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The state of food security and its determinants in Ghana: an ordered probit analysis of the household hunger scale and household food insecurity access scale

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ABSTRACT

The issue of food insecurity has been well documented to be severe in northern Ghana. Several attempts have been made to curb the situation, but the effects of these interventions are unknown. Using responses from 405 rural households, this paper estimates the determinants of food insecurity in the Upper East region. Data were analysed using descriptive statistics and an ordered probit regression. The Household Food Security Access Scale (HFIAS) and the Household Hunger Scale (HHS) were the two measures of household food security used in the study. This paper validates and compares the two measures used to check whether determinants and status of household food security differ between the two measures. The findings show that the two measures of food security agreed on most of the significant determinants of household food security. Factors such as education of household head, households' farm size, access to credit and access to extension services were significant determinants of household food security by both measures. Factors such as household size, access to good roads, access to formal cooperative and availability of paid jobs were found to be significant determinants of household food security with the HFIAS, while gender of household head and distance to market were significant determinants of food security in the HHS model. The study recommends improved education, social structures such as good roads and markets as well as support services such as credit and extension to combat food insecurity. These key steps should be taken as pillars to the sustainable implementation of Agenda 2063 for a food secure Africa.

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Introduction

The prominence of the issue of food insecurity is fundamentally due to the magnitude, scale and quantitative evidence of food insecurity globally, especially in developing countries [1]. The first discussions of food security and response date as far

Abbreviations: HFIAS, Household Food Security Access Scale; HHS, Household Hunger Scale; FAO, Food and Agricultural Organisation; SSA, Sub-Saharan Africa; MoFA, Ministry of Food and Agriculture; USAID, United States Agency for International Development; WFP, World Food Program; SDGs, Sustainable Development Goals; MDGs, Millennium Development Goals.

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back as the 1940s in the Hot Springs Conference on Food and Agriculture. This conference paved the way for the formation of the Food and Agricultural Organisation (FAO) in 1945 and later in 1948, access to adequate food was universally declared a human right [2]. According to [3], a total of 842 million individuals in the world between 2011 and 2013 were assessed to be food insecure, this represents one in every eight random people globally. It was against this backdrop that, the first goal of the Millennium Development Goals (MDGs) which targeted to decrease by half the percentage of hungry people across the world by the end of 2015 was not achieved in Sub-Saharan Africa (SSA) [4]. One main contributor to food insecurity is poverty [5]. About 60% of the food insecure people in the world are in SSA and hunger is estimated to worsen in the region throughout the following two decades should measures not be taken to tackle the problem of food insecurity [6]. This comes as no surprise since most of the poorest countries in the world are in SSA [7], given that the principal determinant of food insecurity is poverty [5].

In Ghana, studies have shown that food insecurity challenges in the country are intense in rural settings where livelihoods are largely dependent on agriculture [8]. The Upper East region has the worse food insecurity status in terms of regional distribution, with as much as 28% of its people having food security challenges [9]. A study by [5], in the then three regions in Northern Ghana, found that the Upper East region was the most food insecure region. In terms of district distribution of food insecurity, [5] further found that the region was home to three out of five districts with the most cases of food insecurity in Northern Ghana. The status of the region as a hub of food insecurity has been further confirmed by other studies [9,10]. This presents a worrying narrative needing urgent actions to curb the problem of food in security in the country, particularly in rural areas.

In the African Union's Agenda 2063, the first aspiration which targets a prosperous Africa, focuses on eliminating food insecurity and malnutrition in all forms by 2025 [11]. Goal two of the Sustainable Development Goals (SDGs) of the FAO targets ending global hunger and ensuring all persons everywhere, especially the poor and vulnerable have all-year-round access to food by 2030 [12]. Achieving these goals require serious policy-driven orientations to combat the problem of food insecurity. The government of Ghana, through decentralised agricultural agencies in partnership with civil society organisations and the private sector, have taken steps in recent years in decreasing food insecurity incidences in rural settings of the country, yet there are still significant challenges in food access, availability, utilization and stability [9]. Programmes such as the block farming, Northern Rural Growth Programme (NRGP) introduced in 2007, the National Food Buffer Stock Company (NAFCO) introduced in 2010, the National Climate-Smart Agriculture and Food Security Action Plan (2016-2020) and the Planting for Food and Jobs (PFJ) initiative introduced in 2017 amongst others have been implemented, particularly in the northern regions of Ghana to combat issues of poverty and food insecurity. The effects and contributions of such initiatives on the course of eradicating household food insecurity in the country are yet unknown in literature. Studies on food security have been conducted [9,10,13,14], but none have used more than a single measure of food security to produce robust estimates of the phenomenon with the basis for comparison between estimates. This study, therefore, purposes to fill this gap in the food security literature.

This study, therefore, investigates the state of food security and its determinants. The study achieves these objectives using two different measures of household food security to provide the basis to compare results from two different measures at the same time to see the differences and similarities regarding household food security status and its determinant to produce more robust estimates. To the best of our knowledge, this is the first study that achieves these objectives. With the choice of econometric model and food security measures, this study practically contributes to existing literature by revealing the state of food security and its determinants at the household level using two different measures and, on that basis, makes policy relevant recommendations for onward consideration by all who matter in agenda setting towards eradicating food insecurity, as stated in goal two of the SDGs.

Literature review

Food security is a multidimensional concept making its accurate measurement for policy targeting by policy makers very difficult [13]. Measuring food availability at the country level dates back to the post-world war 1 era, long before the concept of food security was carved [15]. The amount of food available to a nation at that point was assessed on the supply-side by estimating kilocalories of all foodstuffs domestically produced or imported. The term food security was birthed in the 1970s with food availability as its fundamental component. However, it was argued by [16] that only food availability in a much stricter sense was not enough for measuring food security and that under adverse conditions, poorer people may not afford food though it is sufficient at the national level. Owing to such arguments, the definition of food security was amended in 1983 to make room for both economic and physical access to food [17]. The scope of food security kept evolving as conflicting ideas emerged over unequal food supply and access to food not just within a nation, but also within the individual household level. Around the same time, eliminating primary micronutrient deficiency picked up significance subsequently moving consideration from caloric intake to diet quality. Utilization, therefore, became the third component of food security [15]. Utilization addresses the differences in food allocation among households, the dietary quality of the food, and disparity in the level to which the different nutrients in food are absorbed and processed by different household members [15]. Owing to this, the 1996 World Food Summit came out with the definition of food security that has now been accepted widely; when everyone has physical and economic access to adequate and safe food all the time to meet their nutritional and dietary needs so they can live a healthy life [18]. In Ghana, the Ministry of Food and Agriculture (MoFA) has provided an operational definition of food security 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". This study adopts this operational definition by MoFA, given the authoritative role played by MoFA in issues of food security and the fact that their conceptualization of the term agrees with the context of the USAID in designing the HFIAS and HHS, which are the two measures of food security in this study.

There are mainly two general issues in food security literature. These are issues of the best measurement tools and econometric models to use in food security studies. The issue of measurement has to do with the inability to clearly define a tool for measuring food security to differentiate food secure households from food insecure ones. The second issue has to do with the choice of econometric model for analysis. Given the multidimensional nature of food security, many indicators have been developed over the years as proxies of food security. Despite this, the decision on which tool to choose is dependent on the intended purpose of the said study as well as an understanding of the underlying constructs the tool in question measures [19]. Even though there are many options to choose from, choosing the wrong tool comes with its consequences such as measuring a wrong domain, measuring different domains together which are ambiguous and so difficult to interpret, collecting data that is irrelevant to the intended audience or selecting a metric which requires so much resources than the study can support [15].

Household Consumption and Expenditure Surveys (HCES) is a measure used in estimating household-level food consumption patterns, poverty, economic status and consumer price indices of households [15]. With the HCES, information on food expenditures is subject to the monetary value of the quantity of food the household has acquired. The HCES assumes that the quantity of food acquired by a household equals the quantity of food the household consumes [15]. Though the HCES is relatively easy to obtain and also less time-consuming, the above assumption could be problematic as not every food acquired by the household might be consumed [15]. Some of the food acquired might be given as feed to livestock while others might be given out to non-household members as gifts or even wasted. Another limitation of the HCES is it not being able to be frequently and consistently administered due to the time needed to gather the information [20].

The Food Consumption Score (FCS) is a measure that the World Food Program (WFP) usually uses to assess food security at the regional level. According to [21], the FCS is a composite score that focuses primarily on food dietary diversity, frequency of consumption and relative nutritional relevance of diverse food groups over a 7-day recall period. Studies conducted in different parts of Africa proved a positive correlation between FCS and daily per capita kilocalorie consumption, total household expenditure on food as well as asset indices [22]. However, one challenge with the use of FCS is that though the food group weights and food consumption group thresholds are standardized, they are based on some intrinsically subjective choices. [15] argued that although the standardization of cutoffs and weightings in the FCS makes it easier to directly compare the score across different settings, these same weightings may conceal essential national or regional dynamics. For instance, in areas where vegetables and fruits are relatively difficult to access by some households, consumption of these food groups may reflect better economic access to food and consequently food security. The relatively small weight assigned to fruits and vegetables in the FCS computation may, however, mask this very fact [15].

Another metric that has gained momentum over time is the Household Dietary Diversity Score (HDDS). [23] emphasized the importance of dietary diversity as an essential outcome measure of individual or household food security. [24] showed that dietary diversity measures food consumption qualitatively that tells a household's access to a wide variety of foods. It reflects both food access and availability in the sense that a household will consume varied food groups when they have the purchasing power [21]. An increase in dietary diversity has proven to be linked with household food security and socio-economic status of households and when used to measure individual dietary diversity rather than that of the entire household, the score reflects nutrient adequacy [24]. The HDDS could be a good tool for measuring household-level food access in place of other more demanding consumption modules. One challenge with the use of HDDS is the recall period. Critiques have raised concerns that the frequently used 24 h recall period is too short. Also, food groups, reference periods and cut-off points have been noted to vary which makes it difficult to compare across studies [20]. That notwithstanding, past studies utilized it to measure household food security [25].

The Household Food Insecurity Access Scale (HFIAS) is another metric that has gained recognition in recent years. It was developed as part of the Food and Nutrition Technical Assistance (FANTA II) Project [26]. The HFIAS is employed to assess how households in the past four weeks have experienced problems with food access. It captures mainly, the behaviours of households that shows insufficient quantity, quality, acceptable and anxiety over insecure access to food. HFIAS adopted from the approach used in the United States to estimate annually, the incidence of food insecurity, measures household's accessibility to food and the extent of anxiety inherent in food acquisition. It uses nine sets of questions to classify effectively, food secure households from households that are food insecure [26]. This measure of household food security has been used extensively in the food security literature [25].

The Household Hunger Scale (HHS) is also an experience-based indicator derived from the HFIAS, which uses households' deprivation of food experience reactions captured from a survey and summarizes them on a scale to capture the most severe food security behaviours of households [27,28]. The HHS uses three recall questions to measure the extent of hunger experienced by households in food insecure locations. Although all other indicators/measures of the state of food security at the household level have limitations, the HHS is noted as a dependable measure of food insecurity at the household level. [27], indicated that the HHS is distinct from other indicators of food insecurity at the household level in the sense that, it was precisely developed and validated for cross-cultural use in food insecure areas. Studies by [28,29] show that since food security indicators are different in the scope of food security they capture, a combination of indicators improves the

measurement of food security. This indicator has been extensively used in the food security literature for measuring food security [9,30].

Other food security measures that have been used in the food security literature include; the USDA Household Food Security Scale (HFSS) [8], the Food Insecurity Experience Scale (FIES) [31], Dietary Intake Assessment (DIA) [25] and Cost of Calorie function (COC) [32]. Though no single measure of food security is comprehensively all encompassing, thus meeting the criteria of [28], that a good food security measure must be one that is reliable and valid for comparability over time and space as well as capturing all elements of the concept. All measures have their strengths and weaknesses. This study, in an attempt to overcoming the weaknesses of a single measure, uses two different measures of food security.

Determinants of household food security

Factors ranging from household to institutional and locational factors have been identified in literature to influence food security at the household level. These factors include age of household head [13,25,31], gender of household head [13,31], marital status of household head [8,31], education of household head [9,13], household size [8,32], farm size [25,32], access to extension services [33], access to credit [8], access to formal corporate [32].

Methods

Analytical technique

Unlike most previous studies on food security which used binary choice models [8,13], this study employed an ordered probit model to deal with the weaknesses of the binary choice models employed by other studies. With the ordered probit model, the study brings to bear vital information about the true state of household food security which would have been shielded with the use of a binary choice model. Again, the study also departs from earlier studies by using two different measures of household food security, the Household Food Insecurity Access Scale (HFIAS) and Household Hunger Scale (HHS) to produce more robust estimates of household food security and its determinants. These are two well tested and reliable approaches to measuring household-level food security that has been used extensively in the food security literature [9,30].

The HFIAS and HHS were preferred since they have been identified as reliable and valid measures of food security in areas of high food insecurity and as well good for cross-cultural comparisons of the state of food security in different locations [27]. The choice of food security measures also helps the study overcome one major methodological concern in food security studies. These measures allow for the use of a model beyond a binary choice model, where households are categorised as either food secure or food insecure. The methodological issue posed by the use of binary measures is that they tend to hide vital information about the severity of food insecurity or otherwise in the household. The HFIAS and HHS helped us overcome this weakness by categorising households into four and three categories of food security status, respectively. This allowed for the use of models such as ordered probit or logit, which helps reveal more details about household food security status.

In administering the HFIAS questionnaire, households were asked, for example; 1. Did you or any member of your household worry that the household would not have enough food in the past four weeks? For which the respondent was required to answer either Yes or No. should the respondent answer No, the next question in the scale item was asked. But if the respondent answered Yes, then the frequency categories were asked to know how frequent that scale item had occurred in the household for the past four weeks. Following [26], households were categorized under food secure, mildly food insecure, moderately food insecure and severely food insecure based on the algorithmic methodology. The HHS adapts the last three scale items of the HFIAS. Following [27], households were categorized under; little to no hunger, moderate hunger and severe hunger in the household based on their scores obtained as prescribed for the use of the scale. Every household was categorized in order of their score; 1 or less, 2 to 3 and 4 to 6 which shows that the household has little to no hunger, moderate hunger and severe hunger in a household, respectively [30].

Empirical model

Given that the two measures of food security employed in this study are categorical and ordinal, an ordered logit or probit model was found the most appropriate for the analysis, since the measure demands a model outside the use of binary choice econometric models. The multinomial probit or logit models, as noted by [34], would not succeed in accounting for the dependent variable's ordinal nature although the outcome is discrete. The probit model and the logit model assumes normally distributed and logistically distributed error term, respectively. Although they both yield the same results, a review of relevant literature shows that the ordered probit model is the most widely used in econometric studies for ordered response data. Therefore, this study employed the ordered probit model in analyzing the determinants of household food security.

The ordered probit model as formulated by [35] is modelled on an unobservable latent random variable as follows;

$$Y_i^* = x_i' \beta + e_i, i = 1, 2, \dots, N \quad (1)$$

Where $E(e_i/x_i) = 0$ and $\text{Var}(e_i/x_i) = 1$. The observable variable, Y_i , is treated as an ordinal variable with J number of response categories and as a representation of the theoretical random variable, Y_i^* , and $\mu = \mu_{-1} \mu_0 \mu_1 \dots \mu_{J-1} \mu_J$ defined as a

vector of unobservable threshold parameters, with the relation between the observable and the latent variable expressed as;

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

Where $\mu_{-1} = -\infty, \mu_0 = 0, \mu_J = \infty$ and $\mu_{-1} < \mu_0 < \mu_1 < \dots < \mu_J$. The probability can be written as;

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

Where J is the categories of responses to food security and $\Phi(\cdot)$ is the standard normal cumulative distribution function.

$$\frac{\partial \text{Prob}[\text{Cell}j]}{\partial x_i} [\phi(\mu_{j-1} - x'_i\beta) - \phi(\mu_j - x'_i\beta)] x \beta = \tag{4}$$

Where $\phi(\cdot)$ is the standard normal density function. Therefore, the empirical model for the analysis of this objective is specified as follows;

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

The dependent variable, given as FS is the household's food security status proxied by the HFIAS or HHS. The subscript i characterises the i th household, j ($j = 0,1,2,3$) and j ($j = 0,1,2,$) respectively represents, the four categories of the dependent variable indicated as; if household falls within severely food insecure, moderately food insecure, mildly food insecure or food secure categories for HFIAS and the three categories of the dependent variable; if household falls within severe hunger, moderate hunger or little to no hunger for HHS. $\alpha, \beta, \gamma, \delta$ are estimated parameters; W and Z are socioeconomic characteristics, and institutional and location characteristics of the respective household expected to influence their food security status.

Following [36], the Chi-square test was used to analyze whether food security status of households was affected by some independent variables of the study. This was to test the general null hypothesis that food security status of households is independent of the categorical variable of interest. The general alternative hypothesis states that food security status of households is not independent of the categorical variable of interest. This checks the robustness of the ordered probit model used in the study. Chi-square statistics are calculated as stated below.

$$\chi^2 = \sum_k^r \sum_j^c \frac{(O_{kj} - E_{kj})^2}{E_{kj}} \tag{6}$$

$$E_{kj} = \frac{R_k C_j}{n} \tag{7}$$

Where,

- χ^2 - Chi-square k - independent variable classification r - total number of classifications for each independent variable c - total number of food security status categories j - food security status categories ($j = 1,2,3$ or $j = 1,2,3,4$)
- O_{kj} - observed number of households for each classification and food security status categories
- E_{kj} - expected number of households for each classification and food security status categories
- R_k - sum of households for all food security status in the classification k
- C_j - sum of households for all classifications for food security status j n - total number of households

Sampling and data collection

The paper used cross-sectional data collected between February and March of 2019 as part of an MPhil thesis using a multi-stage sampling technique. In the first and second stages, a purposive sampling technique was used to select the Upper East Region and the four districts for the study. Studies have shown the Upper East Region, particularly, the four districts selected for this study as the worst affected in Ghana in terms of food security [5,9]. These districts included Kassena Nankana Municipal, Kassena Nankana West, Talensi and Nabdam districts. For the third stage, a systematic sampling was used to select 10 rural farming communities from each of the four districts based on a list of rural farming communities provided by the respective district assemblies. From these communities, a random sampling technique with probability proportionate to size was used to sample rural farm households as the fourth sampling stage. A total of 405 rural farm households were sampled. The data collection was conducted using questionnaires with the help of trained research assistants who together with the lead author speak the native languages of these districts which was an advantage when interacting with rural farm households. Table 1 presents variables captured and summary statistics.

Results and discussion

The results and findings of this study are presented in two parts. Household's food security characteristics are first presented before results and discussions of empirical models estimated for the determinants of household food security.

Table 1
Description, measurement and summary statistics of independent variables.

Variable/Description	Measurement	Mean	SD
<i>Socioeconomic characteristics</i>			
Age of HH	Number of years	50.491	14.170
Gender of HH	Dummy: 1 = if male; 0 = female	0.841	0.365
Marital status of HH	Dummy: 1 = if married; 0 = otherwise	0.867	0.340
Employable skills of HH	Dummy: 1 = if yes; 0 = otherwise	0.153	0.361
Education	Dummy: 1 = if yes; 0 = otherwise	0.447	0.478
Household size	Number of people in household	6.679	2.795
Farm size	Hectares	1.541	0.946
<i>Institutional and locational characteristics</i>			
Access to Good roads	Dummy: 1 = if yes; 0 = otherwise	0.538	0.499
Distance to market	Kilometres (km)	2.375	2.143
Access to credit	Dummy: 1 = if yes; 0 = otherwise	0.240	0.427
Access to extension services	Dummy: 1 = if yes; 0 = otherwise	0.444	0.498
Access to formal corporative	Dummy: 1 = if yes; 0 = otherwise	0.292	0.429
Job availability (perception)	Dummy: 1 = if yes; 0 = otherwise	0.136	0.343
Access to market information	Dummy: 1 = if yes; 0 = otherwise	0.602	0.490
Access to irrigation	Dummy: 1 = if yes; 0 = otherwise	0.205	0.404

Source(s): Authors' computations

Food security characteristics of sampled households

The results show that about 12% of the sampled households were food secure. Households who were mildly, moderately and severely food insecure represented about 10, 29 and 49% of the sampled households, respectively as measured by HFIAS. This gives a clear indication of how food insecurity is still a challenge faced by the majority of households in the region.

It was observed that 66% of the sampled households experienced little to no hunger in their households, while about 26% and 7% were classified as moderate and severe hunger in the household, respectively. Although the HHS gives better outcomes of food security status as the majority of households are categorized in the best state of food security status of the HHS, it is worthwhile noting that the measure was purposely designed to measure food insecurity in its severest state. In view of that, the severe and moderate hunger in household categories has been described as unacceptable in any human society [9]. The debate will, therefore, be on the little to no hunger category of the HHS, whether the category can be considered desirable or not. But contained in that category are two non-separable groups, thus, households with no hunger of any form and those with little hunger. In the food security discussions, hunger in any of its forms is without any doubt undesirable. We can infer that a number of the households in the little to no hunger category will experience some form of hunger that is not desirable. Against this backdrop, considering the number of households in the severe and moderate hunger categories and the non-separable households who experience little hunger in the little to no hunger category, we can conclude that food insecurity is still a concern in the region that requires urgent attention.

One thing that is clearly observed is the differences between the two measures of food security. This raises questions on what explains the differences and which of the two measures gives the most reliable estimates. These are two issues that have been raised in the food security literature. [29], answered these questions partly by explaining how the two constructs work. They concluded that the HFIAS produced the highest incidence of food insecurity compared to the HHS, which is also the case in this study. [29], explained that this disparity between the two measures is always expected as the HFIAS includes food consumption preferences and psychological anxiety which are less severe indicators of food insecurity whiles, the HHS only classifies households as food insecure if the household exhibits extreme behaviours of severe food insecurity. This confirms both measures as reliable measures of household food security that produce different estimates based on the underpinnings of each construct. This explains the disparity and therefore validates the findings of this study.

The household food security status by gender is presented in Table 2, respectively as measured by the HFIAS and HHS. It was observed that males dominated across all four categories of the HFIAS. This could be due to the sample size difference of the respective gender groups. It will, therefore, be more realistic to discuss the percentages within each group. Out of the 341 male-headed households and 64 female-headed households, more male-headed households (12.61% of the male sub-sample) were categorized under food secure as against only 7.81% of the female-headed sub-sample, as presented in Table 2. The percentage of female-headed households categorized under severely food insecure was, however, more as compared to their male-headed counterparts, thus 67.19% against 45.75%, females against males, respectively.

Again, males dominated across all three categories of the HHS. This again could be due to the differences in the sample size of the respective gender groups. It will, therefore, be more reasonable to discuss the percentages within each group. From the total sample of 405 households, 341 were male-headed and only 64 households were female-headed. The percentage distributions of households food security status based on the gender of household head are presented in Table 2. A higher percentage of male-headed households were categorised under little to no hunger as compared to female-headed households. In contrast, a higher percentage of female-headed households were categorised under severe hunger as compared to households that were male-headed as shown in Table 2. It could be concluded that, with both measures of food

Table 2
Gender distribution of household food security status.

Food Security Status	Male	Female	Total
Household Food Insecurity Access Scale (HFIAS)			
Food Secure	43	5	48
Mildly Food Insecure	36	5	41
Moderately Food Insecure	106	11	117
Severely Food Insecure	156	43	199
Total	341	64	405
Household Hunger Scale (HHS)			
Little to no Hunger	241	28	269
Moderate Hunger	81	26	107
Severe Hunger	19	10	29
Total	341	64	405

Source(s): Authors' computations

security, females are more affected by food insecurity than their male counterparts. This can be a result of the disparity in access to productive resources like land between male and female-headed households. This was confirmed by [37], who concluded that access to productive agricultural resources remains gendered in developing countries. Studies have shown that when women have access to productive resources, their food security status is enhanced [38].

Determinants of food security in the study area

Results for the determinants of food security from the ordered probit models are presented in Tables 3 and 4. The marginal effects of the respective models are discussed in this paper since the values of the coefficients of an ordered probit model do not show the magnitude of the effect of the independent variable. The interpretations of the marginal effects are based on the sign of the food security category. A negative sign of any category would mean an increase in that variable will decrease the probability of being in that food security category, whereas a category's positive coefficient means an increase in that variable will increase the probability of being in that food security category.

We found that male-headed households were less likely to fall within the severe and moderate hunger categories but are more likely to be under little to no hunger in the household using the HHS model. This implies that households with male household heads are more likely to be food secure as compared to their female counterparts for HHS and this can be probably because male household heads have more access to productive resources relative to their female counterparts given that access to productive resources has been found to influence food security positively [38]. This finding is consistent with the findings of past works on food security that also found male-headed households to be food secure than their female-headed counterparts [13,31].

Households with educated heads were more likely to be food secure. Households with educated household heads were less likely to experience severe hunger and were more likely to be categorized under little to no hunger by the HHS. In the same light, households with educated household heads were less likely to severely food insecure but were more likely to be food secure as compared to households with uneducated heads by the HFIAS. This outcome is most probably because educated household heads are more exposed and have the needed expertise to modernize and adopt new technologies to produce and take care of the food needs of their households. These findings are consistent with the results of earlier studies [9,13]. They found that education of household head is a key determinant of food security since educated household heads are more likely to have the knowledge and awareness to secure highly paid jobs which increases their chances of being food secure.

An additional household member makes a household more likely to fall within the severely food insecure category of the HFIAS but less likely to fall under the food secure category. The same direction was reported by the HHS but was, however, not statistically significant. This is consistent with past studies, as a negative relationship was reported between household size and food security status in studies [8,32]. These studies also found that an additional household member plagues the household into food insecurity. This is because an additional household member will mean more resource demand to provide for the food needs of that added household member from the limited resources at the households' disposal.

An increase in a households' farmland by a hectare makes the household less likely to fall within the severely food insecure category but is more likely to be within the food secure category of the HFIAS. In the same light, a hectare increase in a households' farm size makes the household less likely to fall under severe hunger but more likely to be in the category of little to no hunger as measured by HHS. This implies that a hectare increase in the farm size of a household improves the food security of the household as measure by both food security measures. This finding is in line with findings by [32], who found land as an important livelihood asset for households to use in ventures aimed at improving their livelihoods. Land is considered very important in the production processes, especially, agricultural production [37], and having access to land enhances a households' chances of producing enough to provide for the food needs of household members.

Households with access to good road networks are more likely to be categorized under food secure and are less likely to be under the severely food insecure. This is so because having access to good roads aids access to other productive resources,

Table 3
Ordered probit regression results for the determinants of household food security using HFIAS.

HFIAS	Estimates Coefficient	Marginal effects ^a			
		Y=1	Y=2	Y=3	Y=4
Age of HH	-0.001 (0.005)	-0.000 (0.002)	0.000 (0.000)	0.000 (0.000)	0.00 (0.001)
Gender of HH	-0.200 (0.225)	-0.067 (0.075)	0.019 (0.021)	0.016 (0.018)	0.032 (0.035)
Marital status of HH	-0.066 (0.236)	-0.022 (0.079)	0.006 (0.022)	0.005 (0.019)	0.011 (0.037)
Employable skills of HH	-0.167 (0.172)	-0.056 (0.057)	0.016 (0.016)	0.014 (0.014)	0.026 (0.027)
Education	-0.481*** (0.138)	-0.161*** (0.045)	0.045*** (0.014)	0.039*** (0.012)	0.076*** (0.023)
Household size	0.046* (0.025)	0.015* (0.008)	-0.004* (0.002)	-0.004* (0.002)	-0.007* (0.004)
Farm size	-0.260*** (0.073)	-0.087*** (0.024)	0.025*** (0.008)	0.021*** (0.007)	0.041*** (0.012)
Access to Good roads	-0.280* (0.160)	-0.094* (0.053)	0.026* (0.015)	0.023* (0.013)	0.044* (0.025)
Distance to market	0.013 (0.029)	0.004 (0.010)	-0.001 (0.003)	-0.001 (0.002)	-0.002 (0.005)
Access to credit	-0.628*** (0.157)	-0.210*** (0.051)	0.059*** (0.018)	0.051*** (0.014)	0.100*** (0.025)
Access to extension services	-0.360*** (0.138)	-0.121*** (0.045)	0.034** (0.014)	0.030** (0.012)	0.057*** (0.022)
Access to formal cooperative	0.275* (0.161)	0.092* (0.054)	-0.026 (0.016)	-0.022* (0.013)	-0.044* (0.025)
Job availability (perception)	0.508*** (0.194)	0.170*** (0.064)	-0.048*** (0.018)	-0.042** (0.017)	-0.081** (0.031)
Access to market information	-0.195 (0.154)	-0.065 (0.051)	0.018 (0.014)	0.016 (0.013)	0.031 (0.025)
Access to irrigation	0.078 (0.161)	0.026 (0.054)	-0.007 (0.015)	-0.006 (0.013)	-0.012 (0.025)
μ ₁	-2.430 (0.347)				
μ ₂	-1.927 (0.346)				
μ ₃	0.965 (0.341)				
Log-likelihood	-424.699				
Pseudo R ²	0.121				
Chi-square	136.434***				
Prob > chi2	0.000				
Number of observations	405				

***, ** and * denotes statistically significant variables at 1%, 5% and 10% levels, respectively. Figures reported in parenthesis are Robust Standard Errors.
^a Y = 1, 2, 3 and 4 are the marginal effects of a household being classified as severely, moderately, mildly food insecure and food secure, respectively. Source(s): Authors' computations

which in turn will enhance the food security of the household. This was confirmed by earlier studies by [39], who asserted that areas with lack of access to good roads are faced with challenges of transporting food items to consumption centers which have serious consequences on accessibility to food. The importance of roads networks in the food insecurity fight was again affirmed by [40], who concluded that access to good road network aids households to sell farm produce at larger markets at very competitive prices.

Households who travel longer distances to the nearest market were more likely to experience severe hunger and were less likely to experience little to no hunger as measure by the HHS. This implies that an additional kilometre travelled by a household to the nearest market makes them more likely to be food insecure. The possible explanation for this outcome is that, because the market is the main medium for the exchange of commodities and services, the farther a household is from the market, the more difficult it is to engage in daily transactions which may include the purchase of food commodities for household consumption. This finding was affirmed by [14], who also found that a households' nearness to a market enhances their chances of being food secure.

Households with access to credit are more likely to fall within the little to no hunger category and are less likely to have severe and moderate hunger for HHS. The case is no different with regards to the HFIAS, as households with access to credit are more likely to be food secure but are less likely to be severely food insecure. This finding is consistent with findings by [8], who studied the determinants of household food security in Ghana and found that households with access to credit were more likely to be food secure. Access to credit is important to rural household food security not for only

Table 4
Ordered probit regression results for the determinants of household food security using HHS.

HHS	Estimates Coefficient	Marginal effects ^b		
		Y=1	Y=2	Y=3
Age of HH	0.000 (0.005)	0.000 (0.001)	0.000 (0.001)	-0.000 (0.002)
Gender of HH	-0.419* (0.214)	-0.050* (0.026)	-0.083** (0.042)	0.133** (0.067)
Marital status of HH	-0.194 (0.222)	-0.023 (0.027)	-0.038 (0.044)	0.062 (0.071)
Employable skills of HH	-0.080 (0.241)	-0.009 (0.029)	-0.016 (0.048)	0.025 (0.076)
Education	-0.350** (0.155)	-0.042** (0.018)	-0.069** (0.031)	0.111** (0.048)
Household size	-0.024 (0.027)	-0.003 (0.003)	-0.005 (0.005)	0.008 (0.008)
Farm size	-0.232** (0.097)	-0.028** (0.013)	-0.046** (0.018)	0.074** (0.031)
Access to Good roads	-0.046 (0.195)	-0.006 (0.023)	-0.009 (0.039)	0.015 (0.062)
Distance to market	0.060** (0.028)	0.007** (0.003)	0.012** (0.006)	-0.019** (0.009)
Access to credit	-0.392* (0.203)	-0.047** (0.024)	-0.078* (0.041)	0.125** (0.063)
Access to extension services	-0.323** (0.146)	-0.039** (0.018)	-0.064** (0.028)	0.103** (0.046)
Access to formal cooperative	0.225 (0.183)	0.027 (0.023)	0.045 (0.036)	-0.072 (0.058)
Job availability (perception)	0.134 (0.169)	0.016 (0.020)	0.026 (0.033)	-0.043 (0.053)
Access to market information	-0.244 (0.187)	-0.027 (0.022)	-0.044 (0.037)	0.071 (0.059)
Access to irrigation	-0.058 (0.161)	-0.007 (0.019)	-0.011 (0.032)	0.018 (0.051)
μ ₁	-0.897 (0.376)			
μ ₂	0.283 (0.391)			
Log-likelihood	-294.146			
Pseudo R ²	0.106			
Chi-square	68.034***			
Prob > chi2	0.000			
Number of observations	405			

***, ** and * denotes statistically significant variables at 1%, 5% and 10% levels, respectively.

Figures reported in parenthesis are Robust Standard Errors.

^b Y = 1, 2 and 3 are the marginal effects of a household being classified as severe, moderate and little to no hunger in the household, respectively. Source(s): Authors' computations

direct consumption but households with access to credit can purchase inputs for both their agricultural and non-agricultural livelihood activities. This goes a long way to enhance their output in these livelihood earning ventures.

Households with access to extension services are more likely to fall within the little to no hunger category and are less likely to have severe and moderate hunger for the HHS. For the HFIAS, households with access to extension services were less likely to be severely food insecure but were more likely to be food secure. This was as we expected because extension officers share useful knowledge with rural farmers concerning their productive activities, not only limited to their agricultural activities but their non-agricultural activities as well. This helps to enhance the food security levels of households. This finding was confirmed by earlier studies that also found access to extension services as key to overcoming household food insecurity [33].

Farm households with access to formal cooperatives were less likely to be food secure but rather more likely to be severely food insecure as measured by the HFIAS. This finding contradicts earlier findings by [32], who found formal cooperative to help the food security course. But the possible reason for this negative relationship could be the failure of formal cooperative groups to stick to their intended purpose. These groups are intended to enhance the welfare of their members through support services that they attract as a collective. By way of explaining why cooperatives have failed in this quest, [41], associates formal cooperatives' inability to strengthen and expand to meet expectations with poor implementation capacity and low managerial, operational and financial competencies on the part of cooperatives.

Households with available jobs in their neighbourhoods were more likely to be severely food insecure and less likely to be food secure. This result was rather unexpected, as it was expected that the availability of jobs will help households to earn added incomes to provide their food needs. However, the possible reason for this outcome is the fact that most of the available jobs in the study region are menial jobs which in turn pay meagre wages. Engaging in these menial jobs does not allow the time needed to engage in other traditional activities which will relatively pay off better in the long run. Households engaged in such meagre wage earning jobs are plagued back into poverty, thereby, not able to provide the food needs of household members.

Results for the Chi-square test as a robustness test of the ordered probit model are presented in this section. The test was to test the independence of food security status of a household from certain household factors measured categorically. For the HFAS, the null hypothesis of the Chi-square test was rejected in favour of the alternative hypothesis for some variables. The test established that food security status was dependent on variables such as gender ($\chi^2 = 10.091$, $p < 0.018$), employable skills ($\chi^2 = 15.592$, $p < 0.001$), education ($\chi^2 = 32.578$, $p < 0.000$), access to good roads ($\chi^2 = 16.551$, $p < 0.001$), access to credit ($\chi^2 = 49.984$, $p < 0.000$), access to extension services ($\chi^2 = 31.604$, $p < 0.000$), job availability ($\chi^2 = 7.393$, $p < 0.060$) and access to market information ($\chi^2 = 25.661$, $p < 0.000$). The null hypothesis was however, accepted and we concluded that household food security was independent of factors such as marital status ($\chi^2 = 5.303$, $p < 0.151$), access to formal cooperatives ($\chi^2 = 5.305$, $p < 0.151$) and access to irrigation ($\chi^2 = 4.307$, $p < 0.230$).

For the HHS, the Chi-square test results supported the alternative hypothesis that household food security was not independent of gender ($\chi^2 = 19.293$, $p < 0.000$), marital status ($\chi^2 = 11.565$, $p < 0.003$), employable skills ($\chi^2 = 7.344$, $p < 0.025$), education ($\chi^2 = 23.652$, $p < 0.000$), access to good roads ($\chi^2 = 5.855$, $p < 0.054$), access to credit ($\chi^2 = 20.657$, $p < 0.000$), access to extension services ($\chi^2 = 15.415$, $p < 0.000$), access to market information ($\chi^2 = 10.121$, $p < 0.006$) and access to irrigation ($\chi^2 = 6.007$, $p < 0.050$). However, the null hypothesis was supported that household food security was independent of household factors such as access to formal cooperatives ($\chi^2 = 1.710$, $p < 0.425$) and job availability ($\chi^2 = 3.291$, $p < 0.193$). Although the Chi-square test results presented do not confirm the direction of effect of the variables of interest on household food security, they go a long way to confirm that food security status of households are significantly dependent on some factors as shown by the ordered probit model estimates.

Conclusion

The study used new measures of food security, the HFAS and the HHS to estimate the food security status of 405 households and the ordered probit model was used to analyse the determinants of food security in one of the food insecurity prone areas in Ghana. With the use of the two measures of food security, the study compares and validates the two measures used. The choice of model and measures of food security was to overcome the weaknesses of earlier studies on food security.

The analysis revealed that food security as measured by both scales is still a major issue of concern in the study area given that the food security status of sampled households is at undesirable states. Factors such as household size, access to good roads, access to formal cooperative and availability of paid jobs were found to be significant determinants of household food security with the HFAS. With the HHS model, significant determinants of household food security included but not limited to the gender of household head and distance to market. The two measures of food security, however, both agree with the same direction of effect that education of household head, households' farm size, access to credit and access to extension services were significant determinants of household food security.

These findings which were consistent across two food security measures provide solid evidence of relevance to stakeholders involved in food security issues to achieve the set SDGs relating to food security. Policies aimed at improved education, distance to markets, access to good roads, access to credit and access to extension services, farm size should be pursued. The study recommends government through the respective ministries such as the Ministry of Education, Ministry of Agriculture and Ministry of Road Transport and Highways with their regional and district subsidiaries, together with other stakeholders should work on the improvement of social structures such as access to education, good roads and markets as well as support services such as credit and extension services to curb the food insecurity situation in the region. Efforts have already been made by past and current governments to improve the education sector of the country. Most noticeably the introduction of the free SHS policy, but as it stands, the rate of illiteracy is worryingly high, especially in the northern part of the country. We recommend necessary steps be taken to improve the situation if we are to make strides to tackle the issue of food insecurity.

These recommendations offered in this study address a common priority area of the SDGs and the African Unions' Agenda 2063. SDG goal two and aspiration one "A prosperous Africa" of Agenda 2063 both target eliminating, in all forms, food insecurity and malnutrition [11].

One main limitation of this study is the fact that accounting for endogeneity when using ordered response data is still a major issue in econometrics. The use of fixed-parameter ordered probit model led to bias in the results due to the neglect of heterogeneity. Many studies have shown the use of random parameters model as more effective in dealing with issues of unobserved heterogeneity in relation to household food security status. Future studies should consider adopting this model.

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The authors declare that they have no known competing financial or otherwise interests that could have appeared to influence the work reported in this paper.

CRedit authorship contribution statement

Jude Dokbila Kolog: Conceptualization, Investigation, Methodology, Formal analysis, Writing – original draft. **Freda Elikplim Asem:** Supervision, Conceptualization, Methodology, Writing – review & editing. **Akwasi Mensah-Bonsu:** Supervision, Methodology, Writing – review & editing.

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