Drought vulnerability and impacts of climate change on livestock production and productivity in different agro-Ecological zones of Ethiopia

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ABSTRACT

Drought is a complicated natural hazard that has far-reaching social and environmental impacts. In Ethiopia’s diverse agro ecological zones, drought remains a severe challenge and problem. Livestock rising is one of the agricultural sub-sectors that provide income and livelihood to around one-third of African inhabitants and accounts for 30–50 percent of agricultural GDP. Pastoralists on the Ethiopia-Kenya-Somalia border endured extreme suffering, including the loss of nearly 80% of their cattle and huge migration out of drought-stricken areas. Drought can cause severe economic hardship and stress for farmers and local economies, like; lost productivity, population reduction, and the trauma of witnessing livestock, crops, soil, and native vegetation damage. Between 1990 and 2000, and 2001-2002/03, drought-related animal death rates in the Somali region increased by 60% and 80% of the entire cattle population, respectively. Drought has the greatest immediate effects on farmers, including depletion of water resources, crop failure, and an increase in food prices, ill health, livestock output losses and death, and a decline in livestock prices in the Borana zone. Drought adaptation and mitigation measures depending on geography and livestock system may improve the study’s trajectory in the future if further review is done.

1. Introduction

The global climate change is therefore considered a key policy issue of policymakers in this century, as it affects social well-being, problems in economic development and improvements in the atmosphere (Mikayilov et al. 2018). Climate change has been triggered by carbon dioxide emission which poses unparalleled threats to human existence and growth, such as extreme weather, environmental invasion and scarcity of resources (Dong et al. 2019). Livestock has long been recognized as a particular problem due to climate change mitigation, reducing farm pollution, and building more productive food systems and security (Ripple et al. 2014; Vermeulen et al. 2012; Moore and Ghahramani 2013). Furthermore, livestock farming has also been alleged to further stimulate the emission of GHG into the global atmosphere (Sakadevan and Nguyen 2017; Wei et al. 2018; Zhang et al. 2019).

Livestock products account for 17% of world calorie consumption and 33% of global protein consumption, making them an important agricultural commodity for global food security (Rosegrant et al. 2009). Furthermore, the livestock sector contributes to the livelihoods of one billion of the world’s poorest people and employs nearly 1.1 billion people (Hurst et al. 2005). There is an increasing demand for livestock products, which has been dubbed the ‘livestock revolution’ because of its rapid rise in emerging countries (Thornton 2010; Wright et al. 2012). Climate change, competition for land and water, and food security are all expected to have a negative impact on livestock production at a time when it is most needed (Thornton 2010).

Greenhouse gas (GHG) emissions, which result in atmospheric warming, are the primary cause of global climate change (IPCC 2013b). According to Gerber et al. (2013), the cattle sector generates 14.5 percent of global GHG emissions, which might lead to increased land degradation, air and water pollution, and biodiversity loss (Steinfeld et al., 2006; Reynolds et al. 2010; Thornton and Gerber 2015; Bellarby et al. 2013). Simultaneously, climate change will have an impact on livestock production due to competition for natural resources, feed quality and quantity, livestock illnesses, heat stress, and biodiversity loss, while demand for livestock products is anticipated to increase by 100% by the mid-twentieth century (Garnett 2009). As a result, maintaining a balance between productivity, family food security, and environmental preservation is a challenge (Wright et al. 2012).

Following that, the devastating effects of climate change have been noticed in diverse ways among the livelihood options of pastoral and agro-pastoral populations in East Africa for many years (Tsegaye et al. 2010). Although livestock and crop productivity are entirely dependent on land suitability, land degradation caused by human, drought, and climate factors is clearly visible in terms of loss of livelihood sources, biodiversity, and desertification expansion (Adger et al. 2000; Prince 2002; Stringer et al. 2009). These have impaired the adaptive capacity of pastoralists and agro-
pastoralists, who are primarily concentrated in East Africa’s dryland regions (Sandford 2006). Moreover, traditional adaptation strategies such as livestock mobility, diversification, feed procurement, and animal restocking, particularly in Ethiopia, have proven ineffective in meeting their livelihood needs (Wassie and Fekadu 2014; Kima et al. 2015). This necessitates a thorough examination into how numerous coexisting elements influence pastoral and agro-pastoral communities’ adaptive capabilities across climatic zones (Adger et al., 2009).

In Eastern and Western Africa, climate extremes are having a substantial impact on livestock productivity. Droughts are becoming more frequent and intense, and changes in water availability, as well as increasing patterns of temperature and rainfall variability, are all endangering drought-prone communities’ livelihoods and the existence of arid and semi-arid isolated regions (Palombi and Sessa 2013; Ulrichs et al. 2019). Livestock raising is one of the agricultural sub-sectors that provides income and livelihood to around one-third of African communities and accounts for 30–50 percent of agricultural GDP (AU-IBAR 2016). In most pastoral and agro-pastoral communities, livestock is the poor’s most valuable asset, despite the sector’s vulnerability to extreme weather (Fereja 2016).

Ethiopia is home to Africa’s largest livestock population, and it is the continent’s top livestock producer and exporter. The recent livestock population of Ethiopia estimates that the country has about 57.83 million cattle, 28.89 million sheep, 29.70 million goats, 2.08 million horses, 7.88 million donkeys, 60.51 million poultry, 5.92 million bee hive, 0.41 million mules and about 1.23 million camels (CSA 2016). The pastoral areas on the Ethiopia-Kenya-Somalia border faced abject hardships, including loss of about 80 percent of their livestock and mass migration of pastoralists out of drought-affected areas (FAO 2011; Headey et al. 2012). During the rainy season, pastures are more plentiful and of greater nutritional quality, but during the dry season, pastures are of lower nutritional quality, with high fibre and low protein content, resulting in decreased animal productivity (Abebe 2017). Therefore, the overall objective of this review was to examine the current drought susceptibility and climate change implications on livestock output and productivity in Ethiopia’s various agro-ecological zones.

2. Impacts of drought on agropastoralist production in Ethiopia

2.1. Some concepts and definitions of key terms

Climate:- Climate refers to the average of meteorological parameters over a period of time, usually 30 years in a certain location. Climate measures primarily consist of estimates of average weather parameter values and measures of variability close to the average value. Most of the time, these important values are surface factors like temperature, precipitation, and wind. Climate patterns have a significant impact on natural ecosystems, human economy, and civilizations that rely on them. Climate change has an impact on a wide range of agricultural activities, outputs, and input resources such as yields, animal production, land quality, on-farm storage, water supplies, labour migration rates between urban and rural areas, population growth, farm revenue, and farmer skills (Washington and Dawning 1999).

Climate change:- Climate change is defined as a major and long-term (decades or more) shift in climatic conditions. It’s a dramatic change in the atmosphere’s mean state and event frequency. The impact of climate change on cattle diseases is determined by geographic region, land use type, disease characteristics, and animal susceptibility (Thornton et al. 2009). Climate change, particularly rising temperatures, can have a direct or indirect impact on animal health (Nardone et al. 2010). The direct impacts are linked to rising temperatures, which raise the risk of sickness and death.

Climate change manifestations such as rising temperatures, increased irregular rainfall, frequent and severe floods, and droughts have substantial effects for smallholder farming communities’ livelihood security, making them more vulnerable and difficult to live with. In many African countries, agriculture is critical to rural populations’ survival (Gizachew and Shimelis 2014).

Climate variability:- Beyond specific weather events, climate variability is defined as variations in the mean state and other statistics of the climate on all temporal and spatial scales. When compared against long-term statistics for the same calendar period, it is frequently used to denote variances in climatic statistics over a certain period of time (month, season, or year). The El-Nino Southern Oscillation (ENSO) is an example of climate variability caused by interactions between the ocean and the atmosphere. In Ethiopia, there is a strong link between climate and agricultural production in terms of timing, variability, seasonal and annual rainfall, and temperature. Higher temperatures and shifting rainfall levels as a result of climate change, according to Mintewab et al. (2010), would significantly reduce agricultural production in several dry and semi-arid portions of Ethiopia in the next decades.

Weather and Precipitation: Rainfall, snowfall, and other types of frozen or liquid water falling from clouds are referred to as precipitation. Precipitation forms when water vapour condenses, which normally happens in rising air that expands and cools. Weather refers to the day-to-day changes in the atmosphere, as well as the description of the atmospheric conditions at a specific point in time for a single event. The atmosphere, daily air temperature, pressure, humidity, wind speed, and precipitation are all described by weather, which is a short-term occurrence (IPCC 2008; WMO 2007).

Drought is one of the components of weather climate extremes, and it occurs when natural water supply is lower than normal, resulting in water-related difficulties. Streamflows plummet, water levels in lakes and reservoirs fall, and the depth to water in wells increases when rainfall is less than average for weeks to years. Drought is a complicated and recurring natural hazard that can have major negative consequences for agriculture, business, the environment, and people’s lives (Gan et al. 2016; Cammalleri et al. 2017). Drought is predicted to become more common and severe in many parts of the world in the twenty-first century as a result of climate change (Spinoni et al. 2018a, 2018b; IPCC 2014). It is more necessary than ever to gain a better knowledge of the drought phenomena, particularly the physical mechanisms that contribute to drought, its propagation through the hydrological cycle,
societal and environmental vulnerability to drought, and its wide-ranging repercussions. Drought is defined as a lack of precipitation induced by a variety of natural factors such as global climatic variability and high pressure, which results in reduced relative humidity and less precipitation.

Drought is unquestionably one of the most difficult and complex natural calamities to manage (Sivakumar 2014; Van and Anne 2015). It was a result of the climate, and it impacted many countries throughout the world, including Ethiopia and the Horn of Africa, as well as many other Sub-Saharan African countries (Gutierrez et al., 2014). Dracup et al. (1980) found that droughts are caused by changes in precipitation (meteorological), stream flow (hydrological), soil moisture (agricultural), or any combination of these factors.

2.2. Drought types

Ethiopia’s government has adopted a national drought strategy (FDRE 2015), which calls for local stakeholder-driven drought contingency planning to promote long-term water resource management (Megersa et al. 2014). Droughts can be grouped into four types, according to Figure 1: meteorological, hydrological, agricultural, and socioeconomic (Heim 2002).

**Meteorological droughts** (MDs); are water shortages induced by a difference in precipitation and evaporation; precipitation is often employed in MD analyses (Chang 1991; Eltahir 1992). Droughts in the weather have the potential to affect agricultural productivity by reducing the availability of soil moisture (agricultural droughts).

**Hydrological droughts** (HDs) occur when surface and subsurface water resources are insufficient for established water uses in a specific water resource management system. Streamflow data is commonly used in HD analysis (Dracup et al. 1980; Chang 1991). Droughts are generally caused by a lack of moisture in the atmosphere (meteorological droughts). They spread via hydrologic systems, causing water supply shortages (hydrologic droughts). Droughts in agriculture and hydrology are influenced not just by rainfall, but also by other processes including plant water intake (evapotranspiration). Due to lesser humidity, rainfall deficiencies tend to result in warmer temperatures. Droughts have an impact on a variety of other hydrologic processes, including exfiltration and stream baseflow. To gain a better knowledge of droughts, it is vital to analyze droughts using several indicators calculated over different time periods (Karamouz et al. 2009; Ziese et al. 2014).

**Agricultural droughts** occur when crops are harmed, and this drought occurs more frequently than meteorological droughts, but the time interval between the two droughts is determined by the crop stage (Heim 2002). When the soil moisture availability to plants drops to the point that it significantly impacts crop yield and thus agricultural profitability, an agricultural drought is declared. In a nutshell, agricultural drought refers to soil moisture deficit as a result of meteorological droughts and climatic conditions, as well as the effects of these factors on agricultural production and profitability. The basis for evaluating agricultural drought factors is a soil water time series.

**Socioeconomic drought**; because local reservoirs play a vital role in enhancing water supply and coping with extreme climate, it is reasonable to assess socioeconomic drought based on reservoir activities. Droughts can also have serious consequences for rural regions’ socio-economic well-being (socio-economic droughts) (Linke et al. 2015). Drought can have a significant economic impact on farmers and the local economy (Diersen et al. 2002, Horridge et al. 2005, Edwards et al. 2009). The broader societal repercussions of drought, on the other hand, have gotten far less attention (Fritze et al.

![Figure 1. The occurrence of different types of droughts and their effects on the ecosystem.](image-url)
Drought has a number of social effects, including indirect effects of economic factors such as the hardship and stress of lost productivity; population decline; social disruption as a result of the negative economic effects of drought; and the trauma of witnessing damage to livestock, crops, soil, and native vegetation (Berry et al. 2008).

2.3. Drought’s causes, effects, and consequences

Drought has impacted nearly every sector in Ethiopia in the past, including agriculture (loss of crops and livestock), water resources (increased evaporation and decreased availability of fresh water, resulting in water stress), insufficient water for industry, reduced electricity production (from hydropower), and so on. The impact on ecosystems is enormous, despite the fact that it has not been fully examined and documented (loss of wetlands and lakes, loss of forest and soil cover, increased soil erosion and land degradation, etc.). Increased human and livestock diseases, migrations, and water disputes, as well as a drop in the national gross domestic product (GDP) are all significant social and economic consequences. Perhaps nowhere is the impact of changing weather (drought) and climate regimes more visible than in the water sector (Kundzewicz et al., 2007 in Gutierrez et al., 2014), which has a substantial impact on all other sectors as a result of the meteorological drought (Van Dijk et al. 2013).

2.3.1. Crop and livestock damage

Farmers’ perceptions of drought in Ethiopia are based on the failure of seasonal rainfall (June to September) and, as a result, crop and livestock losses (elsewhere it is recognized as agricultural drought). The livestock sector is one of Tanzania’s most important economic sectors that would be badly damaged by climate change if no major measures are done to mitigate its negative effects (MLDF 2015). Seasonal rainfall failure (meteorological drought) is mostly caused by climate variability, and its consequences include widespread failure of seasonal crops, pasture, and forage, as well as significant livestock deaths in pastoralist areas, as well as widespread starvation among the affected population. A population of roughly 10 million people (10%) became hungry as a result of the 2015 drought (estimate based on the number of people requiring food aid). In Ethiopia, the impact on agriculture always results in significant human and cattle loss. Changes in rainfall patterns and rising temperatures are predicted to have severe negative implications on the environment and water resources, crops and livestock, human health, and other rural livelihoods in Ethiopia, according to vulnerability evaluations (Deresa 2006).

2.3.2. Impact on the environment and water resources

Ethiopia is largely rural, with a huge population dependent on agriculture and pastoral activities, although surface water and groundwater supplies for irrigation have been underdeveloped (Ewonetu 2012). Dryland farming is common in Ethiopia, accounting for more than two-thirds of the country’s total agricultural land (MoA 2011). Ethiopia has been plagued by droughts on a regular basis, and they are a major climatic danger that threatens the country’s long-term viability (Meze-Hausken 2004; Mersha and van Laerhoven 2018). Water supplies in both man-made and natural water bodies are rapidly dwindling, affecting the availability of water for irrigation and electricity generation, as well as the economy. When groundwater is polluted with toxic chemical compounds through human activities it can become unsuitable for several years (Akhila et al. 2007). The residence time of chemical pollutants can be retained in the groundwater system for weeks to months, years, and decades (Singh et al. 2019).

Hydrological drought (Van and Anne 2015) is a term used to describe a decrease in lake levels, low river/stream flows, and a decrease in ground water levels. The degradation of water resources is a much-studied phenomenon and can be caused by natural processes (climate change, water-rock interactions, and geological factors) and human activity (agriculture practices and urban waste), as well as the presence of considerable chemical compounds since the industrial revolution (Nagaraju et al. 2016). In addition, the physicochemical and biological characteristics, as well as quality, quantity and availability of water resources, fluctuate because of the impact of natural and human activities (Akhtar et al. 2021). The pollutant types, pathways, and sources, as well as how they influence the surface water and groundwater systems based on natural sources and anthropogenic activities, are shown in Figure 2.

2.3.3. Socio economic impact

In particular Ethiopian hotspot locations, there is a substantial drought potential analysis and assessment of social, economic, and environmental repercussions (Mesfin 1984; Pankhurst 1986; Degene 1990). Four severe droughts were identified as a result of the study: (i) the devastation of oxen by render pest in 1888–1892, (ii) the Tigray famine of 1958, which killed over 100,000 people, (iii) the Wag Lasta famine of 1966, and (iv) the Wollo Famine of 1973–74. Over the years, these droughts impacted a vast number of people. Between 1972 and 2002/3, the number increased dramatically, from 2 million to 14 million, with significant increases in 1976–1977, 1982–1984, and 1991–2002.

As seen in Table 1, drought affected over 10 million people (10%) in 2016, making it the worst drought in the preceding fifty years (USGS 2016). The amount of persons in need of food assistance varied by region: the Tigray, Afar, and Somali regions were particularly heavily struck, with 24, 25, and 21 percent of the population affected, respectively. Oromiya required the most food aid, followed by Amhara and Tigray. More areas in the Afar and Somali regions were affected in terms of large geographic coverage. The drought, which devastated about half of the animals in the region, had a greater impact on children, particularly in pastoralist areas.

2.4. The impact of climate change on Ethiopian livestock production

Ethiopia is situated between 30 and 150 degrees north latitude and 330 and 480 degrees east latitude (Figure 3). The climate in Ethiopia is typically tropical in the southeastern and northeastern lowlands, but significantly cooler in the country’s vast central highlands. In high altitude locations, mean annual temperatures are around 15°C, whereas in the lowlands, they
are around 25°C (McSweeney et al. 2007). Furthermore, the mean annual rainfall distribution contains maxima (>2000 mm) in the southwest and minima (300 mm) in the south northeast lowlands (Ofgeha and Abshire 2021). By 2050, global annual average temperature is expected to be 2°C higher than pre-industrial levels (IPCC 2007). Droughts, floods, heat waves, and other extreme weather phenomena will become more common and intense as the planet warms by 2 degrees Celsius. As a result of global warming, climate model projections suggest a large increase in mean temperatures in Ethiopia over the next century, as well as a rise in rainfall variability and the frequency of both major flooding and droughts (Robinson et al. 2013). Although the direct effects of heat stress on livestock have not been studied extensively, warming is expected to alter the feed intake, mortality, growth, reproduction, maintenance, and production of animals. Collectively, these effects are expected to have a negative impact on livestock productivity (Thornton et al. 2009).

### 2.4.1. Resources for livestock

The production of beef cattle, dairy cattle, goats, sheep, and chickens contributes for around 30% of the total value of agricultural production in Africa, with 92 percent of that coming from beef cattle, dairy cattle, goats, sheep, and chickens (IFAD 2009; IUCN 2010). The growth of the human population, rising living standards (increased demand for animal products as earnings rise), and urbanization are all driving up livestock output in Africa (Philip et al. 2007; IUCN 2010). Ethiopia is Africa’s greatest livestock producer and exporter, with the continent’s highest cattle population. Although domestic demand for animal products is growing in Ethiopia, driven by the urban middle and upper classes, export potential is the driving factor behind livestock expansion and intensification (MacDonald and

### Table 1. Number of people receiving food aid (FORTUNE, 2016)

| Regions   | January | June | Percentage |
|-----------|---------|------|------------|
| Tigray    | 2.3     | 2.3  | 24%        |
| Afar      | 0.4     | 0.4  | 25%        |
| Amhara    | 2.3     | 2.3  | 11%        |
| Oromia    | 3.8     | 3.8  | 11%        |
| SNPP      | 0.8     | 0.8  | 4%         |
| Somali    | 1.6     | 1.2  | 21%        |
| Ben-Gumuz | 0.079   | –    | 8%         |
| Gambella  | 0.043   | –    | 10%        |
| Dire Dawa | 0.057   | 0.057| –          |
| Harari    | 0.014   | 0.014| –          |
| Total     | 11.314  | 10.871|           |
The cattle industry is an important aspect of the country's farming systems. In both the highlands and lowlands/pastoral farming systems, it is the source of numerous social and economic goods such as food, draught power, fuel, monetary income, security, and investment (FDRE 2001). Ethiopia has roughly 52.1 million cattle, 24.2 million sheep, 22.6 million goats, and 44.9 million fowl, according to a recent livestock population estimate (FDRE 2001; Berihu et al. 2014).

### 2.4.2. Climate change's impact on cattle production

Climate change and cattle are inextricably linked (Iqubal 2013). The pattern and availability of rainfall have a huge impact on the spatial distribution and availability of pasture and water (Aklilu et al. 2013). Changes in rainfall patterns and temperature ranges also have an impact on feed availability, grazing ranges, feed quality, weed, pest, and disease incidence (Coffey 2008). As a result, environmental parameters like temperature, precipitation, and the frequency and intensity of extreme occurrences like droughts had a direct impact on cattle output (Adams et al. 1998). Climate change affects animal productivity in two ways, according to Coffey (2008). Similarly, Adams et al. (1998) found that climate change can influence livestock in two ways: the quality and quantity of fodder from grasslands may be changed, and greater temperatures may have direct consequences on livestock. Climate change is projected to have the greatest impact on vulnerable pastoral communities who rely on huge livestock production systems in arid environments (Saidu and Omedo 2010).

### 2.4.3. Indigenous mechanisms of weather forecasting

Pastoralists have long relied on traditional methods to predict seasonal climate occurrences. Reading of animal behaviours and body conditions is indigenously believed among the Borena that specific body conditions and behaviours of animals during resource abundant time give clues about the future weather. To the contrary, the following cattle body conditions and behaviours are regarded as signs of a normal rainy season. They lick each other's body, wander around villages in search of bone to eat, they display a relaxed mood and get away from water points after drinking. They show normal sexual desire and the bull visits many cows within a short period of time. A study report in Kenya reveals that some of these body conditions are interpreted similarly but disagrees that cattle fight over food in view of a future of drought (Speranza et al. 2010). The knowledge of such elders is still highly valued in Ethiopian pastoralist communities (Gebremichael and Kifle 2009). Traditional methods of
predicting climate events, on the other hand, are seen as becoming less reliable as climate variability increases. This ‘raises the question of whether external, meteorology-based climate forecasts could better assist pastoralists in conserving cattle wealth and contributing to the sustainable use of natural resources (Luseno et al. 2003).’

The primary warning is critical for early animal sales to avoid livestock losses, grain purchases before price increases, and alternative options research before households are hit by food shortages (Gebremichael and Kifle 2009). On the other side, wealth in pastoralist societies is seen to be influenced by the amount of cattle held, and livestock sales are thought to lower household wealth. As a result, selling livestock ahead of projected drought is not a popular practice among Ethiopian pastoralists. According to a research by Pantuliano and Mike (2008), efficient EWS allows for early detection of food insecurity during drought.

2.5. Drought management for livestock

Many people working on drought relief in pastoral areas of East and Central Africa agree on the importance of timely and suitable interventions to save cattle during droughts (ECA). Pastoralists use a variety of coping and adaptation tactics to protect livestock assets during droughts, including transferring animals to places with better fodder and water, selling some animals, separating or trading herds, and changing the species makeup of herds over time (Morton et al. 2001). Pastoralists’ animals are a valuable asset, and livestock losses due to drought have a detrimental influence on pastoral livelihood strategies by reducing milk production, reducing revenue from livestock sales, and reducing the asset value of cattle that die. Furthermore, during the current drought in Kenya in 2008-9, certain districts reported fatality rates of above 50% (Zwaagstra et al. 2010). As a result, various academics pushed for the establishment of Drought Cycle Management (DCM) and the more modern Disaster Risk Reduction (DRR) principles (IIRR 2004; ISDR 2009). Drought is a threat that is constantly present in the dry plains of East and Central Africa, according to these two frameworks (ECA).

2.6. Drought impacts and adaptation strategies in Borana zone, southern Ethiopia

Ethiopia is frequently mentioned as a prospective cattle resource country (Shapiro et al. 2015). This resource is an important aspect of the agricultural system and a source of income for a large number of rural and semi-urban residents. However, as drought length, intensity, and coverage have increased in tandem with irregular, highly intensive, and short-duration rainfall, traditional coping techniques have become increasingly constrained (Skinner 2010). Every few years, it’s heartbreaking to witness the same tragedy: a weather cycle that brings terrible drought and hunger to east Africa, putting millions of people’s lives and livelihoods at jeopardy. The weather cycle that is causing these incidents is a ‘La Niña’ that has been exacerbated by climate change. ‘La Niña’ is caused by a drop in ocean temperatures in the eastern Pacific, resulting in dry spells across eastern Africa. The ocean has absorbed about 30% of the CO$_2$ released from human activities, causing a measurable increase in the acidity of the oceans. Warming caused by humans in the western Pacific Ocean is exacerbating the problem. The impacts may be severe, and tropical countries in particular face temperature increases, changes in precipitation patterns, increased heavy rainfall from tropical cyclones and sea-level rise, which may have catastrophic impacts for low-lying Pacific nations (IPCC 2014). The fast warming of the west Pacific as a result of global emissions has resulted in greater rain around Indonesia and worrying but expected rainfall shortfalls in desert, food-insecure eastern Kenya, Somalia, and Ethiopia (Figure 4).

Drought is a typical occurrence throughout the Borana zone’s lowlands, however its impact varies by region. However, the focus of this research was on the 13 districts in the Borana zone that were severely damaged. As a result, the Yabello and Dirre districts of Borana zone were specifically chosen based on the severity of drought effects reported by Borana zone (Figure 5).

2.6.1. Drought’s effects on cattle production

Droughts, combined with cattle recovery times, have had a significant impact on livestock size and composition. Cattle, in particular, are the most vulnerable livestock species in the Borana zone. According to the findings, around 68 percent of the livestock killed throughout the study were cattle. On the other hand, within a decade, the maximum size of animals in the research area was lowered by 315 percent (Figure 6). As a result, the number of households without animals is growing, forcing them to look for alternate sources of income, mainly crop cultivation. Droughts can last for several years, but even a brief, severe drought can cause significant animal feed degradation (IVM 2009).

In contrast, despite the continuous destruction effect of drought, the proportion of goats to other livestock was increasing. It is undeniable that goat populations are on the rise as a result of their high reproduction frequency, drought resistance, low feeding costs, low purchasing costs, and easy management, particularly during feed shortages. Drought can strike anywhere on the planet, but the consequences are less severe in Africa, notably in Ethiopia, due to a lack of adaptive capacity. Droughts have caused massive loss of life and property in the past, as well as mass displacement of people (NAPA 2007). Similarly, as shown in Figure 6, the investigation revealed that even the maximum size of cattle is decreasing with time over a decade.

2.6.2. Effect of climate change on livestock production in Borana zone

Drought-related livestock losses are particularly significant among certain species, ages, and sex groups of livestock (Desta and Coppock 2004). Pastoralists in the Borana area said climate change had an impact on their livelihoods through a variety of ways (Table 2). The four principal effects of climate change on livestock production, as highlighted by pastoralists during the group discussion, are feed shortage, water shortage, reduced productivity, and decreased mature weight and/or longer time to achieve mature weight, in that order.
Figure 4. The severity of the drought affecting the livestock of Borana zone in October 2022

Figure 5. Borana zone is located in Ethiopia’s southern region
Pastoralists in Ethiopia, in general, and in the Borana plateau in particular, have the highest rate of poverty and the least access to basic amenities when compared to other groups, and they are also among the most vulnerable to climate change (Oxfam 2008). Cattle, in general, are the most affected livestock type during severe droughts because they require more input than other livestock species. Due to their drought tolerance, prolific nature, and adaptation of their physiological make-up, small ruminant mortality rates were lower than cattle. According to field statistics, shotts accounted for just about 11% of total livestock deaths during the field study. Furthermore, camels had the lowest death rate, at only 2%, demonstrating their higher tolerance. From highest to lowest, the major vulnerability rank can be associated with cattle, sheep, goat, and camel, as shown in Table 3. Camel is the least drought-prone livestock due to its ability to adapt to extreme conditions.

2.6.3. Drought-relief tactics
Coping techniques refer to strategies that have evolved over time as a result of people’s extensive experience dealing with the known and understood natural fluctuation that they expect in seasons, as well as their unique responses to the season as it unfolds (Cooper et al. 2008). Through their experience, pastoralists in southern Ethiopia have devised numerous alternative coping techniques to combat the suffering effect of drought. However, the increased frequency of droughts threatens to overwhelm the pastoralists’ coping methods and resilience (Stark and Ejigu 2011). Weather, livestock, rangeland, and water-related techniques are presented in the following part to help with the discussion of coping strategies depending on diverse natural and environmental variables.

| Table 2. Major effects of climate on livestock production ranked by pastoralists (Yilma et al. 2009) |
|---------------------------------------------------------------|
| Major effects                                      | Rank |
| Feed shortage                                       | 1st  |
| Shortage of water                                   | 2nd  |
| Reduced productivity                                | 2nd  |
| Decreased mature weight and/or longer time to reach mature weight | 4th  |
| More conflict                                       | 4th  |
| Increased disease prevalence                        | 6th  |
| Increased mortality                                 | 7th  |

2.6.4. Adaptive strategies for livestock and water
Reduced livestock size, livestock movement, livestock and livelihood diversification are all examples of livestock-related coping methods. Approximately 33% of respondent homes used this method during the survey. Despite the fact that livestock remains the most important component of Borana livelihood, the poll found that pastoralists want to reduce their livestock size and even diversify to drought-resistant cattle kinds. Herd mobility is one of the long-standing livestock-related coping methods, which is influenced by the season and feed availability, as well as personal relationships, family structure, and immediate needs for water and pasture. Furthermore, drought is a big contributing element that affects cattle, since some herders will sell their livestock during a drought, disease can alter market pricing, and if food aid is made available, grain prices may be distorted (Morton et al. 2001).

Furthermore, a water resource is a critical resource that is impacted by severe drought and can be used to construct a water harvesting plan, such as a deep well or shallow pond, to collect rainwater for human and livestock consumption. Drought’s qualities, as well as its wide-ranging consequences, make its effects on society, the economy, and the environment difficult to detect and quantify (Wilhite et al. 2000). However, in comparison to ten years ago, the average distance to the water has decreased for both animals and humans due to aggressive water development to address severe water shortages. Increasing frequency and intensity of droughts; changes in water availability; increasing patterns of temperature and rainfall variability, all are profoundly threatening livelihoods of drought-prone areas, and the existence of arid and semi-arid remote regions (Palombi and Sessa 2013; Ulrichs et al. 2019). To address water-related issues, a coordinated effort is needed to develop adequate potable water or a water healing, restorative, or recovery system. (Figure 7).

| Table 3. During the recent drought season, livestock died |
|-----------------------------------------------------------|
| Livestock type            | N | Maximum (TLV) | Mean (TLV) | Std.Deviation |
|---------------------------|---|---------------|------------|---------------|
| Cattle                    | 84 | 94.5          | 8.323      | 21.68         |
| Camel                     | 67 | 3             | 0.18       | 0.26          |
| Sheep                     | 78 | 7             | 0.501      | 11.5          |
| Goat                      | 82 | 7.8           | 0.501      | 12.54         |
| Donkey                    | 73 | 5             | 0.235      | 1.56          |
| Mule                      | 72 | 21            | 1.106      | 5.18          |
| Total                     | 199 | 138.3         | 10.846     | –             |

TLV: Total livestock vulnerability
2.7. Gender participation in drought pastoralist surviving mechanisms in Ethiopia’s eastern region

Pastoral areas of Ethiopia, which are defined as arid and semi-arid rangelands, cover more than 62 percent of the country’s land mass and keep over eleven million heads of livestock (Kassahun et al. 2008). Pastoralism employs roughly 27 percent of the entire national population, contributes about 30 percent of the gross national product, and generates 90 percent of the hard cash from live animal exports, according to Kassahun et al. (2008). As seen in Figure 8, Ethiopia’s Somali and Hararghe, Fentale (kereyu Oromo), and Afar Regional States are primary pastoral habitats, with pastoralism also being practiced to a lesser level in other parts of the nation (World Bank 2002; Mulu 2010).

Pastoralist drought response mechanisms are marginalized by increasing land degradation, conflicts over scarce resources, limited access to information, limited education, skills, and access to financial services, markets required to diversify livelihoods, inadequate government policies, and population pressures, according to Riché et al. (2009) and Kassa et al. (2005). These are similar in the Shinile District of Somali pastoralist region, the research area, which is one of the poorest districts in Somali pastoralist region, characterized by low household livestock ownership compared to other Somali pastoralist regions.
districts (Devereux 2006; Mulu 2010). The climate in Shinile district is described as harsh, with frequent and severe droughts. This district is particularly vulnerable to drought due to its reliance on only one big rainy season and the extended intervals between rains.

2.6. Drought in Ethiopia and its effects on pastoralist communities

Drought is considered a common part of life in Ethiopia’s dry and semi-arid regions, where rainfall is low during rainy seasons and unusually low every few years. For example, there were 15 droughts in these locations between 1978 and 1998 (Brown and Teshome 2007). Pastoralists’ livelihoods have to be carefully adjusted to low and fluctuating rainfall conditions (Devereux 2006). Drought-related animal mortality rates in the Somali region increased by roughly 20%, 40%, 60%, and 80% of the total cattle population between 1930 and 1970, 1970-1990,1990-2000, and 2001-2002/03, respectively (SERP 1990). The problem is particularly acute in the country’s dry and semi-arid regions, which are primarily pastoral and agro-pastoral (Gebremichael and Kifle 2009). Historically, pastoralists faced drought every 5–10 years (Lautze et al. 2003), but drought has been occurring every 1–2 years in recent years.

Furthermore, drought has been occurring every 1–2 years among the pastoral population of Borana, although it used to occur every 6–8 years, as evidenced by the two significant droughts that affected the zone in 2006 and 2008 (Riché et al. 2009). Furthermore, between 2007 and 2009, the two Somali districts of Ayisha and Erer had only 15 and 4 days of rain, respectively. The worst years in terms of drought between these periods were 2007 and 2008, which resulted in the death of a considerable number of animals (80 percent of cattle, 70 percent of sheep, 40 percent of camels and 30 percent of goats). Similarly, pastoralists in the Afar region have been experiencing catastrophic droughts every 2–3 years since 1993 (DPCC 2002). More than 80% of the total livestock deaths in Ethiopia’s pastoral areas are due to drought (Kassahun 2003). The effects of losing these animals vary depending on the type of family and gender. Women-headed poorer homes with less cattle and poorer households, for example, are more sensitive to drought than others (Regassa et al. 2010).

2.9. Supporting livelihoods and appropriate funding to build resilience

The Damte family lives in Magado, Ethiopia’s Borana zone (Figure 9). The family’s 30 cattle, 25 sheep and goats had provided a steady supply of milk and meat prior to the drought. They also provided milk, skins, meat, and calves to the local market for sale (Saving Lives through Livelihoods 2006). Animals contribute for more than 90% of the local economy in the Borana zone, and the sale of livestock and livestock products generates more than 60% of household income. Due to the drought, the Damtes were left with only two frail cows and one goat.

Drought can have severe repercussions on the lives and livelihoods of millions of pastoralists in the Horn of Africa, as the Damte family’s story illustrates. Livelihoods interventions, such as livestock-related efforts (destocking) and water-related interventions such as the construction and rehabilitation of wells and boreholes, help pastoralists save lives while also increasing their resilience. Strategic livelihoods initiatives in pastoral communities have long been recognized for their socioeconomic significance (Aklilu and Wekesa 2002).

For example, a study of a destocking intervention in Ethiopia’s Moyale Woreda during the 2006 drought found a benefit–cost ratio of about 41:1 in terms of aid funding. Destocking provided more than half – 52.4 percent – of the money for the programme’s households, which was used to buy food and care for cattle. Figure 10, designed to cover a variety of household needs, help relatives, and either pay off debts or put money into savings, allowing households to weather the drought without losing all of their assets (Demke 2006).

2.10. Drought effects and traditional drought mitigation strategies

Droughts on the Borana production system in southern Ethiopia occurred in 1983–84 as a result of rainfall shortfalls over four consecutive rainy seasons spanning two years. Drought conditions are caused by a lack of adequate feed supplies, resulting in poor physical condition, which weakens the immune system and makes the animal more susceptible to disease. Drought, insufficient water, heat, and insufficient feed resources are the principal climate stresses in dryland environments, lowering livestock immunity and exposing animals to new diseases and vectors. The current study’s findings echoed those of (Boru et al. 2014), who claimed that drought and land fragmentation contributed to animal deaths and a decline in the cattle population in the eastern Guji zone. Ethiopia has Africa’s largest livestock population and is the tenth largest producer of livestock and livestock products in the world (MacDonald and Simon 2011). Livestock and livestock products account for around 10% of Ethiopia’s foreign currency revenues (Pantuliano and Wekesa 2008). Respondents
declared that the main drivers for livestock decline in the study area is drought and drought-driven impacts (Table 4).

2.10.1. Mitigation of livestock-related risks

Cattle provide the majority of the diet and livelihood in Ethiopia’s Borana zone (Figure 11). If animal sources continue to provide the great majority of their calories, maintaining a sufficiently big herd size will be critical to guaranteeing adequate caloric intakes among the Borana. Although there is a move to non-traditional pastoralist livelihoods, livestock remains the most important component of Borana livelihoods (Wassie et al. 2007). Although huge herds may signify economic and food security, animal well-being and herd mortality are also linked to cattle herd size. Figure 11 shows how bigger herd sizes can increase herd mortality, especially under drought and stress situations (Lybbert et al. 2004). Milk output has declined, according to elders, because to diminishing rangeland quality and quantity. In the current drought, the number of breastfeeding animals required to maintain a household could be as high as 10-20, compared to just one or two lactation animals forty years ago.

2.10.2. Mobility of the herd

The Borana wander with their livestock in search of water and pasture as nomadic pastoralists. Season and forage availability, as well as personal relationships, family structure, and current demands, all influence movement. Drought is the natural danger that affects the greatest number of people worldwide, wreaking havoc. Drought has the most direct effects on farmers, including the drying up of water resources, crop failure, a rise in food prices, ill health, livestock output losses and death, and a drop in livestock prices (Udmale et al. 2014). As climate change has worsened, the Borana have changed their migration patterns, including when, where, and for how

![Figure 11. During the current drought, livestock deaths are on the rise](image1)

![Figure 11. During the current drought, livestock deaths are on the rise](image2)

Table 4. Drivers for livestock decline in the study area (Matiwos et al. 2022)

| Purpose                             | Golba Frequency | Index | Rank | Dida Frequency | Index | Rank |
|-------------------------------------|-----------------|-------|------|----------------|-------|------|
| Drought                             | 54 (56.2)       | 0.429 | 1    | 53 (52.0)      | 0.406 | 1    |
| Disease                             | 39 (40.6)       | 0.323 | 2    | 44 (43.1)      | 0.361 | 2    |
| shortage of grazing land            | 44 (45.8)       | 0.248 | 3    | 64 (62.7)      | 0.233 | 3    |

![Figure 10. Funding appeals and contributions](image3)
long they travel. According to Dr. Roobaa Basaayyee, the chairman of the Borana Zone Livestock Development and Health Agency, cattle going from the south, where tsetse flies are scarce, to the north, where they are plentiful, could catch trypanosomiasis, resulting in large livestock deaths (Yabello, July 2011).

2.11. Drought and climate-related hazards have an impact on livestock production in Ethiopia’s Afar and Tigray regions

2.11.1. The effects of emergency livestock feeding on livestock mortality in the Afar area

FARM Africa, Save the Children-UK (SCUK), and CARE Ethiopia examined the impact of an emergency livestock feed supplementation programme in the Afar Region’s Amibara, Teru, and Abala districts (Figure 12).

The evaluated feed supplementation programme was created in response to the poor performance of both the Sugum (short rains in March-April) and Kerma (long rains in July-September) rains in 2009. Drought is a severe and recurring climate occurrence that affects the lives of millions of people around the world, and it is considered the most serious natural disaster in terms of economic, social, and environmental consequences (Mniki 2009). This revealed a severe lack of pasture and water in many parts of the region, as well as low trading terms. It also revealed that pasture and water constraints have caused lactating for cows to dry up and browsers (goats and camels) to produce far less, putting the nutritional status of households, particularly offspring and pregnant or lactating mothers, at risk. Tables 5 and 6 indicate the impact of this livestock feeding intervention on cow and small ruminant mortality.

2.12.2. Farmers’ perceptions of drought and its socioeconomic consequences in Ethiopia’s Tigray and Afar regions

Climate change is real, and it is already happening. It will worsen in the future, with more negative consequences for rural poor communities in developing countries. Climate change and catastrophic weather events have gotten a lot of press in recent years (IPCC 2007). Furthermore, a recent IPCC assessment (IPCC 2013a) stated that the climate system is clearly warming, and that many of the changes seen since the 1950s are unprecedented for periods ranging from decades to millennia. Data on the economic effects of drought is few, incomplete, unreliable, and dispersed. Addressing these issues could be critical in decreasing the socioeconomic effects of drought, especially in Africa’s least developed countries (Brida et al. 2013; Debela et al. 2015).

From March to June 2016, a cross-sectional examination of the study was undertaken in three Tigray districts (Alamata, Ofa, and Raya-azebo) and one Afar district (Ab’a’ala) (Figure 13). Drought-prone and desert regions include Tigray, which

| Comparison          | Chi-square | Livestock mortality per Teru | Location  |
|---------------------|------------|------------------------------|-----------|
| Teru vs. Abala:     |            |                              |           |
| Cattle fed          | 26.3, *p* < | 3.7% (6/164)                 | 23.8% (31/130) |
|                     | 0.001      |                              |           |
| Small ruminant fed  | 20.2, *p* < | 3.3% (9/272)                 | 18.2% (12/66) |
|                     | 0.001      |                              |           |
| Cattle not fed      | 26.3, *p* < | 22.3% (105/471)              | 41.5% (86/207) |
|                     | 0.001      |                              |           |
| Small ruminant not fed | 98.5, *p* < | 10.2% (87/852)               | 42.6% (58/136) |
|                     | 0.001      |                              |           |

Table 5. Drought-related mortality in Teru and Abala study herds was compared
is located in Ethiopia’s northern and hilly highlands, and Afar, which is located in Ethiopia’s northeastern region. The study districts were chosen for comparison of drought consequences in mid, highland, and lowland areas based on their previous histories. Alamata, Ofia, and Raya-azebo districts had populations of 85,403, 126,889, and 135,870, respectively, according to the 2007 national population and housing census (CSA 2007).

Farmers’ perceptions of drought and its effects found that 96.2 percent believe drought is a natural disaster rather than a man-made calamity. Furthermore, 77.5 percent of respondents have experienced drought, with 78.8, 17.5 percent, and 15% having experienced drought in 1983, 1989, and 2003, respectively, in addition to the current drought (2015/2016). In addition to the above drought years, the respondents mentioned other drought years they had lived through. Droughts were reported to occur more frequently than expected by 67.5 percent of research participants, while 56.25 percent of respondents predicted the commencement of drought. Droughts have substantial economic consequences because they disrupt populations’ main economic activity (Antonio et al. 2013).

### 2.13. Effects of climate change on Ethiopian agriculture, livestock, and the economy

The global economy and social progress are both threatened by climate change. Because their economies are primarily dependent on climate-sensitive activities like rain-fed agriculture, its effects would be disproportionately felt in Sub-Saharan African countries like Ethiopia. Agriculture accounts for over 47% of Ethiopia’s GDP, and more than 70 million people (85% of the country’s population) rely on it directly or indirectly for their livelihoods (MoFED 2013). As a result, any impact on Ethiopia’s agricultural will have a huge impact on the country’s economy. Climate change is expected to cause periodic droughts and excessive rainfall in various parts of Ethiopia, limiting the amount of land available for agriculture and lowering crop output.
2.14. Policy implications of the drought resistance mechanism in livestock production

Drought policies based on the principle of risk reduction can change a country's approach to drought management by lowering the negative consequences (risk). To address this problem, crops and livestock must be grown in livestock systems that require less water or in areas where water is abundant (Nardone et al. 2010). Furthermore, mitigation strategies such as increasing nitrogen use efficiency, plant breeding and genetic modifications using organic fertilizers regular soil testing, using technologically advanced fertilizers, and combining legumes and grasses in pasture areas may help to reduce GHG emissions in feed production (Denef et al. 2011, 2014). The national climate change strategy is broken down into three sub-documents (sub-strategies), each of which corresponds to one of the three pillars of climate policy: a national decarbonization roadmap for mitigation, a national adaptation strategy for adaptation, and a climate change partnership plan for raising awareness.

3. Conclusion and recommendation

Drought has wreaked havoc on Ethiopia’s pastoral and agro-pastoral communities’ cattle, water, and grazing lands, as well as the pastoral and agro-pastoral communities’ socioeconomics. Drought continues to be a serious challenge and problem in several agro-ecological zones, particularly in Ethiopia’s southern, eastern, and northern regions, where cattle is dominating due to an abundance of range land. Climate change, competition for natural resources, feed quality and quantity, livestock illnesses, heat stress, and biodiversity loss all have a negative impact on livestock output. Traditional adaptation measures in Ethiopia, such as livestock movement, diversification, feed procurement, and animal restocking, have been insufficient to meet their livelihood needs. Drought can occur in practically all climatic zones and is caused by a lack of precipitation over a lengthy period of time, usually a season or the long-term average condition in a specific area. Ethiopia is Africa’s greatest livestock producer and exporter, with the continent’s highest cattle population.

Climate change has a direct impact on cattle; the spatial distribution and availability of pasture and water are highly dependent on rainfall patterns and availability. Changes in rainfall patterns and temperature ranges also have an impact on feed availability, grazing ranges, feed quality, weed, pest, and disease incidence. Climate change can influence livestock in two ways: the quality and quantity of feed from grasslands may be affected, as well as direct consequences on animals owing to rising temperatures. Yabello and Dirre districts in Borana zone were chosen since drought severity harmed animals owing to a lack of quality and quantity water and feed. In the Borana zone of southern Ethiopia, almost 65 percent of cattle died, making them the most vulnerable animal kind. Pastoralism employs roughly 27% of Ethiopia’s entire population, generates 30% of the country’s gross domestic product, and generates 90% of the country’s hard cash from live animal exports. Drought-related animal death rates in Somalia increased by a factor of 20, 40, 60, and 80 percent of the total cattle population from 1930 to 1970, 1970–1990, 1990–2000, and 2001–2002/03. In terms of livestock management, a quick response to the first failure of the long rains in April 1983 was to adjust cattle allocation from a 71:29 ratio for home-based and satellite herds to a 34:66 ratio within seven months.

The following recommendations were forwarded to cattle populations fleeing drought based on the introduction, review of associated literature, and conclusion. Increased land degradation, conflicts over finite resources, restricted access to (knowledge, education, skills, and financial services), poor government policies, and population pressures are all important obstacles for pastoralist drought response techniques. There is still limited research regarding the impacts of climate change on livestock production. Interactions between climate change and livestock production are still not well understood, despite the amount of research performed. Governments should pay attention to and support technical innovation, particularly in the area of forage reservation. In drought-prone areas, pastoralists must be aware that drought incidence is dependent on the season in order to protect their animals from starvation, vector-borne disease, and tse-tse fly infestation. During the season, the local community should establish coping techniques for evacuating cattle from drought by traveling from place to place in the best climatic conditions and gaining access to feed. Finally, including climate data into the existing application of adaptation and mitigation approaches based on location and livestock system may improve the study’s trajectory in the future.

Declaration of competing interest

The authors state that they have no known competing financial interests or personal ties that may have influenced the work presented in this study.

Data availability

On the request of an online user, data will be made available.

Funding statement

This review article received no specific support from public, commercial, or non-profit funding entities.

Disclosure statement

The authors declare no conflict of interest.

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Public interest statement

Drought is one of the elements of weather and climate extremes, and it happens when the natural water supply is lower than usual, leading to problems with the availability of...
water. The biggest population of livestock in Africa lives in Ethiopia, which are also the continent’s leading producer and exporter of livestock. Weather-related droughts have the potential to lower agricultural productivity by decreasing the amount of moisture in the soil. The most susceptible pastoral communities that depend on extensive livestock production systems in dry regions are predicted to be the most affected by climate change. In the past, droughts have resulted in significant loss of life and property as well as significant population displacement. Increasingly frequent droughts pose a challenge to the pastoralists’ ability to cope and be resilient, and in particular, the Borana Southern region of Ethiopia was extremely sensitive to drought weather and climate extremes in the period between 2021 and 2022.

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