# Exploring women's perspectives on food insecurity and the impacts of climate change in the Karaga district of Northern Ghana: A community-based mixed-methods study

Jessica Boxall

j.l.boxall@soton.ac.uk

University of Southampton    https://orcid.org/0009-0009-1912-0380

Amelia Bird

University of Southampton

Alexandria Brown

University of Southampton

Michael Head

University of Southampton

Mohammed Malle Abdulai

Ghana Health Service

Victor Mogre

University for Development Studies

Abdul Kasiru Shani

Songtaba

Patience Kanyiri Gaa

University for Development Studies

Additional Declarations: The authors declare no competing interests.

# Abstract

Food insecurity is a prevalent issue in rural communities within Ghana and particularly within the Karaga District (Northern Region), where climate change is intensifying vulnerabilities. Extreme and unpredictable weather events are disrupting agriculture and worsening food insecurity across all four pillars: availability, accessibility, affordability, and utilisation. Despite women's central role in household food decisions, limited evidence exists on their experiences of food insecurity under climate change. This study surveyed 384 women in Pishigu (Karaga District) in March 2025, assessing food insecurity (Food Insecurity Experience Scale), climate impacts (using the Global Strategic Food Insecurity & Nutrition framework), health (RAND SF-36), and dietary diversity (Global Diet Quality Project). Rasch modelling estimated prevalence, descriptive statistics explored climate impacts, and multivariate logistic regression identified predictors of severe food insecurity. Results revealed that 93.4% experienced moderate or severe food insecurity, and 52.6% were severely food insecure, exceeding national and regional averages. Nearly two-thirds reported worsening food insecurity over five years, with climate change affecting all pillars: 83.1% cited crop and livestock losses, 86.98% reported reduced storage capacity, and 86.72% noted reduced income. Only 30.2% consumed a sufficiently diverse diet, and mean general health scores (56.12, SD ± 18.23) were lower than urban areas. Relative wealth, perceived energy, dietary diversity, knowledge of climate change and nutrition-related healthcare use were significant predictors of severe food insecurity. Findings underscore the urgent need for gender-sensitive, climate-informed policies and education, to strengthen resilience and empower women, ensuring sustainable progress in Karaga District and similar rural communities.

# Introduction

Climate change is increasingly recognised as a significant driver of food insecurity (FI) and health inequalities - two issues that are inextricably linked. Research shows that undernutrition will be the largest health impact of climate change (Food and Agriculture Organisation et al., 2022). Rising temperatures, erratic rainfall and more frequent and severe extreme weather events (such as floods and droughts) destabilise food systems (Akudugu MA, 2012). They are also increasing the burden of health issues such as vector-borne diseases, heat stress and respiratory issues (Constantin De Magny et al., 2006). Consequent malnutrition caused by FI compromises individuals' health and further increases vulnerability to diseases (Katona & Katona-Apte, 2008). This established interplay continues to be a priority globally, but especially for those countries who are most vulnerable and experiencing the harshest effects of climate change (FAO, 2024).

The Food and Agriculture Organisation (FAO) define food security as consistent access to sufficient, safe, and nutritious food; Sustainable Development Goal 2 sets this as target to be achieved by all nations by 2030. Yet in 2023, one third of the world's population were deemed food insecure (FAO, 2024).

Women face disproportionate vulnerability to climate change and FI due to unequal power dynamics, and gendered roles and responsibilities at both household and community levels (Jost et al., 2016). According to UN Women's estimates, in a worst-case climate scenario, by 2050 as many as 158 million women and girls may be pushed into extreme poverty as a direct result of sustained increases in global temperatures(UN Women, 2023). Sub-Saharan Africa (SSA) is predicted to be most impacted with an increase in female FI of 105 million women and girls by 2050(UN Women, 2023). Yet women are typically the decision-makers of the household and an essential part of the food value chain, from growing crops for domestic consumption to storage, processing, preparation and distribution (Amugsi et al., 2016; Duncan BA, 2004; Gnisci D, 2016). Despite this, women often lack appropriate access to financial services, resource allocation or disaster information. Such inequalities undermine women's ability to provide a sufficient, safe and nutritious diet for the entire household, but also to prepare for and recover from climate stressors. Cultural norms may also add to this pressure; patriarchal hierarchies may lead to women in the household eating less relative to other household members in times of food scarcity, despite differing nutritional needs. If current slow rates of progress are to continue, it would take 231 years to eliminate FI among females globally (UN Women, 2023). Climate change is expected to hinder progress towards closing this gender gap regarding FI (UN Women, 2023).

West Africa is deemed a 'hotspot' of climate change by the Intergovernmental Panel for Climate Change (Intergovernmental Panel on Climate Change, 2014); countries within this region, such as Ghana, are among the most vulnerable nations due to their high poverty prevalence, lower levels of development and reliance on rain-fed subsistence agriculture - both for population consumption and the economy (Kiewisch, 2015). These characteristics heighten the risk of FI, and subsequent malnutrition, as climatic changes endanger the agricultural industry. Rural populations in particular have little ability to withstand consequences such as loss of livestock and crops, soil infertility, extreme seasonal changes and pest and disease outbreaks.

Ghana is already experiencing increased temperatures, unpredictable rainfall compared to historical patterns, flooding and extreme heat (World Bank, 2011; Ziblim et al., 2022). Modelling by the World Bank forecasts a further increase of $1-3°C$ by 2060 (World Bank, 2011). Northern Ghana is disproportionately affected due to lower development, higher poverty, and reduced access to healthcare and markets, household reliance on subsistence farming and climate-related shocks (World Food Programme, 2023). According to data from the 2022 Annual Household Income and Expenditure Survey, 49.1% of Ghanaians experienced FI in the first three months of the year. Of Ghana's 30.8 million people, this amounts to 15.1 million. Rural areas have a higher rate of FI than urban areas. In the first quarter of the year, the prevalence of FI in four regions in the northern part of the country; Tamale Metropolis (37.2%), Upper West (61.8%), North East (65.6%), Upper East (73.7%), Savannah (58.8%), and Upper East

were more than twice of that of Greater Accra (Ghana Statistical Service, 2022a). Karaga District, Northern Region, has been one of the most food-insecure and malnourished districts in Ghana for consecutive years, according to national survey data (Ghana Statistical Service, 2022a). In response, multiple interventions have been initiated at national, regional and local levels aimed at improving Karaga's FI, though no substantial or sustainable progress seems to have been made according to the District Health Directorate and regional data (Ministry of Food and Agriculture Republic of Ghana, 2011).

Women's voices remain underrepresented in strategies concerning food security, as well as those mitigating the impacts of climate change on this phenomenon; this is despite FI disproportionately affecting women more than men (FAO, 2024). Additionally, as Mane states the collection of sex-disaggregated data is of significant importance for monitoring the United Nations Sustainable Development Goal (SDG) 2: eradicating hunger (Mane et al., 2025). Amplifying female voices, especially within marginalised populations, will also influence and increase the effectiveness of policies and interventions empowering women and addressing SDG 5: gender equality. There is limited research from the perspective of women, particularly in highly affected areas like Karaga. This study seeks to empower women to fill that knowledge gap, by capturing and elevating their perspectives on household FI and climate change impacts and generating bottom-up knowledge from the community. As Egyir et al states, it is imperative that women's voices are counted when it comes to food and agriculture; as they are among the most affected, and their contribution is vital to design the way forward (Egyir et al., 2023).

## Research Aim

The aim of the research is to understand, from the female perspective, why households in Karaga District are highly food-insecure and how climate change is impacting this.

## Materials and Methods

## Study Design

This cross-sectional divergent mixed-methods study (referred to here as SEED: A mixed-methods Study investigating the Effects of climate change on FI through Empowering women in Karaga District, Northern Region, Ghana). Consisted of household surveys collected in Pishigu, Karaga district (quantitative). Here, the findings from the household surveys will be the focus. Other study components will be reported in forthcoming papers, including focus groups with members of the Pishigu community (qualitative), a narrative review of all interventions initiated in Karaga district within 2005–2025 (qualitative), and subsequent interviews with selected NGO partners who delivered aforementioned interventions (qualitative).

## Study Setting

The study was conducted in Pishigu, a rural community within Karaga district, located around 3 hours travel time north of Tamale city in the Northern Region of Ghana (Fig. 1). Ghana is an English-speaking lower-middle income country, located just north of the Equator in West Africa. There is a tropical savannah climate, with dry and rainfall seasons that determine the agricultural calendar. Northern Ghana's rainfall season usually occurs from March to November, though due to climate change this has become more unpredictable. For instance, there was a prolonged dry spell during 2024, that hindered the growing season for the following year. Typically, the "hunger period" takes place from April to July, whilst anticipating the harvest and stored food stocks run low. The household surveys took place on the 3rd to the 12th of March 2025.

Pishigu is one of 194 communities in Karaga district, with a population of 3,414 people (Ghana Statistical Service, 2021; Karaga District Assembly, 2024). Approximately 70% of the district is rural, with the main economic activity being agriculture across the population (Ghana Statistical Service, 2021). Pishigu was chosen in discussion with the Karaga District Health Directorate, selected as a representative rural community of the district with high levels of poverty and illiteracy among the female population.

## Participants

Eligible participants included women aged 18 years and over, who were residents of Pishigu for more than 6 months and able to provide informed consent.

To ensure that the community were informed and happy for the research to take place, community entry was carried out as part of the study consent process (this is further detailed in a separate practice note).

## Sample Size

The power calculation conducted for the study determined a minimum sample size of 384 to be sufficient, assuming a minimum effect size of 0.2, a statistical power of 80% and a significance level of p = 0.05. 384 survey responses were collected, meeting the threshold and ensuring sufficient statistical power.

Participants were recruited via household selection using the random-walk method; this sampling method is recommended in low-resource settings by UNICEF and has been used in previous studies by the research team (Afreh et al., 2023; Boxall J, 2024; UNICEF). At each randomly selected household, one female representative was asked to complete the survey with the data collector. Women who wished to take part were provided with a Participant Information Sheet (in English) and talked through the process with the data collector, who could engage in the local language as needed. Those who agreed to take part then gave electronic written informed consent on the data collection tool.

# Data collection

For household surveys, data collectors were Pishigu-based healthcare workers or teachers chosen by the Director of the Karaga District Health Directorate and trained by staff from the University for Development Studies (UDS). This ensured local acceptability and also capacity-building within the community, upskilling workers for future research and monitoring. Data collectors were trained to use Kobo Toolbox v2021.2.4 (http://www.kobotoolbox.org/), which is a secure, offline-compatible data collection tool. This electronic data capture tool is ideal for remote areas with limited connectivity, as the data can be synced when network coverage resumes.

Participants were surveyed in their preferred language, either English or Dagbani; if the latter, data collectors translated answers into English on the data collection tool.

# Variables

Household survey data included dichotomous, Likert-scale and multiple-choice questions evaluating participant's experiences of FI, perceptions of the impact of climate change and dietary diversity. Several validated scales were used. A breakdown of the survey variables is as follows (the full survey can be found in Appendix A).

Demographic variables captured age, ethnicity, marital status, education level, employment and main economic activity. Religion, household size, number of dependents, how many years they had lived in the community and if they were pregnant or breastfeeding at time of completion was recorded. To further understand socio-economic status, a country-adapted Wealth Asset Index was included; respondents were asked if they had household ownership of 19 different assets including a mobile phone, TV, radio or motorcycle.

FI was measured using the Food Insecurity Experience Scale, a validated 8-question tool from the FAO measuring insecurity in lower-income settings (Food and Agriculture Organisation, 2023). The binary questions ascended in severity, capturing mild, moderate and severe FI over the last 12 months, as detailed in Table 1. People experiencing moderate FI were deemed to have reduced the quantity or nutritional quality of their intake and are uncertain about the sustainability of their food supply. Households experiencing severe FI have gone without eating for a day or longer. Comparable national and global data is taken from the 2021–2023 Gallup World Poll (Viviani, 2016).

Table 1
Questions included in the Food Insecurity Experience Scale (FIES) and the thresholds by which mild, moderate and severe food insecurity are defined.

| FIES Question | Question description (if the participant or anyone in her household has experienced the following scenarios in the last 12 months due to lack of money or other resources) | Severity of FI |
|---|---|---|
| 1 | Worried about not having enough food | Mild |
| 2 | Unable to eat healthy and nutritious food | Mild |
| 3 | Only ate only a few kinds of foods | Mild |
| 4 | Had to skip a meal | Moderate |
| 5 | Ate less than you thought you should | Moderate |
| 6 | Household ran out of food | Moderate |
| 7 | Went to sleep hungry | Severe |
| 8 | Went a whole day and night without eating anything | Severe |
| Total FIES score = Sum of Q1-Q8 (0–8) | | |

Further questions exploring the reasons for FI and impact of climate change, aligned with the Global Strategic Food Security and Nutrition Framework (United Nations Committee on World Food Security (CFS), 2017). This allowed us to investigate the four dimensions of FI, namely availability, accessibility, affordability and utilisation and understand which is affected.

To understand the impact of FI and any climatic exacerbations on nutrition adequacy, participants were also asked to complete the Global Diet Quality Project's Diet Quality Questionnaire (DQQ), adapted for Ghana (Global Diet Quality Project, 2021, 2023a). The DQQ provides contextually appropriate and standardised indicators of dietary quality, that can be compared between populations. The DQQ collects data on 29 food groups total, however this analysis focuses on 10 food groups in line with the DQQ analysis protocol for Ghana, which is used to assess the minimum dietary diversity scores for women (MDD-W) as demonstrated in Table 2.

Table 2
The Diet Quality Questionnaire (DQQ) captures information on 29 food groups as detailed below. The Dietary Diversity Score (DDS) is a measure of how many of 10 categories of these (organised as in the table) are consumed by an individual. The Minimum Dietary Diversity score for Women (MDD-W) is 5 or more of these 10 categories. 1 point is available for each of the listed categories.

| Food group | DQQ adapted for Ghana | Points |
|---|---|---|
| Grains, white roots and tubers, and plantains | Q1,2, 3 | 1 |
| Pulses (beans, peas and lentils) | Q4 | 1 |
| Nuts and seeds | Q21 | 1 |
| Dairy | Q14, 15, 25 | 1 |
| Meat, poultry and fish | Q16, 17, 18, 19, 20 | 1 |
| Eggs | Q13 | 1 |
| Dark green leafy vegetables | Q6.1, 6.2 | 1 |
| Other vitamin A-rich fruits and vegetables | Q5, 8 | 1 |
| Other vegetables | Q71, 7.2 | 1 |
| Other fruits | Q9, 10.1, 10.2 | 1 |
| DDS: Sum (0–10) | | |
| Adequate MDD-W: DDS of ≥ 5 | | |
| Inadequate MDD-W: DDS of < 5 | | |

Additionally, the RAND Short Form Health Survey (SHF-36) was included to capture self-reported health status through 8 different dimensions: physical functioning, bodily pain, role limitations due to physical health problems, role limitations due to personal or emotional problems, emotional well-being, social functioning, energy/fatigue, and general health perceptions (Rand Health Care). This measure has been used in other studies on women's health in Ghana, where the self-reported outcomes were found to align well with objective health data, and also provides data on a key outcome and potential confounder on the relationships between food insecurity and perceptions of climate change (Darko et al., 2012). Here, we focused on the physical health dimensions, specifically physical functioning, role limitations due to physical health problems, energy and general health perceptions; mental health and the association between FI and dietary diversity are explored in a forthcoming publication (Parish et al).

The survey was piloted prior to rollout, and their responses were excluded from the final analysis.

## Analysis

Data analysis was conducted using STATA SE v19. Descriptive and summary statistics were generated for demographic variables and exploratory FI questions.

Relative wealth was measured by coding each of the assets as a binary variable where '1' indicated the asset was owned, and '0' indicated it was not. Principal Component Analysis was then applied to generate a continuous wealth score, which could be categorised into relative wealth quintiles (Vyas & Kumaranayake, 2006).

In this analysis, FIES was first treated as a continuous variable to understand the distribution of the data. FIES data was also analysed using unweighted Rasch modelling in R Studio (version 2025.09.1 + 401). Rasch modelling is the recommended approach within the FAO FIES protocol, ensuring reliable and valid estimated by calibrating the data against the global FIES reference scale (Cafiero et al., 2018; Food and Agriculture Organisation, 2023; Viviani, 2016). This model gave the prevalence of moderate or severe food insecurity ($FI_{mod+sev}$) and prevalence of severe food insecurity ($FI_{sev}$), that can be equated for cross-country, national and regional comparison (Smith et al., 2017).

To calculate a continuous dietary diversity score (DDS), a binary variable for each of the 10 food groups was combined as a sum (Table 2) using the Global Diet Quality Project's analysis tool (Global Diet Quality Project, 2023a). From the DDS, the Minimum Dietary Diversity Score for Women (MDD-W) was calculated as the percentage of women consuming minimum dietary diversity (DDS of 5 or more). The MDD-W can then be compared to national averages for Ghana (Global Diet Quality Project, 2023b). Descriptive statistics of the 10 food groups were also included.

Scores of each of the items to be examined within the physical health SHF-36 dimensions were recoded as per the RAND protocol and averaged to produce continuous scores from 0-100, where higher scores indicate better perceptions of health (Rand Health Care).

A binary multivariate regression model was conducted to determine predictors of severe FI as the data were non-linear and under-dispersed. The dependent variable used FIES as a categorical variable; either 'food secure to moderate food insecurity' (FIES score of less than 7) or 'severe food insecurity' (FIES score of 7 or more), as the data were highly skewed with high levels of severity in the population (Essilfie et al., 2024). Independent variables included age, household size, whether the participant was pregnant or breastfeeding, wealth quintiles, general health perception and energy scores from SHF-36, DDS, knowledge and confidence in climate change score (composite variable using the mean of 2 questions asking participants' confidence that climate change is real, and confidence in their knowledge of climate change), and whether the participant had accessed healthcare due to a nutrition-related condition. The largest group of each categorical variable was used as the reference groups. All assumptions were checked, and univariate models were constructed first to assess the extent to which each covariate independently predicted severe FI. Other covariates not listed, such as education, were discarded from the model here due to multicollinearity. Statistical significance was set at $p = 0.05$

# Ethics

Ethical approval was granted by University of Southampton Faculty of Medicine (ERGO: 99811) and University for Development Studies Research Ethics Committees (Ref No. IRB). Written informed consent was obtained from all participants.

## Results

## Participant Characteristics

Of 384 participants, the mean age was 39 years (SD ± 11.09), ranging from 18–79 years old (Table 3). The largest age group was 30–39 years (n = 153, 39.84%). Over a third of the women were pregnant or breastfeeding (n = 143, 37.24%) and the majority were married (n = 337, 87.76%). Almost all participants were Muslim (99.2%) and of Dagomba ethnicity (95.31%). Most had received no formal education (n = 314, 81.77%), with 12.5% (n = 48) having attended primary or senior high school. Household sizes varied from 1–87 members, with the mean being 13.58 (SD ± 9.03).

When asked about employment status, 54.17% (n = 208) said that they were unemployed, whilst 45.57% (n = 175) described their current status as self-employed. Most participants were engaged in agriculture as their main source of income, either on their own farm (n = 296, 77.28%) or someone else's (n = 83, 21.67%). Other main source of income included trading (n = 25, 6.53%), home duties (n = 16, 4.18%) or education (n = 1, 0.26%). The most owned assets were electricity (n = 371, 96.61%) and mobile phones (n = 305, 79.43%).

Table 3
Participant demographic information for the
household survey.

| Variable | N (%) |
|---|---|
| Number of participants | 384 |
| Age groups | |
| 18–29 | 69 (17.97) |
| 30–39 | 153 (39.84) |
| 40–49 | 89 (23.18) |
| 50–59 | 40 (10.42) |
| 60+ | 33 (8.59) |
| Pregnant or breastfeeding | |
| Yes | 143 (37.24) |
| No | 241 (62.76) |
| Marital Status | |
| Single | 3 (0.78) |
| Married | 337 (87.76) |
| Divorced | 1 (0.26) |
| Widowed | 43 (11.20) |
| Highest level of education | |
| No formal education | 314 (81.77) |
| Primary school | 41 (10.68) |
| Junior high school | 22 (5.73) |
| Senior high school | 7 (1.82) |
| Employment status | |
| Unemployed | 208 (54.17) |
| Self-employed | 175 (45.57) |
| Paid employee (full-time) | 1 (0.26) |
| In education | 1 (0.26) |
| Apprenticeship | 2 (0.52) |
| Main source of income | |
| Agriculture (own farm) | 296 (77.28) |
| Agriculture (someone else's farm) | 83 (21.67) |
| Education (e.g. teacher) | 1 (0.26) |
| Housewife/home duties | 16 (4.18) |
| Trading | 25 (6.53) |
| Other economic activity | 2 (0.52) |

# Prevalence of Food Insecurity

The median FIES score for the population was 8 (LQ = 7, UQ = 8), indicating that the average household within the sample population is severely food insecure. Rasch modelling gave the $FI_{mod+sev}$ at 93.4%, and the $FI_{sev}$ as 52.6%. These percentages are higher than those measured by Ghana Statistical Services (GSS) in rural Northern Region, in the first quarter of 2025 (same time period as our study took place). The GSS data showed $FI_{mod+sev}$ to be 70.7% and $FI_{sev}$ was 29.0% (Table 4). Included in Table 4 below is the prevalence of FI in Sang, Mion (another district within the Northern Region) for comparison, where our research team measured FI in May 2023 at 61.5% $FI_{mod+sev}$.

Looking at the national and regional levels of FI collected by the FAO, Pishigu's FI is far more severe (2021–2023 average): $FI_{mod+sev}$ was 42.4% and $FI_{sev}$ was 8.2% for Ghana's national average. Disaggregated data was available from FAO reports on West Africa for the female and rural populations that showed similar numbers (Table 4). This disparity in FI prevalence between the study population in Pishigu and comparable regional and national averages is displayed in Fig. 2.

Table 4
Prevalence of moderate and severe food insecurity for Pishigu (Karaga District, Northern Region), compared to Sang (Mion District, Northern Region), Northern Region, Ghana, West Africa, Africa, LMIC and global averages. Prevalence rates for Mion district were collected by the research team in a previous study (Boxall J, 2024). Regional data comes from the Ghana Statistical Services (Ghana Statistical Service, 2022b). National data and those for West Africa and Africa by degree of urbanisation and gender were sourced from the FAO, and global prevalence rates were ascertained from the Gallup World Poll (2021–2023) (FAOSTAT, 2023).

| Population | $FI_{mod+sev}$ (%) | $FI_{sev}$ (%) |
|---|---|---|
| **Pishigu, Karaga District, Northern Region (2025)** | | |
| Female | 93.4 | 52.6 |
| **Sang, Mion District, Northern Region (2023)** | | |
| All | 61.5 | 26.4 |
| **Northern Region (Q1, 2025)** | | |
| Rural | 70.7 | 29.0 |
| **Ghana (2021–2023)** | | |
| All | 42.4 | 8.2 |
| **West Africa (2023)** | | |
| Female | 61.7 | 18.8 |
| Rural | 57.0 | 17.0 |
| **Africa (2023)** | | |
| Female | 57.2 | 21.3 |
| Rural | 60.2 | 22.9 |
| **LMIC (2023)** | | |
| Rural | 45.6 | 17.8 |
| **Global (2023)** | | |
| Female | 26.7 | 10.0 |
| Rural | 31.9 | 11.3 |

# Impact of Climate Change

Of 384 participants, 64.58% (n = 248), reported that their FI has been 'getting much worse' over the last 5 years (Table 5). The most frequently reported reasons for this were that participants couldn't afford sufficient food (n = 338, 88.02%), there is a shortage of food items to buy (n = 189, 49.22%), they cannot reach markets due to transport (n = 90, 23.44%) and unexpected weather patterns or events have worsened their FI (n = 68, 17.71%). Nearly all participants (n = 367, 95.57%) had heard of climate change.

Most respondents reported that climate change is adversely affecting each of the four pillars of FI. Regarding availability of food, 83.07% (n = 319) stated that the loss of crops and livestock due to flooding or drought was the most frequently reported effect of climate change experienced, followed by the loss of stocks or less reserves throughout the dry season due to flooding or drought (n = 235, 61.20%). The three largest issues that climate change poses for accessibility of food are: flooding or other weather-related obstructions (n = 226, 58.85%), higher reliance on food aid programmes (n = 163, 42.45%) and climate-related issues with transport of food to markets from farms (n = 184, 47.92%). In terms of climate change impacts on affordability, the most commonly reported effect was reduced income (n = 333, 86.72%), food prices were higher (60.42%, n = 232) and growing fewer crops to sell (51.56%, n = 198). Conversely, 19.53% (n = 75) said that due to climate change, they could afford *more* food. Finally, regarding the utilisation of food, 86.98% (n = 334) of participants stated that climate change has meant that they do not have the capacity to store or preserve more food and 53.14% (n = 204) answered that there is less safe water available.

Just under half of participants (n = 177, 46.09%) grow all of what they eat for the household, whilst the same number 46.09% (n = 177) indicated they grow most of what they eat. Most participants (98.18%) reserve most or all of the food they grow, selling only some. Around half (n = 207, 53.91%) reported that they sell less than they used to 5 years ago.

When asked how confident participants felt in their knowledge of climate change, 74.4% were somewhat or very confident. Additionally, 78.38% were somewhat or very confident that climate change is real, and 69.01% regarded climate change as very important to their livelihood.

Table 5
This table details the different questions that participants were asked with regards to their perception of the impact of climate change on the four pillars of food insecurity (availability, accessibility, affordability, utilisation) on their community, and their responses by percentage.

| Variable | N (%) |
|---|---|
| *Do you feel that your food insecurity has been getting worse over the last 5 years?* | |
| Getting much worse | 248 (64.58) |
| A little worse | 61 (15.89) |
| Stayed about the same | 15 (3.91) |
| A little better | 19 (4.95) |
| Much better | 36 (9.38) |
| I don't know | 3 (0.78) |
| Not recorded | 2 (0.52) |
| *What do you feel is affecting your food insecurity negatively?* | |
| Cannot afford sufficient food | 338 (88.02) |
| Shortage of food items to buy | 189 (49.22) |
| Cannot reach markets due to transport | 90 (23.44) |
| Lack of safe water for preparing food | 42 (10.94) |
| Lack of knowledge for preparing food | 4 (1.04) |
| Inability to store food | 34 (8.85) |
| Unexpected weather patterns or events | 68 (17.71) |
| Other | 1 (0.26) |
| Prefer not to say | 2 (0.52) |
| *How does climate change affect food availability?* | |
| Loss of crops and livestock on own land due to flooding or drought | 319 (83.07) |
| Loss of stocks or less reserves throughout the dry season due to flooding or drought | 235 (61.20) |
| Less food available at the markets | 144 (37.50) |
| Specific food items unavailable (cultural perspective) | 4 (1.04) |
| Pests or disease outbreak destroying crops or livestock | 59 (15.36) |
| Increase in food available | 4 (1.04) |
| It does not affect the amount of food available | 4 (1.04) |
| I don't know | 2 (0.52) |
| Prefer not to say | 1 (0.26) |
| *How does climate change affect your household's ability to access adequate food?* | |
| Issues with transport of food to markets from farms | 184 (47.92) |
| Higher reliance on food aid programmes | 163 (42.45) |
| Cannot physically access food due to flooding or other weather-related obstructions | 226 (58.85) |
| Our ability to access food is improved | 3 (0.78) |
| It does not affect our ability to access food | 9 (2.34) |
| I don't know | 5 (1.30) |
| Prefer not to say | 1 (0.26) |
| *How does climate change affect your household's ability to afford food?* | |
| It affects my income, meaning I cannot afford as much | 333 (86.72) |

| Variable | N (%) |
|---|---|
| I do not grow as much surplus crops to sell | 198 (51.56) |
| Food prices are higher | 232 (60.42) |
| I can afford more food | 75 (19.53) |
| It does not affect our ability to buy food | 4 (1.04) |
| Other | 1 (0.26) |
| Prefer not to say | 1 (0.26) |
| *How does climate change affect your household's ability to utilise the food you have?* | |
| We do not have the capability to store or preserve more food | 334 (86.98) |
| There is less safe water available for preparing foods | 204 (53.12) |
| It has a positive effect on how we can use food | 0 (0.00) |
| It does not affect our ability to use food | 11 (2.86) |
| I don't know | 2 (0.52) |
| Prefer not to say | 1 (0.26) |
| *How much food do you grow for yourself?* | |
| We grow all of what we eat | 177 (46.09) |
| Most of what we eat | 177 (46.09) |
| About half of what we eat | 14 (3.65) |
| A little of what we eat | 12 (3.12) |
| We buy all the food we eat | 2 (0.52) |
| Not recorded | 2 (0.52) |
| *Of the food that you grow, how much do you reserve for your own/community use, and how much do you sell?* | |
| Reserve all the food we grow, sell none | 194 (50.52) |
| Reserve most of the food we grow, sell some | 183 (47.66) |
| Reserve about the same as we sell | 3 (0.78) |
| I don't know | 2 (0.52) |
| Not recorded | 2 (0.52) |
| *Has this changed during the last 5 years?* | |
| We sell more than we used to | 21 (5.47) |
| We sell less than we used to | 207 (53.91) |
| No obvious change during the last 5 years | 147 (38.28) |
| I don't know | 7 (1.82) |
| Not recorded | 2 (0.52) |
| *How confident or unconfident do you feel in your knowledge surrounding what climate change means and what it is caused by?* | |
| Very unconfident | 44 (11.46) |
| Somewhat unconfident | 22 (5.73) |
| Neither confident nor unconfident | 8 (2.08) |
| Somewhat confident | 15 (3.91) |
| Very confident | 272 (70.83) |
| I don't know | 6 (1.56) |
| Not recorded | 17 (4.43) |

| Variable | N (%) |
|---|---|
| *How confident or unconfident are you that climate change is real?* | |
| Very unconfident | 44 (11.46) |
| Somewhat unconfident | 15 (3.91) |
| Neither confident nor unconfident | 3 (0.78) |
| Somewhat confident | 10 (2.60) |
| Very confident | 291 (75.78) |
| I don't know | 4 (1.04) |
| Not recorded | 17 (4.43) |
| *How important is the issue of climate change to you concerning your livelihood activity?* | |
| Not important at all | 42 (10.94) |
| Slightly unimportant | 14 (3.65) |
| Neutral | 30 (7.81) |
| Slightly important | 10 (2.60) |
| Very important | 265 (69.01) |
| I don't know | 6 (1.56) |
| Not recorded | 17 (4.43) |

# Dietary Diversity and Health

The mean Dietary Diversity Score (DDS) was 3.7 (SD ± 1.7), which is lower than both the average of Ghana's rural population (DDS = 4.4) and national average (DDS = 4.5) as reported by the Global Dietary Quality Project in 2021 (Table 7) (Global Diet Quality Project, 2023b).

Table 6
Percentage of participants who have consumed each of the 10 food groups in the 24 hours prior to the survey, as used by the Global Diet Quality Project to analyse the percentage of women consuming the minimum dietary diversity.

| Food Group | % who had consumed this food group in the 24 hours prior to survey |
|---|---|
| Grains, roots & tubers | 91.4 |
| Pulses | 6.0 |
| Nuts or seeds | 73.7 |
| Dairy | 7.8 |
| Meat, poultry & fish | 64.1 |
| Eggs | 4.7 |
| Dark green leafy vegetables | 40.9 |
| Vitamin A-rich fruits and vegetables | 4.2 |
| Other vegetables | 69.0 |
| Other fruits | 5.0 |

The percentage of women consuming minimum dietary diversity (MDD-W) in Pishigu was 30.2%. Again, this is lower than Ghana's overall levels, for both rural areas (43.0%) and nationally (44.0%). Table 6 shows that participants' diets are primarily made up of starchy carbohydrates such as staple grains, roots and tubers (91.4%), nuts or seeds (73.7%), as well as dark green leafy (40.9%) and other vegetables (69.0%), and animal-based proteins (64.1%). Very few women had consumed pulses, dairy products, eggs or fruits in the 24 hours prior to the survey.

Table 7
Dietary Diversity Scores (DDS) for Pishigu
(Northern Region) and nationally,
including by rural population in 2021
(Global Diet Quality Project, 2023b).

| Population | |
|---|---|
| **Pishigu** | |
| DDS, mean (± SD) | 3.7 (± 1.7) |
| MMD-W (%) | 30.2 |
| **Ghana (rural)** | |
| DDS, mean | 4.4 |
| MMD-W (%) | 43 |
| **Ghana (national average)** | |
| DDS, mean | 4.5 |
| MMD-W (%) | 44 |

The mean score for general health perceptions was 56.12 (SD ± 18.23), with a minimum score of 15 and a maximum score of 100 (Table 7). The mean energy score was 54.15 (SD ± 12.47), with a minimum reported score of 15 and a maximum of 85. When asked if participants had seen a doctor or healthcare professional for any nutrition-related health issues, 34.64% (n = 133) said that they had.

Table 8
Average scores of the physical health dimensions for the RAND Short Health Form-36 survey:
general health perceptions, physical functioning, role limitations due to physical health problems
and energy/fatigue.

| Variable | Mean | ±SD | Minimum | Maximum |
|---|---|---|---|---|
| General health perceptions | 56.12 | 18.23 | 15 | 100 |
| Physical Functioning | 71.50 | 32.41 | 0 | 100 |
| Role limitations due to physical health problems | 42.38 | 47.68 | 0 | 100 |
| Energy/Fatigue | 54.15 | 12.47 | 15 | 85 |

# Predictors of Severe Food Insecurity

Multivariate binary logistic regression analysis identified several factors significantly associated with severe FI (Table 9 & Fig. 3). In the univariate model, women aged 40–49 years old had twice the odds of being severely food insecure compared to those who were 30–39 years old (OR = 2.05, 95% CI [1.00, 4.17], $p$ = 0.049). However, no age group was significant in the multivariate model. Larger household size was also associated with increased odds of severe FI (OR = 1.05 per additional member, 95% CI [1.01, 1.08], $p$ = 0.010) in the univariate model, though not in the multivariate. Whilst higher general health scores were associated with lower odds of severe FI in the univariate model (OR = 0.98, 95% CI [0.97, 0.99], $p$ = 0.006), this was no longer the case when adjusted for other covariates. Pregnancy and breastfeeding status was not significantly associated with severe FI in either model.

After adjusting for additional factors in the multivariate model, associations persisted for wealth, energy scores, DDS, climate change knowledge, and nutrition-related healthcare usage. Compared to participants in the lowest wealth quintile (poorest), those in the highest quintile (wealthiest) had 61% lower odds of experiencing severe FI (OR = 0.39, 95% CI [0.16, 0.95], $p$ = 0.039). Each one-point increase in energy score reduced the odds by 3% (OR = 0.97, 95% CI [0.95, 0.99], $p$ = 0.022), and each unit increase in DDS reduced the odds by 23% (OR = 0.77, 95% CI [0.68, 0.87], $p$ < 0.001). Participants who had attended a nutrition-related healthcare visit had significantly increased odds after adjusting for covariates, with nearly five times the odds of being classed as severely FI (OR = 4.67, 95% CI [2.32, 9.40], $p$ < 0.001).

Additionally, greater knowledge and confidence regarding climate change were marginally protective, with lower odds of severe FI (OR = 0.78, 95% CI [0.61, 1.00], $p$ = 0.050).

Table 9

Multivariate binary logistic regression model showing effects of selected characteristics and survey responses on the severity of food insecurity in Pishigu (n = 384). The dependent variable is the binary variable of 'secure to moderate food insecurity' and 'severe food insecurity', as collected by the Food Insecurity Experience Scale.

| | Univariate | | | Multivariate | |
|---|---|---|---|---|---|
| | OR [95% CI] | $R^2$ | *p* | OR [95% CI] | *p* |
| Age (ref. = 30–39 years) | | | | | |
| 18–29 | 0.64 [0.34, 1.19] | 0.03 | 0.157 | 0.71 [0.34, 1.50] | 0.369 |
| 40–49 | 2.05 [1.00, 4.17] | 0.03 | *0.049** | 2.04 [0.89, 4.63] | 0.091 |
| 50–59 | 1.81 [0.70, 4.64] | 0.03 | 0.219 | 1.35 [0.46, 3.94] | 0.585 |
| 60+ | 0.85 [0.36, 1.99] | 0.03 | 0.709 | 0.86 [0.31, 2.36] | 0.771 |
| Household size | 1.05 [1.01, 1.08] | 0.02 | *0.010** | 1.03 [0.99, 1.08] | 0.084 |
| Pregnancy/breastfeeding status (ref. = no) | | | | | |
| Yes | 0.80 [0.49, 1.30] | 0.00 | 0.364 | 0.86 [0.45, 1.61] | 0.628 |
| Wealth quintile (ref. = 1st) | | | | | |
| 2nd | 0.83 [0.34, 2.03] | 0.03 | 0.681 | 0.78 [0.29, 2.08] | 0.613 |
| 3rd | 0.46 [0.21, 1.01] | 0.03 | 0.052 | 0.47 [0.20, 1.12] | 0.087 |
| 4th | 0.51 [0.24, 1.12] | 0.03 | 0.094 | 0.60 [0.25, 1.45] | 0.254 |
| 5th | 0.32 [0.15, 0.68] | 0.03 | *0.003** | 0.39 [0.16, 0.95] | *0.039** |
| General Health score | 0.98 [0.97, 0.99] | 0.02 | *0.006** | 0.99 [0.97, 1.01] | 0.414 |
| Energy score | 0.96 [0.95, 0.98] | 0.03 | *< 0.001** | 0.97 [0.95, 0.99] | *0.022** |
| DDS | 0.82 [0.75, 0.90] | 0.05 | *< 0.001** | 0.77 [0.68, 0.87] | *< 0.001** |
| Knowledge & confidence of climate change | 0.84 [0.68, 1.03] | 0.008 | 0.090 | 0.78 [0.61, 1.00] | *0.050** |
| Nutrition-related healthcare visit (ref. = no) | | | | | |
| Yes | 2.44 [1.37, 4.34] | 0.03 | *0.002** | 4.67 [2.32, 9.40] | *< 0.001** |

Note: The left columns show the results of the variables in univariate regression models. The columns on the right show the multivariate analysis, including beta and P values. All 95% CI's have been rounded to 2 d.p., those which are significant do not cross 1.

*Significant value if p < 0.05.*

# Discussion

# Key Findings & Interpretation

The aim of the research was to understand, from the women in the Pishigu community the level of FI here, why households in the Karaga District continue to experience FI and how climate change is impacting this situation.

$FI_{mod+sev}$ was measured in the study population at 93.4% and $FI_{sev}$ at 52.6%. The median FIES score was 8 (IQR: 7–8), reinforcing the low household variation amongst participants. This demonstrates far higher FI than was measured for the Northern Region in the same quarter, continuing to identify Karaga as a hotspot of FI and a priority for intervention and policy (Ghana Statistical Service, 2022b). A similar study in the Upper East region also reported high levels of FI, finding that female, rural participants reported household FI at 97.2% (Atitsogbey P, 2018). The nature of the study collecting female-only data may also contribute to the reporting of higher FI. Analysis of the 2014–2022 Gallup World Poll data found that women are consistently more likely to experience FI than men, even after controlling for confounders such as income, employment and education (Mane et al., 2025). This is likely to be rooted in gender disparities in agency, time allocation and privileges amongst cultural norms, as was observed in a study in southwestern Ethiopia (Hadley et al., 2008). Cultural practices often prioritise other members of the household first, despite 70% of food growers, 95% of agroprocessing workers and 85% of those who work in food distribution being women in Ghana (Egyir et al., 2023). Nonetheless, women face significant barriers when accessing land, resources, technologies, credit and markets (Food and Agriculture Organisation et al., 2023). These factors contribute to a lack of empowerment, and combined with economic vulnerability, further erode resilience to FI (Odey et al., 2022).

Our results describe how it is likely that climate change is impacting each of the four pillars in the Global Strategic Food Security & Nutrition framework, increasing pressure on communities. The priority issues according to the participants are loss of crops and livestock due to flooding and droughts, with a lack of reserves to buffer the reduction in yield, and an inability to afford food at markets, where there is a shortage of certain items and thus higher food prices. This vicious cycle entraps households with little money and little food, reducing their resilience to any further shocks. Northern Region and the Karaga District has been identified as an area prone to flooding and drought, which disrupts access to markets and health services. A contributory factor to this disruption is the poor quality of the road infrastructure (Ghana Statistical Service, 2022a; Ministry of Food and Agriculture Republic of Ghana, 2011). Prior to the study taking place, a prolonged dry spell occurred when rains were otherwise expected in 2024, which saw high food prices further reduce purchasing power (World Food Programme, 2024). The COVID-19 pandemic had already had a significant impact on food prices before this, pushing food price inflation to 59.3% (World Food Programme, 2023). The aforementioned study in the Upper East region concluded that alterations in the climate are a "hunger-risk multiplier" for those households with entrenched vulnerability (Atitsogbey P, 2018). Figure 4 demonstrates the most pressing issues according to those surveyed amongst the community, and where along the food system they are creating pressure points for FI. As shown, climate change is introducing additional stresses at multiple points along the journey, making it very difficult to continue to adapt and mitigate the issues, especially with limited resources. It is worth noting that around one fifth of participants (19.5%) answered that climate change has meant that they can afford *more* food. This is an important avenue to explore further, since there may be opportunities to learn lessons from those who may have adapted productively, by for instance planting different or drought-resistant crops.

As to be expected with such severe FI among the community, dietary diversity is lower than national averages, with only 30.2% of women meeting the threshold for adequate dietary diversity and eating 5 or more food groups a day. The most consumed food groups were grains, roots, and tubers, nuts and seeds, vegetables and meat and fish. The typical diet of Ghanaian diets is usually made up of large amounts of starchy carbohydrates and animal-based protein. Few women were eating eggs, dairy products and fresh fruits, including those fruits and vegetables rich in Vitamin A. This sub-national variation puts a significant proportion of women at risk of micronutrient deficiencies, and thus immunodeficiency, especially those who are also pregnant or breastfeeding. Nationally, Vitamin A deficiency and anaemia are widespread issues among women, exacerbated by low dietary diversity (Agble et al., 2009). A systematic review investigating dietary diversity and micronutrient adequacy among women of reproductive age in 14 low and middle-income countries (including Ghana), found women typically consume 3 or 4 food groups per day, in line with these results (Islam et al., 2024). According to the World Food Programme (WFP), the drought in 2024 saw a decline in Food Consumption Scores across all food groups, which may be the same picture seen here (World Food Programme, 2024). This may also be interlinked with the mean reported perception of general health, measured at a moderate 56.12 (SD ± 18.23) just above the population-based norm of 50 points, as households experience the health effects of malnutrition. A collaboration between WFP and the Government of Ghana in 2024 found that 55% of the population are unable to meet their basic food needs, and at least 44% of households are unable to afford the cheapest nutritious diet; making it unattainable for households to consume all food groups and a sufficiently nutritious diet to ensure good health (World Food Programme, 2023). A study on women's health in Accra that used the same measure, found a mean general health score of 71.8 (SD ± 19.7), showing a lower perception of general health in this rural community (Frempong-Ainguah et al., 2018). As climate change continues to increase the frequency of these extreme weather events, it also increases the prevalence of certain diseases – such as vector-borne and respiratory diseases – which those who report low DDS are more susceptible to due to compromised immunity (Bush A, 2022; Guleria et al., 2019; Katona & Katona-Apte, 2008).

Wealth, self-reported energy, dietary diversity, knowledge of climate change and nutrition-related healthcare use were all statistically significant predictors of $FI_{sev}$. Whilst it is known that the community has high levels of poverty, even relative wealth here is protective; those women in the 5th quintile are 61% less likely to be severely FI. Those who had a more positive general health score in the univariate model were less likely to be severely FI, though this was no longer statistically significant in the multivariate model. However, a higher health score may be confounded by, and a proxy indicator for, wealth and thus, this effect is minimised when both included in the regression model. For every point increase in the DDS, participants are 23% less likely to be severely FI, though low dietary diversity could also be a consequence of this relationship rather than a driving factor. If women had sought health professional advice related to their nutrition, they were 4.67 times more likely to be severely FI. There are different ways this could be interpreted; this finding could be a good indicator that those who are struggling with their nutrition know where to seek appropriate advice. It could also mean that interventions through the health service would be very effective, and that this could be an efficient way to identify those at most risk in the community. Finally, knowledge and confidence in climate change was a significant predictor of $FI_{sev}$, where for every 1-point increase in the scale, participants were 22% less likely to be severely FI. This could be a proxy indicator for those who are more informally educated; the majority of the study population had received no formal education, however it is well documented that education plays a protective role against FI, increasing employment opportunities, empowerment and economic agency among women (Amugsi et al., 2016; Essilfie et al., 2024). The protective effect of knowledge of climate change against FI was also documented in our research in Mion District, Northern Region, and aligns with IPCC findings and other literature that community-based education and knowledge on clime change can improve FI (Boxall J, 2024; Intergovernmental Panel on Climate Change, 2022; Mohammed et al., 2021). Giving agriculturally dependent communities the tools and knowledge regarding climate change and how to adapt can improve resilience and protect against negative coping strategies such as reducing consumption (Mohammed et al., 2021).

Age was not found to be a significant predictor of severe FI in contrast to other research; analysis by Mane showed that those up to the age of 34 years old were more at risk of FI, whereas those over the age of 65 were more protected. Here, despite the lack of significance, we see that 18–29 and 65 + years were both more at risk of being severely FI (Mane et al., 2025). However, this could be due to the homogenous nature of the dataset, where the distribution of FI is skewed to severe levels.

Overall, the picture of FI in Karaga District continues to be very alarming, despite already being identified as a priority. Increasing resilience within these rural communities should be of utmost importance for future interventions (Kernoe et al., 2022).

## Generalisability

Whilst there may be limited external validity of the study results, the findings here are still very applicable to similar settings. The population here is experiencing high levels of poverty, low literacy rates and a high proportion of the community are dependent on agriculture for food and income. These characteristics are true of many other communities across northern Ghana and beyond its borders, where they are also experiencing the effects of climate change and alarming levels of FI. In the Upper East region of Ghana, there is severely high levels of FI according to female rural participants, demonstrating similar entrenched vulnerability in other regions (Atitsogbey P, 2018). Our framework proposed here can be a useful tool to identify where in the food system targeted interventions may be most useful at improving resilience to climatic stresses and shocks.

## Implication

FI and climate change are significant public and global health threats independently, and even more so when communities are facing the consequences both. This study is important in raising the profile of females within rural, under-served communities and increasing their visibility and insight to decision-makers. From the findings, we can understand that the FI and subsequent health and dietary diversity of the community is alarming. There are other communities within the Karaga District and the Northern Region who will be facing the same challenges as described in this study. Ghana Statistical Services report that 30.7% of all FI in Ghana is concentrated in the Northern Region, demonstrating the need for further consideration of these communities in national agricultural and nutrition policies (Ghana Statistical Service, 2022a). Combined with less development than the southern regions, and increased economic inequalities, the northern areas of Ghana are far more vulnerable to climatic events (World Bank, 2024). Results showed that whilst most households were struggling financially, 79.83% of households had access to a mobile phone. With the rise in digitisation in Ghana, there is perhaps potential for digital intervention that increases community cohesion and improves FI.

Thus, if Ghana is to make progress towards the UN SDGs for FI and climate action, such evidence should be considered in future strategies. Globally, countries are not on track to reach any of the 7 nutrition targets by 2030, highlighting the need to pivot how policies are currently designed and ensure those most under-served are not left behind (FAO, 2024). If, as in Ghana, women make up the majority of the workforce that provides the food, their perspectives should be considered in order to protect national food production from climatic disruptions. We have seen from this study that improving knowledge of climate change is protective against severe FI, yet most participants have not accessed formal education. Integrating climate education into community programmes is a clear area for intervention, giving women the tools to make informed decisions to mitigate climate effects whether that be agriculturally-related or to diversify the sources of household income as protection. However, at a national level this is encompassed in the pressing need to improve social and economic inclusion and empowerment, including access to education for girls in rural areas (Caulker C, 2023); implementing gender-sensitive policies that eliminate disparities in education, income and labour force participation could close 52% of the global gender gap in FI (Mane et al., 2025). This further demonstrates the importance of considering studies that concentrate on female voices to improve community resilience and wellbeing; the evidence base agrees that addressing gender dynamics and improving the socioeconomic standing of women are central to improving household resilience against FI (Kiewisch, 2015; UN Women, 2023).

In the WFP Strategic Plan for Ghana (2024–2028), both gender and climate change are mentioned in the strategic outcomes, acknowledging that both gender-sensitive and climate-informed strategies are the key to improving FI and inadequate nutrition. However, most of the government's national policies on climate change are focused on sustainable urban development, rather than the needs of the rural under-served communities. Recently, the Ghana Ministry of Health included climate and health within their research agenda, with FI featuring as a priority, demonstrating the increased governmental focus (Boxall J, 2025). In this study, the community have identified key areas where climate change is impacting their local food system, providing clear direction for future policy and interventions (Fig. 4). Increased access to, and strengthening, infrastructure would help to lessen inequalities for under-served communities; irrigation systems would improve crop yields during future droughts, and improved durability of roads would enable enhanced links between remote communities for food distribution and possibly ease shortages (including aid). Understanding robust storage needs to preserve more food during extreme weather and the lean season would increase the stability of household FI. Finally, nationally the government could consider economic intervention, such as price control and subsidies for traders, to prevent spikes in food prices during times of crisis.

Another dimension to consider is the negative cycle by which women are most affected by FI, which will impact their health negatively and their capacity to work. The findings here have shown the low percentage of women who are achieving sufficient dietary diversity, and so we can hypothesise that many women are suffering with micronutrient deficiencies that will be impacting their energy and ability to function well day-to-day. The logistic regression model indeed showed that those respondents with higher energy scores were less likely to be severely FI. Coupled with the finding that those who accessed the healthcare service for a nutrition-related issue were more likely to be FI, there is potential for effective intervention via community healthcare providers. It is vital to improve these low levels of dietary diversity to prevent further vulnerability to poor

health, and impacts on future offspring for those who are pregnant. It is important to note that there have been previous interventions in the Karaga District that do attempt to address these deficiencies that it would be imperative to learn from for future interventions. However, the biggest shortfall for organisations such as the WFP and in fact, globally at present, is secure and sustainable funding. Many projects are closing or have limited resources due to a lack of funding, exacerbated in the current economy with the loss of USAID.

The researchers designed a conceptual framework (see Fig. 5) that can be used to understand similar issues in other communities, and take into account both the current literature and the priorities the community identified.

## Limitations

The main limitation of the study is the cross-sectional design, which limits the ability to determine any causal inference. A longitudinal design that encompasses seasonal variations would enable this. Furthermore, the sample size and geographical limit to one community limits external validity. On this occasion the community was purposively selected, to ensure the criteria of the study design was met, and to enable community entry through the Health Directorate. Future research could scale up the study and increase the scope to other randomly selected communities to reduce selection bias.

Whilst the survey was co-created with local researchers, increasing contextual relevance, the survey tool was designed in English due to time constraints and language capacity of the research team. Whilst the data collectors were able to speak both English and the local language of Dagbani for delivery, and also received training on the survey, it would allow for a higher level of accuracy if the electronic data capture tool were to also be in the local language. As the methodology meant that all outcomes and exposure variables were self-reported, this does increase the possibility of recall bias, affecting validity. Limiting the recall period for future questionnaires could mitigate this, though it would not reflect seasonal variability if the FIES was shortened to below 12 months (Binyaruka & Borghi, 2018). Finally, further relevant covariates beyond the scope of this survey could be explored and added to the regression model to improve the fit.

## Next Steps

To expand the initial knowledge base here, future research could deploy the survey to other areas within Karaga District of rural, peri-urban and urban type, as well as beyond the Northern Region to measure differences. Furthermore, the survey could be conducted with both men and women, and include the Women's Empowerment in Agriculture Index to understand further gender disparities within communities (Egyir et al., 2023). Other quantifiable measures of resilience could also be incorporated to explore households' ability to respond to the climate stresses identified in this study. Finally, further routine health data and biosamples could be collected to supplement the self-reported information in this study. For instance, anthropometric data and blood samples could highlight both malnutrition, and more subtle forms of nutritional deficiency due to hidden hunger (Coomson et al., 2025). Routine health data would also help us to understand the nature of the healthcare visits that women attend, as they seem to be such a substantial indicator of severe FI, and also to provide more evidence for the varied self-reported health status that were given in this study.

## Conclusion

This study highlights the alarming severity of FI in Pishigu, Karaga District, and the role that climate change has in increasing household vulnerability to inadequate nutrition. With the overwhelming majority of participants experiencing moderate or severe food insecurity, and just under a third meeting minimum dietary diversity requirements, these findings underscore the urgent need for targeted interventions to improve both FI and the subsequent effects on health. Climate change is exacerbating vulnerabilities across all four pillars of FI, exacerbated by the complex nexus between these issues and gender inequality. Empowering women within rural communities through knowledge exchange and climate awareness is essential to improving resilience. As Ghana strives towards achieving the SDGs, future policy and intervention to improve FI must be climate-informed, community-driven and gender-sensitive to ensure sustainable progress for the Karaga District.

## Declarations

## Funding

Compliance with Ethical Standards

The authors have no competing interests to declare that are relevant to the content of this article. Informed consent was given by all participants.

## Author Contributions

Boxall was responsible for conceptualisation, data curation, formal analysis, writing the original draft, visualisation, project administration and funding acquisition. Bird was responsible for methodology, analysis and writing (review and editing). Brown contributed to writing the original draft of the manuscript. Head acted as supervisor and contributed to writing (review and editing). Malle Abdulai and Shani were responsible for resources locally, project administration and methodology, supervision and writing (review and editing). Mogre supervised and edited the manuscript. Gaa was involved with conceptualisation and methodology, investigation and resources, writing (review and editing), and project administration.

# Acknowledgements

# Data Availability Statement

The data that support the findings of this study are available at: https://doi.org/10.6084/m9.figshare.30933212

# References

1. Afreh OK, Angwaawie P, Attivor EJK, Boateng LA, Brackstone K, Head MG, Manyeh AK, Vidzro GAA (2023) Examining confidence and hesitancy towards COVID-19 vaccines: A cross-sectional survey using in-person data collection in rural Ghana. Vaccine 41(13):2113–2119. https://doi.org/doi.org/10.1016/j.vaccine.2023.02.024

2. Agble R, Bader E, Solal-Celigny A, Palma G, Dop C (2009) M. *Nutrition Country Profile: Republic of Ghana*. https://www.moh.gov.gh/wp-content/uploads/2016/02/Nutrition-Country-Profile-Ghana.pdf

3. Akudugu MA, Dittoh S, Mahama S (2012) The Implications of Climate Change on Food Security and Rural Livelihoods: Experiences from Northern Ghana. J Environ Earth Sci 2(3):21–29

4. Amugsi DA, Lartey A, Kimani E, Mberu BU (2016) Women's participation in household decision-making and higher dietary diversity: findings from nationally representative data from Ghana. J Health Popul Nutr 35(1):16. https://doi.org/10.1186/s41043-016-0053-1

5. Atitsogbey P, Steiner-Asiedu M, Nti C, Ansong R (2018) The impact of climate change on household food security in the Bongo District of the Upper East Region of Ghana. Ghana J Agricultural Sci 52:145–153. https://www.ajol.info/index.php/gjas/article/view/179661

6. Binyaruka P, Borghi J (2018) Validity of parental recalls to estimate vaccination coverage: evidence from Tanzania. BMC Health Serv Res 18(1):440. https://doi.org/10.1186/s12913-018-3270-z

7. Boxall J, Abugri AB, Amoore B, Ayichuru B, Brackstone M, Dotse-Gborgbortsi K, Fothergill-Misbah W, Kunc N, Miah M, Tweneboah K, Wright E, Head J, Mogre M V (2024) Associations between Perceived Climate Change and Food Insecurity in a Last Mile District of Rural Ghana: A Mixed-Methods Study. SSRN Lancet 121. https://doi.org/http://dx.doi.org/10.2139/ssrn.4965932

8. Boxall J, Atengble AE, Dotse-Gborgbortsi K, Head W, Atiwoto M (2025) W. *Addressing climate change and health in Ghana and West Africa: a Summit report*

9. Bush A, Wrottesley S, Mates E, Fenn B (2022) *Nutrition and Climate Change - Current State of Play: Scoping Review*. https://www.ennonline.net/nutritionandclimatechange

10. Cafiero C, Viviani S, Nord M (2018) Food security measurement in a global context: The food insecurity experience scale. Measurement 116:146–152. https://www.sciencedirect.com/science/article/pii/S0263224117307005

11. Caulker C, Oduah EJ, Siddiky A (2023) A E. 30 March 2023). To Reach Gender Equality Ghana Needs to Prioritize Social and Economic Inclusion. https://blogs.worldbank.org/en/nasikiliza/reach-gender-equality-ghana-needs-prioritize-social-and-economic-inclusion

12. De Constantin G, Cazelles B, Guegan JF (2006) Cholera threat to humans in Ghana is influenced by both global and regional climatic variability. *EcoHealth*, *3(4)*, 223–231. https://doi.org/https://dx.doi.org/10.1007/s10393-006-0061-5

13. Coomson JB, Smith NW, McNabb W (2025) Impacts of Food Fortification on Micronutrient Intake and Nutritional Status of Women of Reproductive Age in Africa-A Narrative Review. Adv Nutr 16(7):100463. https://doi.org/10.1016/j.advnut.2025.100463

14. Darko R, Adanu RM, Duda RB, Douptcheva N, Hill AG (2012) The health of adult women in Accra, Ghana: self-reporting and objective assessments 2008–2009. Ghana Med J 46(2):50–57

15. Duncan BA (2004) *Women in Agriculture in Ghana* (2 ed.). https://library.fes.de/pdf-files/bueros/ghana/03695.pdf

16. Egyir IS, O'Brien C, Bandanaa J, Opit GP (2023) Feeding the future in Ghana: Gender inequality, poverty, and food insecurity. World Med Health Policy 15(4):638–671. https://doi.org/https://doi.org/10.1002/wmh3.578

17. Essilfie G, Sebu J, Baako-Amponsah J (2024) Does Women's Empowerment Matter for Household Food Security? Evidence From Northern Ghana. Sage Open 14(2):21582440241245076. https://doi.org/10.1177/21582440241245076

18. FAO I, WHO (2024) UNICEF, WFP,. *The State of Food Security and Nutrition in the World 2024: Financing to End Hunger, Food Insecurity and Malnutrition in All its Forms*

19. FAOSTAT (2023) *Food Insecurity Indicators*

20. Food and Agriculture Organisation (2023) Food Insecurity based on the FIES. In Hunger and Food Insecurity (Ed.), *Food and Agriculture Organisation*. Rome

21. Food, Organisation A, International Fund for Agricultural Development, United Nations Children's Fund, World Food Programme, & World Health Organisation, UNICEF, WFP, WHO (2022). *The State of Food Security and Nutrition in the World 2022. Repurposing food and agricultural policies to make healthy diets more affordable.* (The State of Food Security and Nutrition in the World (SOFI), Issue. I. FAO,. https://www.fao.org/3/cc0639en/online/sofi-2022/food-security-nutrition-indicators.html#:~:text=SOURCE%3A%20FAO.,Table%203%20and%20Table%204)

22. Food, Organisation A, International Fund for Agricultural Development, United Nations Children's Fund, World Health Organisation, WHO (2023), World Food Programme, & *The State of Food Security and Nutrition in the World 2023. Urbanisation, agrifood systems transformation and healthy diets across the rural-urban continuum.* (The State of Food Security and Nutrition in the World (SOFI), Issue. I. FAO, UNICEF, WFP,. https://www.fao.org/3/cc3017en/cc3017en.pdf

23. Frempong-Ainguah F, Bailey CE, Hill AG (2018) Women's health status in urban Ghana: dimensions and differentials using short form 36. Health Qual Life Outcomes 16(1):74. https://doi.org/10.1186/s12955-018-0894-y

24. Ghana Statistical Service (2021) *2021 Population and housing census: Karaga District analytical report* [Census Report]. G. S. Service. https://statsghana.gov.gh/gssmain/fileUpload/pressrelease/Karaga.pdf

25. Ghana Statistical Service (2022a) *Food Insecurity is Concentrated in the Five Regions in the Northern part of Ghana*. https://www.statsghana.gov.gh/infobankdetails.php?infobank=MTg3Mzc5MDg0Ni43MzE1/infodesk/20q928qr2p

26. Ghana Statistical Service (2022b) Ghana Anual Household Income and Expenditure Survey: Quarterly Food Insecurity Report. Ghana Stat Service. https://www.statsghana.gov.gh/gssmain/fileUpload/pressrelease/AHIES%202022%20Q1%20and%20Q2%20Food%20Insecurity%20Report.pdf

27. Global Diet Quality Project (2021) *Ghana: Diet Quality Profile*. http://www.dietquality.org./countries/gha

28. Global Diet Quality Project (2023a) *Diet Quality Questionnaire (DQQ) Indicator Guide*. https://www.dietquality.org/calculators

29. Global Diet Quality Project (2023b) *DQQ data 2021–2023*. https://www.dietquality.org/indicators

30. Gnisci D (2016) Women's Roles in the West African Food System: Implications and Prospects for Food Security and Resilience. West Afr Papers 3https://doi.org/https://doi.org/10.1787/5jlpl4mh1hxn-en

31. Guleria R, Mathur V, Dhanuka A (2019) Health effects of changing environment. Nat Resource Management: Ecol Perspect [Internet] 95–107. Retrieved 25 May 2023, from

32. Hadley C, Lindstrom D, Tessema F, Belachew T (2008) Gender bias in the food insecurity experience of Ethiopian adolescents. Soc Sci Med 66(2):427–438. https://doi.org/https://doi.org/10.1016/j.socscimed.2007.08.025

33. Intergovernmental Panel on Climate Change (2014) *Climate Change 2014: Synthesis Report (Longer Report). Contribution of Working Groups II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.*

34. Intergovernmental Panel on Climate Change (2022) Chapter 5: *Food Security* (9781009157988). (Climate Change and Land: IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems, Issue. https://www.cambridge.org/core/product/AB0D996CA6E915F6EAF7A2EEB77AD09D

35. Islam MH, Nayan MM, Jubayer A, Amin MR (2024) A review of the dietary diversity and micronutrient adequacy among the women of reproductive age in low- and middle-income countries. Food Sci Nutr 12(3):1367–1379. https://doi.org/10.1002/fsn3.3855

36. Jost C, Kyazze F, Naab J, Neelormi S, Kinyangi J, Zougmore R, Aggarwal P, Bhatta G, Chaudhury M, Tapio-Bistrom ML, Nelson S, Kristjanson P (2016) Understanding gender dimensions of agriculture and climate change in smallholder farming communities [Article]. Climate Dev 8(2):133–144. https://doi.org/10.1080/17565529.2015.1050978

37. *Karaga District Composite Budget 2024*. Ministry of Karaga District Assembly, Ghana F (2024) https://mofep.gov.gh/sites/default/files/composite-budget/2024/NR/Karaga.pdf

38. Katona P, Katona-Apte J (2008) The Interaction between Nutrition and Infection. Clin Infect Dis 46(10):1582–1588. https://doi.org/10.1086/587658

39. Kernoe L, Mitra P, Okou C, Filiz Unsal D (2022) 9th December 2023). How Africa Can Escape Chronic Food Insecurity Amid Climate Change [Internet]. *International Monetary Fund*. https://www.imf.org/en/Blogs/Articles/2022/09/14/how-africa-can-escape-chronic-food-insecurity-amid-climate-change

40. Kiewisch E (2015) Looking within the household: a study on gender, food security, and resilience in cocoa-growing communities. Gend Dev 23(3):497–513. https://doi.org/10.1080/13552074.2015.1095550

41. Mane E, Macchioni Giaquinto A, Cafiero C, Viviani S, Anríquez G (2025) Closing the gender gap in global food insecurity: Socioeconomic determinants and economic gains in the aftermath of COVID-19. Global Food Secur 45:100850. https://doi.org/https://doi.org/10.1016/j.gfs.2025.100850

42. Ministry of Food and Agriculture Republic of Ghana (2011) *Karaga*. https://mofa.gov.gh/site/directorates/district-directorates/northern-region/258-karaga

43. Mohammed K, Batung E, Kansanga M, Nyantakyi-Frimpong H, Luginaah I (2021) Livelihood diversification strategies and resilience to climate change in semi-arid northern Ghana [Article]. Clim Change 164(3–4) 23, Article 53. https://doi.org/10.1007/s10584-021-03034-y

44. Odey GO, Adegbite MA, Denkyira SA, Alhaj SM, Lucero-Prisno DE (2022) Chapter Two - Women and food security in Africa: The double burden in addressing gender equality and environmental sustainability. In M. J. Cohen (Ed.), *Advances in Food Security and Sustainability* (Vol. 7, pp. 35–59). Elsevier. https://doi.org/https://doi.org/10.1016/bs.af2s.2022.07.001

45. Rand Health Care *36-Item Short Form Survey (SF-36) Scoring Instructions*. https://www.rand.org/health-care/surveys_tools/mos/36-item-short-form/scoring.html

46. Smith MD, Rabbitt MP, Coleman-Jensen A (2017) Who are the World's Food Insecure? New Evidence from the Food and Agriculture Organization's Food Insecurity Experience Scale. World Dev 93:402–412. https://doi.org/https://doi.org/10.1016/j.worlddev.2017.01.006

47. UN Women (2023) *Gendered analysis of the impact of climate change on poverty, productivity and food insecurity*. https://data.unwomen.org/publications/gendered-analysis-impact-climate-change-poverty-productivity-and-food-insecurity

48. UNICEF Chapter 6: Conducting the Field Work. In *Multiple-Indicator Survey Handbook* (p. 15). https://mics.unicef.org/sites/mics/files/chap06.pdf

49. United Nations Committee on World Food Security (CFS) (2017) *Global Strategic Framework for Food Security & Nutrition (GSF)*. https://openknowledge.fao.org/server/api/core/bitstreams/6f4569fa-44d7-49ef-80f8-6dbefba76bfe/content

50. Viviani S (2016) *Manual for the implementation of the FAO Voices of the Hungry methods to estimate food insecurity: RM.weights packae in R*.

51. Vyas S, Kumaranayake L (2006) Constructing socio-economic status indices: how to use principal components analysis. Health Policy Plann 21(6):459–468. https://doi.org/10.1093/heapol/czl029

52. World Bank (2011) *Vulnerability, Risk Reduction and Adaptation to Climate Change: Ghana*. http://sdwebx.worldbank.org/climateportalb/doc/GFDRRCountryProfiles/wb_gfdrr_climate_change_country_profile_for_GHA.pdf

53. World Bank (2024) Bridging the divide: Insights into Regional Poverty and Inclusion in Ghana. World Bank. https://documents1.worldbank.org/curated/en/099060524110822074/pdf/P179858163db7405d1aa991a202aeb31866.pdf

54. World Food Programme (2023) *Ghana Country Strategic Plan (2024–2028)*. https://docs.wfp.org/api/documents/WFP-0000151708/download/?_ga=2.133820491.471367067.1745492727-527721798.1745492727

55. World Food Programme (2024) *Ghana Annual Country Report 2024*. https://docs.wfp.org/api/documents/WFP-0000165361/download/?_ga=2.98694235.471367067.1745492727-527721798.1745492727#page=12.12

56. Ziblim S-D, Mogre V, Kpebu S, Amoore B, Abugri BA, Sison R, Boateng L, Vedathan R (2022) *Public Perception of the Health and Social Risks of Extreme Heat in Northern Ghana*
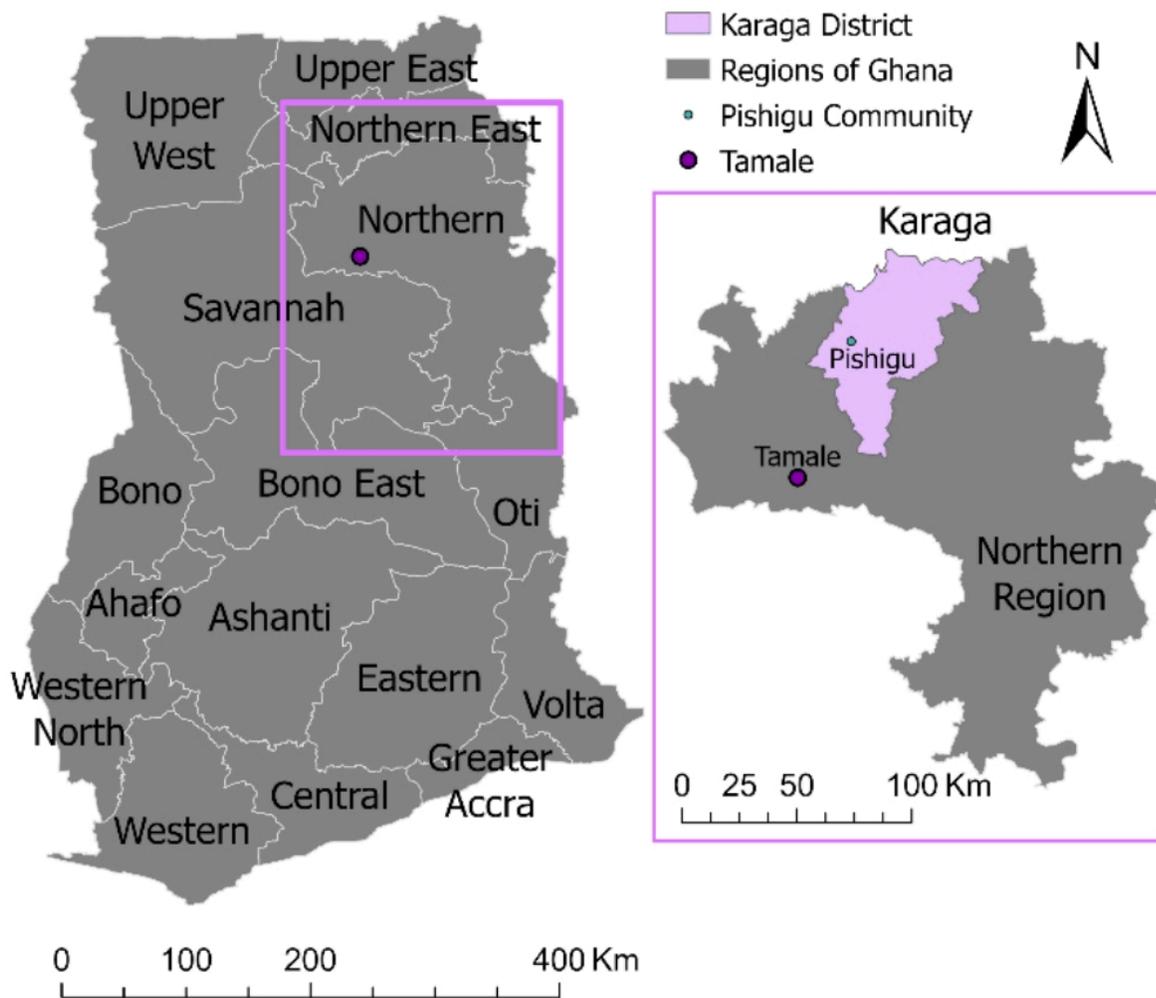
# Figures

**Figure 1**

Map showing the Pishigu community within the Karaga District and Ghana, created by Gracie Horton at the University of Southampton. Sources: Ghana Statistical Services (2025) Ghana – Subnational Administrative Boundaries. Available at: https://data.humdata.org/dataset/cod-ab-gha
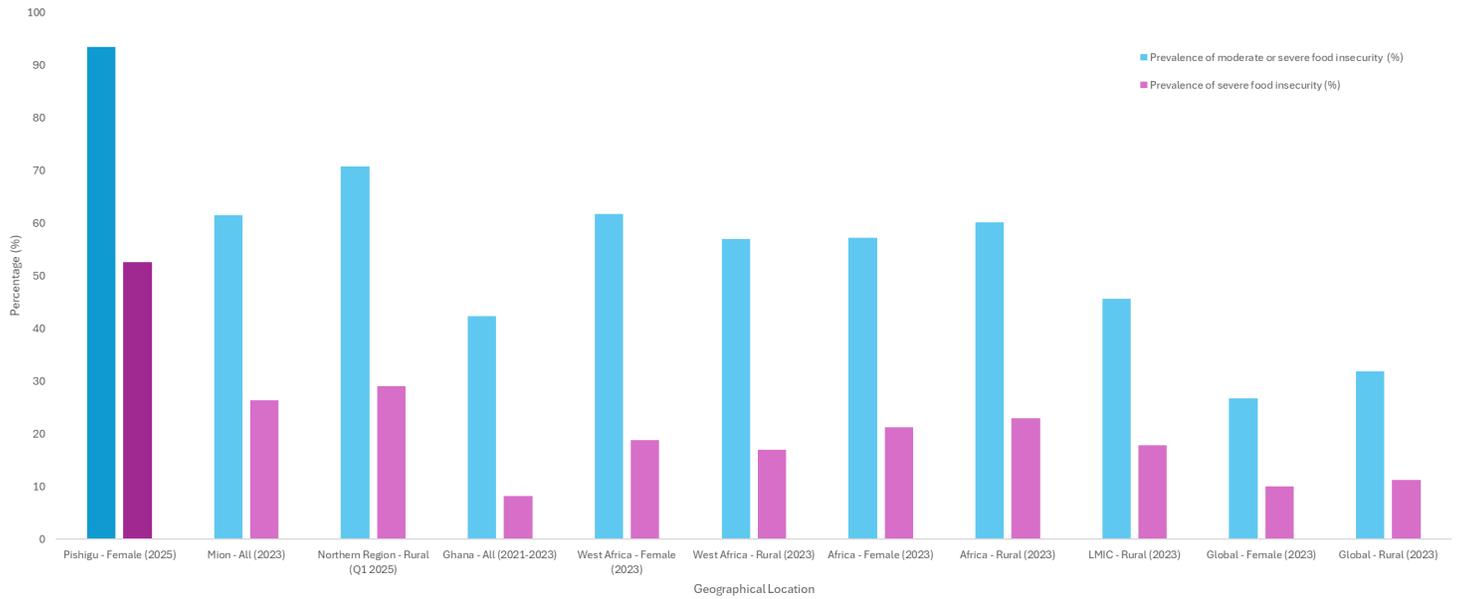
**Figure 2**

Prevalence of moderate and severe food insecurity for Pishigu (Karaga District, Northern Region), compared to Sang (Mion District, Northern Region), Northern Region, Ghana, West Africa, Africa, LMIC and global averages. Prevalence rates for Mion district were collected by the research team in a previous study (Boxall J, 2024). Regional data comes from the Ghana Statistical Services (Ghana Statistical Service, 2022b). National data and those for West Africa and Africa by degree of urbanisation and gender were sourced from the FAO, and global prevalence rates were ascertained from the Gallup World Poll (2021-2023) (FAOSTAT, 2023).
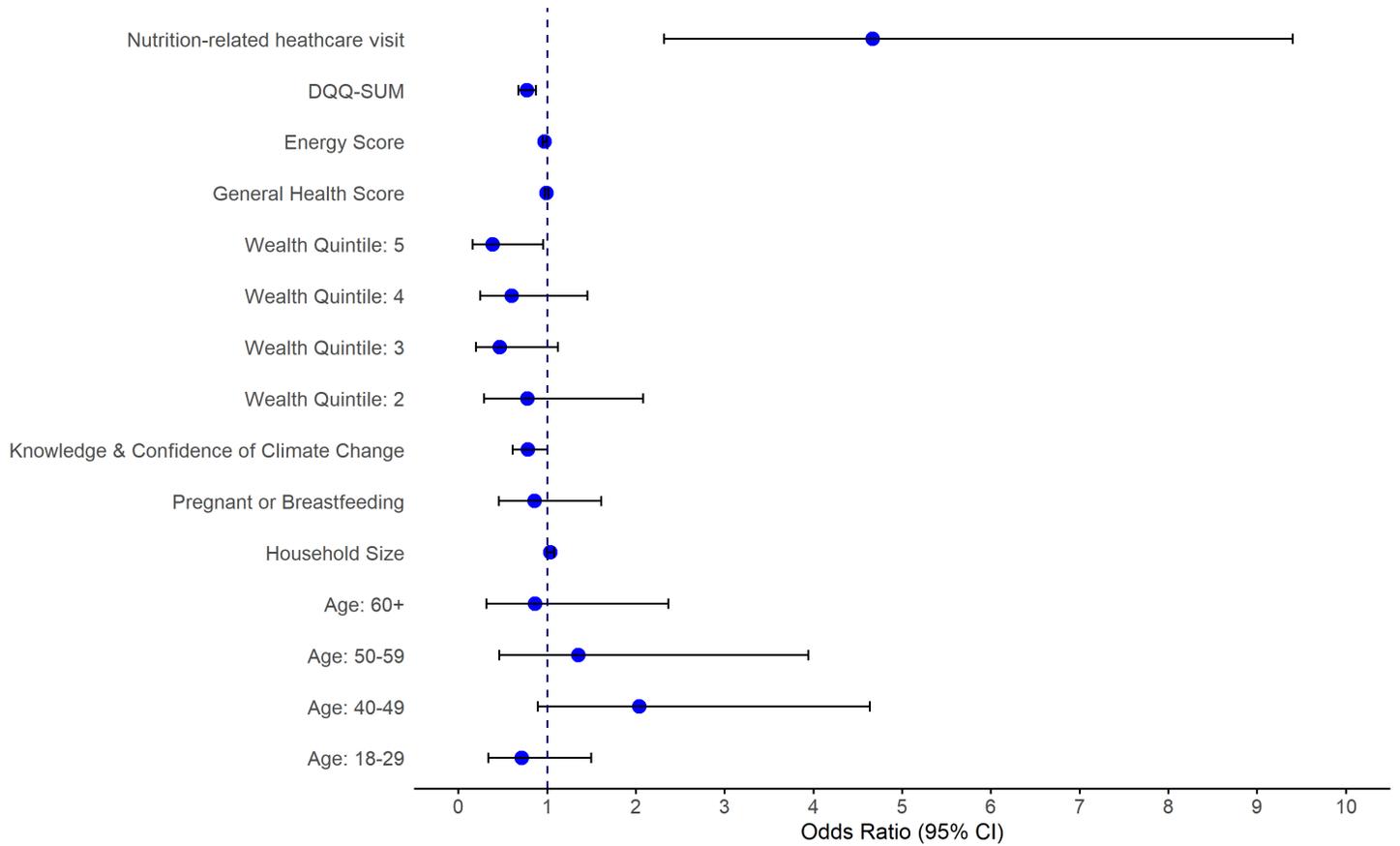


**Figure 3**

Forest plot of multivariate binary logistic regression model showing effects of characteristics, knowledge of climate change and nutrition-related use of healthcare on severe food insecurity.
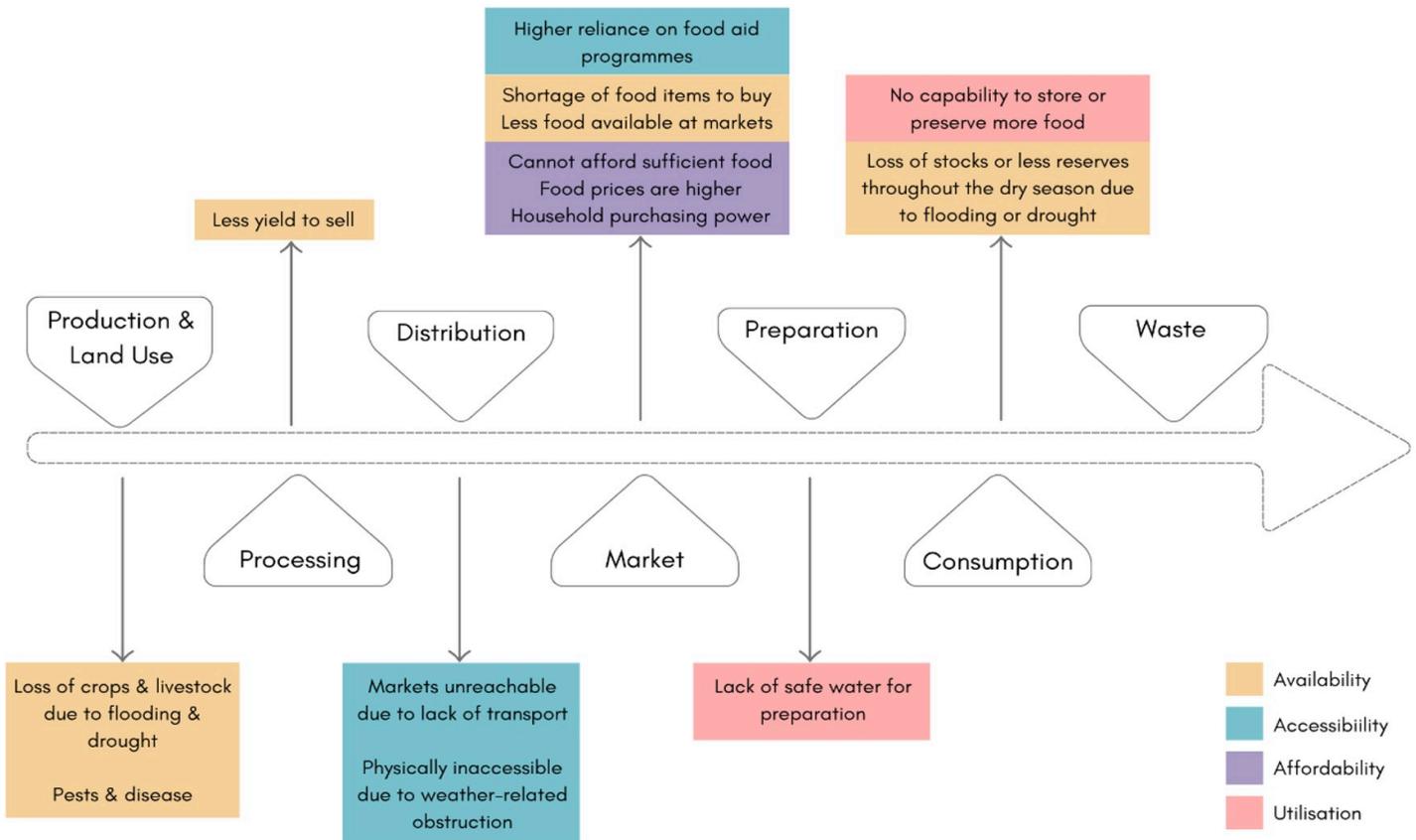


**Figure 4**

Visual representation of the most pressing issues climate change presents to household food insecurity by survey response, aligned with the stages of the local food system and the four pillars of food insecurity: availability (yellow), accessibility (blue), affordability (purple) and utilisation (red).
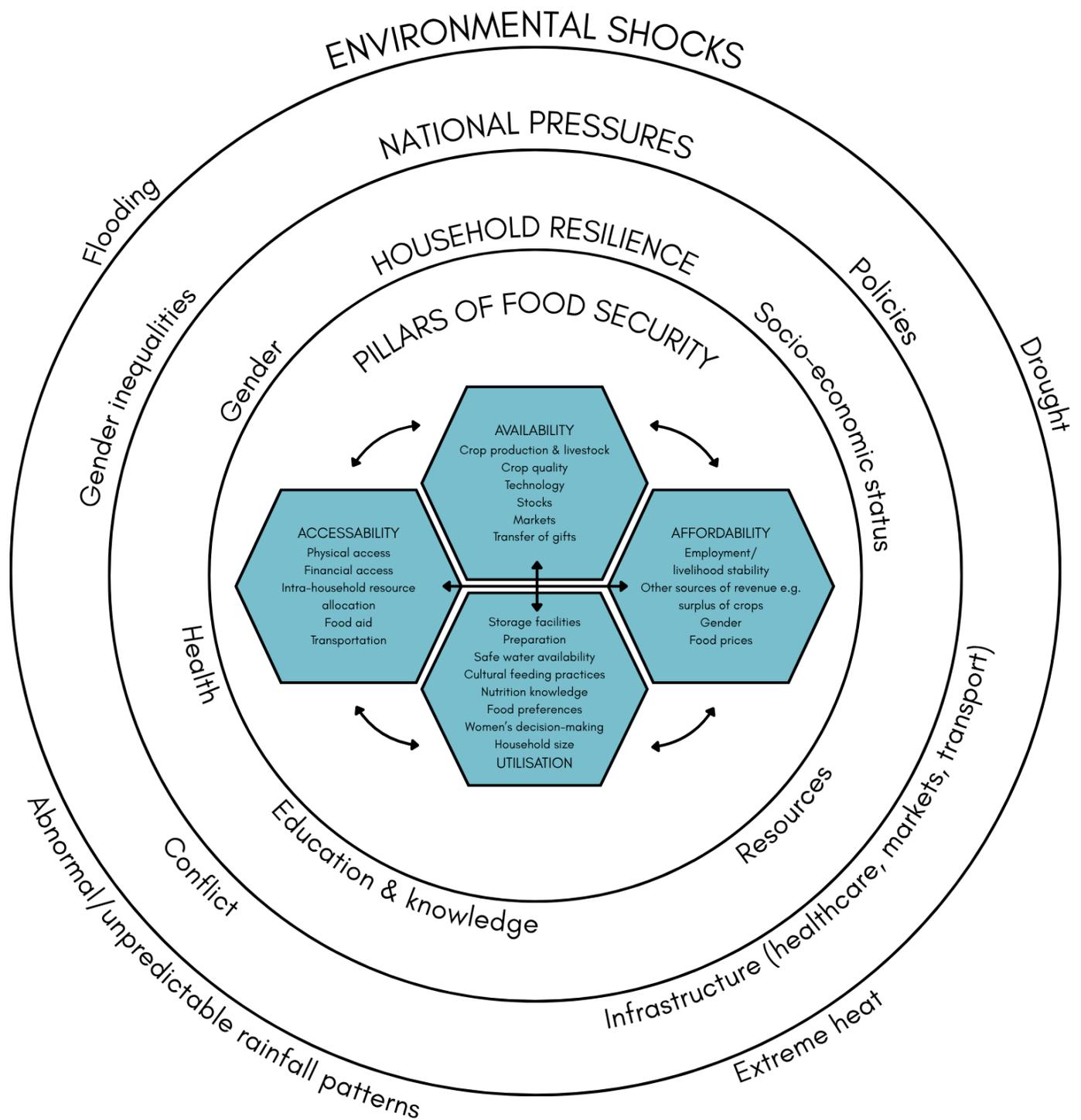
**Figure 5**

Conceptual framework depicting the four pillars of food insecurity, how they affect one another, and the external pressures that impact household resilience, factors influencing national pressures and the environmental shocks that exacerbate these issues.

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Appendix.pdf