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Assessment of community-driven drought risk management strategies in pastoral and agro-pastoral district of Bale zones south east Ethiopia

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Pastoral communities in Ethiopia's Bale Zone face a constant threat: drought. The Bale lowlands are Particularly vulnerable due to unpredictable rainfall patterns. A 4-year drought cycle had gripped the region, as reported by the pastoralists themselves. Rising temperatures and declining rainfall painted a concerning picture, leading to a cascade of problems: crop failures, food insecurity, outbreaks of diseases, and increased child school dropout rates. This in-depth study aimed to shed light on the impact of drought on these communities and their remarkable capacity to adapt. By bridging the knowledge gap on drought's influence and local coping mechanisms, the study hoped to inform future interventions. The objectives were to identify the impact of drought on Bale's pastoral communities and to identify the coping mechanisms employed by these communities. The study utilized a mixed-methods approach to capture both qualitative and quantitative data. Data collection techniques included: Engaging with knowledgeable community leaders provided valuable insights into historical trends, community perceptions, and local decision-making processes, Facilitating group discussions allowed community members to share their experiences, concerns, and coping mechanisms in a collaborative setting and administering standardized surveys to a representative sample of households allowed for the quantification of drought's impact and the prevalence of various adaptation strategies. The Results shows all study locations experienced drought for four consecutive years (100%), Pastoralists reported rising temperatures and declining rainfall. The drought resulted in, Crop failures, Food insecurity, Livestock deaths, increased human and livestock diseases increased child school dropout rates. The study concluded that despite the challenges, the study revealed a heartening story of resilience. Bale's pastoral communities have not succumbed to despair. Instead, they have developed a multifaceted approach to cope with drought, including: Utilizing existing water sources and creating communal grazing areas for better water conservation, Splitting herds to reduce grazing pressure, implementing early morning grazing to capitalize on dew, diversifying livestock breeds, and strategically destocking herds before droughts to ensure long-term herd sustainability, Diversifying income through trade, transportation services, and petty trade to reduce dependence on livestock production during droughts. Leveraging the enduring strength of traditional social safety nets ("hirpa," "dare," and "hameessa") for crucial support and assistance during hardships. The study underscores the importance of supporting these existing strategies. Policymakers and NGOs can play a vital

role by strengthening social safety nets, promoting the adoption of drought-resistant agricultural practices, investing in research on improved water management techniques and drought-resistant crop varieties.

KEYWORDS

adaptation strategies, bale pastoral, contingency plan, drought, preparedness

1 Introduction

Droughts are a growing threat worldwide, becoming both more frequent and severe (Kogan et al., 2016). Considered as one of the deadliest natural disasters, droughts unleash a cascade of disaster including crop failures, food shortages that risk famines, malnutrition, health problems, and even mass migrations (IPCC, 2012). While developing countries are often considered more susceptible to droughts, history shows these events can be widespread and devastating (Glantz, 1994). The trend is towards more frequent and severe droughts, threatening even major grain producers like the US, China, and Europe (Kogan et al., 2016). Developing countries face a disproportionate burden and despite experiencing only 8% of global disasters particularly vulnerable to droughts (Sharma and Ravindranath, 2019, IPCC, 2012/14).

Droughts have a severe and multifaceted impact on developing countries, exacerbating poverty, food insecurity, and health issues (Tache, 2008; Amsale, 2010 and Funk et al., 2018). Agriculture, the backbone of many developing economies, suffers tremendously as crop yields plummet and livestock perish due to water scarcity (Bryan et al., 2013 and Funk et al., 2018). This results in significant income loss for rural communities heavily reliant on agriculture (Kurukulasuriya, and Rosenthal, 2013). The economic strain is further compounded by water scarcity, which not only impedes farming but also disrupts daily life and industrial activities, creating a ripple effect throughout the economy (Bessachi, and Announ, 2023). For instance, recurrent droughts in sub-Saharan Africa have led to chronic food shortages, forcing millions into malnutrition and driving up food prices (Bishop, and Dimoulias, 2024). Furthermore, the lack of clean water sources due to drought increases the risk of waterborne diseases, placing a burden on already fragile healthcare systems and contributing to higher mortality rates, particularly among children (Bishop, and Dimoulias, 2024). These factors combine to demonstrate that the impacts of drought in developing countries are complex and far-reaching, undermining development progress and exacerbating existing vulnerabilities (Manger, 2000).

Sub-Saharan Africa endures most of drought's impact due to its large population reliant on rain-fed agriculture (IPCC, 2014; Masih et al., 2014). The Sahel region serves as a tragic example, experiencing exceptional drought since the 1960s (Mishra and Singh, 2010). This area, already stressed by climate challenges, has seen a particularly worrying rise in droughts since the late 1800s, with three major events causing severe environmental and socioeconomic damage (Gautam, 2006). Droughts are not limited to the sahel; regions like the greater horn and southern Africa are also highly vulnerable (Hansen et al., 2004; Gautam, 2006). These frequent and prolonged droughts impact communities at all levels, from households to entire nations, with Eastern Africa experiencing a rise in drought frequency compared to a slight decrease in West Africa over the past 50 years (Gautam, 2006).

The vulnerability stems from a combination of climatic factors such as lack of rainfall, hot temperatures, and increased evaporation that are often worsened by human activities like deforestation and overgrazing (Gautam, 2006; Abubakar and Yamusa, 2013; Adegboyega et al., 2016). Climate change further compounds these issues by shortening growing seasons and reducing yields and places even greater stress on livestock, a critical asset for many poor pastoral communities (UNFCCC, 2007; Fereja, 2016). Ethiopia has a long history of battling severe droughts with devastating consequences (Gebrehiwot et al., 2011; Alemayehu, 2023). The country has experienced over 30 major droughts, with some causing widespread death tolls and hardship (Melaku, 2013; Bayissa et al., 2017). The 2017 drought triggered by the Indian Ocean Dipole serves as a recent example (FAO, 2017). Ethiopia faces erratic weather patterns, including a concerning decline in rainfall during the crucial cropping season (Mertz et al., 2009). This erratic rainfall is linked to the country's frequent and devastating droughts, which have caused famines since the 1960s (Alemayehu, 2023). The historical frequency of droughts is worsening, with occurrences potentially becoming annual events (Margaret, 2003; FAO, 2017; Bogale and Erena, 2022). Several factors exacerbate Ethiopia's susceptibility to droughts, including unreliable rainfall, rising temperatures, persistent drought conditions, and the El Niño Southern Oscillation (ENSO) phenomenon (Goitom and Asefa, 2017; Worku and Sahile, 2018; Habte et al., 2022).

Climate change is a significant driver of these issues (Mogotsi et al., 2013; Weldegebriel and Prowse, 2013) while biophysical and social factors like poverty and resource depletion further worsen vulnerability (FAO, 2017; Goitom and Assefa, 2017; Mohammed et al., 2017). These factors create a vicious cycle when combined with droughts. Ethiopia's heavy reliance on rain-fed agriculture makes it highly vulnerable to declining agricultural productivity due to rising temperatures and decreasing rainfall (Deressa et al., 2008; Temesgen, 2010; Blauhut, 2020; World Bank, 2020). This decline directly threatens food security in the country livestock, particularly cattle, are a critical source of income for Ethiopia (World Bank, 2020). However, climate change poses a significant threat to this sector by reducing livestock productivity (Yilma et al., 2009). Factors like lower quality and quantity of forage, increased diseases, and heat stress all contribute to this decline (Kefyalew and Tegegn, 2012; Gashaw et al., 2014; Hidosa and Guyo, 2017). Droughts, like other hydrological extremes, trigger a complex chain reaction of negative consequences. The "domino effect" aptly captures how a single event, like a drought, disrupts one sector and sets off a series of interconnected problems (income loss, food scarcity, instability) (de Brito, 2021). However, the "cascading hardships" concept goes a step further by highlighting the accumulating nature of these impacts. Each triggered event creates additional challenges, making the overall situation progressively worse over time (de Brito et al., 2024). Droughts in Bale zone trigger a series of negative

consequences and reduced rainfall leads to land degradation, biodiversity loss, and overgrazing (BZPADO, 2022). This combination creates a domino effect where cumulative effect produced when one event sets off a series of similar or related events, a form of chain reaction (Wang and Weng, 2020), causing severe soil erosion, lowering the water table, drying out the soil, and damaging pastures (BZPADO, 2022). The result is crop failures, deaths among people and livestock, and even border conflicts for resource access (BZPADO, 2022). Droughts further exacerbate existing challenges by causing increased migration, disputes over boundaries, and outbreaks of diseases (BZPADO, 2022).

Ethiopia's pastoral communities, heavily reliant on livestock, face the brunt of climate change (Scoones, 2004). Unfortunately, research suggests a decline in both the pastoral resource base and the customary institutions that govern them (Oba, 1998; Helland, 1998; Kamara, 2003; Boku, 2008). This weakening foundation threatens the very livelihood of these communities. These repeated droughts expose the critical issue of feed shortages in Bale's pastoral districts (BZPADO, 2022). Research documented significant livestock deaths between 2016 and 2018, with problems persisting (Delbiso et al., 2018). Decades of drought have made some of Bale zone districts the most food-insecure in Ethiopia, reliant on aid programs like the productive Safety Net Programme (PSNP) (Belay et al., 2005; Foran et al., 2012).

The Ethiopian government acknowledges the country's vulnerability to droughts due to climate change (Lemma, 2013). Furthermore, they recognize the need for more localized research on drought patterns and adaptation strategies specific to Bale's pastoral communities (Lemma, 2013). Existing studies on climate change impacts, local adaptation options, and community response plans in these areas are limited (Sinay and Carter, 2020). This research gap highlights the importance of understanding how droughts affect these communities and the coping mechanisms they employ. Examining the consequences of droughts and potential adaptation strategies is crucial to inform policymakers and planners (BZPADO, 2022). Therefore, this research aimed to fill this gap and contribute by conducting assessment on community-driven drought risk management strategies in pastoral and agro-pastoral district of Bale zones southeast Ethiopia and the outcomes of this research are useful in similar study areas with similar challenges.

2 Research Methodology

2.1 Studyarea

Pastoral and agro-pastoral production systems are a cornerstone of life for a substantial portion of Ethiopia's Oromia Regional State. These pastoral and agro-pastoral (PAP) systems are practiced across eight zones: Borana, Guji, West Guji, East Bale, Bale, East Showa, West Hararghe, and East Hararghe. Encompassing 43 districts, this vast area covers 152,070 square kilometers, which translates to 43% of the Oromia region's landmass (OPADCC, 2019 unpublished). This territory stretches from Moyale in the Borana zone to Chinaksan in the East Hararghe zone. The predominant vegetation in Oromia's pastoral areas is savanna-type grassland and bushland. This ecosystem provides sustenance for a variety of livestock, including cattle, camels, and small ruminants like goats and sheep. These pastoral lands are scattered across the southern, southeastern, and eastern parts of the Oromia region. Compared to other regions, Oromia's pastoral communities tend to have a lower degree of livelihood diversification, meaning their income relies heavily on pastoral activities. These communities also have a lower level of market integration, suggesting they may sell or purchase fewer goods and services compared to other areas. The spread of invasive plants like *Acacia drepanolobium* presents a growing threat to herders' livelihoods (Gebremeskel et al., 2019). It outcompetes native plants, reducing grazing land and forcing herders further for forage. This weakens the ecosystem and potentially reduces crop yields, creating a cycle of declining productivity and resource limitations. The pastoral areas within both Bale zones share these characteristics with other pastoral regions in Oromia and across Ethiopia (Figure 1). The chosen districts, Rayitu, Sawena, Gura Dhamole (pastoralist) and Lagahidah, Dalo mena, and Harena Buluk (agro-pastoralist), represent a variety of ecological zones, livelihood types, and factors that might arise during a drought or border conflict. By including these diverse locations, the investigation aims to gather well-rounded information applicable to a wider range of scenarios.

2.2 Sampling procedure and sample size determination

This research employs a multistage purposive sampling approach to ensure the collected data accurately reflects the realities faced by pastoralists in the Bale zones, particularly regarding the impact of recurring droughts on their livelihoods (Bernard, 2017). This approach prioritizes capturing in-depth data from the most relevant populations, even though it may not be statistically generalizable to the entire Bale zone population. In the first stage, six districts were chosen purposefully, considering two key factors such as livelihood type and drought severity considerations (Scoones, 2004). Accordingly, three agro-pastoralist districts (Lagahida, Dalo mena, and Harena Buluk) and three pastoralist districts (Rayitu, Sawena, and Gura Dhamole) were selected to ensure the survey captures the experiences of both groups who may have distinct vulnerabilities and adaptation strategies during droughts. In addition, Geographic representation, and the severity of recent drought conditions within the Bale zones influenced the selection of specific districts (Mutimba and Mortimore, 2005). Therefore, districts' experiencing more frequent or intense droughts in recent years were prioritized to ensure the sample reflects a range of drought experiences and allows for exploration of potential variations in coping mechanisms across these diverse drought conditions.

In the second stage, two villages were purposefully chosen from each of the six selected districts. Like district selection based on drought prevalence, location, and accessibility villages with a documented history of frequent or severe droughts were prioritized consulting local reports on drought occurrences from Bale zone (Gebrehiwot et al., 2011). In addition, villages were chosen from geographically diverse locations within each district to ensure the research captures potential variations in drought impacts due to factors like microclimates or proximity to water sources (Desta and

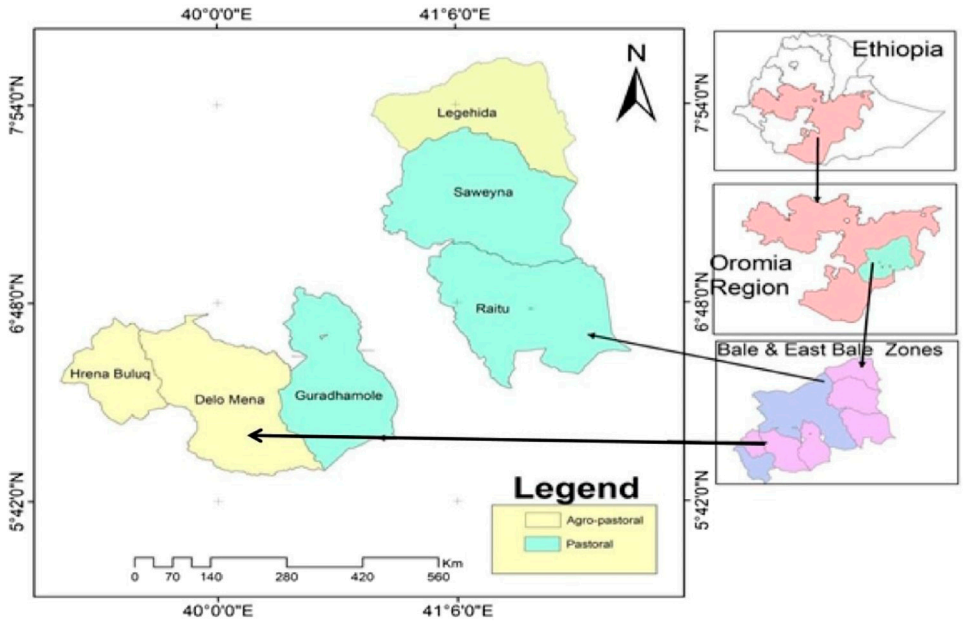

FIGURE 1
Location Map of Bale pastoral areas.

Hailemariam, 2010). Moreover, ease of access for conducting the household survey was also considered to ensure logistical feasibility (Bernard, 2017). A specific Yamane's single population proportion formula was used to determine the final sample size of households for the survey (Yemane, 1967).

$n = \frac{N}{1+N(e)}2$, where n is the sample size, N is the population size and e is the precision level at 95%CI (confidence interval) with 0.5 degrees of variability and at 7% precision level (Yemane, 1967) Population size N = 4897(No of HH of the selected Villages and accordingly 288 respondents were selected for the questionnaires.

2.3 Data collection and analysis method

This research employed a mixed-methods approach to comprehensively assess community-driven drought risk management strategies in Bale zones' pastoral and agro-pastoral districts. This approach combines quantitative and qualitative data collection methods to achieve a well-rounded understanding of the topic (Creswell and Plano Clark, 2018).

2.3.1 Data collection methods

For quantitative data collection Household Surveys were conducted. A representative sample of households across the study villages was selected using a stratified random sampling technique (Babbie, 2010). The questionnaire was developed based on existing literature on drought, drought early warning and adaptation strategy (Beyene and Kussa, 2018; Gebrehiwot et al., 2011) and pre-tested in the field to ensure clarity, cultural appropriateness, and internal consistency (De Vaus, 2002).

For qualitative data collection focus group discussions (FGDs) and Key Informant Interviews (KII) was employed. Focus group discussions were conducted in each village with purposefully selected participants from diverse demographics (age, gender, socio-economic status) within the pastoral and agro-pastoral communities (Morgan, 2019). A semi-structured discussion was used to facilitate discussions on community experiences with drought, early warning system, existing coping mechanisms, and challenges faced (Morgan, 2019). In addition, key informant interviews with semi-structured interviews were conducted with community leaders, elders, and development agents who possess in-depth knowledge of the region's drought history, local adaptation practices, and social dynamics (Bernard, 2017). The interview focused on exploring topics such as community preparedness, effectiveness of existing strategies, and perceived impacts of drought on livelihoods (Bernard, 2017).

The research employed a set of questions themes to organize the data collection instruments (questionnaires, interview guides, FGD discussions) and guide the overall investigation of community-driven drought risk management strategies in the Bale zones. These questions' themes encompass various aspects of drought experience and response within pastoral and agro-pastoral communities, sample questions were summarized in the following Table 1.

2.3.2 Data analysis

The collected quantitative survey data was entered and cleaned in a statistical software program (SPSS). Descriptive statistics (frequencies, percentages) were used to summarize the prevalence of different adaptation practices across the study population (Field, 2018). For qualitative data analysis from KIIs and FGDs was used in narrative analysis to capture the lived experiences and perspectives of participants regarding drought adaptation consider the social context that shapes decision-making around drought risk management, such as cultural beliefs and traditional practices (Riessman, 2008). In addition, the data collected through both quantitative and qualitative methods was triangulated to ensure the robustness and validity of the findings by comparing data from

TABLE 1 Summerized questions used for the research (but not limited to the following).

Theme	Description	Example questions
Community Perception of Droughts	Explores how communities perceive the spatial patterns, frequency, and weather patterns associated with droughts	Distribution and frequency of drought occurrence: * Where in the Bale zones do droughts seem to occur most often? * How often do you experience droughts here? * Has the frequency of droughts changed over time (e.g., increased, decreased)? Rainfall and temperature trends: * How has the amount of rainfall changed in recent years (more, less, variable)? * Have you noticed any changes in average temperatures (hotter, colder)? * How do these changes in rainfall and temperature affect droughts (severity, duration)?
Impacts of Droughts	Investigates the social, economic, and environmental consequences of droughts on communities	Social consequences of droughts: * How do droughts impact relationships and social interactions within the community (increased tension, cooperation)? * Does drought lead to increased social conflict (over resources, displacement)? * How do droughts affect access to education and healthcare (school closures, limited services)? * Does drought affect all community members equally (consider age, gender, family size, wealth, education)? Economic consequences of droughts: * How do droughts affect livestock health and productivity (disease, mortality, milk production)? * Are there changes in crop yields during droughts (reduced harvest, crop failure)? * How do droughts impact your income and ability to purchase necessities (food, medicine)? Environmental consequences of droughts: * How do droughts affect soil quality and vegetation cover (erosion, loss of biodiversity)? * Have you noticed any changes in water availability during droughts (dwindling water sources, dried-up wells)? * Are there any long-term environmental consequences of repeated droughts (desertification)?
Community Responses to Droughts	Assesses community awareness adaptation strategies, and preparedness measures for droughts	Drought risk awareness: * How do you know when a drought is coming (early warning signs)? What are the early warning signs of drought in your experience (changes in vegetation, animal behavior)? * Does the community discuss drought preparedness strategies? Adaptation and contingency planning * What strategies do you use to cope with droughts (e.g., livestock movement, water conservation, alternative income sources)? * Does the community have any long-term plans for dealing with droughts (diversification of livelihoods, resource management)? * How do you manage water resources during droughts (rationing, water harvesting)? Preparedness measures: * Do you store food or water in preparation for droughts? * Are there any livestock management practices used before droughts (selling weak animals, early breeding)? * Does the community work together to prepare for droughts (collective action, resource sharing)?
Understanding Droughts and Responses	Delves deeper into community understanding of droughts and their long- term adaptation strategies.	Perception of droughts by the community: * What causes droughts in your area, according to your beliefs (traditional explanations, climate change)? * How do droughts differ from normal dry seasons (severity, duration, impact)? * How do droughts affect different members of the community (e.g., men, women, children - consider vulnerability and coping mechanisms)? Adaptation strategies for droughts: * Have traditional coping mechanisms changed over time in response to droughts (e.g., migration patterns, resource use)? * What are the most successful strategies for surviving droughts in your experience? * Are there any new practices being adopted to deal with droughts (technologies, livelihood diversification)?

(Continued on following page)

TABLE 1 (*Continued*) Summerized questions used for the research (but not limited to the following).

Theme	Description	Example questions
Early Warning Systems and Responses	Explores how communities monitor droughts and the actions they take based on early warnings	Drought risk indigenous early warning systems: * What natural signs do you use to predict droughts (changes in animal behavior, plant life cycles)? * Are there any traditional knowledge systems used for drought forecasting (e.g., weather proverbs, cyclical patterns)? * How does the community communicate drought warnings (informal channels, community meetings)? Drought risk anticipatory actions: * How does the community prepare differently when a drought is predicted (increased resource collection, adjustments to livestock management)? * Are there any changes in resource use or economic activities before a drought (reduced spending, focus on essential needs)? * Does the community have a system for coordinating responses to drought threats (leadership roles, resource allocation)?

diverse sources (surveys, interviews, FGDs) to identify convergence and divergence (Flick, 2018). This process will allow for a more comprehensive understanding of community-driven drought risk management strategies in the Bale zones.

3 Results and discussions

3.1 Demography and socio-economic status of study area community

The household survey, focus group discussion and key informant interview result suggests that pastoral and agro-pastoral activities remain the dominant economic drivers in the region while other livelihood strategies are on their early stage and introduced by developmental agents or organizations. In addition, the FGD and KII show that crop productions and all other income sources except livestock rearing is dominated by Youngers aged up to 35 years; while older are sticks to livestock only. The household surveys (n = 288) revealed gender imbalance, with a higher representation of male participants (80.5%) compared to females (19.9%). This imbalance is due to cultural and religious norms. In addition, at the time of data collection most of females migrated to other nearby areas and relatives taking their children while men remained at home to treat their livestock. Future research should employ strategies to ensure more balanced participation, such as conducting interviews at convenient times for women and offering childcare options.

Livelihood strategies varied, with pure pastoralists (41.8%), agro-pastoralists (40.5%), other livelihoods (11.7%), farm owners (7%), small businesses (6%) and other income sources (4.7%). Pure pastoralists group relies primarily on livestock, including cattle, goats, sheep, camels, and equines. The specific composition of herds might vary depending on cultural preferences, ecology, and market demands. Agro-pastoralists households combine livestock rearing with crop cultivation (maize, sorghum, teff, mung beans, and sesame). A small percentage reported income sources beyond pastoral and agro-pastoral activities and limited land ownership for large-scale farming. Small Businesses' (6%) presence indicates some economic diversification.

The following Graph sheds light on the age, gender, and education levels of survey respondents in pastoral and agro-pastoral communities (Figure 2). A sizable portion of the surveyed population falls within the 18–35-year-old age range (16.1%). The younger population shows less experience coping with droughts compared to older generations. Regarding gender women make up 19.5% of the surveyed population and often play a critical role in managing household water and food security in these communities. In terms of education a substantial portion of the population (65.8%) has no formal education. This can significantly influence access to information and resources for coping with drought. Individuals with higher education (6.3%) reported better equipped to understand drought forecasts and implement mitigation strategies.

3.2 Distribution and frequency of drought perception

The research reveals a unanimous understanding across all communities (through surveys, FGDs, and key informant interviews) that rainfall patterns are negatively impacting livelihoods. Participants reported a decrease in rainfall, harming crop production and livestock rearing, the region's main economic activities. Additionally, according to all FGD participants and key informants, a concerning trend of shorter rainy seasons alongside rising temperatures was observed. These findings align with existing research by Yimam and Mohammed (2016) who documented similar trends in southern Ethiopia. Furthermore, studies by Deressa et al. (2008), Bewket (2012), and Viste et al. (2012) support these observations, highlighting a broader national trend of decreasing rainfall and rising temperatures. This convergence of evidence underscores the significant challenge posed by changing climatic conditions.

The household surveys and qualitative data from key informant interviews and focus group discussions (FGDs) paint a concerning picture of increasing drought challenges in the study area. Both the frequency and spread of droughts throughout the primary and secondary rainy seasons (Genna and Hagaya) were reported as high. The years 2021 and 2022 saw

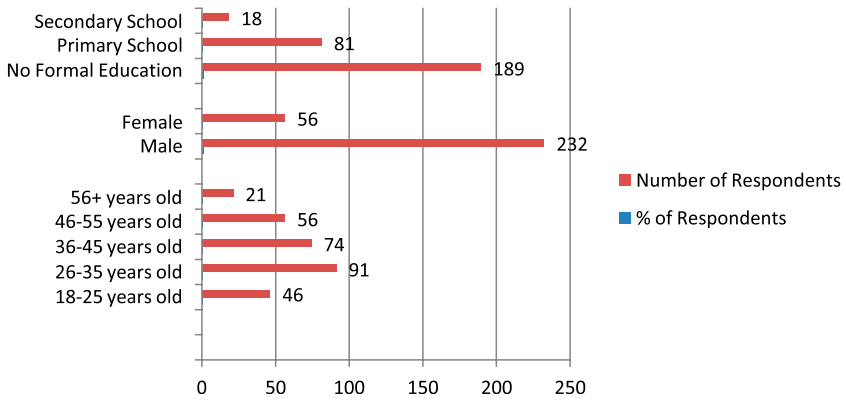

FIGURE 2
Demography status of study area community.

extreme drought pressure across the region, with varying intensities impacting separate locations and survey results also supported these observations. A staggering 96.9% of participants reported an increase in drought frequency over the past 35 years, with over half (58.02%) experiencing annual droughts and another third (33%) feeling the impact every year. Community members, particularly elders participating in key informant interviews and FGDs, attributed this rise in drought frequency and intensity to several factors: deforestation, population growth, and overgrazing. They reminisce about a time when the area was covered by forests, and the two rainy seasons were sufficient to sustain both livestock and crops. This historical perspective sheds light on the potential causes of the current situation. Previously, communities could manage with some assistance if the expected heavy rains failed during one or both rainy seasons. However, recent droughts have become more severe and prolonged, making adaptation significantly harder. This increased variability in rainfall patterns disrupts traditional planning for the rainy season, hindering preparedness efforts. These observations align with existing research (Huho and Mugalavai, 2010; Kogan et al., 2016) highlighting the global rise in droughts. Additionally, studies by Deressa et al. (2010) and Bayissa et al. (2015) demonstrate a concerning trend of more frequent and intense droughts in Ethiopia over the past 3 decades.

3.3 General impacts of drought in the study area

Pastoralists in the study area painted a grim picture of the drought's consequences. Key concerns included drying water sources, widespread crop failure, and livestock deaths due to lack of water and forage, and pasture degradation (Table 2). The economic impacts were equally severe, with rising food prices and plummeting livestock prices squeezing household budgets. Social issues arose as well, with children forced to drop out of school due to hardship. The rising temperatures further exacerbated the situation, contributing to poor human health and livestock infections. These impacts intensified during the recent drought period (2019–2022) and similar years preceding it. The burden of supporting the affected communities stretched beyond pastoral and agro-pastoral households. The government, NGOs, individuals, private sectors, and even the Ethiopian diaspora all felt the strain of helping in these drought-stricken areas. The study shows a grim scenario where drought has decimated livestock herds, a crucial source of income contributing to the country's GDP. Crop failures further compound the issue, jeopardizing food security.

Focus group discussions with community leaders and elders confirmed the widespread prevalence of the previously mentioned impacts. For instance, due to children dropping out of school and water scarcity, satellite schools were forced to close during the drought years of 2019–2022. This highlights the disruption to education caused by drought. Furthermore, the lack of water during prolonged dry seasons leads to frequent outbreaks of waterborne illnesses like diarrhea. Survey data provided a quantitative perspective on the severity of these impacts. All respondents (99.7% and 99.2% respectively) rated pasture deterioration and water scarcity as having a remarkably high impact during drought years. These factors significantly affect livestock health and survival, with 98.2% of respondents reporting extremely high livestock death rates due to drought. The economic consequences are equally concerning for 94.6% and 90.5% of respondents experiencing severe food scarcity and a decrease in household income.

The long dry season and drought years exacerbate these issues. According to key informant interview a huge portion of respondents (73.7%, 86.5%, and 97.5%) reported a high impact on health, household income, and food insecurity respectively during these extended dry periods. While less prevalent, other drought-related issues such as population migration (56.5%), unemployment (63.85%), conflict over resources (40.7%), and child school dropout (82.3%) were still considered to have a high impact by a substantial portion of the population. This data paints a clear picture of the devastating impact of drought on pastoral communities in the study area. It affects not only their livelihoods and wellbeing but also disrupts social structures and educational opportunities.

This situation aligns with a study by Bekele and Amsalu, 2012 exploring the impact of drought on Karrayyu pastoralists in the Fantale

TABLE 2 Drought impact on pastoral and agro-pastoral communities in the bale zone.

Category	Description	Severity (% respondents)	Justification from FGD and KII
Environmental	Drying water sources, pasture degradation	- Water scarcity: 99.2% (High Impact) - Pasture deterioration: 99.7% (Remarkably High Impact)	- Key informant interviews confirm high impact on health (73.7%). Water scarcity contributes to health issues
Livestock	Lack of water and forage leading to livestock deaths, livestock infection	- Livestock death rates 98.2% (Extremely High)	- Animal mortality ranked as a critical problem. KII: -Lack of water and forage increases susceptibility to infections
Agriculture	Crop failure	70% (Estimated High)	- Not directly quantified but mentioned throughout the text. Severity high based on context and pastoral dependence on agriculture
Economic	Rising food prices, declining livestock product, decreasing household income	- Food scarcity: 94.6% (Severe) - Household income decrease:90.5%	- Survey Data: Severe food scarcity (94.6%) and significant decrease in household income (90.5%) suggest a strong link between drought impacting livestock (reduced products) and income decline (primary livelihood)
Social	Children forced to drop out of school, conflict over resources, population migration	- Child school dropout 82.3% (High Impact) - Population migration: 56.5% (High Impact) - Conflict over resources: 40.7% (High Impact)	- Schools closed due to water scarcity, leading to child school dropout
Health	Poor human health, waterborne illnesses	40% (Estimated Moderate)	- Not quantified extensively but mentioned - Focus group discussions highlighted impact on livelihoods more than human health (suggesting moderate severity) - Water scarcity can increase the risk of waterborne diseases according to KII.
Others	Rising temperature, food scarcity (linked to crop failure), family income reduction, unemployment	- Rising temperature: 30% (Estimated Low- Moderate)	- Temperature increases but impact on health and livestock uncertain - Food scarcity (linked to crop failure): Included in Agriculture section - Family income reduction and Unemployment: Linked to income decrease (90.5%) as mentioned in KII.

woredas. The study underscores the critical importance of understanding drought's effects for all stakeholders involved in developing and implementing measures to mitigate its consequences (Pandey and Bhandari, 2009; Catley et al., 2021). By acknowledging the severity of the problem, relevant parties can work together to create effective solutions that protect these communities and their way of life. In addition, this finding aligns with existing research on the social and economic impacts of drought in various regions (Bekele, 2012; Lekapana, 2013; Kogan and Guo, 2016; Udmale et al., 2014; Menghistu et al., 2018), highlighting the widespread challenges faced by communities across the globe.

3.4 Impact of drought on women in Bale's pastoral and agro pastoral communities

The below Table 3 shows the potential impact of drought on various aspects of women's lives in Bale's pastoral and agro pastoral communities. Drought significantly increases the workload for women, particularly in water collection (70%) and food management (60%). With more time spent fetching water (40%), other aspects of their lives can be strained. This strain is further compounded by reduced food availability (60%), potentially leading to higher malnutrition rates (40%) for both women and children. Utilizing drought-resistant crops (25%) and food preservation techniques (40%) were crucial coping mechanisms in these situations. Disruptions to traditional livelihoods (50%) force women to seek alternative income sources. Developing small businesses (30%) and joining income-generating groups (25%) are potential strategies. However, access to microloans or grants (20%) was limited, hindering their ability to establish these income sources. Limited water access (60%) increases the risk of waterborne illnesses (60%). Water treatment (50%) and prioritizing hygiene (70%) are essential coping mechanisms. However, only 40% have access to healthcare services, highlighting a potential gap in support systems. The increased workload limited women's participation in household decision-making (20%), potentially reducing their influence on resource allocation during drought. Reduced access to nutritious food (40%) was leading to nutritional deficiencies and dietary diversification (35%) and rationing (60%) were potential coping mechanisms.

The increased pressure on women (20%) due to these various burdens can indirectly impact girls' education. Advocating for girls' education (30%) and seeking support for childcare (20%) could help mitigate this impact. Encouraging girls' participation in household tasks that are compatible with education (15%) might also be beneficial. Finally, the increased stress and anxiety (30%) due to various burdens highlight the need for social support from other women or family members.

The findings in this table align with existing research on the gendered impacts of drought in pastoral communities. For instance, studies by Scheelbeek et al., 2021; Awiti, 2022 highlight how drought disproportionately increases women's workload, particularly in

TABLE 3 Impact of drought on women in bale's pastoral and agro pastoral communities.

Factor	Impact mechani sm and % of responders	Potential consequ ences (social and economic) and % of Respondents	Coping mechanisms and % of respondents	% Of respondent perceived The impact
Water Collection	-Increased distance and difficulty in fetching water due to drought	- Increased workload and time spent collecting water (30%)	- Water harvesting techniques (20%) - Collaboration with other women for water collection trips (40%) - Investing in water storage containers (30%)	70%
Food Security	- Reduced household food availability due to drought	- Increased responsibility for food preparation and managing rations (20%)	- Utilizing drought- resistant crops (25%) - Food preservation techniques (drying, salting) (40%) - Seeking food assistance programs (35%)	60%
Livelihood Activities	- Disruption of traditional Livelihood activities (dairy production, etc.)	- Increased pressure to find alternative income sources (selling crafts, etc.)	- Developing or adapting small-scale businesses (handicrafts food processing) (30%) - Seeking microloans or grants for income generation activities - Joining income- generating groups with other women (25%)	50%
Health	- Increased risk of waterborne illnesses due to limited clean water access	- Greater exposure to physical strain from water collection and workload	- Water treatment techniques (boiling, chlorination) (50%) Prioritizing hygiene practices for themselves and their families (70%) Seeking healthcare services for waterborne illnesses (40%)	60%
Nutrition	- Reduced access to nutritious food due to drought	- Increased risk of malnutrition, impacting both women and their children	- Dietary diversification with available resources (wild plants, legumes) (35%)	40%
Education	- Increased pressure to manage household needs during drought, potentially impacting girls' Education	- Indirect impact through girls' roles in supporting household chores	- Advocating for girls' education within family (30%) Seeking support from schools or NGOs for childcare or flexible learning options (20%)	20%
Psychological Wellbeing	- Increased stress and anxiety due to burdens of water collection, food security, and childcare	- Potential for mental health issues	- Seeking social support from other women or family members	30%

water collection and food management. This is further supported by Akpalu, D.A., 2005; Anbacha,and Kjosavik, 2019 who emphasizes the pressure on women to ensure household food security during times of drought. In addition, this aligns with Pukunyiem, 2020 who argues that women often play a crucial role in income generation during droughts, particularly through small-scale businesses and income-generating groups. Moreover, aligns with Moser (1998) who emphasizes how crises can exacerbate existing gender inequalities. Furthermore, this is supported by Moser and Felton (2010) who discuss how girls are often pulled out of school to help with household chores during crises.

3.5 Impact of drought on pastoral and agro-pastoral communities in study area

Pastoral communities represented respondents (100%) perceive reduced grazing land and water resources, leading to a high prevalence of livestock mortality (60%) and potential decreases in milk production (50%) and breeding cycles (50%). Most (80%) experience increased pressure on resources and overgrazing, with 40% facing social conflicts due to competition (Table 4). Significant income loss from livestock sales (70%) is another challenge. The coping mechanisms employed by pastoral communities focus on mobility (herding animals to distant pastures) for 50% of respondents, and collaborative grazing management for 30%. To manage livestock health, destocking weak animals (40%) and using drought-resistant fodder (25%) are utilized. Sharing resources and cooperation within communities are also important (20%). Like pastoral communities, most agro-pastoral communities (80%) perceive reduced grazing land and water resources. High percentages experience crop failure and reduced yields (90%), leading to increased reliance on livestock (reflected in the 60% who perceive difficult choices regarding selling livestock for food). Livestock mortality (50%) and decreased milk production (40%) are also concerns, though social conflicts are a potential concern for a smaller portion (20%) compared to pastoral communities. The majority (70%) report increased pressure on resources and overgrazing, with half (50%) perceiving increased

TABLE 4 Impact of drought on pastoral and agro-pastoral communities in study area.

Community type	Impact on livestock	Impact on agriculture	Social and economic Impacts	Coping mechanisms (in % respondents)
Pastoral	- Reduced grazing land and water resources (100%)	- Not Applicable	- Increased pressure on resources and overgrazing (80%)	- Mobility: Herding animals to distant pastures (50%) - Collaborative grazing management (30%)
	- Livestock mortality (60%)		- Social conflicts due to competition (40%)	- Livestock destocking (40%) - Sharing resources and cooperation (20%)
	- Disrupted breeding cycles and decreased milk production (50%)		- Loss of income from livestock sales (70%)	- Supplementation with drought-resistant fodder (25%) - Early destocking (15%)
Agro-Pastoral	- Reduced grazing land and water resources (80%)	- Crop failure and reduced yields (90%)	- Increased pressure on resources and overgrazing (70%)	- Mobility: Herding animals to distant pastures (if possible) (30%) - Collaborative grazing management (20%)
	- Livestock mortality (50%)	- Loss of livestock feed (80%)	- Social conflicts due to competition (20%)	- Livestock destocking (30%) Sharing resources and cooperation (15%)
	- Disrupted breeding cycles and decreased milk production (40%)		- Difficult choices: selling livestock for food (60%)	- Supplementation with drought-resistant fodder (15%) - Early destocking (10%)
			- Increased vulnerability (50%)	- Diversifying income sources (40%) - Utilizing drought-resistant crops (20%) Seeking support (food aid) (30%)

vulnerability. Agro-pastoral communities utilize mobility for livestock less frequently (30%) due to potential limitations on suitable grazing areas. Collaborative grazing management (20%) and destocking (30%) are still practiced. Utilizing drought-resistant crops is a potential strategy (20%) under practice with a lower percentage of community members (model farmers). Diversifying income sources (40%) and seeking external support (food aid) (30%) are part of crucial strategies for these communities.

The general output demonstrates strong parallels with existing research on how droughts differentially impact pastoral and agro-pastoral communities. For pastoral communities, the perceived near-universal reduction in grazing land and water resources (100%) aligns with studies by Tolera, and Senbeta, (2020) highlighting how droughts force pastoralists to travel further for sustenance. Similarly, the high prevalence of perceived livestock mortality (60%) echoes is in line with Anbacha, and Kjosavik, 2019 work on the devastating impact of drought on livestock wealth and food security. The potential for social conflicts due to competition (40%) resonates with Jury, and Vaux, (2007) emphasis on how crises can exacerbate existing tensions over scarce resources.

3.6 Pastoralists and agro-pastoral drough trisk Adaptation contingency planning and preparedness

3.6.1 Pastoralists' perception and adaptation strategies for drought

Scientifically human activities like population growth, agricultural expansion, and deforestation contribute to droughts. In the same way in the study area drought is a recurring natural phenomenon attributed to factors like population growth, agricultural expansion, and deforestation for charcoal production indicating human activity contribution to drought. However, the perception of drought's causes varies among the pastoral communities. A survey conducted with 288 households confirmed this diversity of perspectives with varying degrees. In addition, focus group discussions and key informant interviews revealed a range of opinions, with some participants attributing drought solely to natural factors. In line with this approximately 60% of discussants considered drought a natural disaster, while 31% of them believed human activities were the culprit. The remaining 9% saw a combination of both factors at play. This aligns with existing research by Hassen (2008), Lekapana (2013), Ashraf and Routry (2013), Udmale et al. (2014), Mengistu (2016), and Menghistu et al. (2018) that resonates with research by suggesting that individual experiences and environmental knowledge significantly shape how people perceive drought's causes.

3.6.2 Pastoralists and agro-pastoralists drought risk indigenous early warning system

In study indigenous early warning systems play a crucial role in mitigating drought's impact. According to focus group discussion and key informant interview the primary function of elders know of having knowledge of forecasting the weather is to alert communities to potential droughts, allowing them to prepare and minimize losses in livestock, crops, and food security (Figure 3). In addition, the study observed that pastoral households in the Bale zone rely on technical indicators and traditional methods for weather forecasting and drought prediction. These methods, often passed down through generations and honed through experience with climate variability, empower elders to anticipate droughts and guide the community in taking measures to reduce associated risks. This highlights the value of integrating

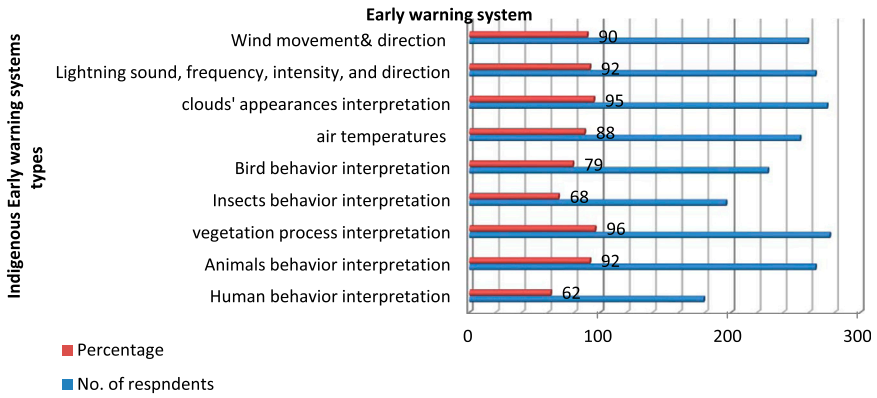

FIGURE 3
List of Indigenous Early warning system.

traditional knowledge with modern scientific approaches for a more comprehensive drought preparedness strategy.

According to the survey, FGD and KII, pastoral communities in the study area demonstrate a remarkable reliance on traditional knowledge systems (90.5%) for weather forecasting and drought prediction. Modern media sources and government warnings play a minor role (10.5%) compared to these time-tested methods passed down through generations. This traditional approach incorporates a variety of observations, including animal behavior (changes in bird calls, cattle behavior, even insect activity), plant behavior (the timing and presence of leaves on specific trees as a signal for rain), and celestial observations (star and moon arrangements, wind direction) to predict rainfall patterns and potential droughts. By combining this traditional knowledge with modern scientific approaches, a more comprehensive drought preparedness strategy can be developed for the wellbeing of both communities and their livestock.

The study also explored the role of animal behavior in weather prediction. While some might dismiss this practice, locals believe animals can sense changes in their environment. For instance, they observe ant behavior, interpreting their relocation to secure areas as a sign of impending weather shifts. Similarly, frog calls and movements are used to forecast weather patterns. According to FGD and KII about 85% of weather forecasting and drought prediction is almost accurate, the implementation by local community is around 58.8% due to cultural view the community has for their livestock. These findings highlight the intricate ways in which pastoral communities have learned to interpret the natural world around them. The general finding of this study aligns with research by Wario (2011) in Borena and a 2012 study by Khetran, suggesting that animals might indeed detect storms and exhibit specific behaviors before they arrive.

3.7 Pastoralists and agro-pastoralists drought risk anticipatory action and coping mechanisms

The consolidated findings from surveys, focus group discussions (FGDs), and key informant interviews (KIIs) offer valuable insights into the community's current comprehension of anticipatory action, their perception of existing risks, preparedness capacity, and willingness to collaborate on enhancing a proactive approach towards drought mitigation. Respondents observed that anticipatory action involves utilizing early warning systems to prompt pre-planned interventions aimed at protecting families and their assets prior to a disaster. Participants indicated a readiness to proactively respond to drought warnings by implementing pre-established measures such as distributing drought-resistant seeds, selling livestock before market prices drop, or securing access to alternative water sources.

This proactive strategy enhances community resilience by emphasizing two critical capabilities. Firstly, it involves the ability to anticipate risks through pre-emptive assessment of potential drought threats, enabling the development of appropriate mitigation strategies. Secondly, communities are encouraged to prepare and adjust by providing them with tools and resources to make informed decisions amidst uncertain future risks. Adopting anticipatory action enables communities to shift from a reactive to a proactive stance, facilitating the preservation of lives, protection of assets, and minimization of overall disaster impact, thereby fostering a more secure and resilient future.

Resource management emerges as a vital component of community survival, with most participants (90%) engaging in early livestock grazing practices to optimize resource use and animal wellbeing (Table 5). Similarly, adjusting planting schedules based on rainfall patterns is universal (92%). These practices highlight the community's pragmatic and adaptable approach towards resource utilization. Furthermore, a substantial percentage (60%) rely on traditional methods such as constructing open ponds (62.8%) and strategic migration for water and forage (81.9%). The widespread adoption of communal enclosures (96.5%) reflects the community's adaptability to evolving environmental and social challenges. Additionally, a sizable portion (over 60%) utilize livestock distribution across zones (61.7%) and alternative feed sources like evergreen tree leaves (75%) to supplement grazing resources. This find is inconsistent with research report of Duguma and Janssens, 2021 on assessment of livestock feed resources and coping strategies with dry season feed scarcity in mixed crop–livestock farming systems Agriculture is essential for ensuring food security, with over 80% of individuals cultivating drought-resistant crops such as sorghum and millet (Table 6). The majority also prioritize short-season, high-yielding varieties of these crops, with over 90% adjusting sowing times to optimize planting based on weather patterns. Additionally, 60% of communities adopt improved crop varieties and practice intercropping to further enhance yield and soil health.

TABLE 5 Livestock sector coping mechanisms for drought management.

Cate gory	Coping mechanism	% Adoption	Brief description	Key benefits	Explanation
Resource Management	Storing livestock feed	75%	Storing crop residue and using leaves of evergreen trees to supplement livestock feed	Supports livestock during periods of scarcity	Resourceful approach to utilize available resources and ensure animal wellbeing
	Making communal enclosure	96.50%	Shift from communal migration to individual enclosures for livestock due to population pressure and government directives	Mitigates impact of drought and violence on livestock	Adaptation strategy in response to changing environmental and social conditions
	Preparing open pond mechanism	62.80%	Human-made ponds to store rainwater for people and livestock	Vital water source during dry seasons	Traditional water harvesting technique demonstrating community resource management
	Grazing livestock early in the morning	94.70%	Grazing animals early for cooler temperatures and dew-laden foliage, reducing water needs and improving forage palatability	Minimizes water requirements and improves livestock nutrition	Practical strategy to maximize resource utilization and animal health
	Splitting livestock into different areas	61.70%	Zonal distribution of livestock herds across different ecological zones	It reduces the risk of mass die-offs, optimizes animal health, and improves rangeland health	Demonstrates deep understanding of ecological variations and promotes sustainable grazing practices
	Migrating livestock before the drought in search of water and forage	81.90%	Seasonal migration to highlands or river basins for water and pasture	Ensures livestock survival during droughts	Well-established strategy for pastoral communities to adapt to seasonal variations
Livestock Management	Increasing the herd densities dominated by females	56.90%	Not specified in the provided data	Not specified in the provided data	Requires further investigation into purpose and potential benefits/drawbacks
	The decreasing number of livestock (destocking)	58.40%	Selling or slaughtering livestock due to drought conditions	Reduces pressure on limited grazing resources and preserves remaining animals	Difficult decision for pastoral communities but helps ensure herd survival during extreme droughts
Diversifica Tion	Diversification of Livestock	52.50%	Raising diverse types of livestock species (e.g., camels, goats) with varying water and grazing needs	Spreads risk of drought impact and potentially improves overall herd resilience	Long-term strategy to adapt to drought by managing herds with a diverse range of livestock

In addition to recovery programs, livelihood diversification plays a crucial role in providing a safety net during droughts (Table 7). A significant majority (over 60%) of community members engage in alternative income sources such as petty trade or transportation services (63.1%), displaying their entrepreneurial mindset. This is further supported by robust social safety nets within the communities, with many individuals adapting their livelihoods (83%) and seeking refuge with relatives in less affected areas (48.2%) during times of crisis. Another prevalent strategy is the distribution of family labor across various activities (54.6%), further reinforcing the community's resilience is moderately prevalent (40%–60%).

4 Discussion, conclusion and recommendations

4.1 Discussion

The household surveys, key informant interviews, and focus group discussions conducted in the study area have revealed a worsening drought situation, with high frequency and spread reported during both the primary and secondary rainy seasons in 2021 and 2022. The survey results indicate a significant 96.9% increase in drought frequency over the past 35 years, with more than half of the participants experiencing annual droughts. These findings are consistent with previous research by Huho and Mugalavai (2010) and Kogan et al. (2016) that highlight a global rise in droughts, as well as studies by Deressa et al. (2008) and Bayissa et al. (2017) showing more frequent and intense droughts in Ethiopia. The changing rainfall patterns have had a negative impact on livelihoods, with decreased overall rainfall harming crop production and livestock rearing (Bekele, 2015). Additionally, participants have noted shorter rainy seasons and rising temperatures, which align with research by Yimam and Mohammed (2016), Deressa et al. (2008), Bewket (2012), and Viste et al. (2013) indicating a national trend of decreasing rainfall and increasing temperatures.

Droughts in Bale zones of Ethiopia disproportionately burden women in pastoral and agro-pastoral communities. In support of this finding, the studies by Cruikshank, 2010, and Quandt (2019) show a significant increase in their workload, particularly for water collection and food management, straining their time and resources. Ngoc et al. (2023) further highlight that droughts heighten the risk of malnutrition and waterborne diseases for women and children due to

TABLE 6 Agricultural practices for drought management in bale zones.

Category	Coping mechanism	% Adoption	Brief description	Key benefits	Explanation
Crop Selection	Cultivating Short-Season Crops	91.70%	Planting drought- resistant crops (mung bean, Amaranthus sesame)	Ensures food security and dietary diversity	Proactive adaptation strategy for food security
	Use of Drought-Tolerant Crop Species	84.80%	Planting crops like sorghum and millet that thrive in dry conditions	Improves chances of harvest during droughts	Risk management strategy for crop production. Reduces dependence on rain for successful harvest
	Utilizing Drought-tolerant Seed Varieties	30%	Planting seeds specifically bred for drought tolerance	Enhanced drought resilience and potential yield improvement	Requires access to improved seeds which may be limited in availability or cost prohibitive
	Use of Improved Crop Variety	59.20%	Utilizing higher- yielding or disease- resistant crop Varieties	Enhances productivity and reduces risks	Investment in modern techniques for better crop yields and resilience to pests and diseases
	Intercropping	57%	Planting multiple crops together to optimize land use and improve soil fertility	Maximizes yield and promotes soil health	Sustainable agricultural practice for efficient land use and improved soil conditions
	Adjusting Sowing Time	92.30%	Planting crops at the most appropriate time based on rainfall Patterns	Increases probability of successful germination and Harvest	Adaptation strategy to optimize planting based on weather conditions. Improves chances of crops establishing before dry periods
	Utilizing Mulch	65%	Covering soil with organic materials (straw, leaves) to retain moisture and suppress weeds	Reduces evaporation, improves soil moisture retention, and suppresses weeds	Requires access to organic materials and knowledge of proper mulching techniques. Adoption varies depending on resource availability
Soil Management	Conservation Tillage Practices	15%	Minimizing soil disturbance to reduce moisture loss and improve soil health	Enhances soil structure, organic matter content, and water infiltration	Requires specific equipment or adaptations to traditional tillage practices. The low adoption rate might be due to limited access to equipment or knowledge
Water Management	Rainwater Harvesting	20%	Collecting and storing rainwater for later use	Improves access to water for irrigation during dry periods	Requires investment in infrastructure (cisterns, etc.) and knowledge of rainwater harvesting techniques. Adoption depends on existing infrastructure and financial resources

biological vulnerabilities and caregiving roles. The study has also revealed a diversity of perspectives among pastoral communities regarding drought causation, with approximately 60% of participants viewing drought solely as a natural phenomenon, 31% attributing drought entirely to human activities, and the remaining 9% acknowledging the interplay of both natural and human-induced factors. Pastoral households in the Bale zone heavily rely on traditional methods for weather forecasting and drought prediction, with a reported reliance of 90.5% on traditional knowledge systems, Abate, 2016; McOmber, 2020 reported inconsistent concept in southern ethiopia and africa. The study also suggests an 85% accuracy rate in weather forecasting using traditional methods, although implementation by communities is around 58.8%. These findings underscore the importance of how pastoral communities interpret the natural world around them and align with research by Abarufa (2011), Svoboda et al., 2011 and Khetran et al. (2012) suggesting animals can detect storms and exhibit specific pre-emptive behaviors.

The study delves into the potential for a change in thinking in how Bale communities approach drought mitigation with the concept of anticipatory action, which leverages early warning systems to trigger pre-planned interventions before a disaster unfolds that in line with Anita et al., 2010; Abdela 2022 finding. The study suggests that communities are open to moving beyond a reactive stance of simply waiting for droughts to arrive, instead utilizing early warnings to activate pre-established actions like the concept reported by Desta, 2013. The finding that over 62.8% of respondents participate in preparing ponds in the study area aligns with Agrawal, and Saberwal, 2004 research on communal resource management in pastoral societies, showcasing the communal effort and cultural tradition of Bale communities. Additionally, the high prevalence of migration (81.9%) as the primary coping mechanism during hardships underscores the crucial role seasonal migration plays in ensuring the survival of pastoral communities during harsh climatic conditions, aligning with existing research by Hasan (2008), Bekele and Amsalu, 2012, Abdulatife and Ebro (2015), and Teshome (2016), as well as research by Ellis and Freeman (2004) and Leweri (2022). Moreover, the study highlights a shift away from traditional communal migration practices towards individual approaches like enclosure due to the decreasing availability of grazing land in the Bale lowlands, with 96.5% of respondents ranking individual migration as the most common strategy. This reflects the challenges faced by pastoral communities, with government

TABLE 7 Livelihood diversification strategies for drought management and coping.

Category	Coping mechanism	% Adoption	Brief description	Key benefits	Explanation
Income Generation	Engaging in Alternative Income Sources	63.10%	Activities like chat trading, honey production, petty trade, or transportation services	Financial security, self-reliance, income generation during limited livestock holdings	Enables communities to find alternative sources of income when traditional livelihoods are affected by drought. Diversifies income streams and reduces dependence on vulnerable activities
	Depending on Aid	72.9%	Receiving assistance from government or NGOs (food aid, cash transfers)	Meets basic needs and reduces pressure on household resources	External support system but may not be sustainable or reliable in the long term
Resource Management	Bartering or selling livestock products (milk, hides)	19%	Exchanging livestock products for essential goods	Generates income to purchase necessities	Leverages existing resources for immediate needs but can deplete livestock assets
Labor Allocation	Livelihood modification	83%	Adapting livelihoods in response to drought conditions (e.g., petty trade)	Generates income for essential needs	Flexible approach to secure income during challenging times. Enables communities to find alternative income sources when traditional activities are limited by drought
	Wage labor (farm labor, construction work)	25%	Taking temporary jobs for cash income	Provides immediate financial resources but may be limited in availability or required skills	
Risk Management	Splitting family members for different assignments before the drought	54.60%	Distributing family labor across activities to minimize risks	Ensures some level of income or resource acquisition even if one activity fails	Risk management strategy through diversification of labor within the family. Spreads risks associated with livelihood failure in a single activity
"Social Safety Nets"	Sending family members away to relatives	48.20%	Seeking temporary refuge and support from relatives in less affected areas	Reduces pressure on household resources during drought	Social safety net strategy through reliance on kinship networks. Strengthens community resilience by leveraging social connections for support during hardship
	Borrowing money or food from relatives/friends	-	Accessing resources from social networks to meet basic needs	It provides temporary support during hardship but can create future burdens or strain relationships	

directives potentially contributing to the shift. Additionally, splitting livestock into different areas and employing a zonal livestock distribution strategy can minimize overall herd losses during droughts, aligning with research by Kurukulasuriya and Rosenthal (2013), Hassan (2008), Abate, et al., 2009 and Huho et al. (2011) on the benefits of diversification in promoting the long-term sustainability of the rangeland ecosystem.

The research highlights the crucial role of herd diversification among pastoral communities in the Bale lowlands, enabling them to cope with harsh environmental conditions and adapt to a changing climate, as emphasized by researchers Ifejika (2010), Teshome (2016), and Rojas et al. (2017). To combat drought, Bale pastoral communities demonstrate remarkable innovation by cultivating drought-resistant crops, adopting intercropping techniques, and prioritizing female-dominated herds for long-term herd recovery. These strategies showcase their commitment to food security. This strategy, supported by research from Vandermeer (1992), Degefa, 2008 and Ayanlade et al. (2018), serves as a form of crop insurance and enhances productivity while mitigating risks associated with monoculture cropping systems. The study also reveals a shift towards agro-pastoralism among Bale pastoral communities, integrating crop cultivation into their practices to diversify livelihoods and address challenges such as population growth and environmental change, in line with research by Degefa, 2008,Lenaiyasa et al. (2020) and Alary et al. (2022).

4.2 Conclusion

The research in Bale zone southeast Ethiopia, reveals a unanimous understanding across communities: declining rainfall patterns are negatively impacting livelihoods. This decreases, alongside rising temperatures, aligns with existing national and global trends. Both surveys and qualitative data paint a concerning picture of intensifying droughts. Droughts are increasing in frequency and intensity, disrupting traditional agricultural practices. Community elders attribute this shift to deforestation and overgrazing, highlighting potential causes demanding further investigation.

Water source depletion, widespread crop failures, and livestock deaths due to lack of water and forage have crippled livelihoods. Social issues like school dropouts and health problems exacerbate the situation. Drought decimates livestock herds, a crucial economic pillar, and jeopardizes food security through crop failures. Survey data quantifies the severity, with near-unanimous reports of extremely high impacts on pasture, water scarcity, and livestock death rates. The economic consequences concern a vast majority experiencing severe food scarcity and income decline. While less prevalent, issues like population migration, unemployment, conflict, and school dropout still hold a high impact for a substantial portion of the population. Focus groups with leaders reveal animal mortality, food scarcity, and water scarcity as top concerns, highlighting the profound impact on the foundation of pastoral life. The situation worsens during prolonged dry seasons, with some resorting to migration that can lead to conflict.

Drought disproportionately burdens Bale's pastoral women. Workloads surge in water collection and food management. Malnutrition risk rises for women and children due to reduced food availability. Women seek alternative income, but limited access to microloans hinders efforts. Water scarcity increases waterborne illness risk, highlighting the need for improved water treatment and sanitation. Increased workload also reduces women's decision-making power and access to nutritious food.

The study reveals significant impacts of drought on both pastoral and agro-pastoral communities in Bale. Reduced grazing land and water scarcity cripple livelihoods, leading to high livestock mortality and declining milk production. Pastoral communities face intense pressure and potential conflict due to overgrazing. Both groups experience income loss, but agro-pastoralists are additionally burdened by crop failure, forcing difficult choices. Mobility, destocking, collaborative grazing, and resource sharing are crucial coping mechanisms, with agro-pastoralists also utilizing drought-resistant crops and income diversification.

Human contributions like population growth and deforestation contribute to droughts in Bale. However, community perceptions vary, with some attributing drought solely to natural factors while others acknowledge human influence. Bale's pastoralists rely heavily (90.5%) on traditional methods for weather forecasting (animal behavior, plants, stars,etc.) passed down through generations. Modern methods play a minor role. This study highlights the value of combining traditional knowledge with science for better drought preparedness.

The study highlights a shift towards proactive drought mitigation in Bale communities. They value early warnings and envision using them to take pre-emptive actions like distributing drought-resistant seeds or securing water sources. This proactive approach focuses on understanding potential threats and being prepared to adapt. Bale's pastoralists display remarkable resilience against droughts through a multifaceted approach. They leverage seasonal migration and strategic herd management to secure water, pasture, and animal health. This includes diversifying herds with drought-resistant species and strategically selling livestock before droughts. Furthermore, over 97% cultivate drought-resistant crops, employing intercropping techniques to maximize resources. These findings highlight the pastoral communities' deep understanding of their environment, resourcefulness, and long-term planning for the wellbeing of their herds and communities.

4.3 Recommendations

The study's findings paint a clear picture of the challenges faced by Bale's pastoral communities–a relentless cycle of drought exacerbated by water scarcity. Based on these insights, the following recommendations are proposed to enhance community resilience and promote long-term sustainability.

4.3.1 Prioritizing water security

Governmental and non-governmental organizations (NGOs) at all levels should prioritize the construction of permanent open ponds, maintenance of existing ones, and exploration of groundwater drilling or alternative water sources. Introducing irrigation schemes, where feasible, can further bolster water security and promote drought-resistant agriculture.

4.3.2 Sustainable resource management

Implementing effective rangeland management practices is crucial for long-term sustainability. Collaborative efforts are needed to develop and enforce regulations to prevent overgrazing and promote responsible resource utilization. Conservation initiatives focusing on soil and water preservation should be prioritized to ensure the health of the ecosystem upon which these communities depend.

4.3.3 Early warning systems

The valuable traditional weather forecasting methods employed by pastoral communities should be strengthened by integrating them with modern technologies for more accurate and advanced drought prediction. The government should establish reliable channels for disseminating real-time, drought-predicting information using contemporary technologies to allow communities to prepare effectively.

4.3.4 Strengthening livelihoods and food security

Research institutions and agricultural extension programs should focus on introducing and promoting drought-resistant crop varieties suitable for the Bale region. Encouraging the cultivation of short-season crops can provide a vital source of food during drought periods.

4.3.5 Community capacity building

Investing in comprehensive awareness programs at all levels is essential to maximize the effectiveness of existing drought coping and adaptation strategies within communities. Governmental and non-governmental actors should prioritize long-term interventions that empower communities to become self-reliant rather than relying solely on short-term, consumptive aid.

4.3.6 Market facilitation and risk management

During droughts, the government and other stakeholders should facilitate and support the livestock market by improving infrastructure and market access for pastoralists. Community-

based drought risk contingency planning and preparedness efforts should be developed, aligning with the government's existing plans to ensure a comprehensive and coordinated approach. By implementing these recommendations, policymakers, NGOs, research institutions, and the pastoral communities themselves can work collaboratively to build a more secure and sustainable future for Bale. By combining traditional knowledge with scientific advancements and prioritizing long-term solutions, this region can weather the storms of drought and ensure the continued flourishing of its unique pastoral culture.

Data availability statement

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

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the (patients/participants OR patients/participants legal guardian/next of kin) was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

UG: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing–original draft, Writing–review and editing.

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Conflict of interest

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

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