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Food security in the Savannah Accelerated Development Authority Zone of Ghana: an ordered probit with household hunger scale approach

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Abstract

Background: Food security has been observed to be severe in northern Ghana than any other area of the country. Though this has been acknowledged, few attempts have been made to curb the situation. One of such intervention areas resides in providing policy-based evidence to guide efforts in fighting this problem. This study employs an ordered probit model using data set from the baseline survey of the USAID's Feed the Future programme in Ghana to estimate the determinants of food security in northern Ghana. We perform the analysis using a new indicator of food security—the household hunger scale. This measure is different from other household food insecurity indicators since it has been specifically developed and validated for cross-cultural use.

Results: The estimates show that crop producers, multiple crop producers, yield and commercialization are key policy variables that determine food security. A key policy implication of this result is in tandem with one of the intermediate results of the Ghana Feed the Future Initiative which seeks to increase competitiveness of food value chains through increased productivity and market access.

Conclusions: Based on the results, stakeholders should step up efforts to enhance productivity of farm households and provide necessary market infrastructure to boost commercialization, as these are fundamental to ensuring food security.

Keywords: Food security, Household hunger scale, Cross-sectional data, Ordered probit, Ghana

Background

Food security is more prominent on the policy agenda today than it has been in the past [1]. Undoubtedly, the scale, magnitude and quantitative evidence of food insecurity is fundamentally responsible for this prominence. For example, one in every eight people in the world, representing a total of 842 million between 2011 and 2013, was estimated to be food insecure and suffering from chronic hunger [2]. Perhaps, the greatest area justifying the prominence of food security is the fact that the Millennium Development Goal (MDG) 1, aimed at eradicating extreme poverty and hunger, was not achieved by the end of 2015.

While food insecurity is a global concern and for that matter not continent and country specific, the disproportionate nature of food insecurity is a serious concern. For example, Van Eeckhout [3] observes the following as the regional distribution of people suffering from hunger: 578 million in the Asia Pacific region; 239 million in sub-Saharan Africa; 53 million in Latin America and the Caribbean; 37 million in North Africa; and 19 million in developed countries. From these statistics, it can be deduced that food insecurity is more pronounced in developing countries and this observation has been supported by a number of empirical findings. For example, FAO, IFAD and WFP [4] note that the vast majority of

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hungry and malnourished people live in developing countries.

There is no doubt that Africa is an enormous victim of food insecurity among all the other continents since most of the world's poorest countries are in Africa. As a result, many of these poverty-stricken countries face food insecurity challenges in a manner that undermines development efforts. Sub-Saharan Africa is identified as one of the regions most affected by food insecurity as it houses 60% of the world's food-insecure people and is the only region of the world where hunger is projected to worsen over the next two decades if measures are not put in place [5]. This is supported by Folaranmi [6] who observes that Africa's food security and nutrition situation is worsening.

Food insecurity persists in Ghana. According to WFP [7], about 1.2 million people, representing 5% of the population of Ghana, are food insecure and 2 million people are vulnerable to food insecurity in an event of any natural or man-made shock. The food insecurity problem is fundamentally influenced by subsistent production which in turn is usually characterized by low and declining production and productivity, and the employment of rudimentary technology [8]. Despite the fact that the agriculture sector is a significant contributor to the growth of the economy and employing majority of the labour force, Ghana is yet to achieve self-sufficiency in the production of food. Data from Ghana's Ministry of Food and Agriculture (MoFA) show that the country has deficits in the production of cereals, meat and fish but only self-sufficient in the production of root and tubers though the self-sufficiency is chequered—with pockets of scarcity, sufficiency and glut depending on the season. This is worsened by decreasing yields of the crops and fishing subsectors [9].

These facts are further aggravated by food price hikes, poverty, climate change and increasing population. For example, prices of rice, maize and other cereals between 2007 and 2008 recorded hikes between 20 and 30% [10]. Though the country has performed remarkably well in eradicating poverty, the problem is far from over. Poverty still ravages a significant number of people and has been observed to spread into urban areas. WFP [7] finds that about 46% of farming households are identified as the most affected among all economic sectors. At the same time, climate change is jeopardizing agricultural production, deepening the woes of food-insecure or vulnerable households. Climate change causes erratic rainfall patterns and decreasing crop yields, contributing to increased hunger [11]. In the midst of all these food-insecurity-worsening situations is the issue of increasing population amidst declining production. The population is growing at 2.5% per annum. The limited empirical evidence about Ghana shows that food insecurity is concentrated in the rural areas [7, 12].

Northern Ghana, which includes the Northern, Upper West and Upper East regions, is poorly endowed with natural resources and the income per capita of its population falls well below the national average [13]. These regions constitute the most backward regions in Ghana and have been described as the most poverty-stricken and hunger spots in Ghana [14]. The incidence of poverty, malnutrition, and stunting among children under-5-years of age is higher in northern Ghana [15]. WFP [16] observes that more than 680,000 people were considered either severely or moderately food insecure of which 140,000 were classified as severely food insecure, having a very poor diet consisting of just staple foods, some vegetables and oil. In terms of regional distribution, the Upper East region has the worse insecurity status (28%) followed by Upper West region (16%) and the Northern region (10%). It is therefore imperative to investigate the key factors influencing food security in this part of the country. Efforts towards alleviating food insecurity largely depend on adequate evidence that provides the pathway for appropriate policy. This is the mandate of this paper: to investigate the determinants of food security or insecurity in northern Ghana.

The study departs from previous studies by its application of the household hunger scale (HHS)—a reliable and well-tested approach of measuring food security. Evidence based on this new approach would have significant policy impact and provides the basis for comparison across cultures and settings. Also, studies of food security in Ghana have considered smaller geographical areas. Kuwornu et al. [17] studied the forest belt of the Central region, Aidoo et al. [12] studied the Sekyere-Afram Plains District, and Nata et al. [18] studied the Ga West District in Greater Accra. This study covers the three poverty-stricken and the most deprived regions of Ghana usually referred to as the Savannah Zone. Though Quaye [19] studied this subregion, the analysis was qualitative and did not identify influencing factors of food security. Owusu et al. [20] also studied this area but focused on the impact of non-farm work on household income and food security. A further departure from most food security studies is in terms of methodology. Most food security studies that apply econometric methodology usually use binary models. This study applies an ordered model as a way of providing useful evidence that preserves vital information of order as opposed to the binary models which obscure such information. In addition to these, the study makes a practical contribution by scouting for critical factors influencing food security and, on that basis, makes policy relevant contributions to inform priority setting in policy considerations for eradicating food insecurity in Ghana.

Definition of food security

Early definitions of food security focused on the ability of a region or nation to assure an adequate food supply for its current and projected population [21]. One of these definitions was provided by the United Nations (UN) in 1974 as: "availability at all times of adequate world food supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices". This definition was improved by the World Bank [22] to: "access by all people at all times to enough food for an active and healthy life". The inadequacies of these definitions saw the UN expand the concept in 1996 to accommodate and reflect the complex arguments of nutrition and human rights in food security as follows: "Food security, at the individual, household, national, regional and global levels is achieved when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life". This definition is quite universally acclaimed as it integrates stability, access to food, availability of nutritionally adequate food and the biological utilization of food [12]. MoFA [23] provides an operational definition for food security in Ghana as "good quality nutritious food hygienically packaged, attractively presented, available in sufficient quantities all year round and located at the right place at affordable prices". Given that MoFA is an important authority in Ghana and the fact that their definition plays into the conceptual space of the HHS, we adopt this definition.

Literature review

Two notable issues are identified in food security studies. The first has to do with measurement of food security. A general limitation in the literature is the inability to have a clearly defined metric of food security against which to identify and compare food-secure and food-insecure households. This weakness is rather a confounding one as it poses serious problems in the empirics of food security. The second is about econometric models used for analysis. These two issues are intertwined as the measurement dictates the econometric model to use. Food security is multidimensional and thus presents a variety of measurements [24–26]. Various indicators have been developed as proxies for food security. Table 1 presents categories of food security measures.[1]

Maxwell et al. [1] note that a comprehensive all-encompassing measure of food security would be that measure that is valid and reliable, comparable over time and space, and which captures different elements of food security. In the assessment of Coates and Maxwell [27], none of these measures satisfies the criteria. However, Maxwell et al. [1] find strong evidence that all these measures reflect the multidimensional nature of food security though there is paucity of evidence as to which dimensions of food security are captured by each measure and few direct empirical comparisons among them.

Table 1 Categories of food security measures

Category	Measurement indicator
Dietary diversity and food frequency	Food Consumption Score (FCS)
	Household Dietary Diversity Scale (HDDS)
Spending on food	Cost of Calorie (COC)
Consumption behaviours	Coping Strategies Index (CSI)
	Reduced Coping Strategies Index (rCSI)
	Food Security Index (FSI)
Experiential measures	Household Food Insecurity and Access Scale (HFIAS)
	Household Hunger Scale (HHS)
	Latin America and Caribbean Food Security Scale (ELCSA)
Self-assessment measures	Self-assessed measure of food security (SAFS)

Despite the limitations of all measures, the HHS has been identified as a reliable measure of food security. The HHS is a new, simple indicator to measure household hunger in food-insecure areas. It is different from other household food insecurity indicators in that it has been specifically developed and validated for cross-cultural use [28]. They indicate that the HHS produces valid and comparable results across cultures and settings so that the status of different population groups can be described in a meaningful and comparable way. The use of the HHS in the measurement of food security in northern Ghana is thus appropriate since this part of Ghana records substantial food insecurity. The HHS consists of only three questions and three frequency responses as detailed in Ballard et al. [28]. These questions and responses are recoded for tabulation into three HHS categories as shown in Table 2.[2]

The categories in Table 2 are the measures of food security used to indicate the percent of households affected by three different severities of household hunger: (1) little to no household hunger; (2) moderate household hunger; and (3) severe household hunger. This measure is adopted in this study since it has been identified to be robust. Since there is no single indicator to

[1] For details about these measures and how they compare, see Maxwell et al. [1].

[2] The process of recoding is also detailed in Ballard et al. [28].

Table 2 Household hunger scale categorical indicator *Source* Food and Nutrition Technical Assistance, 2011

HHS score	Household category
0–1	Little to no hunger in the household
2–3	Moderate hunger in the household
4–6	Severe hunger in the household

measure food security, analyses are varied and diverse. Those quantitative measures such as the Food Security Index (FSI) implemented using the Recommended Daily Calorie approach [29–31] and the Cost of Calorie (COC) approach [17, 32, 33] have been widely used. In these studies, households are categorized into food secure and insecure based on the calculated FSI or COC. These categorizations under the FSI and COC form the basis for the application of categorical (binary) choice models. The binary logit [12, 17, 34, 35] and binary probit [33, 36] are the widely used models.

In these studies, one methodological issue arises, principally from the confounding issue of measurement. The construction of the food security variable into only two categories is problematic since it assumes that households are either food secure or insecure. The limitation of this assumption is that it obscures or discards vital information of households who happen to have indices ranging between the lowest and highest values of food security indices. Since food security indices are a continuum from zero to hundred, at least three possibilities are expected—low, moderate and high—which provide the basis for ordering indices of households. It is very important to provide an ordering of households for appropriate policy interventions than the limited information the binary categorization of secure and insecure presents.

The appropriate way to overcome the limitation of the binary categorization is to apply models that order food security as a dependent variable. Based on this, Nata et al. [18] applied an ordered logit model to analyse the effect of household adoption of soil-improving practices on food insecurity in Ghana. The weakness of this study lies in the measurement of the food security variable. The various categories of chronic, transitory and vulnerable as measures of insecurity are not as far-reaching as the HHS measure. Also, the study was done in Greater Accra region (the national capital). It can be argued that the justification for the study area becomes problematic when the northern part of the country is identified as the hub of food insecurity problems. Thus, this study contributes to the literature by applying the HHS to analyse food security in northern Ghana using an ordered model. The strength of this econometric approach is twofold. First, it is able to exploit the inherent ordering information in food security. Second, it defines preselected boundaries or cutoff points (with only one fixed) that segregate severe hunger, moderate hunger and food secured households, and in this regard, the ordered approach is both novel and better at handling the subjectivity of ad hoc metrics used to measure food insecurity.[3]

An important dimension to food security studies worthy of mention is the analysis of calorie and nutrient demand functions. Notable contributions to this literature include Wolfe and Behrman [37], Pitt [38], Garrett and Ruel [39], Bhargava [40], Subramanian and Deaton [41], Grimard [42], Skoufias [43], Abdulai and Aubert [44], Aromolaran [45] and Ecker and Qaim [46]. The fundamental goal of these studies is to measure the impacts of critical factors notably income and price elasticities, on demand for calories and nutrients. An important lesson from these contributions is that estimates of these demand functions present a vent to indirectly make inferences of the impact of these correlates on food security. For example, income and price as correlates of demand for calories aid in making inferences on the levels of vulnerability of households to income and price shocks. This present study departs from these studies in the use of the HHS and the ordered approach.

Another noteworthy contribution to the food security literature is a recent contribution by San-Ahmed and Holloway [47] who applied Bayesian econometric approach to skilfully overcome the problem of endogeneity in their procedure. In the light of the ordered approach, Bayesian econometric procedure is able to derive estimates without the boundary condition [48]. However, this study employs a classical econometric approach.

Methods

Empirical model

The measurement of food security (see Table 2) dictates an econometric model beyond the application of binary choice models. Greene [49] notes that although the outcome is discrete, the multinomial logit or probit models would fail to account for the ordinal nature of the dependent variable. Given that the food security measures are categorical and ordinal, ordered probit or logit models are the most appropriate for analysis. While the logit assumes a logistic distribution of the error term, the probit assumes a normal distribution. The logistic and normal distributions generally give similar results in practice [49]. Also, Davidson and MacKinnon [50] indicate that the ordered probit is the most widely used model for ordered response data in applied econometric work. Therefore, the ordered probit is used in this study.

[3] The authors gratefully acknowledge a meticulous reviewer for calling their attention to this fact.

The ordered probit, developed by McKelvey and Zavoina [51], is constructed on a latent (unobservable) random variable which is stated as follows [52–54]:

$$y_i^* = x_i'\beta + e_i, \quad i = 1, 2, \ldots, N \tag{1}$$

where $E(e_i|x_i) = 0$ and $\text{Var}(e_i|x_i) = 1$. Treating Y_i, the observed variable, as a categorical variable with J response categories and also as a proxy for the theoretical (unobserved) random variable, y_i^*, and defining $\mu = \mu_{-1}\,\mu_0\,\mu_1 \ldots \mu_{J-1}\,\mu_J$ as a vector of unobservable threshold (or cutpoint) parameters, the relationship between the observed and the latent variables can be written as:

$$Y_i = j \quad \text{if} \quad \mu_{j-1} < y_i^* \leq \mu_j, \quad j = 0, 1, 2, \ldots, J \tag{2}$$

where $\mu_{-1} = -\infty, \ \mu_0 = 0, \ \mu_J = \infty$ and $\mu_{-1} < \mu_0 < \mu_1 < \cdots < \mu_J$. The probabilities will thus be given as follows:

$$\begin{aligned} \text{Prob}[Y_i = j] &= \text{Prob}\left[\mu_{j-1} < y_i^* \leq \mu_j\right] \\ &= \text{Prob}\left[\mu_{j-1} - x_i'\beta < e_i \leq \mu_j - x_i'\beta\right] \\ &= \Phi\left(\mu_j - x_i'\beta\right) - \Phi\left(\mu_{j-1} - x_i'\beta\right) \end{aligned} \tag{3}$$

where $\Phi(\cdot)$ is the standard normal cumulative distribution function and J is the response categories, in this case 0, 1 and 2 since there are three categories for food security.

As observed by Greene [55], since there is no meaningful conditional mean function and the marginal effects in the ordered probability models are not straightforward, the effects of changes in the explanatory variables on cell probabilities are normally considered. These are given by:

$$\frac{\partial \text{Prob}[\text{cell}j]}{\partial x_i} = \left[\phi\left(\mu_{j-1} - x_i'\beta\right) - \phi\left(\mu_j - x_i'\beta\right)\right] \times \beta \tag{4}$$

with $\phi(\cdot)$ being the standard normal density function.

In the light of the preceding discussion, the empirical model of this study is specified as:

$$\text{FS}_{ij} = \alpha + \beta W_i + \gamma X_i + \delta Z_i + \varepsilon_i \tag{5}$$

where FS is food security proxied by the HHS; subscript i represents a household, subscript j (j = 0, 1, 2) represents the three-pronged categorization of alternative dependent dummy variables indicating (i) whether a household falls within severe household hunger category, (ii) whether a household falls within moderate household hunger category, and (iii) whether a household is within little to no household hunger category; *W, X* and *Z* are, respectively, socioeconomic, food production and consumption, and institutional and location characteristics hypothesized to influence food security (these variables are presented in Table 3); *α, β, γ, δ* are parameters to be estimated and $\varepsilon \sim \text{NID}(0, 1)$.

Data

The study uses data collected by the Monitoring Evaluation and Technical Support Services (METSS) in the Savannah Accelerated Development Authority (SADA) regions (identified as the zone of influence, see Additional file 1), namely Upper East, Upper West, Northern, Brong Ahafo and Northern Volta in 2012 under the USAID Feed the Future Initiative and published in 2014. The Feed the Future Initiative aims to help developing countries address root causes of hunger and poverty specific to their individual and unique circumstances through the transformation of agricultural production and improvement in health and nutrition. In Ghana, the initiative seeks to increase competitiveness of maize, rice and soya value chains; improve resilience of vulnerable households and communities, and reduce undernutrition, and improve nutritional status of women and children.

The data were collected on eleven modules including household demographic information, household hunger scale (HHS), cultivation of key crops, access to productive capital, access to credit, consumption of food items, non-food consumption expenditure, group membership, dwelling characteristics, women's dietary diversity, and women's anthropometry. In all, 4410 households were sampled and interviewed. However, 357 households were dropped in the analysis as a result of incomplete responses.

Results and discussion

In this section, we present the results and findings. Food security characteristics of households are first presented. This is then followed by empirical estimation results and discussions.

Food security characteristics of households

Table 4 shows the results on food security status in the SADA zone. The results show that less than 1% of the sample experienced severe hunger. This implies that households—(i) who had no food of any kind to eat in the last 4 weeks before the survey and happened often, (ii) who had at least a member go to sleep at night hungry and happened often, and (iii) who had at least a member go a whole day and night without food and happened often—represented only 0.89% of the sample. Households with moderate and little to no hunger represented about 36 and 63%, respectively.

While the results could mean that severe food insecurity in the SADA zone reflected through hunger is not pervasive, it is important to understand the construction of the HHS. It measures the relative degree of hunger among households. The moderate and little to no hunger categories still provide useful information about

Table 3 Description, measurement and statistics of explanatory variables

Description/variable	Measurement	Mean[a]	SD
Socioeconomic characteristics			
Age of household head (AGE)	Number of years	44.40	16.39
Gender of household head (GEN)	Dummy: 1 = if male; 0 = otherwise	82.38%	
Educational level of household head (EDUC)	Number of years in school	2.14	4.71
Marital status of household head (MARST)	Dummy: 1 = if married; 0 = otherwise	79.50%	
Household size (HHSIZE)	Number of people in household	5.65	3.35
Ownership of private means of transport (MTRANS)	Dummy: 1 = if yes; 0 = otherwise	73.30%	
Ownership of farm mechanized equipment (FRMEQ)	Dummy: 1 = if yes; 0 = otherwise	2.27%	
Ownership of farm non-mechanized equipment (FRNMEQ)	Dummy: 1 = if yes; 0 = otherwise	77.99%	
Food and consumption characteristics			
Yield index of maize, rice and soya (YIELD)[b]	Output index/farm size (kg/ha)	438.27	498.49
Household commercialization index (HCI)	Percentage	21.25	29.36
Production of crops (CPRDN)	Dummy: 1 = if yes; 0 = otherwise	74.12%	
Production of multi crops (MLTCRP)	Dummy: 1 = multi-crop; 0 = otherwise	36.98%	
Ownership of agricultural land (ALAND)	Dummy: 1 = if yes; 0 = otherwise	83.17%	
Ownership of poultry (PLTRY)	Dummy: 1 = if yes; 0 = otherwise	60.45%	
Ownership of small animals (SANIM)	Dummy: 1 = if yes; 0 = otherwise	55.74%	
Ownership of large animals (LANIM)	Dummy: 1 = if yes; 0 = otherwise	21.54%	
Total weekly food consumption expenditure (FEXP)	Ghana cedi	70.08	110.78
Total weekly non-food consumption expenditure (NFCEXP)	Ghana cedi	370.66	833.97
Institutional and location characteristics			
Locality of residence (LOC)	Dummy: 1 = if rural; 0 = otherwise	73.92%	
Region of household (REG_NR)	Dummy: 1 = if Northern; 0 = otherwise	62.45%	
Region of household (REG_UW)	Dummy: 1 = if Upper West; 0 = otherwise	6.39%	
Region of household (REG_UE)	Dummy: 1 = if Upper East; 0 = otherwise	17.89%	
Region of household (REG_BA)	Dummy: 1 = if Brong Ahafo; 0 = otherwise	13.27%	
Access to cash credit (CCRED)	Dummy: 1 = if yes; 0 = otherwise	27.02%	

[a] For dummy variables, the values under the "mean" column describe the proportion possessing the attribute; [b] Maize, rice and soya are strategic crops identified by the Feed the Future (FtF) Initiative as having the potential to alleviate poverty and improve food security. Unfortunately, only 9.7% of the sample produced all three crops at baseline. To use only such individuals, means over 90% of the total sample will be dropped. To avoid such large attrition, the outputs of these crops are converted into kilograms and then combined to give a composite output index for each household in kilograms. Farm size is measured in hectares. Thus, yield index is in kg/ha

Table 4 Food security status of households in the SADA zone

Food security status	Frequency	Percentage
Severe hunger in the household	36	0.89
Moderate hunger in the household	1449	35.75
Little to no hunger in the household	2568	63.36
Total	4053	100.0

the situation of food insecurity in the area. Moderate and little hunger are not acceptable in any human society. While it is not possible to segregate those without any hunger from those with little hunger, the number of households falling within this category suggests that a significant number of households had little hunger. If we re-categorize, at least 50% might experience varying degrees of severe, moderate and little hunger. These are relatively different, yet none is acceptable. Hence, the food security situation in the zone can still be described as worrisome and requires efforts from various stakeholders to tackle the menace.

Food security status by region and gender are, respectively, shown in Figs. 1 and 2. Figure 1 shows that the Northern region has the highest incidence of all the categories of hunger scale. This is probably due to the sample size difference. Brong Ahafo and Northern regions maintain the order of the entire SADA region where little to no hunger category is more than the moderate category, which is also more than the severe category.

However, Upper West and East regions violate the order where the moderate categories outweigh the little to no categories. Figure 2 indicates that in all hunger

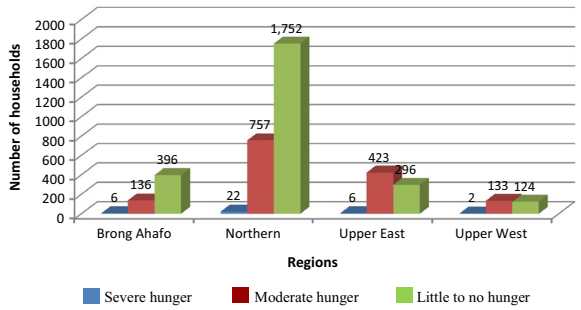

Fig. 1 Food security status by region

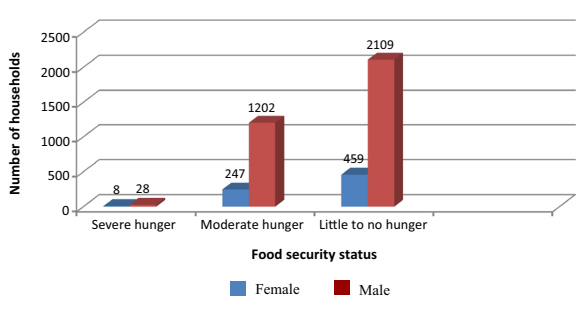

Fig. 2 Food security status by gender

categories, males are more affected than females. While the reason for this is not clear to us, sample size differences could account for this observation.

Determinants of food security in the SADA zone

The results of the determinants of food security are presented in Table 5. Since the coefficients of the ordered probit do not represent the magnitude of the effects of the explanatory variables, the marginal effects are discussed. These marginal effects are interpreted based on the sign and category. An estimated positive coefficient for a category indicates that an increase in that variable increases the probability of being in that category, whereas a negative coefficient indicates a decrease in probability of being in that category. The marginal effects corresponding to the significant variables are also significant.

We find that one more year in school (level of education) decreases the probability of experiencing severe and moderate hunger and increases the probability of experiencing little or no hunger. A plausible explanation for this finding is that a higher educational attainment of household heads could lead to their awareness of the possible advantages of modernizing agriculture by means of adopting new technologies and diversifying household income, which, in turn, would enhance household food supply. Thus, being literate reduces the chance of becoming food insecure. This conforms to expectation and confirms the finding of Tefera and Tefera [34] which shows that educated households have a better chance of adopting soil conservation measures which, in turn, increases crop production. Again, educated household heads have the capacity to innovate and to adopt timely technology and have better understanding of the cash crops that can help them to have a better income than the non-educated household heads.

Further, higher levels of education guarantee numerous options of employment in the formal sectors of the economy which, in turn, deliver higher incomes to aid food consumption expenditures. According to the Ghana Statistical Service (GSS) [56], about 60% of legislators or managers, 87.4% of professionals, and 63.4% of technicians and associate professionals have attained at least secondary school education. The GSS [56] further reveals that almost half of household income is from non-farm self-employment, contributing 48.3% to sources of household income. Wages from employment is the second major contributor (36.3%) with household agriculture accounting for one-tenth (10.1%). These statistics show that people with higher levels of education earn higher incomes than those in agriculture. This evidence contradicts the finding of Beyene and Muche [35], who explain that educated households might not utilize their knowledge for the advancement of food security.

Households with means of transport are less likely to fall within the severe and moderate hunger categories and more likely to have little or no hunger. While the reason for this observation may not be certain, it may suggest the effect of wealth on boosting food security.

Households with mechanized farm equipment are less likely to belong to severe and moderate hunger categories and more likely to have little or no hunger. This is consistent with expectation since mechanized equipment enhances the productive capacity of these households in farm businesses. Alternatively, revenues from the use of the equipment on other peoples' farm businesses can be used to support food expenditure and/or invested to produce more output or earn more income to meet household food needs.

The yield (as an index) obtained by households decreases the probability of experiencing severe and moderate hunger and increases the probability of experiencing little or no hunger. Increasing the productivity of households is the sufficient condition to enhancing food security. This observation has key policy implication for government and other stakeholders in the fight against food insecurity.

The level of commercialization of agriculture decreases the probability of households falling within the severe and moderate hunger categories while increasing the

Table 5 Results of ordered probit model

Variable	Estimates		Marginal effects					
	Coefficient	SE	$Y=0$	SE	$Y=1$	SE	$Y=2$	SE
AGE	0.0011	0.0013	−1.91e−05	2.0e−05	−0.0004	0.0005	0.0004	0.0005
GEN	−0.0657	0.0587	0.0010	0.0009	0.0233	0.0207	−0.0243	0.0216
EDUC	0.0106**	0.0049	−0.0002**	0.0001	−0.0038**	0.0017	0.0040**	0.0018
MARST	0.0476	0.0558	−0.0008	0.0010	−0.0171	0.0201	0.0179	0.0210
HHSIZE	−0.0011	0.0066	1.77e−05	0.0001	0.0004	0.0024	−0.0004	0.0025
MTRANS	0.0946*	0.0490	−0.0017*	0.0010	−0.0339*	0.0177	0.0356*	0.0186
FRMEQ	0.3073**	0.1350	−0.0036***	0.0012	−0.1038**	0.0424	0.1074***	0.0434
FRNMEQ	−0.0546	0.0644	0.0009	0.0010	0.0194	0.0228	−0.0203	0.0238
YIELD	0.0001***	0.0001	−2.38e−06**	0.0000	−0.0001***	2.0e−05	0.0001***	2.0e−05
HCI	0.0042***	0.0008	−0.0001***	2.0e−05	−0.0015***	0.0003	0.0016***	0.0003
CPRDN	−0.2633***	0.0633	0.0038***	0.0010	0.0919***	0.0215	−0.0957***	0.0223
MLTCRP	−0.1462***	0.0479	0.0026***	0.0010	0.0524***	0.0172	−0.0549***	0.0181
ALAND	−0.0852	0.0724	0.0013	0.0011	0.0301	0.0254	−0.0315	0.0264
PLTRY	0.1068**	0.0475	−0.0018**	0.0009	−0.0382**	0.0170	0.0400**	0.0179
SANIM	0.0944**	0.0475	−0.0016*	0.0009	−0.0337**	0.0169	0.0353**	0.0178
LANIM	−0.1258**	0.0530	0.0023**	0.0012	0.0452**	0.0192	−0.0475**	0.0203
FCEXP	0.0007***	0.0002	−1.11e−05**	0.0000	−0.0002***	0.0001	0.0002***	0.0001
NFCEXP	1.63e−05	3.01e−05	−2.73e−07	0.0000	−5.81e−06	1.0e−05	6.08e−06	1.0e−05
LOC	−0.1323**	0.0530	0.0021**	0.0008	0.0467**	0.0186	−0.0488**	0.0193
REG_NR	−0.0239	0.0728	0.0004	0.0012	0.0085	0.0259	−0.0089	0.0271
REG_UW	−0.4972***	0.1002	0.0147***	0.0049	0.1796***	0.0353	−0.1943***	0.0396
REG_UE	−0.6632***	0.0818	0.0201***	0.0045	0.2370***	0.0283	−0.2570***	0.0315
CCRED	−0.0315	0.0457	0.0005	0.0008	0.0113	0.0164	−0.0118	0.0171
μ_2^a	−2.7297***							
μ_2	−0.5746***							
Log pseudolikel.	−2664.3025							
Wald χ^2	336.20***							
Pseudo R^2	0.0593							
No. observ.	4053							

***, **, * Stand for values statistically significant at 0.01, 0.05, and 0.1 levels, respectively; [a] Threshold parameters in ordered probit model

probability of households falling within the little to no hunger category. This conforms to a priori expectation since the more commercialized a household is, the more it is able to generate sufficient incomes which could lead to enhanced accessibility of food, the ability to diversify consumption patterns and increase food consumption expenditure as well as the capacity to invest more in production. This evidence conforms to the observation in agricultural economics that an increase in the incomes of farm households leads to a structural shift from the consumption of staples to the consumption of diversified products such as vegetables and dairy products. The improvement in incomes from commercialized agriculture improves financial access to products and the nutritional quality of consumption, which are key pillars of food security. This finding corroborates Nata et al. [18], Kuwornu et al. [17], Babatunde et al. [31] and Arene and Anyaeji [29] who report a positive relationship between household income and food security. A significant portion of household income is from sale of farm produce.

Farm households who are crop producers (i.e. those producing any of maize, rice and soybean) are more likely to experience severe and moderate hunger and less likely to experience little or no hunger as compared to households who do not produce such crops. This observation, though counter-intuitive, is pointing to a known characteristic of smallholder farm households. These farmers are usually the food producers and the poorest and hardest hit when there is a slight failure in production arising from such catastrophes as drought and loss of produce to fire. They are most vulnerable to food insecurity. We also find evidence that farm households who engage in the production of multiple crops are more likely to experience severe and moderate hunger and less

likely to experience little or no hunger. This observation is also counter-intuitive but lends support to the evidence on production of crops. Smallholders are noted for multiple cropping with lower yields. This indicates that households who concentrate on the production of one crop are able to make more output, sell it and then diversify consumption financed by income from crop sales.

Households with poultry (specifically chickens, ducks, turkey and pigeons) and small livestock (specifically goats, pigs and sheep) are less likely to experience severe and moderate hunger and more likely to experience little to no hunger. This is consistent with the finding of Tefera and Tefera [34] who argue that livestock contribute to food security through provision of cash income and nutrition. It also corroborates the finding of Beyene and Muche [35]. The results indicate that owners of poultry and small livestock are less vulnerable to food insecurity, especially in times of drought when crops fail [57]. However, households with large livestock (specifically oxen and cattle) are less likely to experience little or no hunger and more likely to experience severe and moderate hunger. This is counter-intuitive and suggests that large animals are used as assets for traditional purpose of storing wealth rather than for immediate consumption. It contradicts the findings of Beyene and Muche [35] who argue that large livestock is a source of traction power among rural households.

Households with higher food consumption expenditure are less likely to experience severe and moderate hunger and more likely to experience little or no hunger. This is expected since the level of food consumption expenditure is an indicator of the accessibility, quantity and quality of food.

Rural households are more likely to be severely and moderately food insecure and less likely to be food secure. We expected rural households to be more food secured than urban households since urbanization pushes cost of living higher. Again, since the rural localities are the production centres, we expected abundance of food to culminate into more food security. We explain that though these households are the basic producers of food, the produce ends up at the urban areas especially during planting and lean seasons where food is scarce in the rural areas with prices soaring. Also, the level of vulnerability to food insecurity is more on rural than urban households. According to the GSS [56], the annual average per capita income in urban localities is GH¢7019.72 which implies an average income of GH¢19.23 per person per day, while their rural counterparts have an average annual income of GH¢3302.83 which represents an average income of GH¢9.04 per person per day.[4] The mean income of a household in an urban locality is GH¢20,930.05, while that of a rural household is GH¢11,408.01. Also, urban households spend more on all food and non-alcoholic beverages than their rural counterparts. These statistics may be responsible for this observation.

Households in the Upper West and Upper East regions are more likely to be food insecure than those in Northern and Brong Ahafo regions. This observation is expected since these two regions are poorest in the SADA zone. The three northern regions are the poorest in Ghana with the Upper West region the hardest hit followed by the Upper East region [56]. The Upper East and West regions have the lowest mean annual household income of GH¢7240.5 and GH¢11,977.5 and the lowest per capita expenditure of GH¢1790 and GH¢1753, respectively. These statistics could be responsible for the severity of food insecurity in these two regions. This is consistent in part with the observation of Quaye [19] that Upper East region is the worst affected of food insecurity as it experiences the longest food shortage period, with the Northern and Upper West regions having the same period of food inadequacy.

Conclusions

We applied a new measure of food security, the household hunger scale to analyse the factors influencing food security in the SADA region, an area described as the hub of food security problems in Ghana, using a secondary data set provided by METSS. We applied an ordered probit to estimate the factors of food security as a way of overcoming some of the weaknesses in previous studies. Analysis of the data shows that food insecurity, as measured on the household hunger scale, still persists in the SADA region at levels unacceptable in a modern society. We find that factors determining the various levels of hunger include education, means of transport, farm mechanized equipment, yield, agricultural crop production and commercialization, cultivation of multiple crops, ownership of poultry, small livestock, large livestock, food consumption expenditure, locality and region of residence. The implication of these findings is that stakeholders in food security issues have a task, especially if the sustainable development goals must be achieved. Key policy implication of the results of crop producers, multiple crop producers, yield and commercialization corroborate one of the intermediate results of the Ghana Feed the Future Initiative of increasing competitiveness of cereal value chain through increased productivity and market access. As it stands, crop production with its variant of multiple cropping is not rewarding in food security efforts. Productivity enhancement, as this study reveals, is one of the bridging platforms to making crop production

[4] The exchange rate as quoted by www.xe.com as at 1 October 2016 was US$1.00 = GH¢3.9649.

and multiple cropping remunerative and thus helping reduce food insecurity. A comprehensive approach to productivity enhancement is needed. We recommend an amalgam of agro-inputs made both physically and financially available, appropriate mechanization (e.g. availability of tractor services and irrigation) and support services (e.g. extension, credit, monitoring, research and private sector engagements in mechanization).

Efforts to enhance commercialization of agriculture cannot be overemphasized in achieving food security. As indicated already, a policy measure of productivity enhancement is one way of intensifying commercialization. Another is the provision of necessary market infrastructure and services such as creation of effective market information as well as upgrading rural roads. A massive diversification into livestock production should be considered by stakeholders since the results show this enhances food security, especially for ownership of poultry and small ruminants. Livestock production complements crop production, especially in periods of crop failure. Finally, these results notwithstanding, it is important to point out that accounting for endogeneity in ordered data models is still grey and that remains a weakness of this study.

Additional file

Additional file 1. Zone of influence of Ghana's Feed the Future Initiative.

Abbreviations

FAO: Food and Agriculture Organization; FtF: Feed the Future; GSS: Ghana Statistical Service; IFAD: International Fund for Agricultural Development; METSS: Monitoring Evaluation and Technical Support Services; MoFA: Ministry of Food and Agriculture; SADA: Savannah Accelerated Development Authority; UN: United Nations; WFP: World Food Programme.

Authors' contributions

PKN conceived of, but all authors planned the study. BMA prepared data and performed statistical analysis, under the guidance of PKN and HI. All authors drafted the manuscript, critically reviewed it for important intellectual content, contributed to the interpretation of results. All authors read and approved the final manuscript.

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Competing interests

The authors declare that they have no competing interests.

Availability of supporting data

The data set used in this study is a property of the US government and is available online. However, the version analysed in this study is available from the corresponding author on request.

Consent for publication

All authors consent to the publication of this manuscript.

Ethical approval and consent to participate

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