quisumbing et al., 2015). The sex of the household head was found to significantly influence food consumption patterns in the study area. Specifically, it has a negative influence on dietary diversity and the monetary value of food consumed, while exerting a positive effect on calorie intake. This suggests a nuanced relationship: although male-headed households may spend less on diverse food items or show lower dietary diversity in terms of food categories, they tend to consume diets that are higher in calories. Conversely, female-headed households appear to allocate resources differently, potentially prioritizing dietary variety over caloric intake.

This pattern aligns with studies in nutrition and household economics, which indicate that gender roles and control over household resources influence both the diversity and quantity of food consumed (Doss, 2013; FAO, 2011). Therefore, policy interventions aimed at improving household nutrition should consider gender dynamics in resource allocation and decision-making, as the nutritional outcomes of households are partly shaped by the sex of the household head.

Marital status: The household head's marital status has a positive effect on the quantity of food consumption, but a negative effect on calorie intake. This result indicates that households whose heads are married consume a higher quantity of food. However, their daily calorie intake is somewhat lower when compared to their unmarried counterparts.

Education: The coefficients for education, measured by the years of schooling of household heads, had a positive effect on both dietary diversity and calorie intake. This indicates that households with more educated heads tend to consume a more diverse diet and higher caloric intake. This finding aligns with the studies of Pauzé et al. (2016) and Ogundari (2017), who reported that households headed by individuals with more years of schooling exhibit a higher demand for dietary diversity. Pauzé et al. (2016) highlighted that greater access to formal education is a key driver of varied food consumption, while Ogundari (2017) reported similar results. These findings

suggest that improving access to formal education could be an important strategy for enhancing household dietary diversity. Education has a positive and significant effect on calorie intake and dietary diversity, supporting the view that education improves nutrition knowledge, food choices, and the efficient use of available resources (Smith and Haddad, 2015)

Income: Household income had a positive effect on diet diversity, implying that the higher household income results in higher dietary diversity. Daniel (2016) stated that households that earn higher income consumed more varied diets (allocated their income to more diverse foods) than their low-income counterparts, who devoted a larger income share to staple foods. However, household income hurts per capita calorie intake, indicating that poor households are characterized by inadequate calorie intakes as they consume substantially lower quantities of food.

Livestock ownership: The total livestock numbers had a significant positive effect on dietary diversity. This implies that livestock ownership leads to a more varied dietary intake by the household. Mannaf and Uddin (2012) suggested that livestock ownership as an asset reduced the food insecurity status of households and increased the probability of a more diverse diet. This finding is similar to the one reached by Pellegrini and Tasciotti (2014).

Farm size: Farm size had a positive effect on the food consumption value and diet diversity. This implies that as the area of plots cultivated by farm households increases, the more diverse their diet is.

Access to credit: Access to credit was found to have a positive effect on the dietary diversity of farm households. This indicates that households with access to credit are better positioned to purchase a wider variety of food items, enhancing the diversity of their diets compared to households without credit access. The availability of credit likely provides households with the financial flexibility to invest in nutrient-rich foods and to smooth consumption, especially during periods of low farm income or seasonal scarcity.

This finding aligns with existing literature, which suggests that access to financial resources enables households to make more diverse and balanced food choices, thereby improving overall nutritional outcomes (FAO, 2011; Nandi and Demir, 2020). By reducing liquidity constraints, credit allows households to overcome short-term budget limitations, supporting the acquisition of different food groups rather than relying solely on staples.

Therefore, promoting credit access among rural farm households could be an effective strategy for improving dietary diversity and nutritional wellbeing, particularly in resource-constrained settings.

Number of crops cultivated: The number of crops cultivated had a positive effect on the food and nutritional indicators. This association established the fact that the number of cultivated crops drives the calorie and diet intake. Hence, households tend to have

more options to increase their calorie intake and dietary diversity as the number of food crops they cultivate increases.

Crop Diversification: The crop diversification index and the number of crops cultivated are positive and statistically significant across all three outcome measures, confirming the central hypothesis of the study. This implies that households cultivating a wider range of crops not only consume more calories and higher-value food but also enjoy more diversified diets.

The results indicate that crop diversity has a positive effect on both the value of food consumed and dietary diversity among farm households. This suggests that households engaged in diversified crop production not only consume a wider variety of foods but also allocate more resources toward their food consumption. Essentially, a diversified crop portfolio provides multiple revenue streams, enabling households to purchase additional food items that they do not produce themselves, thereby enhancing dietary variety and overall food expenditure.

These findings are consistent with empirical evidence from Sub-Saharan Africa showing that on-farm crop diversity improves household dietary diversity by increasing direct access to multiple food groups and stabilizing food availability across seasons (Sibhatu et al., 2015; Jones et al., 2014). This observation is consistent with findings from previous studies in Malawi (Jones et al., 2014), Ethiopia (Melku et al., 2018), and India (Rajendran et al., 2017), which show that smallholder farmers practicing mixed cropping produce food both for home consumption and for sale. Since farmers cannot cultivate all the foods they consume, the income generated from selling surplus crops allows them to access non-cultivated foods, improving household nutrition. These results highlight the dual role of crop diversification in supporting both income generation and dietary adequacy, emphasizing the importance of promoting mixed cropping systems as a strategy for enhancing household food security.

Table 6. Effects of crop diversity on food and nutrition security outcomes

Explanatory variables	Per calorie of food consumed		Per capita value of food consumed		Dietary diversity	
	Coeff.	t-value	Coeff.	t-value	Coeff.	t-value
Urban residence	-0.03**	-2.16	0.01***	3.04	-0.03***	-3.82
Age of household head	-0.18***	-3.14	0.02***	3.83	-0.03*	-1.88
Sex	0.24***	4.16	-0.18***	-5.62	-0.21***	-3.13
Marital status of household head	-0.02***	-3.22	0.08***	4.04	0.33	0.43
Education	0.03**	2.12	-0.02	-0.11	0.02*	1.76
Income	-1.46***	-2.56	0.61	1.12	0.01***	3.33
Crop diversification index	0.16**	2.32	0.21**	2.44	0.03***	4.74

Explanatory variables	Per calorie of food consumed		Per capita value of food consumed		Dietary diversity	
Total livestock units	0.03	1.11	0.01	0.98	0.03***	4.67
Farm size	0.14	0.68	0.02**	2.16	0.02***	2.54
Number of crops cultivated	0.03***	3.43	0.02***	3.33	0.01**	2.23
Access to extension	0.02	1.52	0.02	0.88	0.02	1.55
Access to credit	0.13	1.02	1.18***	2.16	0.04***	3.91
Non-farm participation	0.16	0.86	0.03	0.73	0.05***	2.52
Farming experience	0.04	1.35	0.16	1.11	0.06	0.89
Constant	0.63***	3.28	1.18***	41.22	1.14***	44.17
R-squared	0.34***		0.82***		0.71***	
F-value (6, 293)	28.45		32.18		41.26	
Prob > F	0.00		0.00		0.00	
Root MSE	1.237		0.84		1.11	

Note: ***, **, * implies $p < 0.01$, $p < 0.05$, and $p < 0.1$ significance level respectively.

Conclusion

This study demonstrates that crop diversification significantly improves household food and nutrition security in Ogun State, Nigeria. Households cultivating a wider variety of crops exhibit higher dietary diversity, increased per capita calorie intake, and greater food expenditure, highlighting the dual role of diversification in supporting both nutritional adequacy and economic resilience. Socioeconomic factors, including education, income, household size, and gender of the household head, further shape these outcomes, emphasizing the importance of context-specific interventions.

Despite generally adequate average calorie consumption, dietary diversity remains suboptimal, suggesting that households' diets are calorically sufficient but nutritionally limited. This underscores the need for nutrition-sensitive agricultural policies that promote diversified cropping systems alongside improved access to extension services, credit, and markets.

The findings indicate that enhancing crop diversity is a viable pathway for achieving sustainable food security and improving nutritional outcomes among smallholder farming communities. Future research should explore seasonal variations in production and consumption, as well as the impact of value chain interventions on household diet quality.

Conflict of interests

The authors declare no conflict of interest.

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