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Full Length Research Paper

Community-Based Recurrent Drought Coping Strategies and Their Implications to Households' Food Security in East Bale Zone, Ethiopia

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Abstract

Drought is a major consequence of climate change that has made it more frequent and severe for the livelihoods of farming communities in Ethiopia. The general objective of the study was to identify community-based recurrent drought coping Strategies and indicate its implication to households' food security in East Bale, Ethiopia. The study employs a cross-sectional research design, and data were collected from 323 randomly selected households through focus group discussions, key informant interviews, and a household survey. In the study area, 98% of households adopted different drought coping strategies, including flock depopulation, reliance on relief support, and seasonal mobility. The study findings clearly reveal the effect of recurrent drought on agricultural (crop and livestock) production. Food security analysis also shows that, in the study area, 81.73% of the sampled households were food insecure while only 18.27% were food secure. The investigation of gender differences showed that women faced limited access to resources, which hinder the decision making roles and economic participation to improve their livelihoods. The study recommends that it is important to enable women and empower gender equality to improve community-based resilience and food security. To reduce the impacts of recurrent drought on agricultural production, livelihood, and food security in the study area, policy recommendations include drought tolerance and resistance in high-yielding varieties, increasing access to water by using water harvesting technology and use for irrigation, and launching community self-support networks.

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1. Introduction

Drought is defined as a sustained period of no or little rainfall as compared to the multi-year statistical average rainfall of the area, leading to substantial water shortages that adversely affect agriculture, livestock, and ecosystem health. This phenomenon is characterized by its gradual

nature and can take many different forms, affecting various industries and geographical areas (Ghosh and Bera, 2024). It is one of the main environmental problems that are currently threatening ecosystems worldwide and endangering livelihoods that mainly depend on agriculture and livestock (Edwards *et al*., 2024, and Moss *et al*., 2024). In the area anywhere, agriculture is the key economic sector are particularly susceptible to climatic variability, and the impacts of drought are mainly severe there (Liu *et al*., 2024).

In several regions of the world, climate variation has made droughts more frequent and severe, which has exacerbated pressures on natural resources and food security, which are essential to rural communities' livelihoods (Tofu, 2024). Although both developed and developing countries suffer greatly from drought, the latter are more at risk due to their dependence more on agriculture and insufficient resources. Developing countries experience effects such as drought conditions, which lead to loss of livelihoods (Rinaldo et al., 2024; Edwards et al., 2024). Critical socioeconomic problems, such as rapid population growth and resource degradation, contribute to the current drought in SSA and make the region more vulnerable (Sodoge, 2025).

Drought is a major consequence of climate change that has made it more frequent and severe for the livelihoods of farming communities around the world (Oloitipitip *et al*., 2024). Communities that depend on seasonal agriculture and livestock are still highly vulnerable to climate change and variability on a global scale, and they require resilient strategies to deal with erratic conditions in a timely manner (Abdela, 2024; Oloitipitip *et al*., 2024). The Recurrent droughts cause food insecurity, affect livelihoods, and exacerbate poverty in farming communities in developing nations like Ethiopia (Abdela, 2024), where agriculture frequently serves as the backbone of livelihoods and rural economies (Tofu, 2024).

In an increasing number of countries worldwide, community-based coping strategies have now become a major route through which recurrent drought impacts are addressed, particularly for lowland community. In the event, community-driven approaches that tap local knowledge and collective action have indeed proved effective in enhancing resilience (Abdela, 2024). These make community-based coping strategies all the more significant in maintaining food security among pastoral households.

Drought is one of the perennial problems in Ethiopia, and lately, it would seem to be an increasing occurrence (Musungu *et al*., 2024). Based on the work of Senamaw *et al*. (2021), in most parts of the country, there has been a high rise in drought probability, especially from 2011 onwards. Droughts in the recent past have adversely affected the economy of Ethiopia and especially the agricultural sector, relying for more than 90 percent of its food production on rain-fed systems (Alemu *et al*., 2024). This disruption of rainfall patterns is manifested in terms of delayed onset, insufficient amount, and irregular distribution, which further causes reduced crop production, mortalities of livestock, and widespread food insecurity (Gutierrez *et al*., 2014). These, in turn, contribute to long-term environmental degradation and increase socio-economic problems such as poverty, resource limitation, and weak governance structures (Mugandani *et al*., 2022). Food-insecurity remains a great problem as sustained drought conditions negatively impinge upon agricultural output and livelihoods (Zhao *et al*., 2022).

The effects of drought are very conspicuous in Ethiopia, including the East Bale Zone. The area is highly dependent on livestock and rain-fed agriculture, hence being highly vulnerable to climate change (Birhanu *et al*., 2017). These areas are normally associated with a high level of vulnerability due to recurrent drought, which has seriously threatened food security by exacerbating levels of poverty, inadequacies of food, and displacement. Scarcity of water, loss of livestock and agricultural yield, further reduced the food-insecurity and economic hardship among the population, particularly in the rural parts. Moreover, 6.8 million people were affected by the drought from 2020 to 2022. More than 260 000 cattle died in eastern and southern Ethiopia

(OCHA, 2022). Climate change predictions have shown that these kinds of drought events are likely to happen more often and be even more intense, thus posing a greater danger to food security and agricultural stability in the region (Negatu, 2016).

Drought, food insecurity, and a lack of adaptation resources already compound into a heavy burden for households in the East Bale Zone. Currently, local communities are facing low crop yields, livestock mortality due to a lack of adequate fodder, and poor water resources, not only for humans but also for the livestock. The livelihoods of this region are largely agriculture and livestock-based; therefore, the effects of drought threaten economic stability at the household and regional levels. The significance of the study was to fill the gap in the available in thoughtful impacts of drought on agriculture and food security of the farming community in East Bale Zone. The objectives of the study were to evaluate the drought effect on agricultural production (crop production and livestock productivity) and to identify the coping strategies used by the community to cope with the impacts of drought in the East Bale Zone. The study has important for the development of concrete solutions that improve the resilience of the community and reduce the future impacts of drought and ensure the stability of food security for long periods in East Bale Zone and beyond in many parts of Ethiopia.

2. Materials and Methods

2.1 Study Area Description

The study was carried out in East Bale Zone, southeastern Ethiopia. It is a vital area dominating the dynamics of recurrent drought. It is found approximately between 6.750° N latitude and 40.250° E longitude. The zone consists Gindir, Sewena, Legahidha, Rayitu, Dawe Sarar, Dawe Qachan, and Gololcha districts. With this, each district has unique socio-economic and geographical characteristics that reflect the challenges faced by local communities.

Specifically, the study focused on Rayitu, Sawena, and Dawe Serer districts. Rayitu district is known for its perennial rivers, Weyib and Wabe, which offer important water potential for humans, agriculture, and livestock. The land use in the Rayitu district consists of 39% pastureland, 37% forest, 17% arable land mainly used for crops such as corn, teff, and sorghum, and 7% classified as wetland or impractical. Based on the 2007 census, the population of Rayitu was approximately reported as 33,169, with 16,876 men and 16,293 women.

As mentioned above Sewena district is characterized by dry climatic conditions. Its elevations found between 400 to 1,850 meters above sea level. Land use classes consists arable land 24.4% and pastureland 46.3%. In the district, the main crops are sorghum, wheat, corn, and teff. From a number of populations, Sewena district was approximated at 65,846 based on the 2007 census, in which 32,996 men and 32,850 women. On the other hand, Dawe Sarar district was located southeast of Gindir town at an altitude of 640 meters. Additionally, the district is found between 06.110767° N latitude and 41.679067° E longitude. It is known by a substantial livestock population in the zone, with approximately over 349,000 goats and 54,403 cattle.

In general, the East Bale Zone is mostly characterized by arid to semi-arid climatic conditions that lead to vulnerability to drought under climate change. These erratic rainfall patterns have a profound impact productivity of agricultural and food security. Hence, in the previous ten years, this zone has been significantly affected by climatic challenges by agropastoral and pastoral communities, since community livelihoods were more vulnerable to climate variability and environmental degradation.

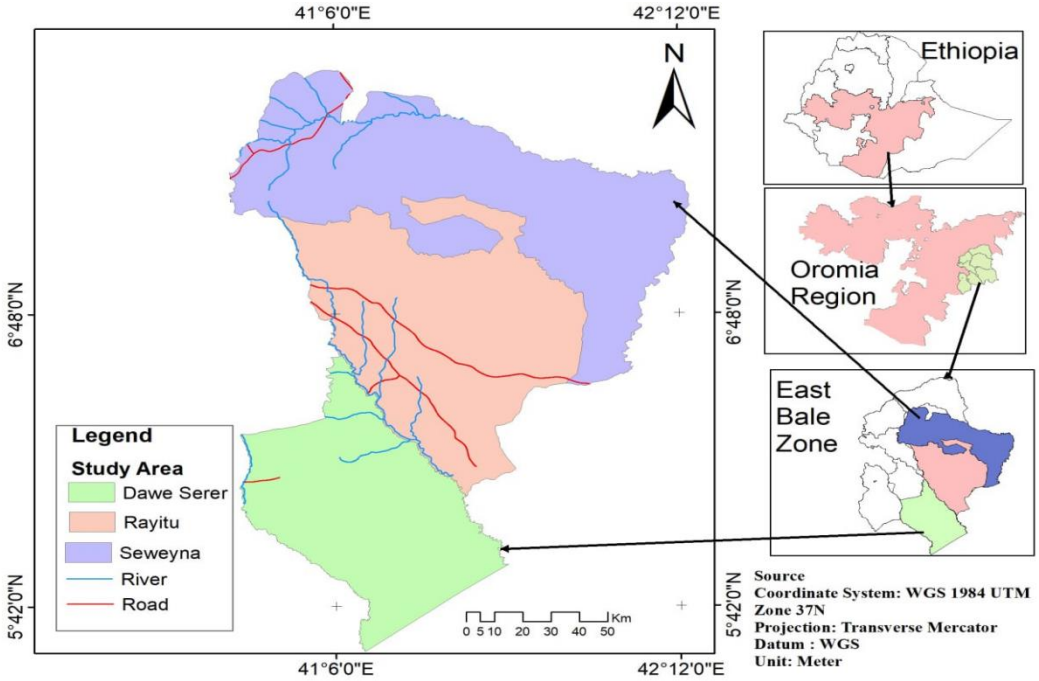

Fig. 1: Study area map

2.2 Study Design, Sampling Procedures, and Sample Size Determination

To examine the climate change impact under various community-based coping approaches, specifically for recurring drought in the East Bale Zone. With this, the study used a cross-sectional study design through a combination of quantitative and qualitative data types. The study employed cross-sectional approaches because its effectiveness in data collection and analysis. It is also important for understanding the complicated issues in food-security and coping strategies. Hence, these methods were allowed to examine the correlations between variables and their frequency.

In this study, to get a reliable and representative dataset, community-based coping strategies were followed to evaluate distinction recurring drought between households in the lowlands of East Bale Zone. Similarly, it is employed multi-stage sampling technique to reduce complexity in the study area and sample respondents' selection. At the first stage, more frequent droughts were selected using purposive sampling techniques from Zones in the country. This selection was also followed by a previous study and reports showing that areas in which vulnerable to climate variability shows serious problems including water scarcity, food insecurity, and livestock low productivity and losses. Based on these realities East Bale zone was purposively selected.

At the second stage, the East Bale Zone was stratified into pastoral and agro-pastoral districts based on zone reports and community livelihood strategies. Thirdly, one district from each livelihood strategy was selected randomly to establish a balanced representation. With this Dawe Sarar was selected from the pastoralist, while Sewena and Rayitu districts were selected from the agro-pastoralist districts. Therefore, to minimize bias and increase acceptability in both livelihood systems, a random number generator was employed as part of the random selection process for a list of eligible districts.

At the fourth stage, a random number generator was also used for Kebele selection. Under this stage, two Kebele per district were selected. Households were selected randomly from Kebele lists based on proportional calculation. Random sampling methods enhance the accuracy of the data collected by lowering selection bias. Hence, Cochran's formula (1977) was employed to determine the sample size for this study.

$$n = \frac{pq(z)^2}{e^2}$$

Where, n= sample size,

z= the value of standard varieties at a given confidence level and to be worked out from the table showing area under the normal curve is 95% zα/2 = 1.96,

p= sample proportion is 0.3, q= 1-p=0.7, e = given precision rate or acceptable error 5% numbers of household heads selected from the selected *Kebeles* were limited by probability proportional to the size of the six selected *Kebeles*.

Therefore, sample size determination is based on the household

$$n = \frac{(1.96)^2 * 0.3 * 0.7}{(0.05)^2} = 322.8 \approx 323$$

Thus, a total of 323 respondents were selected on a random basis from the sample of two *Kebeles* from each district.

2.3 Method of Data Collection

This study used both primary and secondary sources. Primary data were collected at households' level through a household survey using a semi-structured questionnaire. This data collection tool was used to explore the impact of drought on water resources, agricultural productivity, and household response to climate change (Gebre *et al*., 2024). Data collectors were selected based on their experience, educational background, and Afan Oromo language skills. This study took six hours to express the goal of the study to the participants, the aim of the study, questionnaire contents, and the procedures that should be followed for data collection (Gebre *et al*., 2024). Then questioners were undergoing pre-test evaluation using six households from the study area based on the challenges observed and the feedback final version of the questioners were prepared and distributed.

Additionally, key informed interview was employed using household selection criteria, such as of experience, length of year has lived in the area study area, seniority of experts, Abba Gada and Hadha Sinqe members. From these community groups, 18 participants were selected from three districts. With this, household surveys are used to take data on the effects of recurring drought on livestock and crop production, as well as adaptive measures (Molla *et al*., 2023).

Household and key informant interviews were conducted to get deeper information about drought-related dynamics in communities and individual experiences to cope with and resilience to drought. Key informants' interview was conducted using a community representative in specific knowledge related to the study. Hence, parts of the community included in the key informant interview were elders, experts, females, district food security officers, village administrators, district agriculture bureau officers, Abba Gada, and development agents.

Likewise, in supplementing the household data collection methods, for each district, two focus group discussions (FGDs) were conducted. One FGD was consists 12 members through excluding household survey and key informant interview participants. Then, for six Kebele, a total of 6 FGDs were conducted, participating community elders, village council members, women, experts, environmental management groups, and youth farmers. These discussions strengthened a collective understanding of shared coping strategies and community challenges. Checklists and guidelines were prepared for KII and FGD to undertake in-depth interviews and discussions.

Data were systematically and comprehensively organized. The length of the data collection was two weeks in December 2023. This is strategically selected to fall into the post-harvest season so that respondents would provide information about their current state of food consumption based on the recent agricultural yields. Secondary data sources were also sought, with supplementation by actual primary data collection.

2.4 Method of Data Analysis

Combinations of quantitative and qualitative methods of data analysis were employed to get triangulating results for the intended objectives. Consequently, after compilation and preparation of the data, descriptive statistics were carried out to get a clear and coherent representation of the

sample units. Quantitative data were analyzed through percentage, mean, and standard deviation from descriptive statistics, while narration of qualitative data was made to show understandings of key themes. Qualitative and quantitative data analyses complemented each other to further note and understand the data collected. Then, quantitative data-based variables were employed for the test of significance by chi-square tests. This test is used to analyze categorical (dummy) variables, whereas t-tests are used to evaluate variations in continuous variables.

Chi-square and t-test were established to delineate the relationships between the variables as well as their effect on the household food security outcomes. Hence, chi-square tests were formulated for categorical data type for analysis to explore associations between different groups, such as between functional community drought coping strategies and household characteristics. In this regard, household caloric intake was used in analyzing household food security as a primary indicator (Kordel and Gruber, 2023). Dietary intake data for seven days were collected using the recall method. This method was selected since it allows for better accuracy in the recollection of food items consumed within that week. It also minimizes recall bias in household dietary intake data analysis and can be easily used in longer recall periods (Morton et al., 2019). This method was used since respondents may forget to recall the type of foods they have earlier consumed if the recall period is longer than seven days.

Data derivation was employed for dietary household intake in the previous seven-days using the recall method. Along with this, it was converted to kcal through a manual food composition table, which was adapted from EHNRI (1997). The total calorie intake of the households over the previous seven days was then divided by seven to establish their average daily caloric consumption. To estimate food security more validly, this daily caloric intake was adjusted for household size by calculating intake per adult equivalent. In other words, it means a division of total consumption of calories by family size after applying factors of consumption according to age-sex categories (Karageorgou et al., 2018). The result from the analysis of the caloric intake was then compared to the minimum subsistence requirement as estimated by the Ethiopian government at 2,200 Kcal per adult equivalent per day (FDRE, 2014). This number formed a critical threshold that helped categorize the households into food-secure and food-insecure. Households failing to meet this minimum requirement were considered food insecure, while those meeting or surpassing the requirement were classified as food secure (Hailu, 2022).

3. Results and Discussion

3.1 Demographic and Socio-economic Characteristics of the Households

As indicated below, the socio-demographic profiles of the 323 households surveyed in East Bale Zone display the-complex interaction of factors for the prevailing food security situations, and further in the situation of experiencing drought. Of the total, 58% of the households were male-headed, and 42% were female-headed. Food insecurity was more or less evenly distributed between male heads at 49% and female heads at 51%. This inequality points to structural barriers in the way female-headed households access the two most important inputs of land and credit that are integral in ascertaining agricultural productivity and resistance to climatic shocks (Table 1).

Important gender roles and resource access dimensions that are crucial to household poverty and food insecurity vulnerability are captured by the socioeconomic relationships in the East Bale Zone. With more recent reductions in women's potential access to resources like land, credit, and training, gender roles are still determined by cultural and traditional norms. Most interviewees concur that men and women have equal access to professional and technical assistance, contributing to a larger disparity in how men and women manage resources. Women's ability to

participate in decision-making at all levels regarding enhancing resilience against climate-related shocks is limited by these institutional barriers.

The community's economic participation is another important factor affecting food security outcomes; only 21% of households engage in non-farm activity, which differs greatly between 97% of food-secure households and 3% of food-insecure households. Given that households with food security were 4.27 km from markets and those without food security were 11.27 km, proximity to markets has a substantial impact on food security status (Table 1).

Pastoralists believe that livelihoods are impacted by climate change, and many are noticing changes in the climate's variability, such as extended drought and decreased rainfall. Given their roles in caring for and producing food in the home, women and children typically suffer more from food insecurity than others, so such changes make preexisting vulnerabilities worse. Women are frequently forced to take on more responsibilities at the expense of participating in other social or economic activities to the same extent as their counterparts due to increased workload and time poverty. As they adapt to these changes, women experience time poverty and the brunt of increased workloads (Tofu, 2024).

Contrary to these conclusions, research from other areas highlights how crucial it is to address gender differences in order to improve food security outcomes (Ayamga *et al*., 2023). For instance, research has demonstrated that communities benefit from improved agricultural yield and food security when women have equivalent access to assets and decision-making opportunities (Christine and Emmanuel, 2023; Egyir *et al*., 2023; Jemaneh and Shibeshi, 2023). However, 60% of respondents said that cultural customs and religious beliefs have a significant impact on gender roles in the East Bale Zone. Women were mostly restricted to domestic responsibilities, whereas men predominantly control resource decision-making and livestock herding. This gender division of labor limits women's economic participation (Ndjobo, 2023).

Table 1: Demographic and socioeconomic profile of respondents

Characteristic	Description	Findings	Implications for Food Security
Household Composition	• Gender of household head	- Male-headed households: 58% - Female-headed households: 42%	• Gender disparities affect access to resources and decision-making, influencing food security outcomes.
Food Security Status	• Distribution of food security among household heads	• Food-secure male-headed households: 98.31% • Food-insecure: 49.24% male, 50.76% female	• Higher food security in male-headed households highlights the need for targeted support for female-headed households.
Economic Participation	• Engagement in non-farm activities	▪ Overall participation: 21.05% ▪ Food-secure households: 96.61% engage in non-farm activities ▪ Food-insecure households: 4.17%	• Economic diversification is crucial for resilience; promoting non-farm activities can mitigate drought impacts.

Characteristic	Description	Findings	Implications for Food Security
Educational Attainment	• Average years of education for household heads	▪ Overall average: 1.47 years ▪ Food-insecure households: 0.92 years ▪ Food-secure households: 3.41 years	• Addressing educational gaps through training programs can empower communities to adopt sustainable practices.
Proximity to Markets	• Average distance from households to markets	• Food-secure households: 4.27 km • Food-insecure households: 11.27 km	• Closer proximity to markets enhances access to essential goods and services, improving food security outcomes.
Livestock and Land Holdings	• Comparison of livestock and land ownership between groups	• No significant differences noted in livestock and land holdings between food-secure and food-insecure households	• Livestock ownership is critical for food security; promoting sustainable livestock management can improve resilience.
Livelihoods and Livestock Ownership	• Sources of livelihood and livestock ownership patterns	• Livelihood sources: Rearing animals (65%), Crop production (25%), Petty trade (10%) • Livestock ownership: Cattle (70%), Sheep (60%), Goats (55%), Donkeys (40%), Camels (30%)	• Diverse livelihood strategies enhance resilience against shocks; improving livestock management is vital for food security.
Vulnerability to Drought	• Impact of recurrent drought on households	▪ Households affected by drought: 80% reported reduced income sources during droughts ▪ 75% experienced increased food insecurity before and after droughts ▪ Coping strategies include reliance on community support (60%) and selling livestock (50%) during severe droughts	• High vulnerability to drought underscores the need for adaptive strategies in food production and resource management; enhancing community support systems can mitigate impacts on food security.

3.2 Effect of Drought on Agricultural Production

3.2.1 Effect of drought on livestock production

The result in Table 2 reveals how the drought has negatively affected livestock production, highlighting the importance of the situation for the local communities. Livestock heads were significantly lower before and after the drought, and the differences were significant at the 1% level, according to a paired sample t-test. The result of T-test (48.66) indicates that the change was highly significant. On average, cattle production dropped from 8.34 before the drought to 0.78 after it. This significant decrease suggests that a number of cattle must have perished from the severe drought conditions brought on by a lack of water and grazing.

The results again show that, sheep production decreased from 0.57 to 0.23 with a t-value of 3.96, which was consistent with the overall trend of livestock loss. Goats are often regarded as hardy and sturdy, so the sudden decline is concerning. Furthermore, their numbers dropped from 0.74 to 0.35 (t-value: 8.01), which is worrying because they are necessary for the employment and transportation of many households.

With a t-value of 32.48, camel production finally took a startling turn, declining from an average of 2.49 to a pitiful 0.38. Surprisingly, the level of aridity has decreased because camels are known to be resilient creatures that endure prolonged periods of dryness. These quantitative findings that livestock deaths occurred and that people's income opportunities became limited have been supported by focus group discussions. Due to crop performance that suffers from insufficient rains and livestock issues related to feed availability brought on by recurring droughts, the majority of people in the study districts are having difficulties. When she stated, "Camels were called ‘ship of the desert' for their ruggedness, but today we live to see camels starving to death," one of the key informants eloquently captured the seriousness of this problem.

Table 2: Effect of drought on livestock production

Variables		Obs.	Mean	Std. Dev.	t-value
Cattle	Before	323	8.34	5.51	48.66***
	Current	323	0.78	4.42	
Sheep	Before	323	0.57	1.37	3.96***
	Current	323	0.23	0.73	
Goat	Before	323	12.38	5.51	22.19***
	Current	323	3.33	4.42	
Donkey	Before	323	0.74	0.61	8.01***
	Current	323	0.35	0.59	
Camel	Before	323	2.49	1.02	32.48***
	Current	323	0.38	0.71	

Because of the lower calving rates are linked to the drought years themselves, the effects are likely to be more noticeable in the following year for large species, like cattle and camels, which have gestation periods of 9 to 14 months (Bogale and Erena, 2022, Muchie and Faris, 2023). These losses add up to a concerning effect because drought can cause a more than 30% decrease in total livestock populations, which has a significant effect on pastoralists' livelihoods (Bogale and Erena (2022). In addition to endangering food security, the loss of livestock also has an adverse effect on the local economy, which mainly depends on livestock for revenue. Pastoralists who depend on their herds for trade and sustenance have experienced significant economic hardship as a result of the severe drought in the Horn of Africa (Muchie and Faris, 2023).

Due to their longer gestation periods and reliance on dependable feed, large livestock species like cattle and camels are impacted by drought,

according to research by Rodziewicz *et al*. (2022) and Bogale and Erena (2022). Drought will probably cause a sharp drop in livestock numbers over time; in some cases, studies have shown losses of over 30%. This will have an impact on pastoralists' livelihoods. Losses of livestock have a far greater impact on food insecurity.

3.2.2 Effects of drought on crop production

The information highlighted in Table 3 demonstrates that crop production in the study area is significantly impacted by drought. The catchment's primary crops are teff, wheat, barley, maize, and sorghum. It is awful that nearly all of the respondents to the household survey stated that the drought had a detrimental impact on food production. Teff yields ranged from an average of 0.73 Qt/ha to a maximum of 4.5 Qt/ha, with some years seeing no production at all. This would likely suggest that the majority of farmers only have very limited success, with the remaining farmers unable to grow teff because of drought conditions. The average yield of 0.36 Qt/ha and a maximum of 12 Qt/ha, wheat is similar, indicating significant variability and extremely poor overall harvesting. Despite its natural resistance to drought, sorghum is being severely harassed by the current conditions. With some cases of nil output, sorghum yields vary from an average of 1.79 Qt/ha to a maximum of 13.5 Qt/ha. However, Table 3 shows that this was also evident in the production of pulses, with an average of 0.84 Qt/ha for lentils, 0.46 Qt/ha for chickpeas, 0.90 Qt/ha for field peas, and 0.68 Qt/ha for haricot beans.

Table 3: Effects of drought on crop production

Cereals	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**
Teff	323	0.73	1.13	0	4.5
Wheat	323	0.36	0.63	0	12
Barley	323	0.31	0.56	0	9
Maize	323	0.80	1.34	0	15.63
Sorghum	323	1.79	3.15	0	13.5
Pulse					
Lentils	323	0.84	1.04	0	3
Chickpeas	323	0.46	0.84	0	4
Field Peas	323	0.90	1.023	0	5
Haricot beans	323	0.68	1.21	0	7

The result in Table 3 above summarizes the findings and shows that drought has a significant effect on crop production in the study area. Among the crops produced in the area main crops that were affected by drought are sorghum, wheat, barley, *teff*, and maize. These findings were verified by research by Pequeno *et al*. (2021), which highlights the wider effects of drought on these particular crops. For instance, drought conditions in Ethiopia pose a serious threat to food security because they can cut *teff* yield by as much as 50% (Lasky *et al*., 2015). The sharp drop highlights how vulnerable *teff*, a staple crop that is vital to the region's nutrition and revenue streams, is. Barley and wheat are equally susceptible to drought stress (Sabagh *et al*. 2019).

According to research reports, in arid regions, drought conditions can cause a 40% reduction in wheat crop yields (Pequeno *et al*., 2021). Other effects of drought on barley are also not insignificant. Barley plants that have experienced

severe drought conditions have shorter grain filling periods and individual grain weight loss, according to Sabagh *et al*. (2019). Drought conditions can also affect maize yields.

Despite the favorable conditions, the amount of maize that could have been produced is greatly reduced due to the frequent low rainfall. According to reports, prolonged drought can cause a significant loss in maize yield and exacerbate food insecurity for the populations that depend on this staple crop (Adunya and Benti, 2020, Fayera, 2022). Despite being thought of as one of the cereals that can withstand drought the best, sorghum production is also decreasing due to current climate trends. Sorghum may be more drought-tolerant than other crops, but it is not impervious; in areas where the drought has been particularly severe, cases of zero production have been documented. The livelihoods of farmers, who depend on crops for food and income, as well as household food security, are at risk due to the losses accumulated in teff, wheat, barley, maize, and sorghum (Temam *et al*., 2019; Eze *et al*., 2022). According to the focus group discussions, the increasing frequency of droughts is making farming increasingly pointless and contributing to the growing problem of food insecurity.

3.3 Food Insecurity Status of the Sampled Households

The food insecurity status of the sampled households showed that 81.73% of the total surveyed households were food insecure and only 18.27% were food secure, based on the minimum recommended calorie requirement of 2200 kcal/day/AE (Table 4). The average per capita caloric intake of the sampled households was 1,854.99 kcal, which is below the minimum of 2,200 kcal required for an active and healthy lifestyle. One of the main causes of food insecurity in the study area, where most families depend on rain-fed agriculture and livestock rearing, is the frequency of drought.

This is in line with study by Gebre *et al*. (2024), which identifies drought as the primary driver of food insecurity and reveals that 68% of households routinely eat less food than they require. Additionally, households who rely on agriculture are more susceptible to drought circumstances, according to Mesfin *et al*. (2024). The result in Table 4 below reveals that the average daily calorie intake for food secure households was 2,654.613 kcal per adult equivalent (AE) per day, whereas the average daily calorie consumption for food insecure households was 1,676.287 kcal per adult equivalent (AE) per day. The food security analysis shows that the mean difference between food security households and food insecure household were significantly different at less than 1% significance level. This finding is in line with that of Morselli *et al*. (2022), who discovered that households facing food poverty often consume lower-quality meals, which results in inadequate calorie intake and shortages in specific nutrients. Similarly, Agdeppa *et al.* (2021) found that moderate and severe food poverty is linked to a higher intake of foods high in calories but poor in nutrients, which results in a lower total nutritional quality

Table 4: Kilo calories per day per adult equivalent of the sampled households

Kcal/AE/Day	Food secured (18.27%)	Food in secured (81.73%)	Total HH (100%)	T- value
Maximum	4804.65	2185.07	4804.65	
Minimum	2260.38	799.37	799.37	17.0696***
Mean	2654.613	1676.287	1854.99	
Standard Deviation	401.0117	397.3373	548.8663	

Sources: own survey (2023) *** show significant at less than 1% probability level.

3.4 Household-Level Coping Strategies to Recurrent Drought

In Ethiopia's East Bale Zone, households implementing various coping mechanisms showed a high level of engagement (Table 5). According to the analysis, 98% of households used some form of coping mechanism, indicating that they could adjust to the demands of their surroundings. The following coping strategies were commonly reported: communal pooling (60%) involving the sharing of resources and labor among community members; seasonal mobility (73%), where families relocated in search of better dry season resources; and reliance on relief support (58%), which involves the provision of assistance from outside sources during times of need. To diversify household incomes and disempower households, other measures, including flock depopulation (27%) and petty trade (9%) of households, have also been put in place as ways of diversifying household incomes, hence disempowering the threatening control of frequent droughts.

These findings are consistent with broader research showing that drought significantly affects Ethiopia's food security situation, particularly for pastoralist and agro-pastoralist communities. Chronic drought causes high livestock deaths and reduced cultivation, which prolongs hunger in the area, according to research on the pastoralist food system (Abdela, 2024; Gebre *et al*., 2024). According to the Food Security Cluster, extended dry spells have had a negative impact on pastoral conditions and water supplies, both of which are essential for pastoralists. In the East Bale Zone, where recent drought forecasts have been predictably negative, the irrigation department has specifically recognized the significance of early action protocols and such early concern (Abdela, 2024). This highlights the urgent need for suitable actions to mitigate the adverse effects of climate change on the aforementioned populations. According to the survey reports, households' coping mechanisms are not only involuntary, but they are also best prepared for climate variability (Begashaw *et al*., 2024). More capital investments in smallholder irrigation technologies and improved market opportunities, for example, would help stabilize agricultural production and lessen the likelihood of drought (Ogola, 2021, and Tofu, 2024). One way to enable community resilience capital during climatic stress is to prioritize temporal community building and multi-household livestock on loan provision (Misra, 2023; Kelly *et al*., 2024). In addition to meeting immediate needs in the short term, these programs aid in the development of a longer-term strategy for addressing issues that will likely arise in the near future

Table 5: Individual Coping Strategies used by smallholders

S. No	Coping Strategies	No. of respondents	Percentage (%)
1	Seasonal mobility	236	73.07
2	Dependency on relief support	187	57.89
3	Flock depopulation	86	26.63
4	Communal pooling	194	60.06
5	Causal labor	12	3.72
6	Petty trade	30	9.29
7	No coping used	5	1.55

Seasonal mobility is one of the main coping mechanisms used by households in the study area, according to the results shown in Tables 5 and 6. In order to help the majority of drought-prone communities, this involves moving people and their herds from pastoral areas to sedentary villages and vice versa depending on the availability of water and fodder. Calves nursing cows and weak piglets tend to remain on the farm for the milking activity during livestock migration to better environments, even though not all household members or livestock migrate. During these migrations, the adult male herd boys look after the other members of the herd.

This is consistent with the findings of Siripurapu *et al*. (2024), and Abdela (2024), who noted that seasonal mobility helps communities manage the negative consequences of drought by allowing them to utilize various water and grazing resources all year long and minimizing drought losses.

Another helpful coping strategy is communal pooling, which is the practice of using forest resources to make charcoal or sell firewood. During drought, this tactic helps households generate income that can be used to purchase food. However, it is also important to note that communal pooling is not recommended as a long-term coping strategy because it is linked to detrimental environmental effects like deforestation (Kiruki *et al*., 2020). Although such alleviation strategies may provide immediate relief from the issue, their long-term viability is questioned due to the misuse of natural resources (Nyarko *et al*., 2021).

The second strategy is people's reliance on relief assistance, which is when droughts are handled with outside organizations' assistance and Kebede, 2023). Although there is no long-term solution for households that are not at risk of drought stress, this approach can help people and help stop food shortage situations. According to the household survey, government and non-governmental organizations play a critical role in providing food or cash transfer programs to the impacted family members. During drought seasons, various response mechanisms have been facilitated by organizations such as World Vision AFD, PCDP, CARITAS, and Save the Children International. Affected households have also had access to government programs such as the Productive Safety Net Program (RPSNP) (Abate, 2020).

The other mechanism that comes up during droughts is flock depopulation, in which households reduce the number of animals they keep in order to prevent losses brought on by a shortage of water and grass. According to key informants, this allows households to get rid of some animals when there is a drought, and they are unable to feed them. In addition to preventing significant livestock losses, this strategy assists families in replenishing their herds during prosperous periods (Tofu, *et al*., 2024). Because those households have some control over their livestock during these extremely trying times, they can withstand the storms for a while. The concepts of this finding are consistent with a research report by Baudena *et al*. (2023) that states adaptive destocking enhances resilience, allowing recovery from vegetation loss without compromising long-term productivity.

Furthermore, casual labor and petty trade support the coping mechanisms of other households. People whose family members live close to a town or market typically work or engage in petty trade for a living, according to focus group discussions based on the questionnaire. However, most of the households had irrational opinions about these coping strategies as a way to deal with the drought's negative impact on their ability to make ends meet. Due to a lack of resources or practical solutions, rural farmers usually turn to simple coping strategies. According to Destaw and Fenta (2021), a lot of households have trouble implementing all-encompassing coping mechanisms. Petty trade is a major source of income for many people, greatly reducing poverty and promoting economic stability, according to Khatiwada (2019).

Table 6: Drought coping strategies by smallholder farmers

Coping strategies	**No.**	**%**
Seasonal mobility, Dependence on relief support, Flock depopulation, Communal Pooling, Causal labor, Petty trade	43	13.31
Seasonal mobility, Dependence on relief support, Flock depopulation, Communal Pooling, Causal labor	52	16.10
Seasonal mobility, Dependence on relief support, Flock depopulation, Communal Pooling,	54	16.72
Seasonal mobility, Dependence on relief support, Petty trade, Communal Pooling,	41	12.69
Flock depopulation, Dependence on relief support, Communal Pooling,	25	7.74

Seasonal mobility, Dependence on relief support, Communal Pooling,	72	22.29
Seasonal mobility, Dependence on relief support	31	9.60
No coping strategies	5	1.55
Total	323	100

3.5. Effectiveness of Coping Strategies

The results revealed that communities cope with frequent droughts using a variety of coping strategies, with varying degrees of effectiveness for both short term and long term approaches (Table 7). While selling livestock is recognized as an immediate relief strategy, diversifying sources of income over time offers a more sustainable solution. These findings reveal how important it is to identify workable coping strategies that can alleviate the effects of drought on food security while simultaneously identifying the barriers to these strategies.

Creating an environment that encourages adaptation and learning from the past will also help communities develop more resilient farming practices and coping mechanisms in the face of climate variability. Furthermore, by fostering an environment that encourages adaptation and historical learning, communities will be empowered to develop more resilient farming practices and coping mechanisms in the face of climate variability. These results are consistent with recent research showing that a variety of livelihoods can serve as a buffer against shocks caused by climate change (Muthelo *et al*., 2019, Oduniyi et al., al 2020). Long term food security and the development of adaptive capacities depend on community participation in resource management and education on sustainable practices.

Table 7: Effectiveness of coping strategies in response to drought

Component	Findings	Implications for Food Security
Success Rates	- Selling of livestock was reported as the most effective short term strategy which was used by 65% of respondents, providing immediate cash flow. - Reliance on food aid was effective as coping strategies for 60% of households during severe droughts, but sustainability is a concern. - Long term strategies like diversification of livelihoods were effective for 55%, helping to stabilize income sources over time. - Adopting of drought resistant and tolerance cropping showed a success rate of 45%, improving crop yields in adverse conditions.	- Effective coping strategies can reduce immediate impacts of drought on household's food security but may require ongoing support to maintain effectiveness. - Long term strategies are important for building resilience and reducing vulnerability to future droughts.
Barriers to Effectiveness	- The Key challenges include: Lack of resources (reported by 70% of HH) limits the ability to implement long term strategies. - Environmental degradation (reported by 65%of HH) reduces the effectiveness of traditional coping mechanisms. - Market constraints (noted by 60%) hinder	- Improving the efficacy of coping mechanisms requires addressing these obstacles. Community-based programs that increase market accessibility and resource availability can increase resistance to the effects of drought.

Component	Findings	Implications for Food Security
	access to fair prices for livestock and crops, affecting income stability. - External shocks such as conflict and economic instability were mentioned by 50% as additional barriers.	
Adaptation and Learning	- Households have adapted their strategies over time, with 75% of HH changes based on lessons learned from previous droughts. - Common adaptations include: - Increased reliance on communal pooling resources during crises (60%). - Shifting towards more sustainable agricultural practices (50%). - Enhanced planning for seasonal mobility based on past experiences (55%).	- Improving coping mechanisms and boosting resilience require constant learning and change. Promoting community conversations about prior experiences can help future drought responses by fostering information exchange.

3.7. Implications for Policy and Food Security Interventions

The results of findings highlight the critical need for targeted policy initiatives intended to improve food security and community resilience among pastoral and agro-pastoral households in Ethiopia's East Bale Zone (Table 8). There are significant vulnerabilities linked to climate unpredictability, which especially affect women who face barriers to resource access. These findings suggest that building community resilience requires an all-encompassing approach involving local, national, and international players. Stakeholders can significantly improve food security results in these vulnerable populations by promoting sustainable agricultural practices, giving priority to gender responsive policies, and increasing resource accessibility. The creation of robust support networks and infrastructure investments will further improve adaptive capacities in the face of climate related disruptions.

The results of this study are consistent with other research findings reports, as demonstrated by comparable studies conducted in other regions that require a multifaceted strategy involving local, national, and international stakeholders in order to effectively address these challenges. For example, gender-responsive policies can improve women's access to resources and decision-making processes, which are critical for building resilience and enhancing food security outcomes in these communities (Chebet, 2023; Tigabie *et al*., 2022; Beuchelt and Badstue, 2013). Furthermore, it is essential to incorporate sustainable agricultural practices. It has been demonstrated that climate-smart farming methods can both promote sustainable food production and lessen the effects of drought (Davidson, 2015).

According to the evidence, farm productivity and community resilience are significantly increased when women are empowered through resource access and decision-making in agriculture (Chebet, 2023; Dwomoh *et al*., 2023). This is consistent with research from other areas, like Tanzania, where improved food security and favorable environmental effects have resulted from community involvement in resource management (Djurfeldt *et al*., 2020). These findings have ramifications that go beyond quick humanitarian fixes, highlighting the necessity of long-term plans that enable societies to resist shocks in the future. Infrastructure investment and the establishment of strong support systems are essential elements that can enhance adaptive capacities in response to climate-induced disruptions (Abdulah, 2023; Shamsi *et al*., 2019). Furthermore, attaining food security and

advancing gender equity require tackling the sociocultural and gender-specific barriers that prevent women from accessing agriculturally productive resources (Dwomoh *et al*., 2023; Campos *et al*., 2016).

Table 8: Implications for Policy and Food Security Interventions

Component	Findings	Implications for Food Security
Link to Broader Policy Context	- The findings highlight significant vulnerabilities in food security due to climate variability, with 75% of households experiencing increased food insecurity during droughts. - Gender disparities in resource access and decision-making affect coping strategies, with 70% of women reporting limited access to financial resources. - Community-based coping mechanisms, such as shared grazing areas and communal food banks, are essential for resilience but require institutional support.	-Gender-sensitive strategies that improve women's access to resources and give them more influence over decision-making should be given top priority by policymakers. -Local resilience against climate shocks can be increased by incorporating community-based strategies into national policies.
Recommendations for Local Actors	- Promote education and training programs focused on sustainable agricultural practices and resource management tailored to both men and women. - Facilitate access to financial services for women to enhance their economic independence and resilience. - Encourage the establishment of community support networks that facilitate resource sharing during crises.	- By addressing specific community needs, local actors can significantly contribute to the implementation of targeted interventions that enhance food security results. Through capacity-building initiatives, local communities will be empowered to better adapt to climate change.
Recommendations for National Actors	- Develop policies that promote diversification of livelihoods, including investment in drought-resistant crops and alternative income sources. - Implement social protection programs, like food assistance or cash transfers, that offer safety nets during times of drought. - To lessen reliance on rain-fed agriculture, strengthen water management infrastructure, such as	-Long-term sustainability should be given top priority in national policies that address the pressing needs for food security through careful planning and resource allocation. -Investing in infrastructure can significantly improve a community's resilience to climate change.

Component	Findings	Implications for Food Security
	irrigation systems and boreholes.	.
Recommendations for International Actors	Encourage projects that advance studies on climate-resilient farming methods appropriate for agro-pastoral and pastoral systems. Encourage collaborations between regional communities and global organizations to improve resource mobilization and knowledge exchange. Promote laws that take into account the particular difficulties encountered by pastoral communities while addressing the effects of climate change on a worldwide scale.	In order to address the complex issues of food security in vulnerable areas like the East Bale Zone, international cooperation is essential. Cooperation can improve local capabilities, making communities more capable of adjusting to shifting weather patterns.

4. Conclusion and Recommendations

The study assessed community based coping strategies to recurrent drought among rural households in the East Bale Zone and revealed significant socioeconomic and gender related vulnerabilities determining food security outcomes. The food security analysis clearly indicated that in the study area 81.73% of households classified as food insecure. The result reveals that significant gender differences in household composition and resource availability. Despite making up 58% of the sample, 98% of food secure households are led by men, while food insecure households are nearly evenly divided between male and female heads. This difference is a result of structural barriers that female headed households must overcome in order to be coping to drought, especially limited access to productive resources, education, credit, and land. Women economic participation is still limited and many of them depend on small scale commerce and social support networks that frequently break down during dry spells.

Low level of diversification of sources of income increases susceptibility to food insecurity. There are significant differences between food secure and food-insecure households, with only 21.05% of households participating in nonfarm activities. Exposure to drought shocks is increased by a heavy reliance on climate-sensitive activities like crop farming and livestock raising, especially when important crops like teff, wheat, and barley continue to be extremely subject to climate variability. While households apply coping mechanisms like crop diversification, seasonal mobility, and livestock sales, many of them were using other strategies, such as production of charcoal and the sale of distress livestock, which offer temporary respite at the expense of long term livelihood sustainability, environmental degradation, and decreased nutritional security. Perceptions from the community also support rising temperatures and protracted droughts, highlighting the need for sustainable and adaptable solutions.

Finally, the study emphasizes the necessity of mixed method and longitudinal research to better understand the dynamics of food security during repeated drought conditions. Evidence based policymaking will be supported by ongoing environmental trend monitoring, assessment of intervention efficacy, and participatory research methodologies. Scalable and sustained resilience

building methods for pastoral and agro pastoral communities in the Bale Highlands will be further informed by sharing research findings with stakeholders and performing comparative assessments across drought-affected regions.

Author contributions

Drafting, Conceptualization and methodology were carried out by Y.J., M.J., S.B and U.A. The Original draft writing and subsequent editing were also performed by Y.J., M.J., S.B, and U.A. All authors have reviewed and approved the final version of the manuscript for publication.

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Data availability

The dataset used and analyzed in this study is available upon reasonable request.

Competing interests

The authors declare no competing interests.

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