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Farm-related determinants of food insecurity among livestock dependent households in two agrarian districts with varying rainfall patterns in Ghana

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Background: Despite availability of sufficient arable land, many African countries continue to dawdle in agricultural productivity due to over-reliance on rainfall patterns. Thus, undernourishment levels are disproportionately high in Africa. Even though they play key roles in agricultural production, the food security (FS) levels of livestock dependent households are understudied. Our study assessed the FS level and its determinants in livestock farming households in Ghana.

Methods: We compared the FS levels of 287 cattle producing households in two representative agrarian districts with varying rainfall patterns in Ghana (dry vs. wet), using a cross-sectional survey. We assessed household's FS using the Food Insecurity Experience Scale. FS scores and categories were computed, and using generalized linear models, we assessed factors that explained variations in the FS levels among households.

Results: The median herd size of households was 31 cattle (lower quartile = 24, upper quartile = 60 cattle), with a majority (91%) engaged in crop cultivation. Households reported experiencing an average of eight adverse events over a five-year recall period (2014–2018) mainly from animal diseases, cattle theft, and pasture shortages. Most households (81%) were food insecure (moderate = 40%, severe = 41%). In an adjusted model, households raising cattle in the dry district [adjusted Odds Ratio (aOR) = 5.43, 95% CI: 1.94, 15.2] and being married (aOR = 9.48, 95% CI: 2.35, 38.3) were associated with moderate food insecurity. While households raising cattle in the dry district [adjusted Odds Ratio (aOR) = 4.17, 95% CI: 1.44, 12.0], being married (aOR = 3.55, 95% CI: 1.03, 12.2), and increase in number of adverse events experienced (aOR = 1.53, 95% CI: 1.20, 1.96), were associated with increased odds of severe food

insecurity. Household's odds of severe food insecurity decreased with each additional head of cattle in their herds (aOR = 0.97, 95% CI: 0.96, 0.99). We find no evidence of effect modification by farming district on other predictor's effect on food insecurity.

Conclusion: Most of the livestock dependent households are food insecure. The food insecurity levels are worse for households farming in dry areas, those married and who experience increased frequency of adverse events. Government policy interventions focusing on maintaining healthy, secure, and productive animal herds would contribute to improving the productivity of household herds, food safety and food security.

KEYWORDS

food security, livestock dependent population, adverse events, Ghana, rainfed

Background

Globally, malnutrition continues to be a key challenge especially in developing countries where a double high burden of both undernutrition and overnutrition have been reported (Abdullah, 2015). In 2019, about 700 million people were reported to be undernourished globally, with Africa being disproportionately affected; with more than 250 million undernourished (FAO, 2020). One in every ten persons experienced severe food insecurity in 2019 despite the global strategic efforts led by the Food and Agricultural Organization of the United Nations (FAO) toward improving food security globally over the years. And based on the current trend, the global target of achieving Zero Hunger by 2030 is unattainable (FAO, 2020). Farmers are key stakeholders in the global efforts to achieve food security. However, in many African countries including Ghana, despite having more than half of the global uncultivated arable land, productivity remains low as farmers overly rely on subsistence farming with poor production technologies, low financial investment and rainfall over-dependence (Bjornlund et al., 2020; Ali et al., 2021). In Ghana, the livestock sector's contribution has stagnated over the years and key policy interventions in agriculture have focused mainly on the crop sector (MoFA, 2011; FAO, 2015).

Animal source foods contribute a substantial portion of the human diet and smallholder livestock farmers in developing countries remain the main suppliers of the local demand (Molina-Flores et al., 2020). Despite the massive potential for the livestock sector in Africa, it is unable to meet the demand of a growing population (Bjornlund et al., 2020). Different factors have been reported to play a role in this low productivity of the livestock sector in Africa including a lack of optimal investment, climate change, poor technology use, and policy deficiencies among others (Ly et al., 2010; FAO, 2017; Bjornlund et al., 2020; Ali et al., 2021). However, the relationship between nutrition and farmers' productivity is understudied. Indeed, the common adage "Food is Life", is especially relevant to the productivity of the labor force. A poorly nourished workforce affects productivity (Drewnowski, 2020). Previous studies among smallholder farmers who keep long-cycle livestock such as cattle in developing countries show that the farmers rarely consume or sell these animals except in situations of extreme need or during feasts. They prefer to keep them as a stock of wealth (Bettencourt et al., 2015).

Food insecurity increases the risk of hunger and malnutrition especially for vulnerable households, including smallholder livestock farmers in many African countries where food insecurity levels are even further exacerbated by conflicts, drought and/or floods. Prolonged food insecurity exposures present public health threats to affected households; particularly maternal and child health risks of anemia, stunting, and wasting (FAO and ECA, 2018). For instance, with high food insecurity in West Africa, the prevalence of wasting, stunting and low birth weight remain very high, above international emergency thresholds, in spite of some progress in reducing malnutrition levels in the region (Dominguez-Salas et al., 2019). Thus, studies assessing food insecurity levels and its determinants in vulnerable populations would provide key information for policy makers' use in intervention design. However, only few studies on food insecurity focus on vulnerable livestock dependent populations. A previous study in Tanzania assessed social-cultural and environmental determinants of food insecurity (Safari et al., 2022) in pastoral areas while another study evaluated strategies through which livestock interventions could be utilized to improve nutrition in the Sahel (Dominguez-Salas et al., 2019). Our study adds the West African perspective to the existing body of knowledge.

The FAO has over the years led the development of tools to assess the different dimensions of nutrition and food security of individuals and households such as the United States Household

Food Security Survey Module, the Household Food Insecurity Access Scale and the Food Insecurity Experience Scale (FIES; Ballard et al., 2013). Food security entails the availability of enough good quality food to meet a person's nutritional requirements. The measurements of food security are mainly based on food quality and availability. Individuals are classified as food secure if they had sufficient food intake with a reduced food insecurity risk. Individuals are vulnerable or have moderate food insecurity if food intake is sufficient, but food insecurity risk is high, and they are food insecure when they do not eat enough food in addition to a high risk of food insecurity (FAO, 2000).

The FAO utilized the FIES in a global survey conducted by the Voices of the Hungry project in 2014. The observed global prevalence of severe food insecurity was 7%. In developing countries, an average of 12% of the population were severely food insecure with sub-Saharan Africa recording the highest levels of severe food insecurity (25%). In Ghana, the severe food insecurity level was 23% (FAO, 2016). The food security levels are often worse for populations living in harsh weather conditions as well as among the poor (Mayanja et al., 2015; Yakubu and Aidoo, 2015; FAO, 2020). In many African countries including Ghana, smallholder livestock farmers are generally poor compared to other occupations (Ducrotoy et al., 2017; Grace et al., 2017). Given the role livestock farmers play in food availability and quality, understanding their own food security level and factors influencing it will inform strategic policies. Cattle are high value assets that are often kept by smallholder farmers in developing countries as a livelihood source, draft power, food and/or a store of wealth (Rass, 2006). Our study sought to assess the food security level and its determinants in livestock farming households in Ghana. The study targeted only cattle farming households to achieve comparability of the farm-related determinants of food insecurity. By comparing food insecurity in two districts with different rainfall patterns, a major driver of agriculture in Ghana, we can provide evidence of food security levels across the two main farming belts in Ghana. We could also explore the determinants of food security and the role of the farming district on food security levels. By this design, we would be able to explore the roles the environment and livestock as assets to households, play in the food security and wellbeing of livestock dependent households using a One Health approach to research. However, few studies focus on addressing determinants of food security among these livestock dependent households.

Methods

We assessed the food security levels of cattle farmers in two distinct districts representative of the dry and wet farming belts in Ghana.

Description of study site

This cross-sectional survey was conducted in two agrarian districts located in the northern and southern Belts of Ghana (Figure 1). The Bunkpurugu-Yunyoo District lies in the Northern Savannah Agro-ecological zone, an arid belt in the North-East Region of Ghana. More than 94% of households within the district engage in agricultural activities. The district has a single rainfall season annually between April and October (Ghana Statistical Service, 2014a). The Kwahu Afram Plains South District lies in a humid belt in the Savannah vegetation zone, and part of the Eastern Region of Ghana. The district has two rainfall seasons annually in addition to being fed by large portions of the Volta River, creating a conductive environment for livestock rearing in Ghana (Ghana Statistical Service, 2014b). Livestock including cattle, sheep, and goats are mainly raised on a free-range basis in both districts.

Study population and sample

The target population was cattle farmers in Ghana. We stratified Ghana into two farming belts: the Northern and Southern Belts. The Bunkpurugu-Yunyoo and Kwahu Afram Plains South Districts were randomly drawn from a sampling frame of Districts in the two farming belts. The districts' directorates of veterinary services provided a sampling frame of communities in the districts, where cattle farmers raise their animals. Twenty-two of the communities were randomly drawn from the two study districts. The community leaders provided a list of cattle farming households. The farming households were recruited consecutively over 4 weeks per study district and the questionnaire administered after informed consent was obtained. The study sample size was derived using Epi Info™ version 7.2, based on an assumed prevalence of food insecurity of 66% reported in subsistence farming households in Northern Ghana (Yakubu and Aidoo, 2015). We estimate the dry district to have twice the odds of food insecurity compared to the wet district (OR = 2), thus assumed prevalence for wet district was (49%). Taking a 95% confidence level and power of 80%, the minimum sample required was 270 cattle farming households based on Fleiss's approach. After adding 10% to account for non-response, the targeted sample size was 297 farming households, a minimum of 149 per study district.

Data collection and analysis

A structured questionnaire was administered to 287 cattle farming households who were in the two districts. The Food Insecurity Experience Scale (FIES), an 8-item scale with YES and NO responses, was used to measure insecure access to food of the cattle farming households (Table 1). Each question

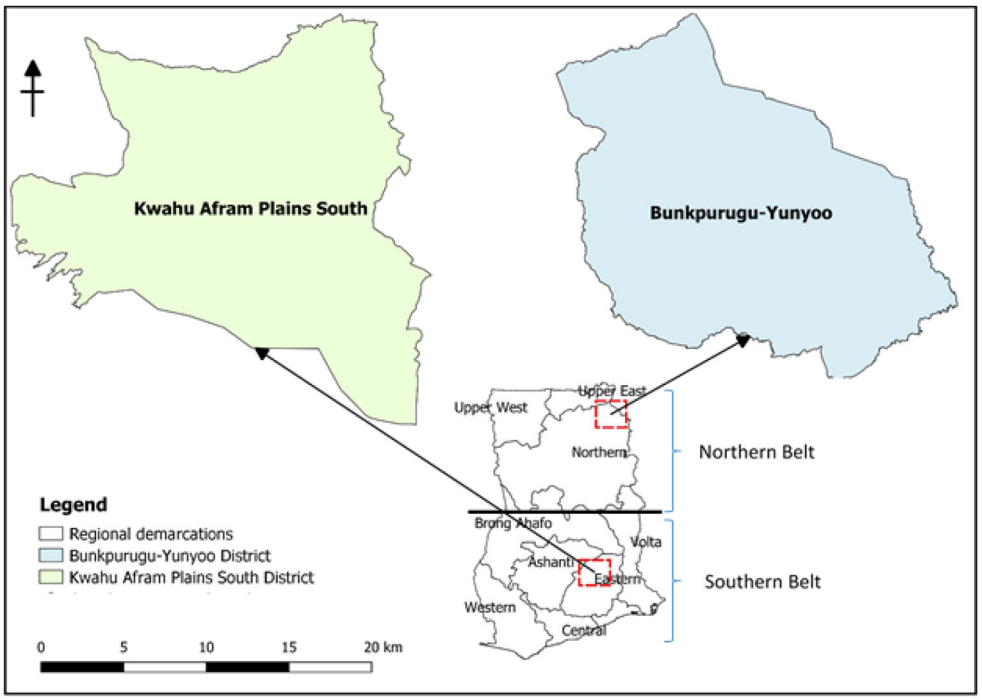

FIGURE 1
Map of Ghana showing the study districts.

in the FIES assesses a unique food insecurity situation with affirmative responses to each subsequent question depicting a more severe level of food insecurity compared to that of the preceding question (Ballard et al., 2013).

The dichotomous responses were transformed into a continuous scale: study respondents who answered NO to any question received a score of zero (0). An affirmative response (YES) to a question was coded on a gradient to reflect the increase in severity of food insecurity on each subsequent food insecurity scenario question. Thus, responding YES to the first question (question 1) yielded a score of 1, responding YES to question 2 yielded a score of 2 and so on. The scores were then reversed as follows: 0 = 9, 1 = 8, 2 = 7, 3 = 6, 4 = 5, 5 = 4, 6 = 3, 7 = 2 and 8 = 1, so that higher scores reflected better food security. Hence, a farmer who responds "YES" to all scenario questions would score 8 (1*8), while a farmer who responds "NO" to all scenario questions would score 72 (9*8). This transformation yielded a continuous scale of scores ranging between 8 and 72, which were categorized. Household heads who had maximum scores (total score = 72) were classified as food secure. Scores less than the maximum score of 72 were categorized into two classes: moderately food insecure (55–71) and severe food insecure (≤54).

The study also obtained socio-demographic, farm characteristics, adverse events affecting cattle production and the support sources to farmers to deal with adverse events. We conducted descriptive and inferential analysis using Stata software (version 15.1). We conducted the inferential analysis using chi-square tests for categorial variables and ANOVA for continuous variables. For variables that were significant at the 5% level, multinomial logistic regression analyses were used to assess the strength of the association between the predictor variables and food insecurity.

Results

Descriptive results

Most of the household heads were male (93%). Their median age was 47 years [lower quartile (LQ) = 39 years and upper quartile (UQ) = 54 years]. Majority of the respondents (67%) attained at least basic education: 46% basic, 16% secondary and 5% tertiary education attainment. Nine in ten of the household heads were married (265/287) having an average of 10 persons per household (LQ = 7 persons and UQ = 13 persons).

The household heads had an average of 31 cattle in each herd (LQ = 24 cattle and UQ = 60 cattle). Most (91%) of the household heads grow crops: mainly cereals, legumes, vegetables, and root tubers, in addition to raising cattle. In a five-year recall period (2014–2018), the households experienced on average eight adverse events mainly including animal disease

TABLE 1 Food insecurity experience scale (FIES).

	Now I would like to ask you some questions about your food consumption in the last 12 months. During the last 12 MONTHS, was there a time when:	**Yes**	**No**
1	You were worried you would run out of food because of a lack of money or other resources?		
2	You were unable to eat healthy and nutritious food because of a lack of money or other resources?		
3	You ate only a few kinds of foods because of a lack of money or other resources?		
4	You had to skip a meal because there was not enough money or other resources to get food?		
5	You ate less than you thought you should because of a lack of money or other resources?		
6	Your household ran out of food because of a lack of money or other resources?		
7	You were hungry but did not eat because there was not enough money or other resources for food?		
8	You went without eating for a whole day because of a lack of money or other resources?		

outbreaks, cattle theft, pasture shortages and conflicts with other land users that negatively affects their raising of cattle. On average, the cattle farming households lose five cattle each year (LQ = 2 cattle and UQ = 9 cattle). Proportionately, the households lost 15% on average of their total herd size per year (LQ = 5% of herd size and UQ = 21% of herd size). To enable them to deal with adverse events that they faced, most household heads (74%) in this study reported receiving some support, mainly from veterinary services, and from friends and family. Twenty-six percent (75/287) of the households did not receive any support.

The age and highest educational level of household head, whether a household grew crops, number of adverse events experienced, total cattle and proportion of herd lost to adverse events, and support households received to deal with adverse events differed significantly between study districts.

Figure 2 shows the food security categories of households. Most households (81%) were food insecure (moderate food insecurity = 40%, severe food insecurity = 41%). In the wet district, 68% of households were food insecure (moderately food insecure = 37% and severely food insecure = 31%). Whereas, in the dry district, 94% of the households were food insecure (moderately food insecure = 43% and severely food insecure = 51%).

Inferential results

Tables 2, 3 presents inferential analysis of categorical and continuous variables respectively. Although the age, educational level, growth of crops, number of adverse events experienced, total cattle lost, proportion of herd lost and support received to deal with adverse events by households differed significantly between the two study districts, we did not find any evidence of effect modification with respect to the district of farming and these explanatory variables (Additional File 1). Based on the chi-square tests, the respondent's sex, district within which a household farms, marital status of household head, and support sources available to the households to deal with adverse events were significantly associated with food security level of the study respondents (Table 2). Based on the ANOVA results, the age of household head, herd size of household, number of adverse events a household faced, and the number of cattle lost to adverse events were significant predictors of the food security level of the households (Table 3).

Table 4 presents the univariable multinomial logistic regression analysis of the food security level predictors. We show the crude odds ratios (cOR) for moderate and severe food insecurity levels vs. the baseline food security category, in addition to their 95% confidence intervals and *p*-values for each predictor variable.

The odds of being moderately food insecure rather than food secure, was 5.4 times higher if the household heads were married compared to if they were unmarried (single, divorced, or widowed) [cOR = 5.38 (95% CI = 1.58–18.4), $p = 0.007$]. The odds of being moderately food insecure rather than food secure, was 6.1 times higher for households keeping cattle in the dry district (Bunkpurugu-Yunyoo) than for those households in the wet district (Kwahu Afram Plains South) [cOR = 6.09 (95% CI = 2.73–13.6), $p < 0.001$]. The odds increase by a factor of 1.32 with each additional adverse event faced by the household, for moderately food insecure vs. the food secure households (cOR = 1.32, 95% CI = 1.11–1.58, $p = 0.002$). However, the odds of moderate food insecurity decrease with the support sources available to households to deal with adversity. The odds of being moderately food insecure rather than food secure are 65% lower if households received support from three or more sources to deal with adverse events than if they did not [cOR = 0.35 (95% CI = 0.14–0.87), $p = 0.023$].

Comparing the severely food insecure vs. the food secure households, the odds of being severely food insecure rather than food secure, was 7.1 times higher if the respondents were male compared to if they were female [cOR = 7.10 (95% CI = 1.38–36.4), $p = 0.019$]. The odds were 8.6 times higher for households keeping cattle in the dry district (Bunkpurugu-Yunyoo) than

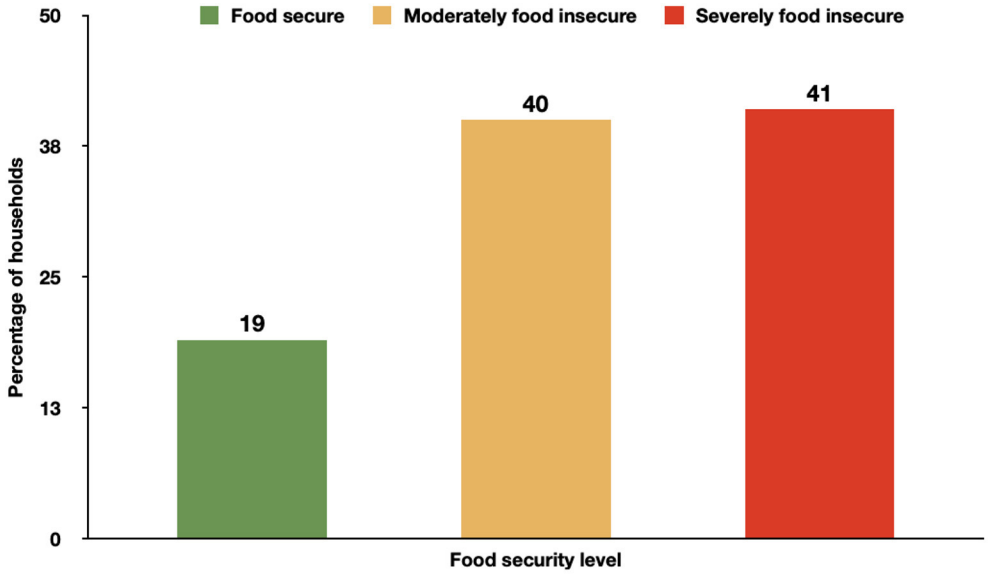

FIGURE 2
Food security level of cattle farming households in Ghana.

TABLE 2 Factors influencing the food security level of cattle farming households in Ghana (Part 1).

Factor	Category	Food secure ($n = 55$)	Moderately food insecure ($n = 114$)	Severely food insecure ($n = 118$)	Column percent (%)	Statistical significance	
						Chi-square	*p*-value
Sex of HH	Female	6	11	2	5.6	7.959	0.008¥
	Male	49	103	116	94.4		
Highest level of education	No formal education	18	38	40	33.4	5.365	0.511¥
	Basic	28	56	48	46.0		
	Secondary	6	14	25	15.7		
	Tertiary	3	6	5	4.9		
District	Wet	46	52	44	41.4	33.37	<0.001
	Dry	9	62	74	58.6		
Marital status	Not married	9	4	9	5.6	8.662	0.016¥
	Married	46	110	109	94.4		
Crop cultivation	No	7	13	6	8.2	3.921	0.141
	Yes	48	101	112	91.8		
Support sources availability	No support	8	32	35	28.9	10.24	0.037
	One to two sources	17	40	47	37.5		
	Three or more sources	30	42	36	33.6		

Numbers (n) of households falling into each category; "severely food insecure" households had a food security score less than 55, "moderately food insecure" households had a food security score between 55 and 71, whilst the "food secure" households scored 72. Percentage (%) denotes the proportion of households with food insecurity within each category of predictor variables and their Chi-square and *p*-value. ¥ denotes Fisher's exact test probabilities for observations less than 5 expected persons in each food security category. 'HH' denotes household head.

TABLE 3 Factors influencing the food security level of cattle farming households in Ghana (Part 2).

Factor	Food secure (mean ± SD)	Moderately food insecure (mean ± SD)	Severely food insecure (mean ± SD)	F-statistic (286 df)	*p*-values
Age (years)	50.4 (11.0)	47.1 (11.0)	45.2 (12.4)	3.74	0.025
Household size (persons)	10.0 (6.1)	10.4 (5.2)	9.9 (4.2)	0.30	0.741
Herd size (cattle)	66.3 (65.8)	51.4 (38.8)	35.3 (21.1)	12.06	<0.001
Number of adverse events faced*	6.4 (2.2)	7.3 (1.7)	7.7 (1.2)	12.64	<0.001
Number of cattle lost^	9.3 (10.1)	7.5 (8.7)	5.2 (6.6)	5.21	0.006
Total proportion of cattle lost (%)^	15.4 (13.5)	15.3 (13.5)	14.1 (14.6)	0.29	0.750

Mean ± SD denote the mean and standard deviations (in parentheses) of each factor, resulting from a analysis of equal variances within the categories of food security "food secure", "moderately food insecure" and "severely food insecure". *denote adverse events faced over a 5-year period (2014–2018). ^denotes number or proportion of cattle lost to adverse events in a 1-year period (2018). F-statistic (286 df) denote the F-statistic for each hypothesis test of equal variances within each food security category. Severely food insecure households had a food security score less than 55. Moderately food insecure households had a food security score between 55 and 71, whilst the food secure households scored 72.

TABLE 4 Univariable analysis of food security level predictors of cattle farming households in Ghana.

	Moderately food insecure		Severely food insecure	
Variables	**cOR (95% CI)**	***p*-value**	**cOR (95% CI)**	***p*-value**
Age of farmer	0.98 (0.95, 1.00)	0.091	0.96 (0.94, 0.99)	0.007
Sex				
Female	ref		ref	
Male	1.15 (0.40, 3.28)	0.799	7.10 (1.38, 36.4)	0.019
Marital status				
Not married	ref		ref	
Married	5.38 (1.58, 18.4)	0.007	2.37 (0.88, 6.35)	0.086
District				
Wet	ref		ref	
Dry	6.09 (2.73, 13.6)	<0.001	8.60 (3.84, 19.2)	<0.001
Support sources availability				
No support	ref		ref	
One to two sources	0.59 (0.23, 1.54)	0.279	0.63 (0.25, 1.63)	0.279
Three or more sources	0.35 (0.14, 0.87)	0.023	0.27 (0.11, 0.68)	0.005
Number of cattle in herd	0.99 (0.99, 1.00)	0.082	0.97 (0.96, 0.99)	<0.001
Number of adverse events faced*	1.32 (1.11, 1.58)	0.002	1.58 (1.29, 1.93)	<0.001
Number of cattle lost^	0.98 (0.95, 1.01)	0.252	0.94 (0.90, 0.98)	0.003

Variables included as predictors of the food security level of cattle farming households in Ghana. cOR, Crude odds ratios with 95% confidence intervals (CI) and the associated p-value for the univariable multinomial logistic regression models are presented. ref denotes the reference category. *denotes adverse events faced over a 5-year period (2014–2018). ^denotes number or proportion of cattle lost to adverse events in a 1-year period (2018).

for the households in the wet district (Kwahu Afram Plains South) [cOR = 8.60 (95% CI = 3.84–19.2), $p < 0.001$]. The odds increase by a factor of 1.58 with each additional adverse event faced by the household, for severely food insecure vs. the food secure households (cOR = 1.58, 95% CI = 1.29–1.93, $p < 0.001$). However, the odds of being severely food insecure rather than food secure are 73% lower if households received support from three or more sources to deal with adverse events than if they did not [cOR = 0.27 (95% CI = 0.11–0.68), $p = 0.005$]. The odds of a household being severely food insecure rather than food secure decreases by a factor of 0.97 with each additional increase in the herd size of households [cOR = 0.97 (95% CI = 0.96–0.99), $p < 0.001$]. The household's odds of being severely food insecure decreases by a factor of 0.94 with each additional cattle lost to adverse events [cOR = 0.94 (95% CI = 0.90–0.98), $p = 0.003$]. The odds similarly decrease by a factor of 0.96 with each year

increase in the age of a household head [cOR = 0.96 (95% CI = 0.94–0.99), $p = 0.007$].

After adjusting for the age and sex of household heads, the number of support sources available to the household to deal with adverse events and the number of cattle lost to adverse events, the household's food security level was significantly related to the marital status of the household head, district where cattle is raised, number of adverse events faced and the household's herd size ($p < 0.001$; Table 5).

After adjusting for other predictors, the odds of a household being moderately food insecure rather than food secure was 5.4 times higher if the cattle are reared in the dry district than in the wet district (aOR = 5.43, 95% CI = 1.94–15.2, $p = 0.001$) and 9.5 times higher if the household head is married than if they are not married (aOR = 9.48, 95% CI = 2.35–38.3, $p = 0.002$).

Similarly, the odds of a household being severely food insecure rather than food secure was 4.2 times higher if the cattle are reared in the dry district than in the wet district (aOR = 4.17, 95% CI = 1.44–12.0, $p = 0.008$) and 3.6 times higher if the household head is married than if they are not married (aOR = 3.55, 95% CI = 1.03–12.2, $p = 0.045$). The odds increase by a factor of 1.5 with each additional adverse event faced by the household (aOR = 1.53, 95% CI = 1.20–1.96, $p = 0.001$). However, the odds of being food insecure decreases by a factor of 0.97 with each additional cattle in the household's herd (aOR = 0.97, 95% CI = 0.96–0.99, $p < 0.001$), see Table 5.

Discussion

Despite global efforts to address food insecurity, the number of food insecure persons continue to grow, with sub-Saharan Africa being disproportionally affected (FAO, 2018, 2020). Food insecurity levels is particularly high in vulnerable rural communities including livestock dependent populations. Our study sought to compare food insecurity levels in two Ghanaian districts with varying rainfall patterns (dry vs. wet), and identify the determinants of the variations in food insecurity among cattle keeping households in Ghana.

Our findings showed that the majority of cattle farming households in Ghana are food insecure, with more than 40% experiencing severe food insecurity, about two times the level observed by the FAO in its food insecurity survey in Ghana (FAO, 2016). A similar level of severe food insecurity was observed in a survey of rural households in eight countries in sub-Saharan Africa between 2016 and 2018 (Fraval et al., 2019). This high level of severe food insecurity thus is unsurprising in our study setting as cattle farmers in Ghana have been previously reported to live in rural isolated settlements with the hope of minimizing conflicts with other land users (Nuvey et al., 2020). Additionally, farmers of long-cycle livestock such as cattle do not readily consume or sell their animals, but prefer to keep them as a store of wealth and prestige (Bettencourt et al., 2015).

The impact climatic events on livestock production particularly in extensive livestock production system was apparent in our findings. Previous studies (Rufino et al., 2013; Alpízar et al., 2020; Bjornlund et al., 2020) have shown how adverse climatic events negatively impact food security. This was evident in our study where we found households farming in the dry district to have a higher odds of food insecurity compared to those in the wet district. This is despite all the households in the dry district engaging in crop cultivation in addition to keeping cattle, compared to about 80% of the households in the wet district. In rainwater dependent agricultural systems such as Ghana, the provision of watering or irrigation facilities particularly in dry areas should greatly improve the productivity of smallholder farmers. However, previous reports have shown that irrigation projects targeting farmers in the Northern Belts of Ghana, where the weather conditions are drier compared to other regions of the country, have been largely ineffective due to inefficiencies in project implementation (Ali et al., 2021).

We also found in our study that households were more at risk of food insecurity if the household head was married. This may be related to the number of dependents a household head must feed. Previous work among cattle farmers in these districts show that the cattle farmers mainly engage the services of herdsmen to graze and oversee their animals rather than their dependents at home (Nuvey et al., 2020). Given an average household size of 10 persons in this study, it is intuitive that food insecurity increases if farmers were married. A previous study in Tanzania found higher risk of food insecurity among households with more than six members (Safari et al., 2022). The size of a household could be an asset if the members contribute productively to the household upkeep, but negative if they do not engage in productive activities but depend solely on household resources.

The experience of adverse events related to the cattle farming of households also play a key role in determining their food security; increasing the odds of food insecurity with every additional adversity faced. However, the number of cattle lost by households to the adverse events appear to independently reduce the risk of food insecurity. This result may be explained by our earlier work in this population where we found that livestock farmers slaughter, smoke and sell diseased animals to recover their losses (Nuvey et al., 2020). Urgent interventions that reduce the incidence and impact of infectious diseases are needed in Ghana to ensure sustainable production by livestock farming households, to improve food safety, food security and profitability of the households.

Increasing the herd size of the households was associated with better food security. In Tanzania, Safari et al. (2022), similarly found that food insecurity risk reduced with increasing livestock holdings. This offers an opportunity to achieve food security both at the livestock farming household level as well as the level of public consumers of meat and meat products. As previous works showed, productivity is hampered if there is

TABLE 5 Multivariable analysis of food security level predictors of cattle farming households in Ghana.

	Moderately food insecure		Severely food insecure	
Variables	**aOR (95% CI)**	***p*-value**	**aOR (95% CI)**	***p*-value**
Age of farmer	0.98 (0.95, 1.01)	0.155	0.98 (0.94, 1.01)	0.152
Sex				
Female	ref		ref	
Male	0.71 (0.21, 2.43)	0.584	4.22 (0.73, 24.4)	0.108
Marital status				
Not married	ref		ref	
Married	9.48 (2.35, 38.3)	0.002	3.55 (1.03, 12.2)	0.045
District				
Wet	ref		ref	
Dry	5.43 (1.94, 15.2)	0.001	4.17 (1.44, 12.0)	0.008
Support sources availability				
No support	ref		ref	
One to two sources	0.77 (0.26, 2.29)	0.635	0.88 (0.29, 2.71)	0.825
Three or more sources	0.83 (0.28, 2.45)	0.735	0.79 (0.25, 2.45)	0.681
Number of cattle in herd	0.99 (0.98, 1.00)	0.052	0.97 (0.96, 0.99)	<0.001
Number of adverse events faced*	1.19 (0.96, 1.47)	0.112	1.53 (1.20, 1.96)	0.001
Number of cattle lost^	1.01 (0.96, 1.06)	0.771	0.98 (0.92, 1.03)	0.398

Variables included as predictors of the food security level of cattle farming households in Ghana. aOR, Adjusted odds ratios with 95% confidence intervals (CI) and the associated p-value for the multivariable multinomial logistic regression models are presented. ref denotes the reference category. *denotes adverse events faced over a 5-year period (2014–2018). ^denotes number or proportion of cattle lost to adverse events in a 1-year period (2018).

poor access to food (Drewnowski, 2020). As infectious livestock diseases have been shown to be the leading source of losses to farmers in Ghana (Nuvey et al., 2020), interventions could address animal health through the adoption of preventive approaches. This would help improve the productivity and food security of farming households, through increases in their herd sizes and household incomes, whilst also meeting the public's demand for food. An experimental study conducted in Bolivia assessed the impact of adopting technologies on smallholder farming, and showed positive impact on the productivity, income and food security of the households (Salazar et al., 2015). Furthermore, as our results showed, when the support available to households to deal with adverse events increase, the odds of being food insecure decreases. Therefore, identifying the areas where support is needed for livestock dependent populations will be a key to the design and implementation of appropriate interventions.

Our study had some limitations. The design of the study did not permit us to determine the temporal relationship between food insecurity and the factors influencing it among livestock farming households. This aspect could be evaluated in future experiments in the study areas. Additionally, it would have been interesting to evaluate the impact of farmland sizes of the households, in addition to the kinds of crops cultivated, and market factors that could similarly affect food security in our study. As our study focused on cattle holding households; we did not evaluate the effect of other livestock holdings on the study households' food insecurity. The availability of these information could provide further clarity and context to the food security dynamics in the study population and area. In spite of these limitations, our study has provided good evidence on the food security levels and farm-related factors that influence it in vulnerable livestock dependent households in Ghana. Additionally, as we have not found a similar scoring approach of the FIES in the literature, we believe our scoring approach is intuitive and provides a simplified, yet relative weighting for the FIES items.

Conclusion

Although livestock farmers contribute to food supply and food security levels in Ghana, the majority of the cattle farming households were found to be food insecure. This high food insecurity level is particularly severe for households rearing animals in dry areas of the northern belt, households experiencing more adverse events and those with large number of dependents. The food security levels of the households improved if farmers had improvements in their herd sizes. The households reported high levels of losses to adverse events especially to animal diseases. Given the high dependence by these vulnerable households on livestock herd productivity,

government policies must target improving the health, security, and productivity of livestock herds of farming households to address the food security issues identified. This could lead to improved food security and productivity of the livestock dependent households while also contributing to better food security for the public.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by the Institutional Review Board of the Noguchi Memorial Institute of Medical Research. The patients/participants provided their written informed consent to participate in this study.

Author contributions

FN, KA, and BB: conceptualization and software. FN, PN, KA, AA-L, KK, CH, GD, and BB: methodology, validation, and writing—review and editing. FN: formal analysis, investigation, data curation, and writing—original draft preparation. BB: resources. FN, PN, KK, and AA-L: visualization. PN, AA-L, CH, GD, and BB: supervision. FN and BB: project administration. KA and BB: funding acquisition. All authors have read and agreed to the published version of the manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs.2022.743600/full#supplementary-material

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