Associations between perceived climate change and food insecurity in a Last Mile district of rural Ghana: a mixed-methods study

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Abstract

Background
West Africa, including Ghana, is a climate change hotspot, experiencing unpredictable rainfall, and extreme weather. Rural Ghana is especially vulnerable, where poverty, and dependence on climate-sensitive activities mean that under-served communities have less capacity to withstand climate shocks. This threatens food security and health.

Methods
This May 2023 study investigated associations between perceived impacts of climate change and household food insecurity in Mion district (Northern Region, Ghana). Participant data came from surveys (n=397) and focus groups (n=16). Rasch modelling analysed Food Insecurity Experience Scale data, compared with national and international data. Multivariate regression identified food insecurity predictors and associations with self-reported knowledge of climate change. Thematic analyses described the focus groups. Geospatial analysis compared pre-survey and long-term precipitation patterns.

Findings
Prevalence of moderate or severe food insecurity Mion is 61.5%, with 26.4% severe, both higher than 2023 national and global prevalence. Monthly precipitation during the survey recall period was similar to preceding 20 years. Nearly all (99.95%) reported climate change was negatively affecting household food supply, and 75.6% perceived climate change has affected their health. Larger households, 20–29-year-olds, unemployment, and those with weaker climate knowledge experienced greater food insecurity (p<0.05). Focus groups reinforced these findings, adding that bush-burning is an urgent problem.

Interpretation
Participants feel that high food insecurity is worsening due to climate change. The most food insecure participants reported lowest climate knowledge, potentially exacerbating their inability to respond. Decision-makers must consider specific challenges that agriculture-dependent areas face to their nutrition and health.

Funding
University of Southampton.

Research in Context

Evidence before this study

There is limited evidence on the prevalence of food insecurity in 'Last Mile' populations, and how these communities perceive climate change to be impacting upon their health. The Last Mile population in question here is Mion, Northern Region, Ghana. The authors searched Medline, Embase and Web of Science, using the terms "food security" (including "food insecurity" and "nutrition"), "climate change" and "Ghana" (also looking at papers and reports that focused on West Africa), with no language restrictions, from 15th June 2002 to 15th June 2024. Studies investigating the impact of climate change, or climate-induced disasters, on adult populations' food security in rural Ghana were reviewed. Previous studies investigated the quantitative effects of climatic changes on crop production and food availability, and do not provide sufficient evidence of community opinion and perceptions.

Added value of this study

This mixed-methods research comprises of quantitative, qualitative and geospatial analysis to emphasise the findings and their robustness. Within the quantitative data, the prevalence of food insecurity has been measured via a validated tool from the Food and Agriculture Organisation, widely used for monitoring the Sustainable Development Goals focused on hunger. There is limited literature using this tool in rural communities within West Africa. However, the main added value of this study is the voice this research gives to the Last Mile population here. The findings are centred around the perceptions and attitudes of the community in Mion; these Last Mile communities rarely receive a voice in research, and their experiences are not well considered in policymaking. As climate change worsens, and their food insecurity and health become increasingly threatened, it is vital that research considers their priorities and needs.

This does not just apply to Mion, but all similar communities across the globe who are dependent on subsistence agriculture for their livelihoods and consumption, and who are under-served and under-developed. For instance, across northern Ghana, prolonged dry spells during the 2024 rainy season, mean that there may be famine in 2025. Crop production has declined compared to last year, and over a million people are predicted to be acutely food insecure due to this event. Thus, listening to these communities is more important than ever.

Implications of all the available evidence

These findings suggest that levels of food insecurity in rural, hard-to-reach areas are higher than the national prevalence. The results also show that confidence and knowledge of climate change has a positive effect on food insecurity. This is reinforced across both quantitative and qualitative findings. Geospatial analysis showed that precipitation patterns across the recall period of the food insecurity questionnaire were aligned to historical patterns, and so this high prevalence of food insecurity was not due to any extreme climatic events. Therefore, in light of the recent interruption of the rainy season in 2024, we can see that this will likely have even greater impact on the situation. Areas in northern Ghana such as Mion are of most concern, where a lack of expected rainfall has meant dire costs to production, income and stocks. If our findings reflected the experiences of a normal period for Mion in recent times, latest developments highlight how necessary it is to address research into rural, vulnerable populations.

Introduction

Background

Globally, around 1 in 3 people (2.3 billion) experienced food insecurity in 2021.[1] Food security, according to the Food and Agriculture Organisation (FAO) of the United Nations (UN), is a state where individuals can access sufficient quantity and quality of nutritional foods, at all times.[1] This can be split into four pillars: availability, accessibility, affordability, and utilisation. The UN Intergovernmental Panel on Climate Change (IPCC) identified that climate change aggravates factors globally which negatively influence the pillars, with Africa being particularly affected due to its dependence upon rain-fed agricultural production .[2,3] Extreme weather events such as floods, heat waves and droughts, have become more severe, unpredictable, and doubled in frequency compared to previous decades.[4]

Ghana, West Africa, has been described as a "hotspot" of climate change by the IPCC. Models estimate a rise of 1-3°C by 2060 and 20-40% reduction in rainfall.[5-7] Around 55% of the Ghanaian population are dependent on rain-fed agriculture, and agricultural yields potentially reducing by 20-50% can have significant economic, social and health consequences.[8]

Ghana has a national prevalence of moderate or severe food insecurity of 39.4% (2020-2022). Communities in the rural north report prevalence as high as 90%, which is the most vulnerable part of Ghana to climatic changes and the impacts on food security.[9] Contributing factors include higher poverty prevalence, reliance on subsistence agriculture, and more climatic hazards including extreme heat.[10,11] Thus, populations are at greater risk of malnutrition, with less capacity to withstand disaster, exacerbating and trapping families in the poverty cycle. Climate change is also impacting vector and food-borne diseases, worsening the malnutrition-infection cycle and health outcomes.[12]

The 'Last Mile' populations are defined by the UN as the most impoverished and under-served, where "development needs are greatest".[13] The 'Last Mile' community involved in this research is Mion, a rural district in the Northern Region of Ghana that has poor healthcare, high levels of poverty, and a reliance on subsistence agriculture.

There is limited data on the prevalence of food insecurity in rural Ghanaian populations, and on how these communities are managing the aftermath of the COVID-19 pandemic.[14] This research aims to understand associations between perceived impacts of climate change and food insecurity in Last Mile populations.

Methods

Study Design

This mixed-methods study used quantitative household surveys and qualitative focus groups to investigate population knowledge and attitudes on climate change, health, and food security. Study location was Sang, within Mion district, northern Ghana (**Appendix I**). Geospatial analysis studied historical precipitation patterns against the survey period.

For the household surveys, researchers trained Mion residents to collect electronic data around their own communities using Kobo Toolbox v2021.2.4 (http://www.kobotoolbox.org/), software that can securely collect data offline in areas where there is poor network coverage. Focus groups investigated the impacts of climate change their community was experiencing.

Setting

Ghana is an English-speaking lower-middle income country in West Africa. There is a tropical savannah climate, with dry and rainfall seasons that determine the agricultural calendar. Northern Ghana's rainfall season occurs from March to November, with a "hunger period" from April to July whilst anticipating the harvest and stocks run low.

The study site was Mion, a rural district in the Northern Region, with a population of ~95,000, who are largely reliant on subsistence farming.[15] Mion was chosen due to already-established research relationships between community leaders and UDS, and because it fits to the characteristics of a Last Mile population.

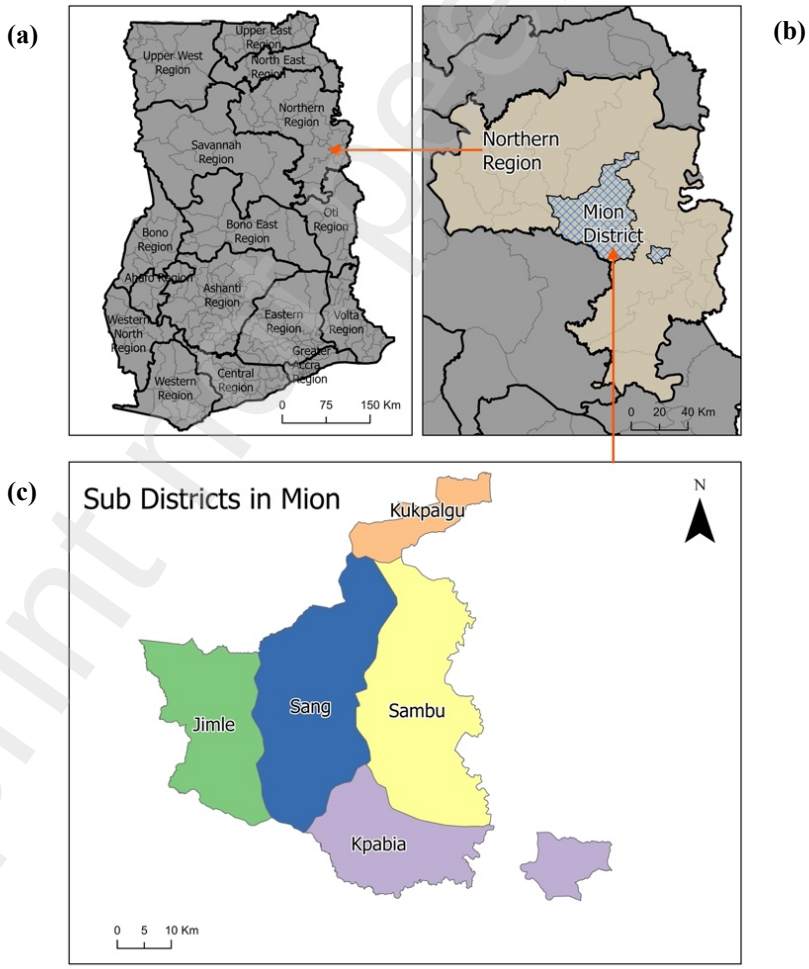

Figure 1. Map showing the location of the Northern Region in Ghana (a), within which is the district of Mion (b). There are 5 sub-districts within Mion (c). *(source of boundaries: geoBoundaries[16])*

Household Surveys

Participants

Household survey participants were recruited using the random-walk method. This sampling method is recommended by UNICEF for data collection in low-resource settings and has been used previously by the research team.[17] Eligible participants were adult residents in Mion who could provide informed consent. 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. Surveys took place on the 15th-20th May 2023.

Variables

Survey data included dichotomous, Likert-scale, and multiple-choice questions surrounding participant knowledge of climate change and perceived impact on health and food security (**Appendix II**). The Food Insecurity Experience Scale (FIES) is a validated questionnaire from the FAO, widely used for measuring food insecurity in low-income settings.[18]

Sample size

Target sample size was 383, at 5% margin of error and 95% confidence, based on population of 95000, and assumption of 50% prevalence of climate change knowledge (https://www.activityinfo.org/support/docs/sampling/snapshot.html).

Statistical methods

STATA SE v18 and R Studio were used for analysis. Descriptive statistics explored population demographics: age, gender, education, marital status, household size, economic activity, and employment status. Previous studies found that these are determinants of food security.[19]

FIES data was analysed using unweighted Rasch modelling in R Studio, as directed by the FAO FIES protocol, to describe food insecurity prevalence.[20] To equate data to global standards, data were analysed manually using the FAO Excel template. The protocol recommended this method over the automatic R function, alongside Gallup World Poll data 2020-2022.[20] Rasch modelling gives the percentage prevalence of food insecurity in 'moderate or severe' (P_{m+s}) and 'severe' (P_s), which were then compared to national, West African (group defined by FAO), and global data, including World Bank Development Indicators (GDP per capita, USD).

Thresholds for moderate and severe food insecurity (**Table 1**) were described alongside FAO categories (**Figure 2**). All FIES questions were binary variables, with 'yes' and 'no' attributed values of 1 and 0 respectively.

Table 1. Thresholds for different levels of food insecurity, in ascending severity. Total scores are derived from the raw sum of the questions answered 'yes' on the Food Insecurity Experience Scale.

Total Score of Food Insecurity Experience Scale	Level of food insecurity
0	Food secure
1-3	Mild
4-6	Moderate
7-8	Severe

Multivariate linear regression analysed FIES scores with demographic variables (gender, age group, household size and employment status). The largest group of each categorical variable were used as the reference groups. A composite variable was created to summarise knowledge of climate change - this took the mean score of participant's knowledge of climate change and belief in its existence (Likert-scale question, where 0 is 'Very unconfident' and 5 is 'Very confident'). Assumptions for linearity were checked.

Figure 2. Visual depiction of the different thresholds in the Food Insecurity Experience Scale. Image created by the FAO.[21]

Nominal questions pertaining to participants' perception of climate change and how this affects their health and food supply were analysed using descriptive techniques, presented as percentages.

Focus Groups

Participants

There were two focus groups, totalling 16 key individual stakeholders in Mion. Male and female attendees were grouped, to encourage dialogue from both genders. Participants included farmers, pastors, healthcare workers, and tribal Chiefs. They were purposively selected by researchers in consultation with district leaders (e.g. Health Director and District Research Coordinator) due to their being locally respected voices and opinion leaders. Focus groups took place on the 25th-26th May 2023.

Qualitative Analysis

Thematic analyses using NVivo identified themes around causes and effects of climate change, how this is impacting food insecurity within their community, and appropriate dialogue between policymakers, communities and researchers.

Assessment of long-term versus pre-survey precipitation patterns

Monthly gridded Climate Hazards Group InfraRed Precipitation with Station (CHIRPS) data were extracted for the study site over the 20-year period preceding fieldwork implementation using ArcGIS Pro v3.1.3.25. CHIRPS is a quasi-global time series of gridded 0.05' (5x5km) resolution precipitation map layers time series derived from in-situ precipitation meteorological observations and thermal infra-red satellite imagery.[22] Monthly precipitation anomaly relative to the 20-year mean was calculated for the survey FIES component's 12-month recall period.

Role of the funding source

This study was funded by the University of Southampton. The University funding body had no role in the collection, analysis or interpretation of the data, nor submitting decision.

Findings

Participants

Of 402 participants, 5 were retrospectively excluded due to not meeting the eligibility criteria for age. The mean age of the included 397 participants (**Table 2**) was 47 years (SD=±13.92, range 20-87 years). The largest age group was 40–49-years (n=103, 25.9%). Over half of participants were male (n=233, 58.7%) and the majority were married (n=374, 94.2%). By religion, 97% of participants were Muslim. By educational status, 81.1% had received no formal education. The main income source was from agriculture (n=365, 91.9%), 34.5% were unemployed, 62% were self-employed and 3.3% were employed by others. Mean household size was 11 people (SD=±7.06, range 1-35).

Table 2. Demographic information of the participants.

Variable	N (%)
Number of participants	397
Gender	
Female	163 (41.1)
Male	233 (58.7)
Not recorded	1 (0.2)
Age groups	
20-29	46 (11.6)
30-39	89 (22.4)
40-49	103 (25.9)
50-59	88 (22.2)
60-69	47 (11.8)
70-79	20 (5.0)
80-89	3 (0.8)
Not recorded	1 (0.3)
Marital Status	
Single	17 (4.3)
Married	374 (94.2)
Separated/Widowed	6 (1.5)
Not recorded	0
Highest level of education	
No formal education	322 (81.1)
Primary school (6-12 years old)	21 (5.3)
Junior secondary (12-15 years old)	17 (4.3)
Senior secondary (15-18 years old)	27 (6.8)
Technical/vocational	1 (0.2)
Higher education (undergraduate/postgraduate)	9 (2.3)
Not recorded	0
Employment status	
Unemployed	137 (34.5)
Self-employed	246 (62.0)
Paid employee (part-time)	3 (0.8)
Paid employee (full-time)	10 (2.5)
Not recorded	1 (0.2)
Main income	
Agriculture	365 (91.9)
Industry	2 (0.5)
Subsistence	8 (2.0)
Professional	14 (3.5)
Other	8 (2.0)
Not recorded	0

Main results

Food Insecurity Experience Scale

The mean raw score of the FIES was 4.54 (*SD*=±2.70) and the median was 5 (*IQR*=2-7), defined as moderately food insecure (**Figure 3**).

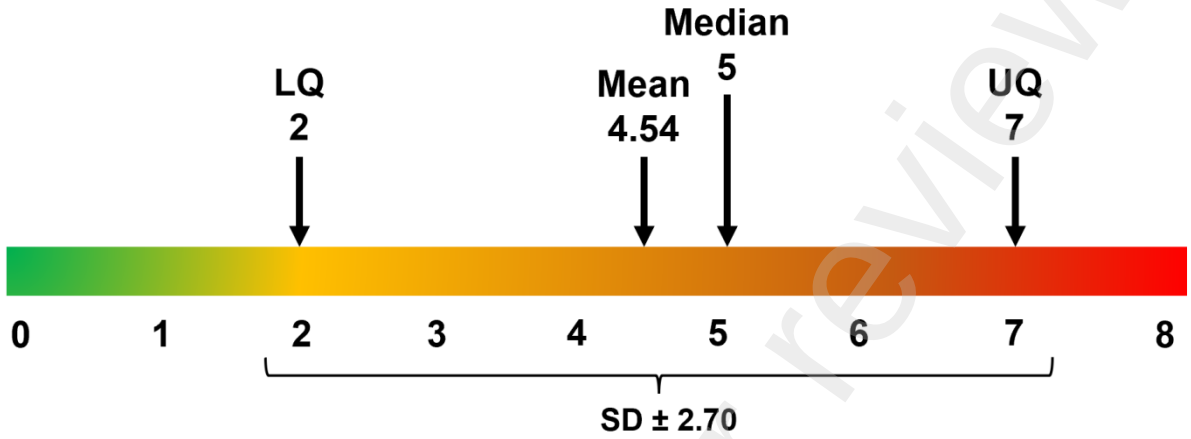

Figure 3. Average score of Food Insecurity Experience Scale in this population. This figure mimics the FAO scale of mild to severe food insecurity, demonstrating the mean and median scores fall within the moderate category. LQ is the lower quartile, and UQ is the upper quartile, thus giving the interquartile range.

The raw FIES scores showed that 100% of participants were food insecure. The Rasch model gave P_{m+s} as 61.5%, and P_s as 26.4%. Both percentages are higher than Ghana's national prevalence (P_{m+s}=39.4%, P_s=6.2%) (**Table 3**).[23] Mion has a slightly lower prevalence of moderate and severe food insecurity than West Africa (64.1%), but a higher percentage of severe (21.2%).

Table 3. Prevalence of food insecurity in Mion, compared to Ghana's prevalence and the global standard from the Gallup World Poll 2020-2022.[23]

	Prevalence of moderate or severe food insecurity (%)	Prevalence of severe food insecurity (%)
Mion	61.5	26.4
Ghana (2020-22)	39.4	6.2
West Africa (2020-22)	64.1	21.2
Global standard (2020-22)	29.5	11.3

The World Bank Development Indicators for FAO-defined West Africa countries show a negative correlation between GDP per capita and food insecurity prevalence (**Appendix III**). The prevalence measured in Mion is more reflective of low-income countries, rather than the lower-middle income setting of Ghana.

Knowledge and Perception of Climate Change

Of 397 participants, 373 (93.9%) perceived food insecurity as getting worse over the last 5 years (**Table 4**). Most participants (96.4%) reported growing at least some of what they eat, with 20.9% growing all that they eat. Further, 41.8% reported reserving all their food and not selling any. All other participants reported selling at least some of their crops, and 80.9% claiming that they sell less now than 5 years previously. Overall, 93% reported feeling confident in their knowledge of climate change and 91.9% were confident that climate change is real. Moreover, 95.7% said that crop yields were decreasing due to climatic factors. When asked how

climate change was affecting household food supply, 99.5% reported this was occurring via a negative facet, including: food shortages (79.1%), higher food prices affecting affordability (10.8%), unavailability of items (4.8%), or the experience of chronic hunger (4.8%).

Finally, by self-reported health status, 62.9% ranked themselves as very/somewhat healthy or healthy, with 21.7% reporting significant health problems. Overall, 75.6% felt that climate change has made a personal difference to their health.

Table 4. Perceptions of the impact of climate change on their community.

Variable	N (%)
Number of participants	397
Do you feel that food insecurity has been getting worse over the last 5 years?	
Getting much worse	303 (76.3)
A little worse	70 (17.6)
Stayed about the same	6 (1.5)
A little better	17 (4.3)
Much better	1 (0.3)
Not recorded	0
How much food do you grow for yourself?	
We grow all of what we eat	83 (20.9)
Most of what we eat	218 (54.9)
About half of what we eat	14 (3.5)
A little of what we eat	68 (17.1)
We buy all the food we eat	14 (3.5)
Not recorded	0
Of the food that you grow, how much do you reserve for your own/community use, and how much do you sell?	
Reserve all, sell none	166 (41.8)
Reserve most, sell some	209 (52.6)
Reserve about the same as we sell	16 (4.0)
Reserve a little and sell most of it	5 (1.3)
Reserve none and sell all of it	1 (0.3)
Not recorded	0
Has the amount of food you sell changed during the last 5 years?	
We sell more than we used to	9 (2.3)
We sell less than we used to	321 (80.9)
No obvious change	66 (16.6)
Not recorded	1 (0.2)
Are there some foods that you no longer eat because of the changes in weather conditions?	
No	138 (34.8)
Yes	255 (64.2)
Not recorded	4 (1.0)
Do you feel confident in your knowledge surrounding what climate change is and what it is caused by?	
Very unconfident	7 (1.8)
Somewhat unconfident	8 (2.0)
Neither confident nor unconfident	13 (3.3)
Somewhat confident	194 (48.9)
Very confident	175 (44.1)
Not recorded	0
How confident are you that climate change is real?	
Very unconfident	7 (1.8)
Somewhat unconfident	7 (1.8)
Neither confident nor unconfident	17 (4.3)
Somewhat confident	210 (52.9)
Very confident	155 (39.0)
Not recorded	1 (0.2)
How is climate change affecting crop yields?	
No effect	3 (0.8)
Increasing yields	14 (3.5)
Decreasing yields	380 (95.7)
Not recorded	0

Variable	N (%)
How does climate change affect household food supply?	
Shortage of food	314 (79.1)
Higher food prices	43 (10.8)
Some food items unavailable	19 (4.8)
Chronic hunger	19 (4.8)
Increased food supply	2 (0.5)
Not recorded	0
On a scale of 1 to 5, how would you rank your health?	
Very healthy	95 (23.9)
Healthy	101 (25.4)
Somewhat healthy	54 (13.6)
Unhealthy	56 (14.1)
Significant health problems	86 (21.7)
Not recorded	5 (1.3)
Do you feel like climate change makes a personal difference to your health or has the potential to?	
Already has made a difference	300 (75.6)
Not yet made a difference but is likely to do so in the future	49 (12.3)
Don't think it will make any difference	9 (2.3)
Unsure	35 (8.8)
Not recorded	4 (1.0)

Note: The two questions that were used for the composite variable on knowledge of climate change were '*Do you feel confident in your knowledge surrounding what climate change is and what it is caused by?'* and *'How confident are you that climate change is real?'*

Predictors of Food Insecurity

Multiple linear regression investigated the relationship between participants' total FIES score and demographic characteristics (**Table 5**). In the univariate model, males had a lower FIES score by 0.87 points than females on average, indicating lower food insecurity (B = -0.87, $p < 0.01$, 95% CI: -1.40, -0.33). However, gender was not significant in the multivariate model. By age group, 20-29-year-olds were more likely to report higher FIES scores, in both univariate and multivariate models ($p < 0.001$; **Table 5**). The adjusted mean difference in scores decreased slightly from 1.68 (95% CI: 0.86, 2.50) to 1.66 (95% CI: 0.81, 2.51).

Household size was significantly associated with higher FIES scores and greater food insecurity in both the univariate and multivariate models; scores increased by 0.08 points on average per household member ($p < 0.001$). Unemployment was a significant predictor ($p < 0.001$) of higher FIES score (B = 1.12, $p < 0.001$, 95% CI: 0.56, 1.68). Additionally, participants who indicated higher self-reported knowledge surrounding climate change reported lower food insecurity. Though the adjusted mean difference decreased slightly, this was still a statistically significant predictor in the multivariate model (B = -0.39, $p = 0.026$, 95% CI: -0.73, -.05). Education was included in the univariate but excluded at the multivariate model due to the confounding effect when included with employment status; thus, only employment was included.

The R^2 value for the multivariate model was 0.198; thus, these factors – gender, age group, household size, employment status and knowledge of climate change – explained 19.8% of the variation seen in the FIES score.

Table 5. Multivariate regression model showing effects of selected demographic characteristics and knowledge of climate change on the severity of food insecurity in Mion (n = 397). The dependent variable is the raw score of the Food Insecurity Experience Scale. There were 3 missing data points (1 for gender, 1 for age and 1 for knowledge) – the mean was taken and included for those items.

	Univariate			Multivariate	
	β (95% CI)	***R²***	***p***	**β (95% CI)**	***p***
Demographics					
Male (ref. = female)	-0.87 (-1.40, -0.33)	0.03	<0.01*	-0.33 (-0.84, 0.19)	0.211
Age groups (ref. = 40-49 years old)					
20-29 years old	1.68 (0.86, 2.50)	0.04	<0.001*	1.66 (0.81, 2.51)	<0.001*
30-39 years old	0.28 (-0.36, 0.92)	0.00	0.392	0.36 (-0.34, 1.05)	0.310
50-59 years old	-0.88 (-1.52, -0.24)	0.02	0.007*	-0.40 (-1.1, 0.30)	0.257
60+ years old	-0.08 (-0.78, 0.62)	0.00	0.824	0.08 (-0.67, 0.84)	0.828
Household size	0.10 (0.07, 0.14)	0.07	<0.001*	0.08 (0.05, 0.12)	<0.001*
Unemployed (ref. = employed)	1.64 (1.11, 2.18)	0.08	<0.001*	1.12 (0.56, 1.68)	<0.001*
Knowledge of climate change	-0.77 (-1.12, -0.43)	0.05	<0.001*	-0.39 (-0.73, -0.05)	0.026*

Note: The left columns show the results of the variables in univariate regression models. All have p<0.2 in univariate analysis. The columns on the right show the multivariate analysis, including beta and P values.

** Significant value if p < 0.05.*

Focus groups

The mean age of the participants was 29 years (SD±7.5, range 24-50 years). A majority (n=10, 62.5%) of the 16 participants were males.

Participants unanimously agreed that the climate has changed over the years, particularly with noticeable decreases in rainfall and water scarcity. This hurts the environment, and agricultural activities:

> *"About climate change's effects on our households, rainfall helps us grow crops for food. This time round no rain. Relating to food, there is no rain for us to farm and so there is no food for us to even give to our children to go to school."(R1,Female)*

The primary causes of climate change identified by participants included bushfires, logging, deforestation for large-scale farming; effects included food scarcity, heavy storms, and decreased crop yield.

Participants observed that climate change has affected access, availability and affordability of foods due to erratic rainfalls and other climatic effects. Foods they used to obtain from their farms are now difficult to access.

> *"In those days there was a lot of food but now there is no food like that. I know it is the reduced rainfall pattern of because I'm still young. Growing up we used to go to the farm and harvest yam filling a lot of baskets. Know it isn't that way again,."(R5,Female)*

Respondents expressed concerns about the future, fearing that future generations will face severe challenges if climate change is not addressed. Almost all participants expressed the need for knowledge generation around climate change and associated effects on the environment, health, and the general population.

> *"If climate change is not remedied, our grandchildren to come will face more challenges than we find ourselves today."(R1,Male)*

> *"Knowledge is the key to everything so I suggest we can have a routine or monthly education on climate change and health..."(R2,Female)*

Participants expressed their trust in local authorities, health workers, and district assembly members**.** Encouraging tree planting, discouraging deforestation, and addressing storm prevention were identified as comfortable topics for discussion.

Assessment of long-term versus pre-survey precipitation patterns

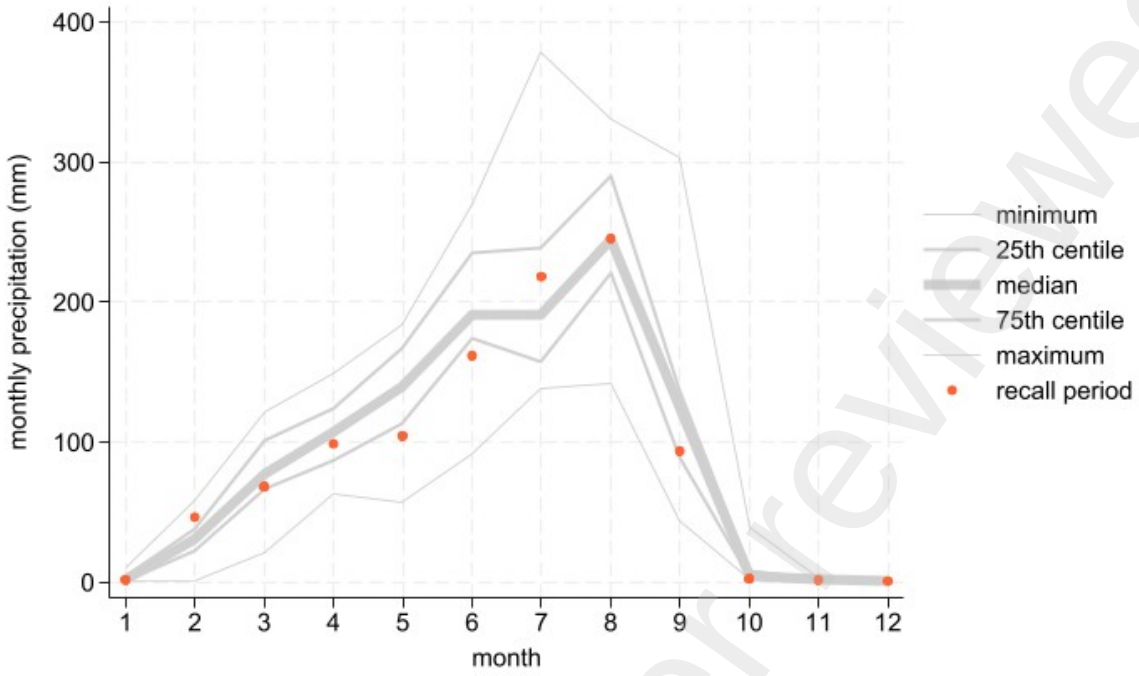

Figure 4. Graph showing the monthly precipitation levels of the 12 months preceding interview (i.e. June 22-May 23, the recall period for the FIES scale). The grey lines show the historic distribution of monthly precipitation in the period 2000-22 (long-term patterns before the survey).

Analysis of CHIRPS gridded precipitation data suggested that monthly precipitation during the FIES survey recall period were broadly comparable with those in the previous 20 years (**Figure 4**). Thus, participants were recalling a typical period in terms of precipitation patterns when reporting on food insecurity.

Discussion

Key results

This study describes high prevalence of moderate and severe food insecurity, and local concerns about climate change in Mion district as a Last Mile population. Household surveys suggest that the dietary diversity and quality of most households is compromised. No participants were food secure, despite 91.9% of participants receiving income from agriculture. Significant predictors of food insecurity included younger age groups (20–29-year-olds), larger household sizes and unemployment. Focus groups described concerns around local practice such as bush-burning, as well as a desire for education to improve utilisation. Geospatial analysis showed that precipitation patterns were similar to the previous 20 years during the FIES recall period.

The higher prevalence of food insecurity in Mion demonstrates the variation seen in vulnerable communities compared with national data. The Northern Region is experiencing more climatic hazards and is vulnerable to further stresses, which could explain why this community perceives worsening food insecurity.[10,24] These findings are similar to low-income countries in the West Africa region, which has been described as having a "food crisis".[9,23] Districts such as Mion are harder to reach, with less developed infrastructure, affecting accessibility of markets and healthcare. The wide standard deviation may demonstrate sub-district variation within Mion, with households ranging from mild to severe food insecurity.

The World Food Programme reported that climate-change-induced events may hinder crop-growing seasons, adversely impacting availability.[25] This is consistent with the evidence that a 1°C increase causes a 4% reduction in food consumption for an average African adult.[26] Nearly all (93.9%) respondents in this analysis

reported that food insecurity has worsened over the last 5 years, that they sell less food than previously and that climate change was reducing crop yield. Focus groups conducted elsewhere across northern Ghana found that climate change had caused food insecurity to become a "normal phenomenon" due to impacts on subsistence farming.[9] It is possible that more products are being retained for household consumption and less can be sold for income, affecting both availability and affordability.

Larger households are likely to have higher numbers of dependents that are unable to contribute economically in lower-income settings.[27] This makes it harder to ensure an adequate diet for all, and thus young children and elders are prioritised.[14] This could explain why 20–29-year-olds were more likely to be food insecure, as they may not always be guaranteed sufficient sustenance.

Participants in Mion who reported a stronger understanding of climate change were more likely to experience food security. The IPCC has shown that community-based education on climate change can improve food insecurity as those engaged in agriculture consider potential consequences and employ mitigating measures.[5] Most respondents were both confident in their knowledge and reality of climate change. Those without higher education typically engage in climate-sensitive occupations, without means of diversifying their income, which makes them particularly vulnerable.[28] As increasing climate knowledge seems to have a positive effect on food insecurity and was a priority for focus group participants, this should be considered in future interventions, accounting for local languages and illiteracy.[28] The trust in healthcare workers indicates they could be the 'messenger' for community-wide education.

Here, 75.6% of participants reported that climate change has made a difference to their health, similar to the 83% reported in a national Ghana study. Climate change perpetuates some health conditions, for example, respiratory diseases and risks of vector-borne diseases.[12] Of this Mion population, 21.7% reported having significant health problems, and so could be at further risk of these health-related consequences.

Building resilient communities is a global priority for government intervention. Ghana's Country Programming Framework (2018-2022) focuses on smallholder farmers and climate change mitigation, including improving women's resource access and expanding irrigation (<1% of farmers across Ghana can make use of current systems).[29] Last Mile communities need greater consideration within national policy and action.

Limitations

The survey was collected from individuals, usually from the household head, but measured the FIES score at a household level. The answers given may not be reflective of the household, dependent on characteristics such as age and gender that may have affected their experience of food insecurity. Additionally, there may be recall bias within the outcomes, affecting validity. Shortening the recall period could mitigate this. The study site was purposively selected as there were existing research links meaning community entry was feasible. Random site selection could reduce selection bias. Other variables could be added to improve the regression model fit. There may be limited external validity from the focus group findings due to the small sample, and potential social desirability bias. Larger longitudinal studies would increase generalisability, explore further patterns at a sub-district level and address temporal changes.

Interpretation

The evidence base linking climate change and food insecurity is strong and highlights significant public health issues. The established nexus between malnutrition, disease and healthcare access can be affected by extreme weather or changing temporal patterns.[2] Climate change is impacting vulnerability through malnutrition, and exacerbating vector, food and water-borne diseases, worsening the malnutrition-infection cycle.[12] The COVID-19 pandemic has also impaired each food insecurity pillar by disrupting supply chains, reducing agricultural labour and outputs, and preventing access to markets.[30]

These communities depend on rain-fed agriculture for their own sustenance, but also a high proportion of Ghana's food is grown in the northern part of the country; yet their capacity to respond to climate-induced disasters is limited.[6] Ghana is unlikely to meet SDG targets, and so must assess the most feasible community-tailored interventions.

Food aid programmes should go beyond consideration of availability. Current solutions provide an unvaried diet, often cereal products, which does not encompass the pillars of food security. Poor storage options, especially post-events such as flooding, mean aid packages will last a limited time. Further considerations include affordability when yields are low and prices are high, access to local markets through better infrastructure, or education on climate-related preparedness.

Improving transport infrastructure would ensure that despite terrain or climate challenges, food is more accessible in harder-to-reach areas, and support earlier access to healthcare for nutrition and climate-related conditions.

Generalisability

These results may be applicable to other rural communities in Ghana and across Sub-Saharan Africa, as the world's most food insecure region, and other developing nations that are becoming more adversely affected by climate change. Other Northern Region districts, such as Karaga, are severely food insecure, despite food aid programmes. Similar findings were found in Adansi North District in Ghana, where 60% experienced moderate food insecurity, 23% of respondents "went to bed on an empty stomach" and 16% had gone a whole day without food, indicating severe levels.[6] Female rural participants in Upper East region reported household food insecurity of 97.2%.[4] Alterations in the climate are a "hunger-risk multiplier", for populations with entrenched vulnerability.[4] At COP28 (2023), 134 nations signed a Declaration to incorporate food systems into climate action.

Conclusion

This study used a validated tool to highlight high prevalence of food insecurity in Mion, Northern Region, Ghana. Factors such as age, household size, employment and climate change knowledge are significant predictors of food insecurity. Interventions should consider local context and go beyond food availability.

Participants report a perception that climate change is having a substantial impact on the food insecurity and health within this community. With the impact of the erratic 2024 rainy season, Last Mile communities such as Mion need more consideration around the pillars of food insecurity and health impact.

Data sharing statement

Survey questions (**Appendix** II) and aggregated participant data will be made available.

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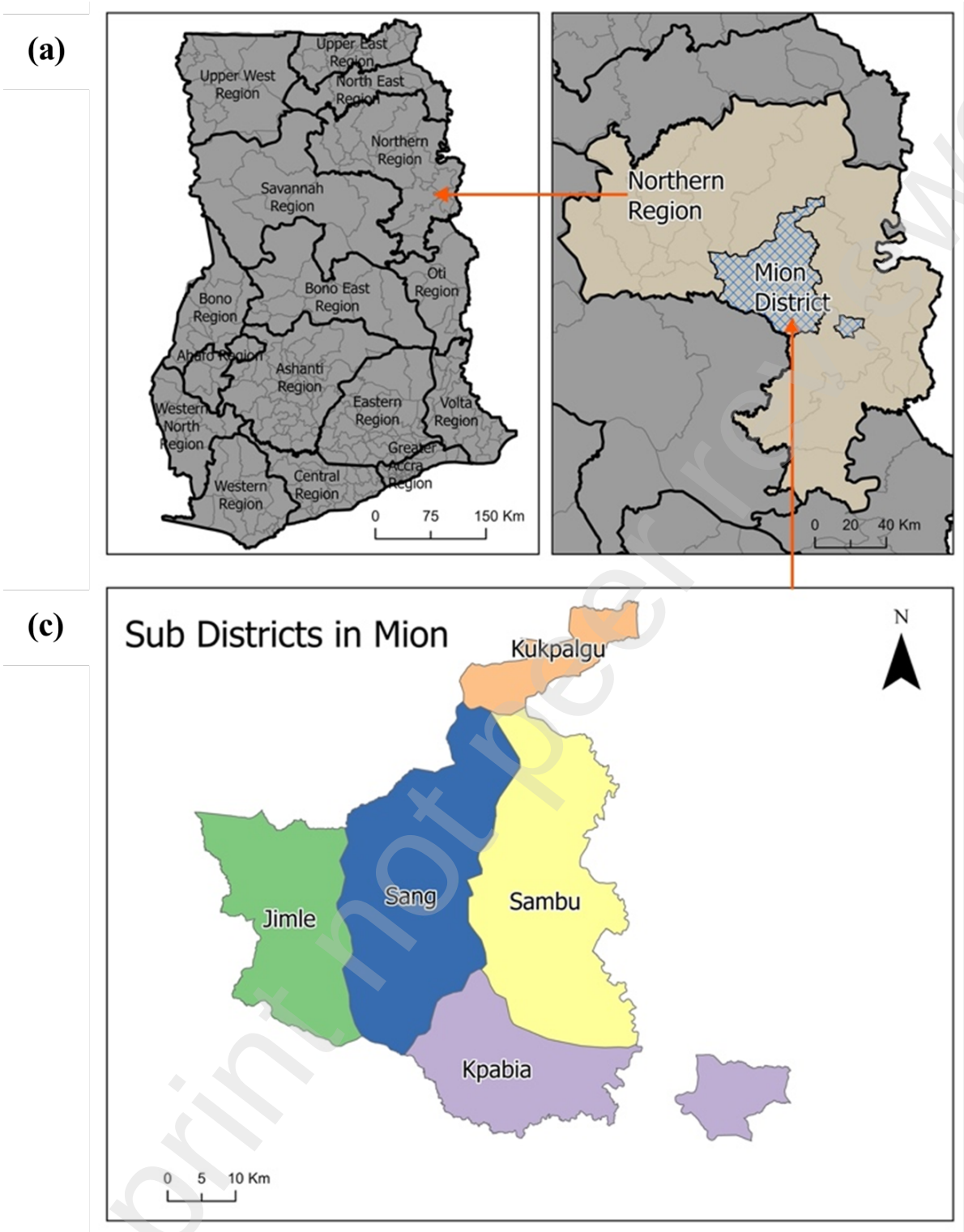

FOOD SECURITY TO MILD FOOD INSECURITY

MODERATE FOOD INSECURITY

This person has:

- insufficient money or resources for a healthy diet;
- uncertainty about the ability to obtain food;
- probably skipped meals or run out of food occasionally.

SEVERE FOOD INSECURITY

This person has:

- run out of food;
- gone an entire day without eating at times during the year.