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Nutritional Outcomes of Farm Households in Nigeria: To What Extent Does Farm Production Diversity Influence Households' Diets?

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Abstract. It has been widely confirmed that diversity in farm production is a strategy for enhancing nutritional outcomes of smallholders as malnutrition remains widespread in the poor population most especially the Sub-Sahara Africa smallholder households. Hence, the question of what extent does farm production diversity influence nutritional outcomes of farm households in Nigeria. This study used 2012-2016 nationally representative households panel data. Two measures of smallholder nutritional outcomes quantities of food calories consumed, and dietary diversity were used as the outcome variable. A food group-based index was used in the estimation of farm production diversification. The farm households have low farm diversity with an index of 0.31. Seasonal analysis of the nutritional outcomes revealed seasonal consumption poverty as the average calorie consumption and dietary diversity were higher in the seasons of the post-harvest than in the post-planting. Production diversity has a positive significant influence on the nutritional outcomes of farm households. Other demographic drivers of nutritional outcomes were location (rural areas), limited market access, sex, age, and income of the household heads. This study confirmed that even-though, farm production diversity is a crucial factor influencing households' nutritional outcomes, it is important that policy issues aimed at improving households' nutritional outcomes focus on increasing farm production and market-related aspects of smallholder agriculture.

Keywords: Calorie, Consumption, Livestock, Market, Season

1. Introduction

Closely, nutrition is linked to agriculture, not because the food comes from agriculture, but because the majority of the undernourished are smallholder farmers who are residents of rural areas in the most developing world (Koppmair, et al., 2017). Policy Interventions aimed at agricultural development have primarily focused on how to improve household food security through increased access to food staples from the own production of farmers. However, despite these policy efforts, chronic malnutrition remained the key challenge among rural populations and this calls for a paradigm shift in policy issues aimed at addressing this challenge. Increasing farm households' access to diverse foods either through own farm production or through the market are some of the policy interventions aimed at improving nutritional outcomes at individual and household levels.

Improving nutritional outcomes of households has remained a problem in much of the developing world. Yet, improve in food and nutrition security is an important strategy as far as the UN's Sustainable Development Goals (SDGs) are concerned. Globally, over 800 million people are still chronically hungry. This hunger has been attributed to access to food being dependent on access to income (FAO, 2015; United Nations, 2017). However, access to income and its distribution largely is unequal, thus promoting poverty, malnutrition, and hunger (Reardon et al., 2000; Van Campenhout et al., 2016). This implies that the distribution of income unequally is that access to the market may not be a pathway sufficient enough to improve food and nutrition security. Therefore, diversity in farm production remains an option to improve the food and nutrition security of households and thus would reduce the effects of unequal distribution of income (Godfray et al., 2010; Jones et al., 2014; Minten and Barrett, 2008).

A variety of nutrition interventions such as nutrient supplementation, food bio-fortifications, and nutrition education have been formulated in many countries to improve the quality of the diet (Pingali, 2012; Johns and Eyzaguirre, 2007). Diversification in agricultural production is one of the advocated strategies to address the nutritional challenges of households' (Koppmair et al., 2017; Powell et al., 2015; Bahadur et al., 2015; Pellegrini and Tasciotti, 2014; Burlingame and Dernini, 2012). At many levels, agrobiodiversity exists, from various ecosystems in which people grow crops and raise livestock from different species to the breed or genetic variability (Frison et al., 2011). Recently, various national policies have been used to define crop types that farmers grow. This has however given a strong indication that farm production diversity is still an important focus for policy intervention toward food and nutrition security. Diversity of farm production enhancement in smallholder has gained increased attention recently particularly due to its potential to enhance food and nutrition security of rural households' (Fanzo et al., 2013; Koppmair et al., 2017; Ecker, 2018).

There have been knowledge gaps in understanding the linkages between farm production diversity and food and nutrition security. These gaps are more evident in small-sector farm households that accounted for the largest proportion of the population that is chronically poor. Some studies stated that market access is more important than diversity in farm production for improved food and nutrition security (Sibhatu et al., 2015). However, in the developing world, as regards smallholder farmers, market infrastructure is poor and there is unequal income distribution, this could be unrepresentative largely. Moreover, Haddinott, (2012) and Jones et al., (2014) posited that farm production diversity is more important than market access. Studies like Jones et al., (2014); Islam et al., 2018; Whitney et al., (2018) addressed the nexus of agriculture (farm production diversity) and nutrition insecurity. However, empirical evidence is still scarce, scanty, insufficient, and disjointed as stated by Shariff and Khor, 2005; Mello et al., 2010; Webb and Kennedy, 2014). Despite this knowledge gap, agriculture and nutrition security are of importance in the eradication of chronic hunger, malnutrition, and chronic poverty (FAO, 2015; Webb and Kennedy, 2014).

Disjointed studies on the agriculture-food security-nutrition nexus have been more evident in the literature. Arndt et al. (2016) and Arndt and Tarp (2017) analysed Sub-Saharan Africa (SSA), and food security (food poverty) but no clear linkages between food security and farm production diversity. Sibhatu et al. (2015) showed results of the association between dietary diversity and market access. Van Campenhout et al. (2016; 2017) in Uganda, studied food poverty but exclude farm production diversity or nutrition from the study. Sekabira and Qaim (2017b) only studied dietary diversity using data from two districts in central Uganda. Besides, a joint study by Jones et al. (2014) and Islam et al. (2018) associated farm production diversity with the dietary diversity of households in Malawi and Bangladesh, respectively. However, Jones et al. (2014) made use of cross-section data but no causal inferences. Islam et al. (2018) on the other hand used panel data but did not explore micronutrient links. Yet, Haddinott (2012) and Jones et al. (2014) agreed that a comprehensive study of diets and nutrition is important in understanding farm households' agriculture-nutrition linkages. Ayenew et al., (2018) estimated the effects of farm production diversity on the nutritional outcomes of farm households' in Nigeria and found that in post-harvest season, an increase in farm production diversification is associated with an increase in dietary diversity, and that, production diversification does not have a significant contribution to the dietary diversity at post-planting.

Therefore, a significant gap exists in literature and inappropriate policy guidance concerning farm production diversity (agriculture), food security, and nutrition security nexus. This study sought to examine the linkages between farm production diversity within farm households in Nigeria, specifically focusing on households' nutritional outcomes using the Nigerian General Household panel data.

2. Materials and Methods

This study used consumption and production data extracted from the Nigerian General Household Survey (GHS)–Panel spanning 2012 /2013 and 2015/2016. This data was collected by World Banks's Living Standards Measurement Study – Integrated Surveys on Agriculture. A total of 11653 households with full information consisted of 2968 households in 2012, 2982 households in 2013, 2819 households in 2015, and 2884 households in 2016. To construct a measure of nutritional outcomes and production diversity of the farm households, the over 100 food items captured by Nigeria's General Household Survey were aggregated into twelve (12) as stated below:

Table 1: Aggregation of Food Items into Groups

Group	Components	Food Items
	Cereals	Local rice, imported rice, wheat flour, bread, biscuits and all baked food, maize grain, corn flour, maize tortilla, popcorn, Guinea corn, sorghum, millet.
	Pulses/legumes/Seeds/Nuts	Soyabeans, Bean-white, Beans-brown, bean cake (akara), moinmoin and groundnut, other pulses, and their products, Groundnut, sesame. Pigeon pea.
	Roots/Tubers/Plantain	Cassava flour, Garri-white, Garri-yellow, Tapioca, Yam Flour, Cocoyam, Water yam, Potatoes.
	Meats/poultry/ offals	Beef, Mutton, Pork, Goat Meat, Canned Beef, Wild-Game Meet, chicken
	Fish /Sea Foods	Frozen Fish, Fresh Fish, Smoked Fish, Snail, Crab, Prawn, Lobster
	Eggs	Agric. Eggs, Local Eggs, Quail Eggs
	Fruits	Cucumber, Eggplant, Tomatoes, Hot/Chili Pepper, Okra, Banana, orange/tangerine, mangoes, avocado pear, pineapples
	Vegetables	Green Vegetables, Spinach, Cabbage, Lettuce etc
	Fat and Oil	Palm oil, Groundnut oil, Palm kernel oil, Butter/Margarine
	Dairy/Milk	Milk, coffee, tea, non-alcoholic beverages, alcoholic
	Sweeteners	beverages, Sugar, jam, honey
	Other foods/Condiments	Spices, Salt, Garlic, Ginger, Onion

Variables Measurement

Households' Nutritional Outcome

Two measures of nutrition (quantities of food calories consumed, and dietary diversity) were used as the outcome variable. The number of calories consumed was used as a measure of the food security (access to food) quantity dimension, while dietary diversity was used as a proxy for the quality of diets. Dietary diversity is a well-recognised and attractive indicator of food access as stated by Kennedy et al., 2011; Swindale and Bilinsky, 2006; Hoddinott and Yohannes, 2002, Secondly, since the typical Nigerian diet is energy-dense, hence dietary diversity, was used as a proxy of nutrient adequacy (Swindale and Bilinsky, 2006).

Calorie Intake Estimation: According to Rischke, (2015), average per capita daily calorie household consumption was estimated by standardising quantities of food consumed per kilogram as provided in the survey manual of the Living Standard Measurement Study (LSMS) by using local units conversion factors to the standard unit. Each food calorie content was derived by multiplying the quantity of food by the per kilogram calorie conversion factor. The household 'i' in period 't' per capita calorie consumption is given as:

$$CI_{it} = \sum_{k=1}^{n} B_{kit} A_k \Big/ Z_{it} \quad (1)$$

Where CI_{it} is the household 'i' in period 't' per capita calorie consumption, B_{kit} is the food quantity in weight in kilogramme consumed by household 'i' in period 't', A_k is the nutrient content per kilogramme of food commodity k that is standardized, Z_{it} is the household size 'i' at time 't'. To obtain per capita calorie intake, the values of food calories obtained were divided by the number of adult equivalent in a household.

Food Consumption Dietary Diversity: Dietary Diversity has always been modeled in the literature with either Dietary Diversity Score (DDS) by Vadiveloo *et al.*, (2015) and Kim *et al.*, (2017), or Dietary Diversity Index (DDI) by Freire and Rudkin (2019). Following Freire and Rudkin (2019), dietary diversity index was constructed from food consumption expenditure of households using the berry index as stated thus:

$$DDI_{it} = 1 - \sum_{g=1}^{n} S_{git}^2 \quad (2)$$

where DDI_{it} is the Dietary Diversity Index, S_{git} is the consumption expenditure share of food group 'g' by household 'i' in time 't', and 'n' is the total number of food groups (Thiele and Weiss, 2003; Liu *et al.*, 2014). This index ranges between 0 and 1, with a value toward 1 implying higher dietary diversity.

Farm Production Diversity: Studies have used various measures of farm production diversity. Past studies (Hawksworth, 1995; Meng et al., 2010), have focused on assessing genetic diversity at the farm and on biodiversity using various measures. One of the widely used measures is species count which is a simple farm count variable capturing not only the crop produced but the livestock species produced regardless of its purposes (Jones et al., 2014, Sibhatu et al., 2015). This measure is limited as it did not account for the difference in terms of nutritional functions of crops and livestock that are produced on the farm (Berti, 2015). However, koppmair et al., 2017; Hirvonen and Haddinott, 2017; Sibhatu and Qaim, 2018b) were used as an alternative farm production diversity score because of the species

count limitation in estimating production diversity. A minor modification was done for this study to the farm diversity score to generate a farm diversity index. This study, therefore, used the ratio of the number of food groups produced on the farm to the total number of aggregated crop and animal food species categorized into twelve as shown in Table 1. From this, the farm diversity index was estimated to assess different crop and livestock nutritional functions produced by smallholders as proposed by Berti (2015). For instance, a household (1) that cultivates groundnuts, rice, okra, and keeps chicken will have a production diversity index of 4/12=0.33 in the sense that the household produced four (cereals; pulses; fruit; meat) different food groups. Besides, if the second household cultivates millet, maize, and rice and also keeps cattle will have a farm diversity index of 3/12=0.25. This is because, millet, maize, rice, and cattle can be derived from three food groups (cereals; meat; and milk and dairy products). Conversely, if the third household produces rice, maize, rice, barley, and wheat, the household will have a production diversity index of 1/12=0.08 as all the crop species come from only one food group. Therefore, first and second households will have a diet that is more diverse than the third household whose farm production is only on cereals. To ensure that both crop and animal species are not counted in two, for instance in the case of a household that produces chicken. The chicken was counted as meat and not eggs. Eggs were only counted if they were produced actually by the household.

Estimation Model

To measure the effects of diversity in farm production on the quantities of food calories consumed, and dietary diversity of the household at the individual level, quantities of food calories consumed, and dietary diversity were specified as a function of the farm household production diversity, households' and individual characteristics. The model specification is specified as follows:

$$Y_{it} = \beta_0 + \beta_1 P_{it} + \beta_2 X_{it} + \varepsilon_{it} \quad (4)$$

Where Y_{it} is a measure of the logarithmic value of dimensions of household food and nutrition security outcomes (per capita daily calorie intake (kcal), and dietary diversity), P is a vector of production diversity, X_{it} is a vector of variables of market integration and households' characteristics, and ε_{it} is the error term. Equation (4) was estimated using the random effects estimator. Explanatory variables were operationalized as follows:

- Farm Production Diversity (index)
- Market Integration (Commercialisation index)
- Season (Surplus/Post-Harvest): 1 for data collected in the post-harvest season, 0 for the post-planting season;
- Location (Rural): 1 for households located in a rural area, 0, otherwise;
- Sex (Male): 1 for male-headed households, 0 otherwise;
- Marital status: 1 for married household head, 0 otherwise;
- Age of the household head (years);
- Education (Formal): 1 for a household head with formal education, 0 otherwise;
- Income status (Low): 1 for household classified as relatively low income, 0 otherwise;
- Livestock Holding: 1 for household engaged in livestock farming, 0 otherwise;
- Non-farm participation: 1 for households engaged in non-farm livelihood activities, 0 otherwise;
- Dependency ratio: 1 for households with under-five years children; 0 otherwise; and
- Agro-ecological zone: There are six dummy variables for the zones as also included in the analysis.

3. Results and Discussion

Farm Household Demographic Characteristics

The information about farm household demographic characteristics by region and location is discussed as shown in Table 2. The mean age of the head of the farm household was 52 years with an average household size of 6 persons. The northern region and rural area accounted for a higher proportion of dependants. 21% of the farm households were headed by a female, with the highest (30.2%) regional occurrence in the South-West. Information on food items consumed and their associated expenditure values revealed that cereals (92.1%), roots/tubers/plantain (90.8), and animal products (72.2) were mostly consumed food items. Meanwhile, expenditure on cereals has the highest expenditure share (33%), followed by roots/Tubers/Plantain (19.1%). Other common food categories include pulses/seeds/nuts (18.6%), animal products (14.3%).

Table 2: Farm Households Demographic Characteristics in Nigeria

Characteristics	**North-Central**	**North-East**	**North-West**	**South-East**	**South-South**	**South-West**	**Urban**	**Rural**	**Pooled**
Mean Age	55	58	60	54	52	50	52	53	52
Mean Household Size	8	8	7	6	7	5	6	6	6
Dependency Ratio	1.4	1.5	1.2	1.1	1.2	1.3	1.1	1.3	1.1
% Female-Headed Household	20.5	18.4	20.5	28.1	28..4	30.2	22.4	20.1	21.3
% married household Head	78.0	77.5	75.2	76.3	70.2	72.1	75.5	77.2	74.0
Mean Years of Schooling	5.4	5.2	4.2	7.8	9.4	8.9	7.3	5.1	5.8
% Housing Ownership	70.2	78.4	82.4	76.5	68.4	58.3	50.1	72.4	61.5
% households Food Consumption									
Cereals	93.4	90.3	91.1	94.5	90.8	91.1	90.1	93.5	92.1
Pulses/Seeds/Nuts	62.4	64.7	62.8	66.6	67.3	61.4	63.3	64.6	64.3
Roots/Tubers/Plantain	93.3	92.2	88.5	90.2	91.7	89.6	88.1	91.3	90.3
Fruits	38.8	42.2	44.7	56.5	56.8	45.3	44.8	48.7	46.8
Vegetables	44.6	45.4	52.3	60.2	58.4	59.8	55.5	58.9	60.4
Animal Products	70.1	72.2	71.4	73.3	74.6	79.2.1	72.5	75.6	73.3
Food Expenditure Share (%)									
Cereals	30	28.4	25.8	32.2	32.8	34.5	30.4	33.2	33
Pulses/Seeds/Nuts	17	18.3	17.6	19.2	19.5	18.1	18.8	18.8	18.6
Roots/Tubers/Plantain	20	22	29.9	22.1	19.3	21	19.8	19.8	19.1
Fruits	6.3	6.5	7.5	7	6	5.2	6.8	6.3	6
Vegetables	9	8	6	6.5	9	9	8	8	9
Animal Products Expenditure	11109.4	10147.4	10125.8	9125.5	9672.7	10542.2	1015.1	9861.3	10019.4

Source: Computed from LSMS Panel Data (2012-2016)

Table 3 also contains information on-farm resource use across zones and sectors in Nigeria between 2012 - and 2016. It was found that 41.8% of the farm households reported using fertilizer; 13.7% used pesticides; 30.1% used herbicides; 20.1% used purchased seeds, and 18.3% reported having used animal traction on their farm plots. Based on sectors, rural farm households used more fertilizer, herbicide, animal traction, and labour on their plots when compared to their urban counterparts. However, farm households in urban areas used more pesticides and purchased seeds. Moreover, labour input use captured by workdays showed that an average household labour workdays (131.2) are larger than that of hired labour workdays (40.6). Also, farm households' that resides in the local area cultivated more crop in all categories, and the main crop cultivated was cereals (45.4%) majorly maize followed by roots and tubers (40.5%).

Moreover, the types of livestock owned by farm households were also discussed. Goats and Chickens accounted for 67.3% and 64.8% of livestock owned by households. The results show that animal production has remained underexploited by farm households in Nigeria and the most reared livestock is the goat. The northern part of the country is famous for livestock production. This is due to the fact the ecology in the region characterised by low rainfall duration, longer dry season, and lighter sandy soils that are friendly to livestock production.
Comparing the results of farm production diversity revealed that the North-eastern part of the country has the highest (0.46) diversity in farm production followed by the North-central of 0.41. However, the South-west has the lowest farm production diversity value of 0.26. The mean farm production diversity index of 0.31 revealed farm households' more reliance on food purchases to meet their dietary needs than their production.

Table 3: Farm Households Resource Use in Nigeria

Main Income Activities/Resource Use	**North-Central**	**North-East**	**North-West**	**South-East**	**South-South**	**South-West**	**Urban**	**Rural**	**Pooled**
Post-planting (August–October)									
Agriculture (%)	58.6	65.7	62.8	48.9	38.8	35.7	30.9	66.5	62.5
Wage employment (%)	25.6	13.2	22.7	20.1	17.8	24.2	24.2	19.3	30.8
Nonfarm Enterprise (%)	10.8	9.3	7.4	20.3	18.4	15.3	18.3	8.6	12.6
Post-harvest (February–April)									
Agriculture	44.5	45.8	47.3	24.3	18.5	13.8	10.8	36.6	47.4
Wage employment	15.4	19.3	20.4	15.63	25.2	23.6	18.4	15.8	18.5
Nonfarm Enterprise	11.6	8.9	7.7	12.72	16.1	17.8	17.1	8.56	10.8
Farm Plot Holdings									
Number of Farm Plots	3.5	3.0	2.5	2.3	2.7	2.8	2.3	2.5	2.5
Average Farm Size (Hectares)	0.5	0.7	0.5	0.38	0.25	0.8	0.3	0.5	0.5
Farm Input Use									
% Fertilizer	38.4	51.7	52.8	46.8	28.0	29.3	40.4	44.1	41.8
% Pesticide	10.2	17.4	26.1	15.6	4.0	25.3	15.6	12.7	13.7
% Herbicide	38.1	35.2	40.0	17.0	15.4	30.1	22.2	31.6	30.1
%Purchased Seed	12.2	12.3	30.2	33.6	19.9	16.5	26.4	18.3	20.1
% Animal Traction	14.5	54.8	45.5	0	0	0	8.4	20.3	18.3
Average Workdays of Household Labour	178.4	185.2	153.2	92.4	111.4	94.1	92.3	150.2	131.2
Average Workdays of Hired Labour	45.2	43.3	54.8	21.11	26.4	64.4	30.4	41.6	40.6
The major crop is grown (%)									
Cereals	31.5	58.8	30.5	24.4	23.5	15.0	40.7	34.2	45.4
Pulses	36.9	28.5	13.2	16.4	16.2	18.3	24.4	18.3	30.2
Roots and Tubers	78.3	55.2	19.5	14.5	28.3	20.9	44.6	30.4	40.5
Fruits	34.6	21.3	33.2	30.4	33.3	20.4	26.3	22.1	27.6
Vegetables	29.2	25.1	28.6	33.4	35.7	38.5	26.4	33.8	30.1
Livestock Ownership (%)									
Calf (male)	2.2	5.8	2.5	0	0	0	0	2.7	2.2
Calf (female)	2.4	5.3	3.5	0	0	0	0	3.0	2.6
Cow	17.4	23.5	21.0	1.1	0.2	2.5	6.5	16.5	15.4
Bull	7.7	15.6	15.4	0	0	0	1.4	11.0	9.2
Chicken	2.7	19.4	3.8	0	0	0	0.4	5.9	5.2
Goat	60.8	72.1	79.1	56.0	45.8	53.7	58.8	68.7	67.3
Sheep	19.1	42.1	57.8	6.9	0.7	4.9	24.2	34.2	33.0
Chicken (local)	74.9	66.4	55.5	74.2	60.2	68.3	55.5	65.2	64.8
Duck	4.8	8.5	1.3	0	2.3	2.5	1.6	3.2	3.0
Guinea fowl	1.7	4.2	9.8	0	0	0	1.2	4.8	4.4
Utilization of Livestock									
Sales	24.4	45.3	20.5	36.0	32.6	21.2	24.3	28.9	28.5
Slaughter	29.5	38.9	19.2	37.9	29.2	36.1	29.2	29.0	29.0
Others	0.4	2.4	0.9	1.1	0.8	1.0	0.5	1.2	1.1
Mean Farm Production Diversity	0.41	0.46	0.39	0.31	0.30	0.26	0.28	0.32	0.31

Source: computation from LSMS panel data (2012-2016)

Results of Household Nutritional Outcomes

Presented in Table 4 were the results of the considered household nutritional outcomes. It was revealed that for the two waves, the average calorie consumption and dietary diversity were higher in the seasons of the post-harvest than in the post-planting. The amount of dietary diversity was higher in 2015/2016 compared to 2012/2013. Comparing the average per capita daily calorie consumption with the recommended FAO (2017) daily per capita calorie of 2500 kilocalories for developing countries, it was found that in post-planting seasons is lower (2483.62/2415.04 kilocalories) but higher (2606.82/2651.96 kilocalories) in the post-harvest seasons. The results imply that on average, farm household calorie consumption was inadequate in the post-planting seasons, but enough level of dietary diversity of calorie consumption during the post-harvest seasons. These findings must be lower than the per

capita daily calorie (2936.99 kilocalories) of Shittu et al., (2018) in the post-harvest season but higher than that of Sibhatu and Qaim (2017) with per capita calorie intake (2428 kilocalories).

Table 4: Dimensions of Household Food Nutritional Outcomes

	Mean	Standard Deviation	Minimum	Maximum
2012 (Post-Planting)				
Per capita calorie (daily)	2483.62	2214.51	564.08	9812.17
Dietary diversity	0.71	0.15	0.00	0.79
Real per capita value of food (weekly)	1014.46	975.22	42.18	13324.43
Total number of households in 2012 = 3869				
2013 (Post-Harvest)				
Per capita calorie (daily)	2606.82	2086.91	508.76	11412.03
Dietary diversity	0.74	0.15	0.00	0.81
Real per capita value of food (weekly)	966.52	956.73	42.34	12622.14
Total number of households in 2013 = 2968				
2015 (Post-Planting)				
Per capita calorie (daily)	2415.04	2063.18	501.01	10161.24
Dietary diversity	0.72	0.16	0.00	0.81
Real per capita value of food (weekly)	1013.12	966.29	47.16	14671.11
Total number of households in 2015 = 2819				
2016 (Post-Harvest)				
Per capita calorie (daily)	2651.96	2142.52	511.17	11182.13
Dietary diversity	0.76	0.17	0.00	0.82
Real per capita value of food (weekly)	994.85	948.26	47.84	14841.62
Total number of households in 2016 = 2884				

Effects of Households' Farm Production Diversity on their Nutrition Outcomes

Table 4, present the results of the effects of socioeconomic and farm production diversity factors on households' nutritional outcomes in Nigeria.

Farm Production Diversity: It was found that diversity in farm production influenced the nutritional outcomes of farm households positively. This implies that farm households' that are involved in the production of multiple portfolios of crop and animal species consume diverse diets, high quantities of food, and higher per-capita calorie consumption. This confirms the assertions that agricultural diversification is indispensable in smallholders' nutritional outcomes improvement either through own farm direct consumption or income generated from farm produce sales used in the purchase of food (Sibhatu et al., 2015; World Bank, 2007; Jones et al., 2014;), and thus it was assumed that income enhances access of smallholders' to more diverse food (Fanzo et al., 2013; Burlingame and Dernini, 2012). However, the magnitude of the influence is small (0.01) for per capita calorie consumption, (0.01) for dietary diversity and 0.02 for food quantity consumed. A similar result is found in Bangladesh by Islam et al. (2018) between diversity in farm production and dietary diversity score of households. Also, Whitney et al. (2018) and Koppmair et al., (2016), found in Uganda and Malawi respectively that diverse farm production influences dietary diversity scores of households positively.

Market Integration: this was captured by the commercialisation index calculated as the ratio of the sold value of farm produce to the total value of farm produce as used by Carletto et al., (2017) and Ogutu and Qaim (2019). It is plausible that market integration positively influences households' dietary diversity implying that commercialised farm households consumed more diversified diets than their less commercialized counterparts. According to Koppmair et al., (2017), income increase through markets sales could raise farm households' demand for more diversified diets on the demand side. This implies that higher incomes generated through the market from produce sales enabled farm households to buy a more diverse food from the market. Hence, market linkages through supply and demand sides, enable smallholder farm households to consume a diverse diet. It is argued that, on the supply side, the market can serve as a means of diverse and nutritious foods available to farm households, even across seasons (Snapp and Fisher, 2015). This reduces farm households' reliance on their food production for consumption, particularly during the off-season. In India, Gupta et al (2019) found that income from cereal crop sales significantly influence positively the dietary diversity scores for women.

Season: The surplus season was positively related to nutritional outcomes of farm households. This implies that farm households consumed more diverse diets and calories in post-harvest seasons (Farayibi and Owuru, 2016). This is because food supply and availability in the market are linked to season and this can in turn influence patterns of food consumption.

The findings indicate that smallholder farmers are vulnerable to seasonal consumption poverty, and often they struggle to achieve an adequate diet partly due to the seasonal nature of most agricultural products. Ayenew et al. (2018) found in season (post-harvest) is associated with an increase in dietary diversity of farm households in Nigeria.

Location: The results also show that farm households' resident plays a vital role in the nutritional outcomes. Households in the urban areas had lower per capita calories and more diverse diets than their rural counterparts. This finding implies rural farm households in Nigeria consumed more calories but had fewer diverse diets. Ideally, rural households should have direct access to what they produce and this could enhance dietary diversification (Weber, 2015), while the urban should only purchase what the market provides (Famine Early Warning Systems Network, 2017). The reverse is the case in this case as rural farm households have a lower dietary diversity. This result is in line with Freire and Rudkin (2019), where being a farmer is associated with lower food diversity. However, Snapp and Fisher, (2015) and Kissoly et al., (2020), found that urban farm households consumed more diverse diets as a result of their easy accessibility to markets. This study posited that smallholders in Nigeria mainly rural are constrained not only in terms of accessing the market for food variety but also lack the basic infrastructure that will improve their production. Hence, we can say that rural farm households in Nigeria are fewer food producers.

Sex: Male household headship was associated with significantly poorer nutritional outcomes in farm households'. This is because males are usually unaware of sufficient food quantities, feeding patterns of household members, or appropriate foods. This result support finding of Sekabira and Qaim (2017b), that where male headship impacted households' nutrition negatively.

Age: The age of the household head negatively influences their households' (calorie intake and dietary diversity) nutritional outcomes, which suggests that as household heads get older, members of their households' may not be able to afford adequate nutrient intake implying that their household members capacity to access food calories, and diet quality declines with age (Adekunle et al., 2020). This result is not in line with Koppmair et al. (2016) in Malawi, Sekabira and Qaim (2017b) in Uganda, and Islam et al. (2018) in Bangladesh which established a positive relationship between the age of household heads and dietary diversity.

Household Size: Household size was associated with significant decreases in nutritional outcomes of the farm households. It is expected that in an agrarian household, an increase in household size should provide labour for food production. However, the reverse is the case in this study implying that the majority of household members were dependently comprising both the elderly and young children who were not able to provide labour but must feed, thus there is an increase in the burden on food that is available. This is also found in Whitney et al. (2018) and Koppmair et al. (2016) an inverse relationship exists between household size and household dietary diversity score in Malawi.

Education: Farm Households' head educational level positively influenced the nutritional outcomes of members of their farm households. This implies that the more educated, the household head, the more easily in understanding the importance of a diverse diet and food calories (Pauzé et al., 2016). This was in line with expectations and most of the studies in the literature (Chegere and Stage, 2020; Ayenew et al., 2018; Koppmair et al., 2017; Murendo et al. 2018; Snapp and Fisher, 2015).

Income: The relationship between income and households' nutritional outcomes was negative. This implies that farm households' classified as low-income earners had lower real per capita consumption, calorie consumption, and diverse diet than their middle/high-income counterparts. This is because increase in income was associated with increasing diets diversity. Banerjee and Duflo (2011), argued that the poor do not always increase their food consumption even when their income increases confirming that increasing calorie intake and/or a dietary diversity was not a priority. In contrast, an increase in the income levels of smallholder farm households should lead to an increase in their diet quality. Several studies documented a positive result of income on food consumption of household (Chegere and Stage, 2020; Murendo et al., 2018; Ayenew et al., 2018; Snapp and Fisher, 2015; Kissoly et al., 2018), suggesting the important role that income plays on households' nutritional outcomes.

Livestock Holdings: Livestock holding contributes positively to dietary diversity. Keeping livestock influences the dietary diversity of farm households in Nigeria. Mekuria et al., (2019) found a positive significant result between the production of livestock and household dietary intake, and food calories in the highlands of Ethiopia. Also, Mango et al., (2018) found a positive relationship between livestock production and food consumption score in central Malawi, and Aweke et al., (2020), found livestock production to be positively related to smallholders' food consumption in East Hararghe, Ethiopia.

Non-Farm Livelihood Participation: Non-Farm Livelihood Participation exerts a positive influence on-farm households' nutritional outcome. This

implies that farm households with income portfolios derived from non-farm activities exhibited high nutritional outcomes compared to their counterparts whose only source of livelihood is farming. This result emphasised the importance of non-farm livelihood activities as an important driver of nutritional outcomes of farm households in Nigeria.

Dependency Ratio: A positive relationship exists between dependency ratio and households' dietary diversity implying that farm households with a high number of under-five year children have greater nutritional outcomes than their counterparts.

Table 4: Effects of Households' Farm Production Diversity on their Nutritional Outcomes

	Food Calorie		Real value of food		Dietary Diversity	
Variable	**Coefficient**	**t-value**	**Coefficient**	**t-value**	**Coefficient**	**t-value**
Production Diversity	0.01**	2.01	0.02***	3.14	0.01***	4.43
Market Participation	0.18	1.53	0.04	1.11	0.02**	2.12
Season (Post-Harvest)	0.02***	2.14	0.02***	3.33	0.01**	2.23
Location (Rural)	0.02*	1.91	0.11	1.32	-1.11***	-3.82
Sex (Male)	0.24	1.01	-0.09***	-4.12	-0.14***	-2.62
Marital status (Married)	-0.02	-1.12	0.02	1.24	0.33	0.43
Age	-0.12	-1.42	0.02*	1.83	-0.03***	-2.93
Household Size	-0.13***	-2.68	-1.04**	-2.12	-0.04***	-4.18
Household head with formal education	0.04***	3.76	0.01	0.64	0.16**	2.17
Low Income household	-0.23**	-2.04	-0.16***	-3.77	-0.03***	-3.32
Livestock holding (dummy)	0.04*	1.96	0.01**	2.11	1.04**	2.16
Non-Farm Participation (dummy)	0.22**	2.18	0.23**	2.22	0.25***	2.84
Dependency ratio (households with under five year children)	1.26	1.73	0.44	1.17	0.24***	2.24
Zone (North central dummy)	-0.01**	2.12	0.01	1.33	0.03	1.44
Zone (North west dummy)	0.11	1.16	0.02	1.24	0.11	0.36
Zone (South west dummy)	0.47*	1.99	-0.14**	2.02	-0.02**	-2.18
Zone (South east dummy)	0.13	1.18	0.02	1.42	0.01	1.13
Zone (South south dummy)	0.03**	2.16	0.33	1.33	0.26***	2.98
Constant	1.36***	3.85	1.12***	4.82	1.18***	4.94
Sigma_u	0.43		0.71		0.52	
Sigma_e	2.12		2.67		2.04	
Rho	0.04		0.06		0.04	

Note: ***, **, *Implies that the estimated parameters are significant at 1, 5, & 10% respectively.

4. Conclusion and Recommendation

Nutritional outcomes of farm households are linked with the performance of agricultural activities, not because food is from agriculture but because many malnourished people reside in rural areas where agricultural activities are domiciled. This study examined how farm production diversity influences the nutritional outcomes of farm households in Nigeria. The results indicated that consumption patterns of food calories and dietary intake were higher in the post-harvest season than in post-planting seasons. The decline in the nutritional outcomes of farm households in the off-season indicated the possible presence of seasonality of hunger and malnutrition. Also, farm households' production diversification and market integration contribute to their nutritional outcomes, particularly in post-harvest seasons. This study concluded that increased households' farm production diversity is needed for their improved nutritional outcomes. Therefore, there is a need for seasonal policy intervention that will promote the production of diverse crop and livestock species in Nigeria to achieve improved nutritional outcomes.

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