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Food Energy Availability from Agriculture at the Farm-Level in Southeastern Nigeria: Level, Composition and Determinants

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Abstract: Among the four pillars of 'food security' (i.e., 'food availability', 'food accessibility', 'food stability' and 'food utilization'), 'food availability (FA)' underpins the core concept because at the micro-level it is strongly related to the overall availability of food, which is determined by domestic food production, food imports and food aid. This paper examines the level of food energy availability (FEA) at the farm level, relationships between farm size and FEA and the determinants of FEA based on a survey of 400 households from Ebonyi and Anambra States of Southeastern Nigeria. FEA in this study refers to Partial Food Energy Availability (PFEA) because it excludes procurement of food from other sources, e.g., purchase from the market, borrow/exchange from others and/or receiving as food aid. Results show that the sample is dominated by small–scale farmers (81% of the total sample) owning land <1.00 ha. The average farm size is small (1.27 ha). Farmers grow multiple food crops. Sixty-eight percent of the farmers produced at least two food crops. Average PFEA is estimated at 4492.78 kcals/capita/day produced from one ha of land area. Approximately 30.92% of the total food produced is set aside for home consumption. Among the food crops, 40.70% of cassava output is set aside for home consumption while most of yam and rice are mainly destined for the market. Inverse farm size–PFEA relationship exists amongst the sampled farmers. The regression results reveal that subsistence pressure, profit motive and share of yam in total output significantly reduces PFEA whereas an increase in the share of cassava in total output significantly increases PFEA. A one percent increase in the share of cassava output will increase PFEA by 0.14%. A one percent increase in subsistence pressure will reduce PFEA by 0.98%. Farmers identified a lack of agricultural extension agents, farm inputs and basic infrastructures as the main constraints adversely affecting food production at the farm-level. Policy implications include investments targeted to improve cassava production and measure to reduce future family size by improved family planning to increase PFEA at the farm-level.

Keywords: food energy availability; cassava; yam and rice; farm-size; multiple regression; Southeastern Nigeria

1. Introduction

Combating hunger and improving food security is one of the greatest challenge of the society despite several attempts to improve the situation. The right to food is one of the most consistently mentioned items in international human rights documents, but it is the one that is most frequently violated [1]. Although the Millennium Development Goal (MDG 1) to "halve the proportion of people suffering from hunger from its 1990 level in 2015" was reached in the developing world [2], 795 million people were still undernourished in 2015 [3]. Goal 1 of the recently announced Sustainable

Development Goals for the 21st Century (SD21) aims to 'End poverty in all its forms everywhere by 2030' (United Nations, 2015) which is even a much stronger goal than MDG 1 [4]. The success of global poverty reduction through the MDGs was not uniform across the developing countries, because there are still large numbers of people living in poverty in Sub-Saharan Africa (51%), South Asia (40%) and East Asia (17%) [5].

Food security is defined as having physical, social and economic access to sufficient, safe and nutritious food at all times by all people [6]. About 15% of the world population do not have sufficient access to basic dietary need, required protein and energy input despite dramatic increase in food production over the past five decades [7].

Africa is the world's second largest and second most populous continent with an estimated population of just over 1 billion, i.e., 14.4% of global population [8]. Although extreme poverty in Africa has declined from 57 percent in 1990 to 43 percent in 2012 based on poverty line of USD 1.90 at PPP 2011 prices, but due to rapid expansion of population in Africa, the number of people living in extreme poverty still increased by more than 100 million [9]. These are staggering numbers and projections show that the world's extreme poor will be increasingly concentrated in Africa [9].

Within Africa, the Sub-Saharan Africa (SSA) is the poorest region. It is also the poorest region of the world. The average real per capita income of SSA in 2010 was USD 688 compared to USD 1717 for the developing economies [10]. The Gross Domestic Product (GDP) growth per capita in SSA has averaged only 0.16 percent per year over the past 30 years and this failure of growth over the long term has resulted in high levels of poverty and food insecurity in the region [10]. An estimated 30 percent of the population in SSA are suffering from hunger and undernourishment [11]. In some cases of food crisis, food may be available, but unaffordable for large parts of the population.

Agriculture serves as a source of employment directly for most people and/or indirectly by generating jobs outside the farm. Although Africa's agricultural growth rate has improved since 2005 at 7 percent per annum, this is mainly due to an increase in commodity prices instead of the expansion of the cropped area or improvements in the underlying structural conditions [12]. Africa still has the resource base and, if it is more intensively farmed, could easily produce another 100 million tons of grain equivalent per year and is the best sector for addressing poverty in Africa [12]. Nevertheless, despite all its potential, Africa continues to be dependent on food imports, with import bills currently stands at USD 35 billion and is estimated to rise to USD 110 billion by 2025 [13].

Agriculture plays a major role in SSA contributing towards 70% of the labor force employment, 40% of exports and 37% of GDP [14]. Nambiro et al. [14] inferred that agriculture has a comparative advantage in reducing poverty and food insecurity. It does this through its growth and participatory effect. Growth effects can be direct (through productivity improvement) or indirect growth (through linkages with the non-agricultural sectors). Participatory effects occur because the poor participate more in agricultural growth, especially in low-income countries. Babatunde [15] suggested that the substantial differences in agricultural productivity between Asia and Africa could be explained by differences in the use of modern inputs. Evidence suggests that better access to infrastructures (such as roads and irrigation) and agricultural services has enabled Asian farmers to have significantly better access to modern inputs. Therefore, without such access, the SSA farmers were not able to fully exploit the benefits of modern agricultural technology.

Nigeria, like most African countries, faces similar difficulty of poverty, hunger and food insecurity. Nigeria is situated in the western region of Africa with a population of over 195 million in 2018 [16], and 18% of total Africans actually live in Nigeria [9]. The country has the largest economy in the continent with an estimated GDP of USD 404.652 million at current prices and when adjusted for PPP 2011 prices increases to 1.02 trillion in 2016 [17]. The per capita GDP at current prices is estimated at USD 2455.9 and at PPP 2011 increases to USD 5861.1 in 2016 [17]. Due to serious data quality issue, the estimates of poverty in Nigeria varies significantly. The Nigeria Living Standard Survey (NLSS) shows the level of poverty at 53 percent in 2009/10 (based on poverty line estimate of USD 1.90 at PPP 2011) whereas General Household Survey Panel (GHS) estimate is half of that figure at 26 percent

2010/11 [9]. Nevertheless, it is clear that poverty is still high in Nigeria irrespective of the variable quality of data used for estimation.

Agriculture is by far the most important sector of the Nigeria's economy for employment, engaging about 70% of the labour force [10]. Agricultural farms are generally small in size and scattered characterized by subsistence farming and use of simple tools and shifting cultivation. These small farms produce about 80% of the total food. About 30.7 million hectares (76 million acres), or 33% of Nigeria's land area, are under cultivation [10].

Poverty amidst plenty is the world's greatest challenge, especially with SSA countries. Increasing the productivity of land under cultivation, increased use of labor saving technologies and improved variety are necessary and a panacea for food security, food availability and poverty alleviation in developing countries like Nigeria [18]. Although Nigeria is still the largest cereal producer in SSA with yield rate of only 1.52 metric tons per ha as compared to the world's largest producer China with a yield rate of 5.45 metric tons per ha [10]. Nigeria's total food consumption is estimated 2638.89 kcal/capita/day during the period 2001–2007 which is substantially lower than the world's top food consumption country Austria, estimated at 3818.8 kcal/capita/day in 2007 [10]. The ambitious projections places food consumption in SSA to 2319 kcal/capita/day in 2015, 2494 in 2030 and 2708 in 2050 [19]. Concerns over food energy availability is driven by the need to feed an increasing population and one of the means of addressing this concern is to increase food production and local food supply, best achieved at the farm household level, which forms the basis of this paper.

Given the level of food insecurity and the problems associated with agriculture in Africa [9,10,12] and the fact that Nigeria is the most populous African country, the need for this study to be carried out in Nigeria cannot be over emphasized. Food security defined by FAO is composed of four components: food availability, food utilization, food accessibility and food stability [20]. In this study, we concentrate on the first and most important component of food security, i.e., food availability, particularly food energy availability. This is because food availability at the micro-level is strongly related to the overall availability of food, which is determined by domestic food production, commercial food imports and food aid [21]. Although, at a conceptual level, food availability can be secured from own resources and/or by trade and/or aid [20] we emphasize on the capacity to produce food from own resources, i.e., domestic agriculture. This is because reliance on procuring food from the market or other external sources (i.e., commercial imports and food aid) can be subject to volatility in trade, uncertainty and other unforeseen bottlenecks, which could ultimately jeopardize 'food security'. Therefore, the goal of this paper is to identify the complex relationships between food energy availability derived from farm production and the socio-economic factors of the households based on a selected sample of 400 farming households from two states (Ebonyi and Anambra) from Southeastern Nigeria. The specific objectives of this paper are to: (a) examine the level and composition of food energy availability from agriculture at the farm household level; (b) examine the relationship between farm size and food energy availability; (c) identify the socio-economic determinants of food energy availability; and (d) explore constraints adversely affecting production of major food crops at the farm-level. The following research hypotheses are tested: (a) food energy availability varies depending on the combination of crops produced; food energy availability is expected to be higher for farmers producing crops which have high calorific value; (b) an inverse farm size–food energy availability exists in food crop production, similar to inverse farm size–productivity relationship observed generally in developing country agriculture; and (c) a host of socio-economic factors determine food energy availability but with varied level of magnitude and direction of influence. The contribution of our study to the existing literature is that we have provided a detailed examination of the level and composition of food energy availability derived from own farming activities and its determinants utilizing a proper theoretical framework for analysis, which is not common in the literature.

The paper is organized as follows. Section 2 describes the methodology, theoretical framework and the data. Section 3 presents the results. Section 4 presents conclusions and draws policy implications.

2. Methodology

2.1. Theoretical Model Underpinning Household Decision Making Behaviours

The food production decision in this study is modelled following the model of production and consumption behaviours of a rural household developed by Singh et al. [22] and Feleke et al. [23]. The household utility function is specified as [22]:

$$U = U(F_p,\ F_m, l; H_c) \quad (1)$$

where U is a well-behaved utility function, i.e., it is twice differentiable, is increasing in its arguments and is strictly quasi-concave; F_p is a vector of goods produced at the farm household and consumed; F_m is a vector of goods purchased from the market and consumed by the household and l is leisure. Therefore, the utility derived by the household depends on the preferences of the members of the household, which are influenced by the household characteristics H_c. The households, who is both a producer and a consumer, is assumed to maximize its utility from the consumption of these goods subjects to the constraints imposed by farm production, income and time given by [22,23]:

$$K\left(Q_i,\ L,\ R^0,\ G^0\right) = 0 \quad (2)$$

$$P_i\left(Q_i - F_p\right) - P_m F_m - w\left(L - L_f\right) + N = 0 \quad (3)$$

$$T = L_f + l \quad (4)$$

where K is an implicit well behaved production function, i.e., it is twice differentiable, is increasing in outputs, is decreasing in inputs and strictly convex; Q_i is a vector of quantities of goods produced on the farm; L is total labor inputs applied to the farm; R^0 is the fixed amount of land of the household; G^0 is the fixed stock of capital; P_i is the price of good i; P_m is the price of good purchased from the market; $(Q_i - F_p)$ is the marketed surplus of good i; w is the wage rate; L_f is the family supplied labour for the farm; N is income obtained from non-farm sources which adjusts in such a way that Equation (6) equals zero; and T is total time available for the household for allocation between work and leisure.

Both the income and time constraints can be combined into one by incorporating Equation (3) into Equation (2) as [22,23]:

$$P_i\left(Q_i - F_p\right) - P_m F_m - w(L - T + l) + N = 0 \quad (5)$$

Rearranging Equation (5) gives [22,23]:

$$P_i F_p + P_m F_m + wl = P_i Q_i + wT - wL + N \quad (6)$$

The left-hand side of Equation (6) is the expenditure on food and leisure by the household and the right-hand side is the total income. The expenditure equation includes imputed cost of goods produced from own farm $(P_i F_p)$, goods purchased from the market $(P_m F_m)$, and purchases of own leisure time of the household (wl). The income equation includes the value of total agricultural production $(P_i Q_i)$, the value of time entitled to the household (wT), the imputed value of family labour and value/cost of hired-in labour used in farming (wL) and nonfarm income N.

The relationship between production and consumption, derived from the first-order conditions of the maximization of the constrained utility function can be set in such a way that the production decisions were made prior to dividing the total income between consumption and leisure activities [23]. The underlying assumption of such setting is that the relevant markets function properly. This is because consumption (food energy availability), as stated here, depends on the production variables but not vice versa. Therefore, if the markets for inputs, including labor and outputs, do not function properly, then farm production decisions cannot be made separately from the consumption decisions.

This is because, if there is an incomplete market for an input, a virtual (shadow) price exists which will be endogenous to the household [22,23].

Therefore, based on the assumption of separability between the production and consumption decisions, we can separately derive the production equation and consumption equation. For the production-side, the first-order conditions can be solved for input demand (L^*) and output supply (Q^*) as a function of all prices, and, the wage rate and stock of capital as:

$$L^* = L^*\left(P_i,\ w,\ R^0, G^0\right) \tag{7}$$

and

$$Q^* = Q^*\left(P_i,\ w,\ R^0, G^0\right) \tag{8}$$

Given an optimal level of labor, the value of full income with maximum profit can be obtained by substituting L^* and Q^* into the right-hand side of the income constraints Equation (6) as:

$$X^* = P_i Q^* + wT - wL^* + N \tag{9}$$

and

$$X^* = wT + \pi^*\left(P_i,\ w,\ R^0 G^0\right) + N \tag{10}$$

where X^* is "full" income under the assumption of maximized profit π^*.

The first-order conditions can be solved for consumption demand in terms of the wage rate, price and income as:

$$F_k = F_k(P_i, P_m, w,\ X^*) \tag{11}$$

where $k = i, m$.

Equations (7), (8) and (11) give a complete picture of the economic behavior of the farm household. The combination is through the effect of profit because the income is determined by the production activities of the household, which implies that changes in variables influencing farm production also changes income; which in turn affects consumption behavior of the farm household. Incorporating the household characteristics, which shape preferences of the household (H_c), the demand for food indicated in Equation (11) can be rewritten as:

$$F_k = F_k\left[P_{i,}P_m,\ w,\ X^*\left(w,\ R^0, G^0, N\right), H_c\right] \tag{12}$$

where $k = i, m$.

Since this study focuses on partial food energy availability from farming and do not consider other additional supplementary (purchase food) sources of food, this allows us to evaluate food energy availability at the subsistence farming level. This is of great importance in developing countries where most of the food producers are subsistence farmers [24]. This also helps in better understanding of food security issues and the relationship between food availability (i.e., food energy availability in this context) and food security in developing countries [25]. This is of paramount importance in developing countries like Nigeria where most of the rural population is engaged in subsistence farming [26]. The rationale for such assumption of subsistence farming holds in our case because 81% of our sample respondents are small-scale farmers owning land less than one ha.

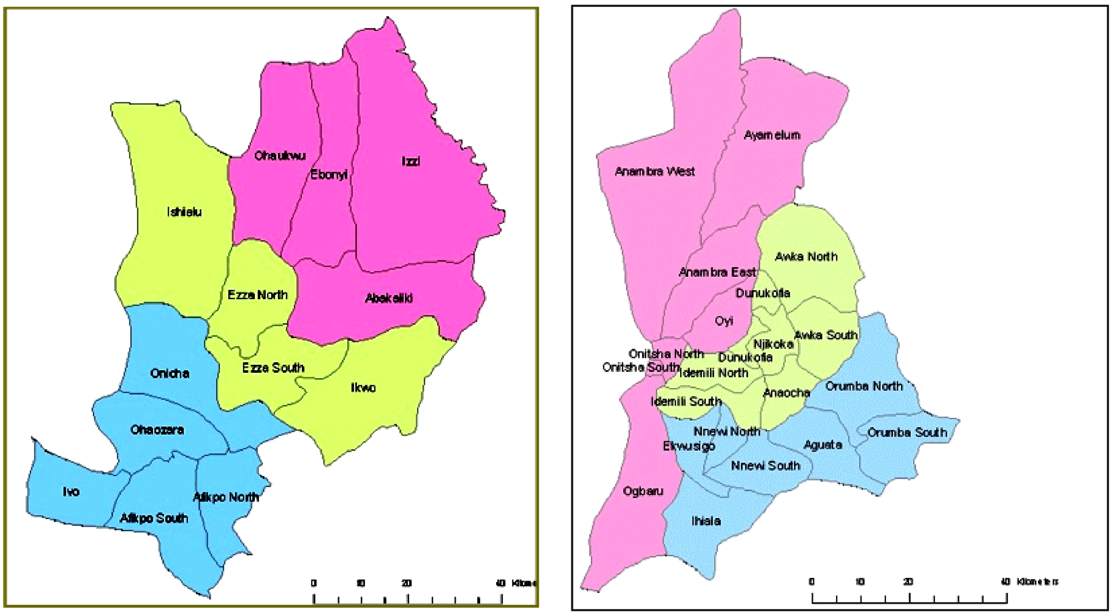
Equation (12), can then be rearranged to reflect this as:

$$F_k = F_k\left[P_i,\ w,\ X^*\left(w,\ R^0, G^0\right), H_c\right] \tag{13}$$

where $k = i, m$.

2.2. Study Area and the Data

The data used for this study were drawn from two states in Southeastern Nigeria, Ebonyi and Anambra states. This is because this region is one of the most dominant region for producing yam and cassava in Nigeria. The reason for choosing these two states are as follows. Anambra is among the oldest state in Nigeria whereas Ebonyi is created in 1996 and is a remote state. The sampling for the study was designed based on the cell structure developed by the Agricultural Development Programme (ADP) in Nigeria. First, three Local Government Areas (LGAs) were then randomly selected from each of the states. These are: Awka North, Anambra West and Ayamelum LGAs from the 21 LGAs of the Anambra state and Ebonyi, Ezza South and Afikpo North LGAs from the 13 LGAs of the Ebonyi state. Figure 1 presents the map of the Ebonyi and Anambra states of Nigeria showing the LGAs. In the next stage, ten communities/villages were chosen randomly from each of the six LGAs. At the final stage. The farmers were chosen from these communities/villages using a simple random sampling procedure. The sample frame is the total number of farm households in the communities/villages.



Ebonyi state Anambra State

Figure 1. Map of Ebonyi and Anambra States, Nigeria. **Source**: Google images.

The sample size (n) of household units in the study area was determined by applying the following formula [27]:

$$n = \frac{Nz^2 p(1-p)}{Nd^2 + z^2 p(1-p)} \tag{14}$$

where n = sample size; N = total number of farm households; z = confidence level at (95% level z = 1.96); p = estimated population proportion (0.5, this maximizes the sample size); d = error limit of 5% (0.05).

The application of the above sampling formula with the specified values helped to maximize the sample size and yielded the total sample of 450, which is statistically representative so that generalizations from the results can be made for a wider context. However, due to difficulty of data collection in developing countries and usability of the returned questionnaires, a reserve of 33% sample was added. Therefore, 600 questionnaires were first distributed (300 in each state and/or 30 in each community). Although 290 questionnaires from Ebonyi and 190 from Anambra states were returned. Complete information necessary for this study was available in only 259 and 141 questionnaires from Ebonyi and Anambra states, respectively. Therefore, the final sample size used in the study is 400 farm households. The field survey was very intensive and carried out during the months of October and November 2011. The questionnaire was pre-tested and modified as required prior to final administration. Farmers were asked to provide details of their production activities, level of inputs used and outputs produced individually for each of the major food crops (i.e., cassava, yam and rice) covering the crop year 2010–2011 based on their recall. In addition, key demographic and socio-economic information from each of the farm households were collected. The co-author and two research assistants who are the final year agricultural undergraduate students were used for collecting primary data. The co-author trained the research assistants on the questionnaire and survey methodology prior to data collection. Therefore, the data collected for this study is a cross-sectional data for 400 households from Ebonyi and Anambra states of Southeastern Nigeria.

2.3. Computing Partial Food Energy Availability

For the purpose of this study, food demand or the amount of food produced by the household from farming is referred to as Partial Food Energy Availability (PFEA), which is the total food available for consumption (in kcals) from total food crop outputs excluding food sold and procured from other sources (e.g., borrowed or purchased from the market). The estimate does not include nutritional content of the produced food. By ignoring food purchases from the market and food transfers, PFEA enabled us to improve our understanding of the foundation of food security, i.e., food energy availability that can be derived from own production activities in developing countries.

PFEA for a household derived from production of food crops from farming is calculated by estimating the number of kcals (C_i) available in each staple food item. Energy availability from each food crop was determined using the standard calorie availability per 100 gm of individual crop weighted by its share of edible portion. The information on calorie availability and the share of edible portion of each crop was taken from SELFNutrition (http://nutritiondata.self.com/). No provision was made on the quality differences of the food crop output. Also, the amount of food lost during post-harvest operation was not included.

The PFEA is defined as the difference between total calorie available from production and consumption need. That is:

$$C_i^* = C_i - \beta_i \quad (15)$$

where C_i is the total calorie availability and β_i is the consumption needs of the *i*th farm household. $C_i^* \geq 0$ Indicates that the farm household has adequate PFEA, while $C_i^* < 0$ indicates that the farm household has inadequate PFEA. Therefore, the total PFEA of *i*th farming household expressed as total calorie per person per day produced from one hectare of cropped area:

$$PFEA_{Ti} = \left\{ \frac{\sum_0^i f\left[\frac{(TR0_i - TR0S_i)\ C + (TY0_i - TY0S_i)C + (TC0_i - TC0S_i)C}{365}\right]}{h_i} \right\} / Hi \quad (16)$$

where:
$PFEA_{Ti}$ = Total PFA of the ith farmer
$TR0_i$ = Total Rice Output of the ith farmer
$TR0S_i$ = Total Rice Output Sold by the ith farmer
$TY0_i$ = Total Yam Output of the ith farmer
$TY0S_i$ = Total Yam Output Sold by the ith farmer
$TC0_i$ = Total Cassava Output of the ith farmer
$TC0S_i$ = Total Cassava Output Sold by the ith farmer
C = Calorific value of each food crop
h_i = Farm size of the ith farmer
Hi = Household size of the ith household.

To conduct the analysis, the following key variables among others were used: Farm output: This refers to the total output (kg/ha) of all food crops produced by the respondent (farmer) in his/her cultivated area in one farming year; Farm size: This refers to the total land area (hectare) cultivated by the farmer during the last farming year. For the purpose of this study, respondents were categorized into three main farm size categories: small farms (cultivating land between 0.01–2.00 ha), medium sized farms (cultivating land between 2.01–3.00 ha) and large farms (cultivating land $\geq$ 3.01 ha) households; Household size: This refers to the number of members living in the same household with the head of the household. It is important to note that household size refers to total number of people and do not reflect the adult equivalent of the household members (e.g., children). Unfortunately, the data does not have information on the age of every individual. Therefore, it was difficult to derive adult equivalent measures of the household accurately, and therefore, was not attempted. In other words, we did not adjust calorie requirement of children in the household.

2.4. The Empirical Model of the Determinants of PFEA

We applied a double-log specification of the model (except dummy variables) to identify the factors influencing PFEA. Use of a double-log specification allows for non-linearity of the underlying model structure and therefore considered superior to simple linear specification. Also, since double-log specification is used, the coefficients on the variables (except the dummy variables) can be directly read as elasticities. The model specification is:

$$ln\ PFEA_i = \beta_0 + \sum_{k=1}^{K} \beta_{ik} lnX_{ik} + \varepsilon_i \quad (17)$$

where $PFEA$ = partial food energy availability; X's are factors influencing $PFEA$, ln is the natural logarithm and ε = stochastic error.

Based on the theoretical framework developed in Section 2.1, a selection of variables representing demand side and supply side determinants were chosen in addition to a range of socio-economic factors influencing PFEA of the household. The variables included as regressors are: X_1 = subsistence pressure (measured by household size, i.e., number of persons in the household); X_2 = distance to the extension office (km); X_3 = total farm size (ha); X_4 = experience of the farmer (years); X_5 = level of education of the farmer (completed years of schooling); X_6 = technology adoption (measured by quantity of inorganic fertilizers in kg); X_7 = amount of loan (Naira); X_8 = gender of the farmer (value is 1 if male; 0 otherwise); X_9 = marital status of the head (value is 1 if married; 0 otherwise); X_{10} = share of yam output in total production (%); X_{11} = share of cassava output in total production (%); and X_{12} = high profit motive (number). For example, the supply side determinants are total farm size and technology adoption. Farm size is the total amount of land used for food production. In general, larger farm size is expected to enhance the likelihood of being food secure [23,28]. Similarly, technology adoption measured as quantity of inorganic fertilizer applied to food production, which is also expected to increase food security through higher output [23]. The demand side determinants are subsistence pressure or family size, distance to extension office and amount of loan. An increase in household size is expected to adversely affect food security [23]. The higher the distance to extension office, the lesser is the likelihood that the farmer will be in contact with the extension services, which may in turn influence access to information and/or adopting modern technologies and therefore, may adversely affect PFEA. Feleke et al. [23] noted that poor physical access to markets (measured in hours spent in travel) is likely to adversely affect the likelihood of being food secure. Rahman and Chima [29] noted less likelihood of adopting modern technologies for farmer located far away from the extension services. Amount of loan is used as a proxy of wealth, which is expected to have positive influence on PFEA. Feleke et al. [23] noted expected positive influence of wealth on food security. Rahman and Chima [29] noted positive influence of access to credit on modern technology adoption in food crops. Farmers were asked to reveal main motives (e.g., high yield, high profit, ready market etc.)

behind choosing one or all of the three major food crops (i.e., cassava, yam and rice) on a five-point Likert scale. The expectation is that higher profit motive will influence farmers to enhance adoption of modern technologies in food production which would lead to higher production and therefore positively influence PFEA. Rahman and Chima [29] and Mariano et al. [30] noted positive influence of profit motive on modern technology adoption. Choice of other socio-economic variables are based on the literature and justification thereof [28,31–33].

2.5. Variance Analyses and Mean Difference Tests

The study also used other forms of analysis. First a One Way Analysis of Variance (ANOVA), was planned to be utilised to examine existence of systematic variation in food availability per ha across farm size categories and crop combinations. The underlying assumption in conducting ANOVA is that the population of farmers from which the sample was drawn are normally distributed. Although, the graphical plots of food availability per ha in a histogram with normal curve imposed showed an approximate normal distribution with a few outliers. Therefore, to avoid undue concerns, we have conducted the alternative non-parametric Kruskal-Wallis test to identify systematic differences in PFEA by farm size categories and crop combinations (details of the test results were presented in the bottom panel of Tables 1 and 2). In order to check differences in PFEA by surveyed districts, student's *t*-test was conducted (please see bottom panel of Table 3). The SPSS V 24 (IBM Corporation, Armonk, NY, USA) was used to conduct cross tabulation and tests [34].

2.6. Multicollinearity

In a regression analysis with multiple variables, multicollinearity can be a problem [33]. Therefore, it is important to check existence of collinearity amongst variables used in the econometric model. Pairwise correlation tests were conducted for all the variables used in the model. Results showed that only about 30% of the variables are significantly correlated and all the correlation coefficients were under 0.35 except correlation between total farm size and share of yam output ($r = -0.52$, $p < 0.01$) and subsistence pressure and farming experience ($r = 0.46$, $p < 0.01$). A general rule of thumb of the presence of serious multicollinearity is to have correlation coefficient in excess of 0.60 for more than two variables [35]. Therefore, multicollinearity is not an issue in this study.

3. Results

To understand the complex relationship between PFEA and socio-economic factors of the household, this study first examines PFEA status at the farm-level over a one calendar year as assessed by the respondents themselves along with reasons provided for their opinion. Then it examines the farm-size and PFEA relationships. Next, the study examines PFEA by type of crops and combinations of crops produced by the farmers. Next, it identifies the socio-economic determinants influencing PFEA of the households. Finally, the section provides information on the constraints in improving food production (and hence PFEA) identified by the farmers and other key stakeholders.

3.1. Partial Food Energy Availability Status

This section discusses how storage capacity of farm households and their efforts to smooth consumption over time is reflected in the PFEA status of the farmers. Respondents were asked to assess or rank their PFEA status over one calendar year under three categories: surplus, at level or deficit. They were also asked to provide reasons for their assessment.

Figure 2 shows that the percentage of respondents assessing their PFEA to be surplus, at level/par or deficit PFEA in different months of the year. It reveals that the surplus PFEA months are January, November and December. The reasons forwarded are that these months are at the peak of harvest period, respectively. It also shows that the farmers have PFEA at level/par during the months of February, March, April, August, September and October. Lastly, it shows that respondents have deficit PFEA during the months of May, June and July. The most severe food shortage is during the months of

June and July, because it is the end of the planting period and crops are still growing in the field with no harvest to be had. These findings are in line with the Nigerian food consumption and nutrition survey, which indicated that certain food crops are largely available only during certain period in a calendar year [36].

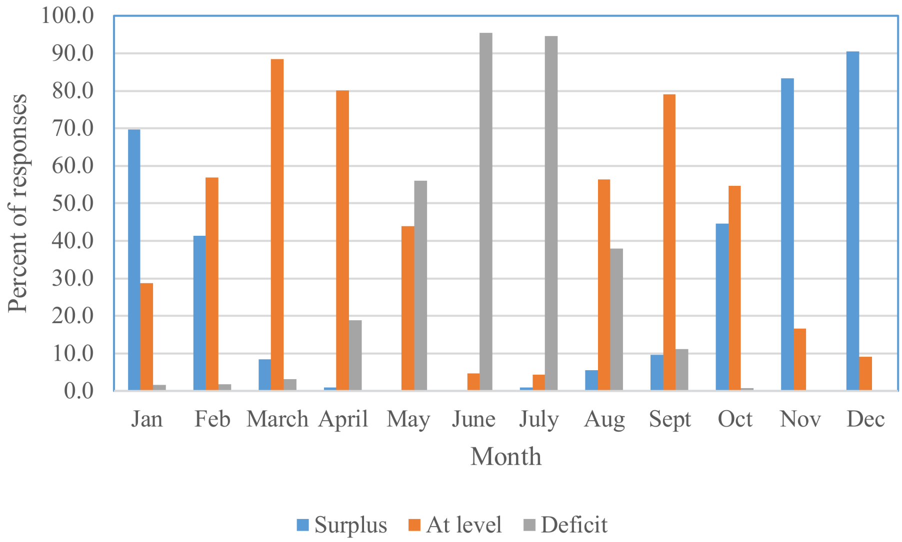


Figure 2. Partial food energy availability status.

3.2. Food Energy Availability and Farm-Size Relationships

An important factor that affects productivity in developing country agriculture is farm operation size. The debate on size-productivity relationship is mixed in the literature. An inverse relationship between farm size and productivity is prominent in areas where farming practice is labor intensive because, for the large farms, high level of labor costs deters them from using hired labor to optimal levels [37]. However, with increased use of modern technology and inputs, the inverse size-productivity relationship has been weakened in recent times [37]. Nigerian farming is characterized by small-scale and labor intensive farming but large farmers are also featured to some extent. For example, Apata et al. [38] noted that 3% of the farm holdings were owned by large farmers with an average farm size of 13.51 ha in Nigeria. Therefore, it is important to test the farm size–PFEA relationships in Nigeria using recent evidence.

Table 1 presents the relationship between total food production as well as PFEA and farm size. Although calorific value of the total food produced from one ha of cropped area is much higher, but it is not a valid measure of food energy availability since farmers do not consume all of the outputs produced from farming and sell some to the market. Table 2 shows that, on average, the respondents have 4492.78 kcals of food available per person per day produced from one hectare of land area for consumption, which excludes any other sources of procuring food. Therefore, food self-sufficiency of the household will depend on the size, the ratio of adult males to females and children in the household and their ability to buy additional food they may need. The information does not take into account their nutritional requirement. According to FAO [39] food and nutrition technical report on human energy requirements, an average adult male require a range of calorie intake per day (2000–2800 kcals) depending on whether he is sedentary (not active, 2000 kcals), moderately active (2200–2400 kcals) or active (2400–2800 kcals). Whilst for an average female adult, the range is from 1600–1800 kcals per day depending on whether she is active or not active [40,41].

Table 1 shows that the mean farm size is 1.27 hectares. It also shows that 81.00%, 10.75% and 8.25% of respondents are small, medium and large farm size farmers, with mean farm sizes of 0.82, 2.54 and 4.04 hectares, respectively. Table 1 also shows that 30.92% of food produced by the households are consumed. Furthermore, 32.12% of food produced by small-scale farmers were kept for home consumption. Similarly, 27.41% and 23.60% of the food produced by medium and large sized farms were kept for home consumption.

Table 1. Partial Food energy availability and its relationship with farm size.

Farm Size Category	Percent of Farmers	Farm Size (ha)	Food Energy Production (Kcals/D/H/ha)	PFEA (Kcals/D/H/ha)	Percent of PFEA
Small	81.00	0.82	13,873.10	5198.76	32.12
Medium	10.75	2.54	6124.33	1654.22	27.41
Large	8.25	4.04	5177.71	1260.14	23.60
All Sample (400)		1.27	12,322.74	4492.78	30.92
Kruskal-Wallis test		187.126 ***	67.748 ***	52.598 ***	

Source: Field Survey 2011. Note: *** significant at 1% level ($p < 0.01$).

Table 1 also shows that small-scale farmers are more efficient in terms of producing food output per hectare. They produce more kcals per person per day from one hectare of land area. Table 2 shows that the share of PFEA from total output produced decreases as farm size increases. Table 2 also shows that PFEA for medium and large farmers are actually lower than the daily calorie requirement of FAO [39] and AND [40]. This finding supports the hypothesis of inverse farm size–PFEA relationships. The Kruskal-Wallis test statistically confirmed that the PFEA significantly varies across farm size groups ($p < 0.01$). This is a very important finding because agricultural production in developing countries are dominated by small-scale subsistence farming households [26,42]. Awerije and Rahman [43] also noted inverse farm size–productivity relationship for cassava in Delta State, Nigeria. Understanding the relationship between farm size and PFEA will help in understanding the complexity of the food security issues in developing countries. These findings are consistent with the literature, such as Igwe [44] and Fabusoro et al. [24] who showed that small-scale farmers produced about 90% of total food in Nigeria.

It is important to note that if a complete measure of food energy availability including purchases and transfers from public programmes or other households were to be considered in the analysis, the picture would be significantly different [45]. According to Baiphethi and Jacobs [25], large-scale farmers are in a position to supplement their food energy availability status, either purchases from the market or transfers from other households, since they are financially better off than the small-scale farmers.

3.3. Partial Food Energy Availability by Crop Combinations

Table 2 presents PFEA by crop combinations of the sampled households. Table 2 shows that 6.25%, 5.25% and 18.0% of the respondents practiced only monocrop of rice, yam, and cassava, respectively. The mean farm size of all monocrop farmers is under one ha which confirms that all these farmers are mainly subsistence farmers at the bottom scale of the small farm category. A total of 68% of the farmers produced at least two food crops. Some 41% of the farmers produced two crops of yam and cassava with a mean operation size of 0.99 ha. About 24.75% of the farmers produced all three crops (rice, yam and cassava) and their mean farm size is the largest estimated at 2.54 ha. The implication is that medium or large farmers are more likely to grow multiple food crops compared to small-scale farmers. The Kruskal-Wallis test results show that farm size varies significantly amongst monocrop and multiple crops farmers ($p < 0.01$).

Cassava is the most efficient in terms of energy output produced per hectare (23,563.60 kcals/D/H/ha) and 40.70% of the output is kept for consumption by the farmers. Yam has the least percentage available for consumption (13.02%), indicating that the farmers sell most of their yam output. This may be due to the high value of yam when compared to the market value of rice and cassava. This is consistent with reports and studies that showed that cassava and its bi-products (e.g., fufu, gari, abacha, cassava flour etc.) are the most popular staple food crop in southern Nigeria [42]. Cock et al. [46] noted that small farms have the highest energy intake from their own consumption in South Africa.

Among the multiple crop producers, producing yam and cassava together is the second most efficient in terms of output produced per hectare (12,707.34 kcals/D/H/ha) and farmers keep 33.17% of the total output available for consumption. Farmers who produce a combination of rice and cassava keep the second lowest share, i.e., 18.77% of the total output, for consumption because they sell most of the rice to the market. The Kruskal–Wallis test results show that total food production and PFEA are significantly difference amongst the farmers producing single and multiple crops ($p < 0.01$).

These findings are in line with similar studies that highlight the importance of cassava as a major staple crop in Nigeria and are reflected in the interview conducted by one of the authors with the country representative of the International Fertilizer Development Centre (IFDC) who emphasized the effects of their Cassava Plus project in Nigeria.

Table 2. Partial Food energy availability as it relates to crop combinations.

Crop Combination	Percent of Farmers	Farm Size (ha)	Food Energy Production (Kcals/D/H/ha)	PFEA (Kcals/D/H/ha)	Percent of PFEA
Rice	6.25	0.79	9127.67	2494.49	25.82
Yam	5.25	0.68	7355.91	1400.79	13.02
Cassava	18.00	0.53	23,563.60	10,457.47	40.70
Rice + Yam	2.50	1.20	6615.73	1965.26	27.85
Rice + Cassava	2.25	1.24	7867.44	1302.47	18.77
Yam + Cassava	41.00	0.99	12,707.34	4516.05	33.17
Rice + Yam + Cassava	24.75	2.54	6352.36	2118.24	32.10
All Sample (400)		1.27	12,322.74	4492.78	30.92
Kruskal-Wallis test		188.421 ***	144.458 ***	87.107 ***	

Source: Field Survey 2011. Note: *** significant at 1% level ($p < 0.01$).

3.4. Partial Food Energy Availability by States

Table 3 shows PFEA classified by location, i.e., states. As mentioned earlier, 64.75% and 35.25% of the sampled respondents are from Ebonyi and Anambra states, respectively. The mean farm size is significantly different between the states. The mean farm size in Ebonyi state is 1.52 ha and Anambra state is 0.83 hectares. Although total food produced from per ha of land area is not significantly different, but the level of PFEA is significantly different between the states, implying that farmers in Ebonyi retains a larger share of total food produced for consumption as compared to farmers in Anambra. The results also prove that PFEA varies significantly at local and/or regional meaning that the macro-level analysis of food security issues (e.g., study on food security in Ghana by Adom [47], actually hides local level realities and may be misleading.

Table 3. Partial Food energy availability at the state level.

State	Percent of Farmers	Farm Size (ha)	Food Energy Production (Kcals/D/H/ha)	PFEA (Kcals/D/H/ha)	% of PFEA
Ebonyi	64.75	1.52	12797.05	4895.72	34.95
Anambra	35.25	0.83	11451.49	3752.85	23.50
All Sample (400)			12322.74	4492.78	30.92
t-test of mean difference		6.195 ***	1.184	1.678 *	

Source: Field Survey 2011. Note: *** significant at 1% level ($p < 0.01$); * significant at 10% level ($p < 0.10$).

3.5. Determinants of Partial Food Energy Availability at the Farm Level

Prior to presenting the results of the determinant analysis of PFEA, Table 4 reports the summary statistics of the variables used in the econometric model. The average PFEA is 4492.78 Kcal/D/H derived from one ha of land area with high level of standard deviation. The average family size is

3.88 persons, 81% of the total farmers are male, average farming experience is just under 20 years and education is above primary level (7.84 completed years of schooling). The amount of loan per household is Naira 5885.40 with high level of variation amongst households. The mean distance from nearest agricultural extension office is 3.64 km. Cassava accounts for 62% of total food output followed by yam at 22%. The mean rank of 'higher profit motive' is 2.63, which is above the neutral level in rank (Table 4).

Table 4. Summary statistics of the variables used in the econometric model.

Variables	Definition and Measurement	Mean	Standard Deviation
Partial food energy availability	Kcal per capita per day produced from one hectare of land (Kcal/D/H/Ha)	4492.78	6522.71
Subsistence pressure	Family size (Number)	3.88	1.91
Amount of loan	Naira	5885.40	29,208.13
Distance to extension office	Km	3.64	3.56
Total farm size	Ha	1.27	1.11
Technology adoption	Quantity of inorganic fertilizers (Kg)	52.70	90.33
Experience of the farmer	Years	19.78	13.62
Education of the farmer	Completed years of schooling (Years)	7.84	4.73
Male farmer	Dummy (Male = 1, 0 otherwise)	0.81	–
Married farmer	Dummy (Married = 1, 0 otherwise)	0.64	–
Share of cassava in total output	Proportion	0.62	0.32
Share of yam in total output	Proportion	0.22	0.23
Higher profit motive	Rank (Number)	2.63	2.07
Total number of observations		400	

Table 5 presents the parameter estimates of the determinants of PFEA using the Ordinary Least Squares regression procedure. Table 5 shows that coefficients on the seven out of a total of 12 variables are significantly different from zero at 10% level at least. About 72% of the total variation in PFEA is explained jointly by these variables (see lower panel of Table 5).

Results show that subsistence pressure (i.e., household size) significantly reduces PFEA and is the most prominent determinant. The coefficient, which is also the elasticity value, indicates that a one percent increase in subsistence pressure will reduce PFEA by 0.98%, which is substantial. This is expected because larger household size will reduce the amount of food available per person from a fixed amount of land, i.e., per ha. An increase in the distance to extension office significantly reduces PFEA, indicating that the further the farming household is from the extension services, the higher is the level of PFEA. The elasticity value shows that a one percent increase in distance to extension services will increase PFEA by 0.03%. PFEA is significantly less for the older farmers. This is because older farmers do not tend to adopt modern technologies. PFEA significantly decreases with an increase in total farm size, which econometrically confirmed the inverse farm size–PFEA relationship observed in Table 2. The share of cassava output in total production significantly increases PFEA. The elasticity value shows that a one percent increase in the share of cassava output will increase PFEA by 0.14%, which is high. In contrast, increase in the share of yam output in total production will significantly reduce PFEA. This is because yam is mainly destined for the market for profit, which consequently leaves less PFEA for home consumption (as seen in Table 3). The high profit motive significantly reduces PFEA as expected. This is because farmers who are motivated to earn profit from farming activities sell a relatively larger share of produced food to the market, therefore, leaving less for home consumption consequently leading to lower PFEA. The gender of the farmer, marital status, the amount of loan and education of the farmer do not seem to have any significant influence on PFEA in the study area.

The aforementioned results of the econometric analysis are largely consistent with the literature, but with some contrasting evidence as well. For example, Asetmir [28] noted that household size significantly reduces food security in Ethiopia. Cock et al. [46] also noted that food insecure households tend to have high household size in South Africa. Feleke et al. [23] also noted that household size has significant and negative effect on food security in rural Ethiopia. Awerije and Rahman [43] also noted that subsistence pressure significantly reduces production efficiency of cassava in Delta State, Nigeria, which implies lower productivity and hence PFEA from farming. All these results are consistent with our key result that subsistence pressure significantly reduces PFEA.

In contrast, Feleke et al. [23] noted that distance to market (measured in hours spent on travel) increases the likelihood of being food insecure. This may be due to fact that farmers who cannot access the market to purchase or trade in food are likely to be insecure. We find that distance from extension services results in farmers producing the main staple food largely used for consumption, i.e., cassava, which increases PFEA because of its high level of calorific content.

Cock et al. [46] noted that food insecure households tend to have elderly heads in South Africa, which is consistent with our findings that PFEA is significantly lower for older/experienced farmers. The inverse farm size–PFEA relationship observed in our study is at contrast with Feleke et al. [23] and Astemir [28] who noted that farm size significantly increases the likelihood of being food secure in Ethiopia.

The significantly positive impact of the share of cassava on PFEA is consistent with the literature because cassava is one of the most important staple foods in Nigeria produced primarily for consumption rather than sale. Feleke et al. [23] noted that households with cereal-based system are likely to be more food secure than the cereal-enset-based farming system. Although we did not find any significant influence of education and gender of the farmer on PFEA, Cock et al. [46] noted that education leads to better food security and female–headed households are relatively worse–off than the male–headed households.

Table 5. Determinants of Partial Food Energy Availability (PFEA) at the farm-level.

Variables	PFEA	
	Coefficient	*t*-Ratio
Constant	9.3477 ***	67.11
Subsistence pressure	−0.9779 ***	−13.25
Amount of loan	−0.0010	−0.19
Distance to extension office	0.0254 **	2.26
Total farm size	−0.2277 ***	−4.27
Quantity of fertilizer	−0.0051	−0.94
Experience of the farmer	−0.0777 *	−1.65
Education of the farmer	−0.0045	−0.40
Male farmer	−0.0096	−0.11
Married farmer	−0.0977	−1.15
Share of cassava in total output	0.1385 ***	10.64
Share of yam in total output	−0.0546 ***	−4.42
Higher profit motive	−0.0233 ***	−2.87
Adj.R squared	0.72	
F (12,386)	85.16 ***	
Number of respondents	400	

Source: Field Survey 2011. Note: *** significant at 1% level ($p < 0.01$), ** significant at 5% level ($p < 0.05$), * significant at 10% level ($p < 0.10$).

3.6. Constraints Faced by Farmers in Improving Production and PFEA

This section highlights the key findings from interviews with key stakeholders, such as, program managers of Agricultural Development Programs (ADP) in Ebonyi and Anambra states, country representatives of the International Fertilizer Development Centre (IFDC) and United Nations Development Program Nigeria (UNDP) conducted by the co-author. The section also discusses the constraints in improving food production and PFEA elaborated by the sampled farmers of the study areas also from the interviews conducted by the co-author.

The summary of key findings are as follows:

- IFDC Nigeria has about 10 programs/projects on the ground in Nigeria, which includes pioneering projects such as the Fertilizer Voucher program and Cassava Plus Project.
- IFDC Nigeria is in the process of expanding these pioneering projects to cover all the states in Nigeria, which will help to reduce the level of corruption in the fertilizer market in Nigeria.
- The 10% Cassava Flour Inclusion policy of the government, which equates to 400,000 tons of cassava flour, will lead to an increase in cassava production and productivity.
- Corruption, inconsistent government policies, poor private sector participation in agriculture among other things are the main constraints affecting agriculture in Nigeria (IFDC, UNDP).
- UNDP Nigeria is helping the government to maintain and strengthen key institutions.
- UNDP Nigeria is involved in international model exchange and help in pointing out to the Nigerian government some internationally accepted models of agricultural development that could be adapted and/or modified to suit the Nigerian context.
- There is a need for agriculture to be sustainable and environmentally friendly and UNDP Nigeria is helping the government to develop policies in these areas.
- Before the Fertilizer Voucher program, only 11% of the allocated farm inputs reached the actual farmers (ADP, Anambra state)
- The ratio of extension agents to farmers in Anambra state is 1:9000 instead of the FAO recommended 1:800–1000; while in Ebonyi state the ratio is much better at 1:2417 farmers (ADP, Ebonyi and Anambra states).
- Agriculture in the study area is still traditional and is dominated by small-scale subsistence farmers (ADP, Ebonyi and Anambra states).
- The government is trying but their policies need to be consistent and there is the need to involve the private sector more in agriculture.
- There is an urgent need for the government to provide adequate facilities, such as, transportation for ADP field staff (ADP, Ebonyi and Anambra states)

In addition to these comments by key stakeholders, farmers also identified a lack of enough contacts with ADP staff, availabilities of credit facilities and farm inputs as the topmost constraints affecting their adoption of modern agricultural technology to increase food crop production. The farmers' main sources of information about modern agricultural technologies are the co-farmers. They identified that improvements in the availability of credit facilities and farm inputs are the main factors. The majority of the respondents stated that they do not have enough money for their farming and that the government is not doing enough to make credit available for farmers due to corruption. The majority of the farmers suggested the use of farmers' co-operatives to distribute loans to farmers and few of them suggested the use of credit vouchers as subsidy. Few of the respondents acknowledged that they have a loan for their farming and most of the farmers sell their farm produce in their local market or at the farm gate where product prices are generally the lowest.

4. Conclusions and Policy Implications

The main goal of this paper was to examine the complex relationships between PFEA and socio-economic factors of the farmers at the farm-level. This was accomplished by examining the level and composition of PFEA at the farm-level, farm size–PFEA relationships and identifying the socio-economic determinants of PFEA. The study was based on a cross-sectional survey of 400 farm households from Ebonyi and Anambra States of Southeastern Nigeria.

Results show that the sample is dominated by small farmers (81% of total) owning land <1.00 ha. The average farm size is also small, estimated at 1.27 ha. Farmers grew multiple food crops with 68% of the farmers grew two or three crops (i.e., cassava, yam and rice). The average amount of PFEA for consumption is estimated at 4492.78 kcals/capita/day produced from one ha of land area. The average share of PFEA is 30.92% of the total food produced per household. Inverse farm size–PFEA relationship exists amongst the sampled farmers, i.e., PFEA is highest for the small-scale farmers estimated at

5198.76 kcals/capita/day/ha. They also keep the highest share of food produced (32.12% of total food output) for consumption. Cassava farmers have the highest PFEA (10,457.17 kcals/capita/day/ha) in the study area. Among the food crops, 40.70% of the cassava output is set aside for home consumption while both yam and rice are mainly destined for the market. The regression results reveal that subsistence pressure, profit motive, total farm size and share of yam in total output significantly reduces PFEA. On the other hand, an increase in the share of cassava in total output and distance of extension services significantly increases PFEA. Farmers identified lack of agricultural extension agents, farm inputs and basic infrastructures as the main constraints adversely affecting food production at the farm-level.

The following implications can be drawn from the results of this study. With respect to food energy availability and status, this study identified that cassava is the most important staple food crop in the study area. Therefore, there is a need for the government and other relevant stakeholders to continue to encourage and support policies and programs, such as, the Cassava Plus project and Cassava Flour Inclusion policy. Second, there is a need to invest in expanding extension services, support and strengthen ADP systems in Nigeria, especially in improving mobility of ADP staff by providing transportation facilities and an increase in the ratio of extension agents to farmers. Third, the study also identified some constraints affecting food production, such as lack of credit facilities and farm inputs, lack of infrastructures, ineffective government policies among others. Therefore, measures should be undertaken to provide access to credit and farm inputs to farmers. The provision of credit services can be achieved through effective dissemination of credit through formal banking institutions and/or facilitating non-governmental development organizations (NGOs) targeted at the farming population. Although these policy options are challenging, effective implementation of these measures will significantly improve food availability at the farm level, particularly for the small-scale farmers in Nigeria.

The limitations of the present study are that it is based on a cross-sectional survey data to examine food energy availability at the household level from own production and did not consider purchase or trading food from the market to supplement availability. Future research could be conducted on a panel data set to obtain information on the dynamics for food energy availability over time and incorporate food purchased and/or traded from the market in order to get a complete picture of the food security status of the farm households

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