The Effect of Perceived Climate Variability on Food Security and Coping Mechanisms Among Pastoralist Household in the Borena Zone, Southern Ethiopia

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Abstract

This paper aimed to assess the effect of climate variability on household food security status and coping mechanisms used by respondents in the selected districts of Borana. Mixed explanatory research design was applied to examine the effect of climate variability and extreme events on household food security. Data were collected from 417 sample pastoral and agropastoral households, key informants, and focus group discussion participants. Data were analyzed using descriptive statistics (e.g. mean, percentage) and econometric models (multivariate probit and multiple linear regression models to evaluate the effect of climate variability on household food security status). The results revealed that 77% of the households perceived an increase in temperature and 89% perceived a decrease in rainfall in recent years. The Household Food Insecurity Access Scale (HFIAS) result showed that about 95% of respondents experienced food insecurity. The most common coping mechanisms employed by respondents include selling charcoal and fuel wood, borrowing money from friends or family, migration, humanitarian relief, and daily labor. It appears that climate-induced food insecurity is a pervasive and serious problem in the study area over the last 20 years. Perception of the effect of temperature increase on crops and livestock has significantly increased the adoption of land contracting

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/leasing, adoption of selling fuel wood, and daily labor increased as a coping response to climate variability among pastoralists and agropastoralist. The perception of the impact of the decrease in annual rainfall on crops and livestock has significantly increased the adoption of borrowing from friends or families and free support of resources among pastoralists and agropastoralist. Business-as-usual perception increases the adoption of borrowing from credit unions, free support of resources, and migration. Regarding the perceived effect of food insecurity, borrowing from credit unions, borrowing from friends or families, and reduction of expenses have reduced food insecurity among pastoralists and agropastoral households. Borrowing from credit unions provides them with access to financial resources during times of need. These loans can be used to purchase food, livestock, or other essential supplies, helping families bridge the gap during periods of food scarcity. Hence, it is highly recommended to implement integrated interventions that address both household food insecurity and viable adaptation responses. These interventions should aim to mitigate the need for coping strategies and prevent maladaptation measures that lead to the depletion of assets.

Keywords*:* food insecurity, coping response, FCS, HFIAS, agropastoral, determinants, perceptions.

1. Introduction

Climate change and extreme events have recently become a global phenomenon with far-reaching implications, particularly for vulnerable communities in Sub-Saharan Africa (Trisos et al., 2022). These events have exacerbated the severity of hydro-meteorological hazards, which have the potential to significantly alter natural ecosystems and hence induce food insecurity (Birkmann et al., 2022; IPCC, 2007). Climate change and extreme events could trigger disaster risks in two ways: firstly, by increasing the likelihood of more frequent and intense weather and climate hazards, and secondly, by amplifying community vulnerability to these hazards (Bouroncle et al., 2016). This vulnerability is primarily driven by ecosystem degradation, reduced water, and pasture availability, and further affect livelihoods and food security (UNDRR, 2008; Birkmann et al., 2022).

Sub-Saharan African countries are more vulnerable to climate change due to high dependency on natural resources and weak adaptive capacity (Omotoso, and Omotayo, 2024; Allahyari et al., 2016; Abid et al., 2015). For instance, subsistence agricultural production can be affected by change in temperature and precipitation patterns (Tetteh, et al., 2022). Empirical evidence confirmed that the yields of most crops have been affected negatively by climate changes over recent decades (Lee et al., 2024; Change, 2019).

Ethiopia is one of the most vulnerable countries to climate change in Africa, with the least capacity to respond (Solomon et al., 2021). The vulnerability of rural communities to climate variability and change poses significant challenges for ensuring sustainable agricultural production (Seid et al., 2015; IPCC, 2014). Droughts, floods, heavy rains, high winds, and heat waves are the common phenomenon that affect and continue to affect the production and productivity of the agricultural sector in Ethiopia (Abebe, 2007). For example, the 2015/16 El Niño event caused a decline in agriculture and cattle production and left more than 10 million people to food aid and acute food insecurity in the country (Holleman et al., 2020). Furthermore, the national and agricultural GDP was reduced by 1.6%, and 3.6% respectively, and increased the number of people below the poverty line from 30% to 31.2% (IFPRI and UNDP, 2019). The country heavily depends on climate-sensitive economic sectors such as subsistence crop cultivation and animal husbandry (Sector, 2014). As a result, Ethiopia ranked among the most food-insecure countries in the world (Solomon et al., 2021; Mohamed, 2017).

Pastoralist communities, such as the Borena, rely heavily on livestock rearing as their primary livelihood strategy (Tofu et al., 2023). Livestock provides food, income, manure, and draught power for pastoralists, as well as a social status symbol (Benti et al., 2022). Thus, the sector is considered pastoralists' economic and social insurance (Benti et al., 2022). However, climate change has significantly affected

the sector and their traditional way of life, threatening their food security, income stability, and overall well-being (Tofu, 2023).

The Borena plateau's grazing systems have become unsustainable in recent times (Degen, 2024; Coppock et al., 2008). The area has been hit by cyclical and prolonged droughts that have decimated livestock, increased poverty (Coppock et al., 2008), and food insecurity (Ayal et al., 2017). Poor infrastructure, decades of neglect by government, unsuitable development intervention, and economic and political marginalization have all contributed for pastoralists' vulnerability to climate change (Busby et al., 2012). The Borena pastoralists have recently vulnerable to climate extremes due to a lack of climate adaptive capacity and techniques (Ayal et al., 2015).

The Borena community was particularly vulnerable to the effects of climate change because of the government's plans to sedentarize the pastoralists and turn the rangeland into farmland, as well as a history of devastating droughts, loss of grazing pastures, interethnic conflicts, and degradation of rangelands. In 2023, over 2.3 million cattle died because of the major issue, and 67,000 households were forced to relocate (Degen et al., 2024). This fact makes the Borena one of the most drought-affected areas in Ethiopia.

Understanding the specific effect of climate change and extremes on pastoralist households in the Borena Zone and their coping responses is crucial for feasible policy formulation and targeted interventions. By examining the local context, traditional knowledge, and the effectiveness of existing coping strategies, the study aimed to contribute to the development of evidence-based approaches that enhance the resilience of pastoralist households and ensure their food security in the face of climate change and extremes. Most of the research done to date in Borena area focused on measurable climate data and missed the necessity of incorporating local adaptation and coping strategies into climate change risk studies (Shibru et al., 2023). These studies have not

fully explored the connection between climate change perception, coping strategies, and food insecurity among pastoral and agropastoral households. Therefore, this study aimed to fill these gaps and answer two questions: How do pastoralists perceive climate change/variability and its effects on crop and livestock productivity among households in Borena? What are the factors that influence food security among pastoral and agropastoral households in the study area?

2. Materials and Methods

2.1. Description of the study area

The study was conducted in the Borena Zone, southern part of the Oromia regional state, Ethiopia. The zone shares boundaries with the Guji zone in the east, the Somali regional state in the southeast, the Southern Nations in the west, and Kenya in the south. The zone is situated at 4º N to 6º N and 36º E to 42º E (Fig, 1). The landscape of the zone is characterized by slightly undulating peaks that reach heights of up to 2,000 meters above sea level in some areas. The Borena Zone comprises 13 districts and covers an area of 48,743 Km^2, with a mean altitude of 1,500m above sea level.

The climate in the zone is predominantly arid and semi-arid, with sub-humid zones. Droughts have had a significant impact on the lowland areas of Borena, and the area experiences fluctuating rainfall patterns. Approximately 50% of the annual rainfall in the lowland areas falls during the long rainy season, which occurs from March to May, while around 30% falls during the short rainy season, which takes place between September and November. Pasture availability in the area is limited and highly variable due to the fluctuating rainfall patterns (NAPA, 2007). In the study site, pastoralism is predominant livelihood (Alemu, 2017; Alemu and Adugna, 2015). Climate variability and change pose significant challenges to household food security in the area (Nigussie et al., 2018). The dominant crops grown are maize, wheat, barley, teff, sorghum, and haricot beans. These crops are essential for food security and livelihoods in the region. However, it is

important to note that the success of crop production in Borena is highly dependent on rainfall patterns and the availability of water resources.

Livestock rearing is also a significant part of the agricultural system in Borena. The main livestock raised in the area include cattle, goats, sheep, and camels (Tilahun et al., 2017). These animals provide milk, meat, and other by-products, which are crucial for the local economy and the livelihoods of the pastoralist communities in the region.

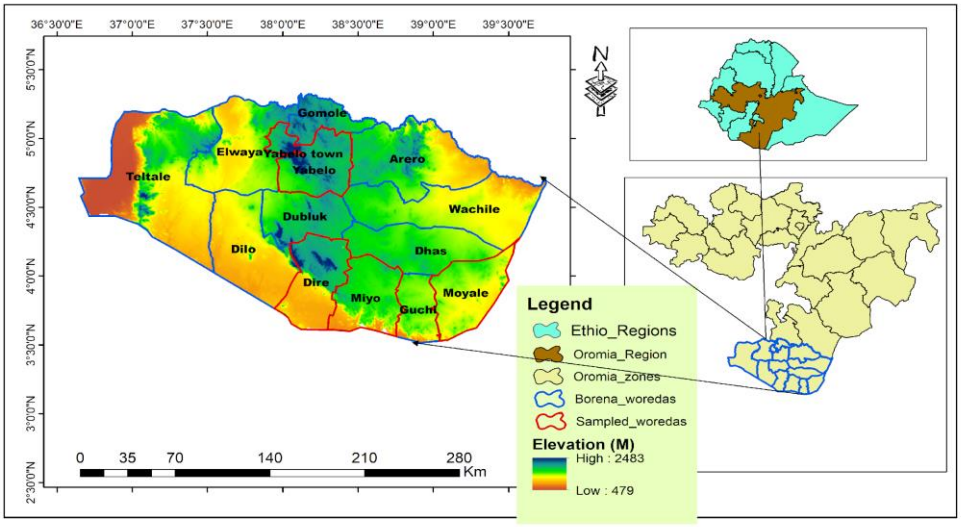

Figure 1: Map of the study area

2.2. Study Design and Methods

The study employed a mixed explanatory research design to gain a deeper understanding of the perceived effects of climate variability on pastoral and agropastoral households, their coping strategies, and the factors influencing household food security status. A mixed approach allows collection of both quantitative and qualitative data from different sources. The quantitative data focused on the perceived effects of climate variability, coping strategies, and food security determinants, while the focus group discussions and key informant interviews were held to collect qualitative data which helped to gain deeper insights

about the effect of climate variability on pastoral and agropastoral households.

2.3. Sampling design

The study used a multi-stage sampling technique to select the study sites and sample respondents. The target population for this study were the pastoral and agro-pastoral households in the Borena zone, Ethiopia. The sample frame was the list of all households in the Borena zone. At the first stage, the Borana Zone and four districts namely Moyale, Yabello, Dire, and Miyo were selected purposively due to high vulnerability to climate variability and high food insecurity level. The Southern and southeastern pastoral areas of the country are among the areas of highest concern about emergencies and crises (FEWS NET, 2022). In the second stage, sample kebeles namely Darito, Bokola, Dida Yabelo, Dibandiba, Silala, Bede, Medacho, and Dida mega were selected using a simple random sampling method from four woredas (Yabello, Dire, Miyo, and Moyale). In the third stage, representative sample households were selected randomly from each kebele proportionally. The sample size was determined using Cochran's (1977) formula, which is widely used when there is a large population and when the study requires accurate variability and heterogeneity of the population.

$$n_o = \frac{Z^2 q(1-q)}{e^2} \quad \text{----------} \quad (1)$$

n_o = required sample size
Z = standard normal value which is 1.96 for 95% confidence interval (5% significance level)
p = estimated proportion of population (maximum variability) (0.5)
q = (1-p) or estimated proportion of failure
e = the desired level of precision (0.05)
Accordingly, the sample size estimated was 384 households. However, the sample size was raised to 422 with the addition of non-response rate of 10%. As expected, 5 households had zero response rate. Therefore, the final sample size was 417 households.

2.4. Data collection

Primary data was collected using household surveys from pastoral and agro-pastoral households using structured questionnaires. In addition, secondary data were collected from reports of the Borena Zone office, farmers' cooperative, Ethiopian Statistical Service-ESS, and published documents. Finally, experienced enumerators were recruited and trained to collect data from the sample households. Focus group discussions and key informant interviews were also conducted.

2.5 Methods of data analysis

Descriptive statistics and econometrics analysis were used to analyze the quantitative data. The household food insecurity access scale (HFIAS), food consumption score (FCS), and household dietary diversity score (HDDS) were used to measure the food security status of households in the study area.

Household food insecurity access scale: Household food insecurity access scale (HFIAS) consists of two types of related questions. The first question type is called an occurrence question. There are nine occurrence questions that ask whether a specific condition associated with the experience of food insecurity ever occurred during the previous four weeks (30 days). Each severity question is followed by a frequency-of-occurrence question, which asks how often a reported condition occurred during the previous four weeks. The HFIAS score is a continuous measure of the degree of food insecurity (access) in the household in the past four weeks (30 days) (Coates et al., 2006). First, a HFIAS score variable is calculated for each household by summing the codes for each frequency-of-occurrence question. The higher the score, the more food insecurity (access) the household experienced. The lower the score, the less food insecurity (access) a household had experienced. The HFIAS indicator categorizes households into four levels of household food insecurity (access): food secure, and mild, moderately, and severely food insecure. Households are categorized as increasingly food insecure as they respond affirmatively to more severe

conditions and/or experience those conditions more frequently (Coates et al., 2007).

Household dietary diversity: According to FAO (2010) household dietary diversity score is an indication of household economic access to food. It was calculated by summing the number of food groups consumed in the household respondent over the 24-hour recall period. Respondents were asked whether they consumed the 12 food groups and their "yes" responses were coded as 1 and the negative responses "no" coded as 0 (INDEX Project, 2021). The next step is summing the dietary diversity variable values of all new food groups and, the potential score ranges from 0 to 12 for HDDS. The higher score indicated that households consumed more diversified food groups. The HDDS of ≤3, 4-5, and ≥ 6 imply low, medium, and high dietary diversity, respectively (Data4diets, 2023).

Food consumption score: According to FAO (2008) cited in Marivoet and Becquey (2019) food consumption score is a composite score based on dietary diversity, food frequency, and relative nutritional importance of different food groups and it can be calculated using the frequency of consumption of different food groups consumed by a household during the 7 days before the survey (Hoddinott, 2002). The following four procedures are important to calculate the FCS,: (i) group all the food items (the 16 food items) into specific food groups (12 food groups), (ii) sum all the consumption frequencies of food items of the same group, and recode the value of each group above 7 as 7, (iii) multiply the value obtained for each food group by its weight (the standard weights for main staples 2, pulses 3, vegetables 1, fruit 1, meat and fish 4, milk 4, sugar 0.5, oil 0.5, condiments 0) and create new weighted food group scores and, (iv) sum the weighed food group scores, thus creating the food consumption score (FCS). FCS of 0-21, 21.5-35, and >35 indicated poor, borderline, and acceptable household consumption respectively. For this study, both HFIAS, HDDS and FCS were calculated at the household level.

Econometrics analysis: In this study, econometric analysis method is applied to examine the determinants of perceived effects of climate variability against coping responses. The dependent variable of this study is a binary variable indicating whether the household has perceived the specified climate variability effect. The variable takes a value of 1 if the household has perceived the effect of temperature increase, rainfall decrease, and business as usual otherwise 0. To identify the determinants of climate variability adaptation strategies (land contracting, borrowing from friends or families, selling wood tree, selling charcoal, free support of resources, migration, reduction of expenses, daily labor, sell assets), a multivariate probit model was applied.

The multivariate probit model is a statistical model that is used to estimate several correlated binary outcomes jointly (Greene, 2012). The multivariate probit model was justified for examining the effect of perceived climate variability on selection of coping strategies among pastoral and agro-pastoral households in the Borena zone due to its ability to analyze multiple correlated dependent variables simultaneously. This model allows for the examination of the complex relationships between various aspects of climate variability, and coping strategies, and providing a more comprehensive understanding of the interplay between these factors. Compared to other possible models, the multivariate probit model offers the advantage of capturing the joint distribution of the dependent variables, which is essential for studying the interconnected nature of climate variability, and coping strategies. However, a weakness of this model was the potential complexity of interpreting the results and the need for robust coping methods to address any weaknesses in the model's assumptions and potential biases in the estimation process. To cope up with this weakness, the study used various methods such as maximum likelihood estimation to estimate the parameters of the model with careful consideration and validation of the model's assumptions. The likelihood function for the multivariate probit model does not have a closed-form solution, so numerical

methods are used to estimate the parameters (Heckman, 1979).

The MVP econometric model is characterized by a set of binary dependent variables (Y_{ij}), such that:

$$Y_{ij}^{*} = \beta_i' X_{ij} + \varepsilon_{ij}, \text{ ----------(2)}$$

and

$$Y_{ij} = \{1,\ if Y_{ij}^{*} > 0\ 0,\ otherwise \quad \text{----------(3)}$$

Where i=1,2,3 denotes perceived effects of climate variability such as 1= temperature increment effect on crop and livestock productivity, 2=effects of rainfall decrease on crop and livestock productivity, 3= business as usual; and j=1, ..., n and n denote the sample size. The Eq. (2) assumption is that a rational j^{th} household has a latent variable, Y*ij, which captures the unobserved preferences derived from the i-th perceived effects of climate variability. This latent variable is assumed to be a linear combination of copying responses of climate variability (Xij), as well as unobserved characteristics captured by the stochastic error term εij. The vector of parameters to be estimated is denoted by βi. Given the latent nature of Y*ij, the estimations are based on observable binary discrete variables Yij, which indicate whether pastoral and agro pastoral households have the i-th perceived effects of climate variability. If the specific climate variability copying responses is independent of another climate variability responses, then Eqs. (2) and (3) specify univariate probit models where information on pastoral and agro pastoral household climate variability effects does not alter the prediction of the probability that they have another perceived effect of climate variability. Since we assumed that a pastoral and agro pastoral household have multiple climate variability effects, the error terms in Eq. (2) jointly follow a multivariate normal (MVN) distribution, with 0 conditional mean and variance normalized to 1. Where ($\rho 1$,$\rho 2$,$\rho 3$) distributed MVN (0, Ω) and the symmetric variance-covariance matrix is given by:

$$\Omega = [1\ \rho_{12}\ \ \rho_{13}\ \rho_{21}\ 1\ \rho_{23}\ \rho_{31}\ \rho_{32}\ 1\ ] \text{ ---------- (4)}$$

where (ρ_{im}) denotes the pairwise correlation coefficient of the error terms corresponding to any two perceived effects of climate variability equations to be estimated in the model.

The off-diagonal elements in the covariance matrix, ρ_{im} which represent the unobserved correlation between the stochastic component of the i^{th} and m^{th} perceived effects climate variability, are important. This assumption means that Eq. (3) tests whether an MVP model was appropriate for the analysis or the univariate probit model suffices for the analysis.

To determine the effect of independent variables on perceived effects of climate variability against copying responses, the final analysis contains marginal effect analysis results based on Eq (5) (Greene, 2012). Therefore, the marginal effect of copying responses (Xij) was calculated because marginal effects measure the effects that a specific copying response has on the perceived effects of climate variability of pastoral and agro pastoral households while all other variables are held constant.

Marginal Effect of X_{ij} = Pr (Y_i = 1|X, X_{ij} = 1) – Pr (Y_i=1|X, X_{ij} = 0) ---- (5)

The study's second objective involved applying a multiple linear regression model to identify factors influencing food insecurity among pastoral and agropastoral households in the Borena Zone, Oromia region, Ethiopia. This approach was chosen to understand the complex interplay of coping responses and adaptation factors on household food security in the area. While multiple linear regression allows for the identification and quantification of specific relationships between variables, it assumes linearity, which may not always hold true in real-world scenarios. To address this, the researchers used coping mechanisms such as standardizing independent variables, including interaction terms, and employing robust regression techniques account for outliers and other non-normal data distributions and to provide a

more nuanced and accurate understanding of the factors influencing food security in the study area (Wooldridge, 2012). Assuming that the research was indeed about factors affecting food security status, the multiple linear regression model was specified as follows eq. (6):

Dependent variable: Food security status (Y), independent variables: Factors affecting food security (X_1, X_2, X_3, ... X_n), therefore, the model was represented as:

$Y = \beta_0 + \beta_1 X1 + \beta_2 X_2 + \beta_3 X_3 + ... + \beta_n X_n + \varepsilon$ ---------- (6)

Where: Y is the food security status, β_0 is the intercept, β_1, β_2, β_3, ... βn are the coefficients for the factors affecting food security, X_1, X_2, X_3, ... X_n are the independent variables representing the factors affecting food security ε is the error term. This model estimates the effects of various factors on food security status in the Borena Zone, Oromia region, Ethiopia using multiple linear regression analysis.

The study utilized the marginal effects of the model to understand how changes in the independent variables affect food security status. This involved interpreting the effect of a one-unit increase in an independent variable on the dependent variable while holding all other independent variables constant. Mathematically, this was expressed as:

$$\frac{\partial Xi}{\partial Yi} = \beta_i \text{ ---------- (7)}$$

Where Y is the dependent variable, Xi is the i-th independent variable, and βi is the coefficient of the i-th independent variable in the multiple linear regression model. All data were analyzed using STATA 17.

3. Results and Discussion

3.1. Descriptive analysis

3.1.1. Demographic characteristics of respondents

The survey participants have a mature age profile, with an average age of 44.4 years (Table 1). The average household size was 2.2. The sex

distribution among household heads was balanced, with 52% male and 48% female. Most respondents were married (84%), while 6% were single and 10% were widowed/divorced. About 77% of respondents lacks basic literacy skills, while only 37% were considered to be literate**.** Thus, the sample participants demographic characteristics could provide perspective about the study area community climate change's perceived effect on food security and their response. Table 1: Socio-demographic characteristics of pastoral and agropastoral households (N=417)

Continuous variables	**Description**	**Min**	**Max**	**SD**	**Mean**	**Percent**
Age of head	Continuous	18	96	14.99	44.40	-
Household size	Continuous	1	4	1.43	2.2	-
Sex of head	Male	-	-	-	-	51.80
	Female	-	-	-	-	48.20
Marital status	Married	-	-	-	-	84.17
	Widowed	-	-	-	-	6.95
	Single	-	-	-	-	5.52
	Other	-	-	-	-	3.36
Education	No formal education	-	-	-	-	77.22
	Primary education	-	-	-	-	18.94
	High school/preparatory					2.88
	Above diploma					0.96

About 76.50% of the households perceive the effect of temperature increase on crop and livestock. Around 89.21% of the respondents aware about the decreasing trend of annual rainfall effect on crop and livestock production and productivity. About 76.02% of the households follow business as usual approach even if they perceived and encountered the effect of climate change and extremes. Previous research reports in the study sites reported that the extent of temperature

increase and rainfall decrease is higher than the national average (Ayal et al., 2018). This finding is also consistent with a study conducted by Mekuyie and Mulu (2021) who reported that 98 % of their respondents perceived that the rainfall has declined and 95 % of households perceived in temperature increase.

The explanatory variables are coping responses adopted to reduce the effect of climate variability and food insecurity. Pastoralists and agro pastoralists were adopted different coping responses to the effect of climate variability and food security. These include humanitarian aid from government or NGOs (100%), migration (86.81%), borrowing from friends or families (82.7%), reduced expenses (79.1%), daily labor (77.0%), free support of resources (62.8%), sell of charcoal (51.80%), sell of fuel wood (50.4%), borrowing from credit unions (36.5%), land contracting (5.8%), and sell assets (2.6%).

Table 2: Description of dependent and explanatory variables

Variables	Description of variables		Percent
Dependent variables			
Perceived effect of temperature increase	*Dummy = 1 if household Perceived the effect of temperature increase on crop and livestock productivity, 0 otherwise*	Perceived Not perceived	76.50 23.50
Perceived effect of decrease in annual rainfall	Dummy = 1 if household Rainfall affects agriculture, 0 otherwise	Perceived Not perceived	89.21 10.79
Perceived business as usual	Dummy = 1 if household Business food insecurity, 0 otherwise	Perceived Not perceived	76.02 23.98
Explanatory variables			
Land contracting	Dummy = 1 if household adopt Land contracting, 0 otherwise	Yes No	5.76 94.24

Borrowing from credit union	Dummy = 1 if household adopt Borrowing from credit union, 0 otherwise	Yes No	36.45 63.55
Borrowing from friends or families	Dummy = 1 if household adopt rain Borrowing from friends or families, 0 otherwise	Yes No	82.73 17.27
Selling wood tree	Dummy = 1 if household Selling wood tree, 0 otherwise	Yes No	50.36 49.64
Selling charcoal	Dummy = 1 if household adopt Selling charcoal, 0 otherwise	Yes No	51.80 48.20
Free support of resources	Dummy = 1 if household adopt Free support money, 0 otherwise	Yes No	62.83 37.17
Migration	Dummy = 1 if household adopt Migration, 0 otherwise	Yes No	86.81 13.19
Aid from government or non-governmental organization	Dummy = 1 if household adopt non-governmental organization, 0 otherwise	Yes No	100.00 0.00
Reduction of expenses	Dummy = 1 if household adopt Reductio of expenses, 0 otherwise	Yes No	79.14 20.86
Looking for daily labor	Dummy = 1 if household adopt Looking for daily labor, 0 otherwise	Yes No	76.98 23.02
Sell assets	Dummy = 1 if household adopt Sell assets, 0 otherwise	Yes No	2.64 97.36

3.2. Food security status of pastoralist and agropastoral households

The food consumption score shows that about 23.02% of participants were at an acceptable food consumption level that met the minimum criteria for an adequate and balanced diet, indicating relatively better access to a variety of food groups and nutritional requirements, whereas 31.18% fell under the borderline food consumption level (Table 3).

These households face some challenges in accessing a diverse range of food items or may have inconsistent access to nutritious foods. While their food consumption may not be classified as poor, it is still below the optimal level. About 45.80% of participant households have poor food consumption scores. Accordingly, a significant number of participants were experiencing challenges in accessing an adequate and diverse range of food items. These households are likely to face higher risks of food insecurity, malnutrition, and nutrient deficiencies.

Table 3: Status of food consumption score, Borena Zone, N= (417)

Food consumption score	Categorization rule	Frequency	Percent
Poor	0-21	191	45.80
Borderline	21.5-35	130	31.18
Acceptable	>35	96	23.02

Table 4 presents the status of the household dietary diversity score of the participant households. Accordingly, 23.98% of the participant households had high dietary diversity score that consume a wide range of food groups, including items from various food categories such as grains, vegetables, fruits, dairy, protein sources, and oils/fats, 30.94% of the households had medium dietary diversity score who consume a moderate variety of food groups but may have limited access to certain food categories or have relatively fewer options within each category, and 45.08% of the households had low dietary diversity score with limited diversity in their food consumption and may rely heavily on a few food groups or have restricted access to a diverse range of food sources.

Table 4: Status of household dietary diversity score, Borena Zone, N= (417)

Household Dietary Diversity Score	Categorization rule (0-12)	Frequency	Percent
Low	HDDS≤3	188	45.08
Medium	4≤HDDS ≥6	129	30.94
High	HDDS>6	100	23.98

3.3. Household Food Insecurity Access Scale of participant Households

Table 5 depicts that about 95% of the participant households were food insecure. Whereas only around 5% of the sampled households were food secure. More explicitly 24.0%, 36.0%, and 35.5% of the households were classified as mildly, moderately, or severely food insecure, respectively.

The three most ranked coping responses were receiving humanitarian aid from government or non-governmental organizations, migration, and borrowing from friends or family. These coping responses demonstrate the desperate measures taken by participant households to obtain the necessary food for their survival.

In addition to the incidence, sample households were asked about the frequency with which the circumstance occurred, i.e., whether it occurred rarely (once or twice in 30 days), sometimes (3–10 days in the previous 30 days), or often (once or twice in 30 days) (if it had happened more than ten times in the past 30 days). Table 5 illustrates that 32%, 7% and 25.2% of the households had worried about food in the last 30 days sometimes and often, respectively. The data reveals that a significant percentage of households faced challenges in accessing their preferred food and had limited food variety. Additionally, a notable proportion of households had to consume food they did not want, and a substantial number frequently consumed smaller meals. A significant

portion of the households had no food of any kind in the household, went to sleep hungry, and went a whole day and night without eating.

Table 5: Summary of the percent of the responses to the HFIAS questions, Borena Zone (N=417)

HFIAS frequency questions	Happened for the last 30 days in the last year		
	No & rarely	Sometimes	Often
Worried about food	4.5	32.7	25.2
Unable to eat preferred food	78.5	40.2	13.1
Eat just a few kinds of foods	15.0	38.3	45.8
Eat foods they really do not want to eat	21.5	28.0	15.9
Eat a smaller meal	10.3	47.7	41.1
Eat fewer meals in a day	12.1	56.1	29.9
No food of any kind in the household	27.1	23.0	4.0
Go to sleep hungry	35.5	36.0	2.0
Go a whole day and night without eating	36.0	11.0	0.0

The HFIAS analysis result shed light that great majority of households were food insecure which indicate the existence of persistent food insecurity in the study sites. These findings are consistent with previous studies conducted in different parts of Ethiopia (Bekele et al., 2020). In addition Rufino et al., (2013) reported that food insecurity was common at all sites with an annual rainfall of 800 mm or less, and critical levels are seen at sites with <700 mm which is the case of Borena lowland. The statistics in table 6 provide insights into the high prevalence and severity of household food insecurity in the Borena zone.

Table 6: Status of household food insecurity access scale (HFIAS), among pastoral and agropastoral households in Borena Zone (N= 417)

No	Household food insecurity access scale	Frequency	Percent
1.	Food secure	19	4.5
2.	Mildly food insecure	100	24.0
3.	Moderately food insecure	150	36.0
4.	Severely food insecure	148	35.5

3.4. Effects of perceived climate variability

The key finding in Table 7 is that the marginal effect of the perception of the effect of temperature increase on crop and livestock has significantly increased the adoption of land contracting ($p<0.1$) which aligns with different studies (Gbetibouo, 2009; Maddison and Bank, 2007) suggesting farmers seek alternative land use or diversification due to perceived threats to existing crops and livestock. Also it increased borrowing from credit unions ($p<0.01$) which resonates with Giordano et al.,(2023) where perceived climate risks motivate investment in adaptation measures like improved seeds or infrastructure, often requiring credit. Similarly, adoption of selling fuel wood and daily labor increased ($p<0.01$) while reduces the adoption of selling charcoal ($p<0.01$), free support of resources ($p<0.01$), and reduction of expenses ($p<0.01$) as a coping response to climate variability among pastoralists and agropastoral. Thus, the perception of the impact of temperature increase on crop and livestock plays a significant role in shaping the choices of coping responses. It appears to influence their decisions to engage in certain coping strategies while discouraging others. Whereas the marginal effect of the perception of the impact of decrease in annual rainfall on crop and livestock has significantly increased the adoption of borrowing money from friends or families and free support of resources ($p<0.01$) while reduces the adoption of borrowing from credit union ($p<0.01$) among pastoralists and agropastoral (table 7). The marginal effect of following business-

as-usual approach increases the adoption of borrowing from credit union ($p<0.01$), free support of resources ($p<0.1$), and migration ($p<0.01$) while reduces the adoption of selling of wood tree ($p <0.05$), reduction of expenses ($p<0.01$) and selling of assets ($p<0.1$) as a coping response to climate variability among pastoralists and agropastoral. The chi-square test (X^2 (3) = 12.0187) assesses the overall significance of the model. The reported p-value (Prob > X^2 = 0.0073) indicates that the variables collectively have a significant effect on the dependent variable.

The qualitative data collected through FGD, and key informants were also in agreement with the quantitative analysis. Mostly, the agropastoral households do more land contracting when they anticipate temperature increase to avoid risk. Borrowing from credit unions is becoming a practice for the pastoralists, whenever they perceive temperature increase and decrease in rainfall. During severe periods people are less likely to borrow from friends and family because they are all in similar circumstances and may not have spare money to lend to others. The quantitative and qualitative result demonstrate that choices about coping strategies are heavily influenced by how one perceives the impact of rising temperatures on cattle and crops. Both the quantitative and qualitative data confirms that it appears to influence their decisions to engage in certain coping strategies while discouraging others.

The study results highlight the significant role of perceptions of temperature increase and rainfall decrease in shaping the choices of coping responses among pastoralists and agropastorals. This aligns with existing literature emphasizing the importance of subjective experiences and risk perception in influencing adaptation strategies.

Table 7: Determinants of perceived climate variability on coping response among participant households in Borena Zone (N= 417)

Variables	Effect of temperature increase on crop, and livestock dy/dx	Effect of annual rainfall decrease on crop and livestock productivity dy/dx	Business as usual approach dy/dx
Coping responses			
Land contracting	1.03*	4.49	-0.09
Borrowing from credit union	1.04***	-1.12***	0.83***
Borrowing from friends or families	-7.01	0.95***	0.11
Selling wood tree	0.73***	-0.66	-0.39**
Selling charcoal	-0.49**	-0.01	-0.17
Free support of resources	-0.51***	1.6***	0.31*
Migration	0.49	-13.45	0.61***
Reduction of expenses	-2.46***	-12.77	-0.54***
Daily labor	1.86***	0.33	-0.70
Sell assets	0.12	9.48	-0.85*
$X^2(3) = 12.0187$		Prob > X^2= 0.0073	

***, **, * are significant at 1 %, 5 %, and 10 %, respectively.

3.5. Determinants of household food insecurity among pastoral and agropastoral households in Borena Zone

The OLS regression showed that selling of charcoal ($p<0.01$) and migration ($p<0.01$) increased the food insecurity of households while borrowing from credit union ($p<0.01$), borrowing from friends or families ($p<0.01$), and reduction of expenses ($p<0.01$) has reduced the food insecurity among pastoralists and agropastoral households (Table 8). In many cases, household heads often resort to migration in search of income for their families, leaving behind the children and women with limited options. Unfortunately, those who remain behind often face significant food insecurity, particularly during times of drought. Additionally, the sale of charcoal, which is a common income-generating activity, does not provide substantial earnings due to the lack of alternative income sources. Besides, the forest cover in the area is

excessively extracted and it is dwindling which is not able to provide enough income for the family. As a result, these households continue to experience food insecurity despite engaging in charcoal sales. When it comes to another variable. The marginal effect for age of sample pastoralists and agropastoral is 0.047. This suggests that a one-year increase in age is associated with a decrease in household food security by 0.047 unit, and this effect is statistically significant at 1% level of significance. The marginal effects for family size are -0.37. This indicates that households that have large family sizes have significantly food security compared to those that have small family sizes. Each unit increase in family size is associated with a decrease in food insecurity by 0.37 units. Access to extension service is statistically significant at a 1% level of significance. On average, households with access to extension services have a good food security status that is 0.02 units than households without access, holding other factors constant.

Table 8 shows that the F-test with a value of 9.97 and a p-value of 0.000 indicates that the regression model is statistically significant, implying that at least one of the independent variables is significantly associated with household food security. The F-test value (9.97) and the associated p-value (0.000) suggest that the overall model is statistically significant. The R-squared value of 0.82 indicates that the independent variables included in the regression model explain approximately 82% of the variation in household food security. This suggests that the model has good explanatory power. These findings are consistent with research like Nhemachena et al., (2018) suggesting that resource depletion through charcoal production and displacement through migration can undermine long-term food security and income generation. In addition, borrowing from credit union ($p<0.01$), borrowing from friends/families ($p<0.01$), and reduction of expenses ($p<0.01$) which align with studies like Giordano, (2023) where access to credit or social support enables investment in food production, resource purchase, or cost-cutting measures, thereby improving food security.

Table 8: Determinants of household food insecurity among pastoral and agropastoral households in Borena Zone, N= (417)

Variables	Standard errors	T-value	Marginal effects
Land contracting	0.832	-0.72	-0.42
Borrowing from credit union	0.43	-3.34	-1.06***
Borrowing from friends or families	0.534	-5.35	-2.58***
Selling wood tree	0.553	-0.55	-0. 62
Selling charcoal	0.535	4.84	2.67***
Free support money	0.463	0.39	-0.21
Migration	0.602	4.83	2.56***
Reduction of food expenses	0.487	-3.86	-1.87***
Looking for daily labor	0.516	-0.17	-0.29
Sell assets	1.216	-0.07	- 0.07
Age of head	0.013	3.55	0.047***
Sex of head	0.38	1.16	0.44
Family size of head	0.10	-3.60	-0.37***
Education level	0.4	-2.13	-0.85**
Access to extension services	0.38	-0.08	-0.02***
Market distance	0.03	3.83	0.12
Mean dependent variable=14.688		R-squared =0.82	
F-test = 9.97		Prob > F =0.000	

, * significant at and 5%, and 1%

4. Conclusion and policy implications

The findings of the study indicated that households in the study area were facing the dual challenges of climate variability and food insecurity. Substantial proportion of them perceived the effect of temperature increase and decrease reflected in annual rainfall variability, crop failure and death of livestock. Approximately 77% of the households perceived that the effect of temperature increases on crop and livestock. Around 89% of the households perceive that decrease in annual rainfall affects agriculture and livestock

productivity. In effect, food security became one of the major concerns in the community where about 95% of households faced different level of food insecurity with about 36 % falling under either severely or moderately food insecure category. The findings further depict that households employ a range of coping strategies in response to increasing climate variability and food insecurity. Receiving humanitarian aid from government or NGOs, out--migration, borrowing from friends or families, reduction of expenses, daily labor, sell of charcoal and fuel wood were the most frequently reported coping strategies. Perception of the effect of temperature increase on crop and livestock has significantly increased the adoption of land contracting adoption of selling fuel wood and daily labor increased as a coping response to climate variability among pastoralists and agropastoral. The perception of the impact of decrease in annual rainfall on crop and livestock has significantly increased the adoption of borrowing from friends or families and free support of resources among pastoralists and agropastoral. The finding also shows borrowing from credit union, borrowing from friends or families, and reduction of expenses has reduced the food insecurity among pastoralists and agropastoral households. To address these pressing issues, specific coping responses have emerged, aiming to enhance resilience and ensure the well-being of the local population. These coping responses have proven crucial in navigating the complexities of climate variability and its impact on food security in the region. Borena pastoralists and agropastoral have developed traditional knowledge and resource management practices to cope with climate variability and food insecurity. They employ various coping strategies to enhance reduce the effect of climate variability and food insecurity on their livelihood.

The overall findings imply the need for integrated interventions that consider the livelihood strategies of pastoral areas that concurrently address poverty, climate change, access to acceptable diet. The use of behavioral change communication advocacy will serve as a strategic bridge to raise awareness about climate change risk management and

reduce malnutrition in all its forms through better diet. Most importantly, a paradigm shifts towards inclusive, community-oriented, indigenous, knowledge-based climate change adaptive capacities, food and nutrition policies would be a noble investment.

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