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Pastoralists' and agro-pastoralists' livelihood resilience to climate change-induced risks in the Borana zone, south Ethiopia: Using resilience index measurement approach

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Abstract

This study was conducted in the Borana zone, Oromia region, southern Ethiopia, with the aim of analysing the livelihood resilience of pastoralists' and agro-pastoralists' to climate change-related risks. A household survey was used to collect quantitative data, whereas qualitative data were collected via focus group discussions, expert group discussions, and personal observations. Descriptive statistics were used to analyse quantitative data, and content analysis was used to analyse qualitative data. The results show that frequent droughts, rising temperatures, and reduced rainfall are the major climate change-induced risks affecting the livelihoods of pastorals and agro-pastorals in the study area. Among the parameters tested, the greatest impacts of climate change-induced risks on pastoral and agro-pastoral livelihood systems were recorded for food [100%] and animal feed or pasture [99%], followed by livestock loss [95%], a decline in species dynamics [95%], and agro-pastoral land degradation [95%]. The average climate resilience index score of the Borena zone is found to be 0.328, implying that 32.8% of the respondents are resilient, with 0.163 [16.3%] pastoralists and 0.417 [41.7%] agro-pastoralists being resilient. However, all the results are below the scale of the minimum threshold [0.5 or 50%], implying that livelihoods and their households are poorly resilient. For the low resilience in Borena, limited access to basic services [0.26] and the adaptive capacity [0.29] of the pastoralists and agro-pastoralists contributed the highest share for resilience capacity compared to other major building blocks of resilience. However, of the two livelihood systems, pastoralists were found to have less resilience [0.249] compared to agro-pastoralists [0.407]. Besides the climatic factors, the resilience of pastoralists' and agro-pastoralists' livelihoods was affected positively and significantly by adaptive capacity and negatively and with statistical significance by the asset endowments of the households at $P < 0.05$. Therefore, policymakers should give pertinent attention to the reduction of the effects of climatic risks and increase the resilience of pastoral and agro-pastoral livelihood systems. Furthermore, actions that focus on increasing access to water, improving the rangeland generative capacity, diversifying the income sources, and providing timely and accurate early warning information are indispensable to building resilient livelihoods among the pastoral and agro-pastoral communities.

Keywords Climate change, Drought, Livelihood, Risks, Resilience

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Introduction

Pastoralism and agro-pastoralism are ways of life among the people living in the arid and semi-arid land areas of the world. These modes of life are mainly dependent on animal husbandry. In both pastoral and agro-pastoral systems, livestock production is of crucial importance to the incomes, economies, and livelihoods of hundreds of millions of Africans in particular and the world at large (Abduletif 2019; FAO (Food and Agriculture Organization), 2021). According to recent estimates, there are currently about 120 million pastoralists and agro-pastoralists worldwide, of which 41.7% live exclusively in sub-Saharan Africa (SSA) (Mohamed 2019). Of the large number of pastoralists and agro-pastoralists, the East Africa corner compromises the very best with nearly half of the livestock in the SSA and being ways of living for greater than 30 million people in the region (FAO (Food and Agriculture Organization) 2021). The sector has an annual market value of $50–80 million in economic contribution to Kenya, 7.5% of Uganda's total GDP and 17% of agricultural GDP, and 90% of Ethiopia's live animal export supply (CELEP (Coalition of European Lobbies on Eastern African Pastoralism), 2017).

In Ethiopia, pastoralists and agro-pastoralists are mainly found in the lowlands, which are commonly arid or semi-arid and sparsely populated (Kurt 2003; FAO, 2018). It covers 61% of Ethiopia's total land mass, with 97% of pastoralists concentrated in the northeast, east, and south. Somalia has the highest number of pastoralists (53%), followed by Afar (29%) and Borana (9%), and the rest 8% are found in the Gambella, Benishangul, and Tigray regions of Ethiopia (USAID (United States Agency for International Development), 2016). It provides livelihoods for more than 12 million Ethiopians, who derive most of their income from keeping livestock and complement it with farming in the case of agro-pastoralists (CSA (Central Statistical Agency), 2013; FAO, 2018). Economically, the sector contributes 20% to Ethiopia's GDP through the livestock subsector (Abduletif 2019; Ayele et al. 2020).

Despite the sector's *significant contribution to the national economy, little attention has been paid to the development of* pastoral livestock, and policymakers often ignore it, focusing on the interests of agriculture and urban dwellers *(*Mohamed 2019*). Given the region's poor development policies, b*asic social services like health, education, electricity, roads, and communications; access to agricultural extension services; access to credit; and insurance services are typically lower than in other regions (UN (United Nation, 2010). As a result of this, *illiteracy is quite high as most children are out of school* (UNICEF (United Nations Children's Fund), 2014). Overall, pastoral areas in Ethiopia experience a lack of development efforts mainly focused on human capital development programmes (Gebremeskel et al. 2019). This suggests that they seek pragmatic policies that are consistent with indigenous knowledge, rather than implementing state-sponsored, centralized policies (Lind et al. 2016; Rettberg et al. 2017).

Despite socio-political ignorance, livestock producers were thought to be the wealthiest part of the community, but nowadays, the situation has been reversed, and groups that rely on large-scale herding for their livelihoods are among the most vulnerable and insecure (Yimer 2015). Pastoral areas of Ethiopia are characterized by recurrent droughts and high livestock mortality, threatening pastoral viability and causing famine resulting in loss of life. Moreover, the rangelands that pastorals and agro-pastorals depend on are shrinking due to various factors such as population growth, agricultural encroachment, land degradation, blocked migration routes, and ethnic conflicts caused by the scarcity of natural resources (Eyasu and Abdi 2010; Rufino et al. 2013; Lind et al. 2016).

Furthermore, the spread of human and livestock disease, insecurity, and recurrent droughts along with other internal factors such as human population growth and loss of rangelands due to non-pastoral investments are among the greatest threats to the stability and viability of livestock and agriculture. It continues to be a devastating and intractable problem (Desta 2020). Increasing poverty and declining living standards are occurring against the backdrop of underdeveloped social services and deteriorating security, which is the viability and adaptation of pastoral livelihood system (Catley 2017). In general, the severity of the associated risks and climatic and non-climatic shocks underscores the loss of pastoralists and agro-pastoralists from robust and prosperous lifestyles, forcing people away from pastoralism (AU 2010).

Despite the internal and external factors that limit pastoralists' and agro-pastoralists' livelihoods, the projected global warming is expected to worsen the situation for the sector. IPCC (Inter governmental Panel of Climate Change) (2019) predicts that climate-related risks to health, livelihoods (i.e., crop and livestock sectors), food security, water supply, human security, and economic growth are projected to increase with global warming. This is mainly because increased pressures from natural shocks such as unpredictable rainfall and frequent droughts and floods create an imbalance between livestock and the resources they depend on to support themselves (Smith et al. 2015). This also means that the natural resources (i.e., rangeland and water) that are strongly tried to the livelihoods of pastoralists and agro-pastoralists are deprived, making pastoralists'

livelihoods more difficult (Ayele et al. 2020). Current climatic shocks prevailing in arid regions of the Horn of Africa, including Ethiopia, are characterized by rising temperatures, scarcity, and variability of rainfall, and their spillover effects (i.e., droughts, diseases, pests, and pasture and water scarcity) will be more severe and frequent (Tofu et al. 2022a). This means that adaptive herd movements, which have been critical to the long-term viability of pastoral and pastoral industries, face significant challenges (FAO (Food and Agriculture Organization) 2021).

Despite the increasing vulnerability factors and consequent pressures on pastoralist livelihoods, the potential remains high to maintain pastoral livelihoods and improve their resilience to climate change-induced disasters such as drought. This may include the development of water interventions in rangelands, especially the construction of wells and permanent water supply systems for human and livestock consumption, enhanced rangeland development and management. Livestock-based commercialization and improved market integration are pathways to transform the livestock industry in pastoral and agro-pastoral areas and sustain livelihoods (Gebremeskel et al. 2019). These interventions focused on increasing resilience to protect pastoral and agro-pastoral livelihoods in the short term (Herrero et al. 2016). Because the investment in resilience is very important to the social, economic, and ecological systems' capacity to absorb, adapt, or transform by avoiding their exposure and sensitivity to climate-induced hazards (Kaur et al. 2019). The successful management of socio-ecological systems requires understanding the contextual factors that drive changes in resource use patterns and influence the societal capacity to adapt and cope with the stresses (Hertel et al. 2021).

There have been many studies conducted so far (Tolera and Abebe 2021; Coppock et al. 2014; Debela et al. 2015; Ng'ang'a et al. 2016; Ambelu et al. 2017; Anbacha and Kjosavik 2018; Bekele et al. 2020; Bekele et al. 2021) that did not address this specific issue of the Borena zone. On the other hand, livestock potential in the region is among the highest in the country, and the current impact of climate change-related risks on the most vulnerable livelihoods is an intensive effort to inform policymakers and development practitioners. This study, therefore, uses the integrative framework of the socio-ecological model to provide specific insights into the broadest range of climate change-related risks, their impacts, and the resilience of pastoral or agro-pastoral to climate risks identified in the Borana region. Therefore, the objectives of this study are to (I) identify commonly experienced climate change-induced risks and measure the associated effects, (II) measure pastoral and agro-pastoral resilience, and (III) identify the determinants of pastoral and agro-pastoral resilience to the effects of climate change-induced risks in the Borena zone, Oromia region, southern Ethiopia.

Research methodology

Study area description

The study was carried out in the Borena zone. Borena zone is among the 21 administrative zones in the Oromia Regional State of Ethiopia. Out of 13 districts in the Borena zone, two districts namely, the Dirree and Moyale districts, were selected considering their reliance on vulnerable livelihoods and severity of drought. The selected districts are located at a distance of 200 km and 165 km from the zonal town (Yabello), respectively. The zonal town is 575 km away from Addis Ababa (the capital city of Ethiopia) (Bekele et al. 2020). The zone covers an area of approximately 95,000 km^2, with an overall population density of six inhabitants per square kilometre. According to the National Meteorological Agency (NMA) of Ethiopia, the climate relay under a mean annual temperature of 19 °C and with a mean maximum and minimum temperature of 24.6 °C and 12.96 °C, respectively. In general, the warmest period of the year is from March to May, while the lowest annual minimum temperatures occur between the months of November and January (NMA (National Meteorological Agency). 2007; Worku et al. 2022). The area is semi-arid with highly variable rainfall ranging between 500 and 900 mm per annum (Ng'ang'a et al. 2016). The rainfall has a bimodal distribution, with long rains occurring between March and June and short rains occurring between August and October (Solomon and Coppock 2004). The elevation ranges from 1000 m above sea level on the plains to 1500 m in the highlands (Solomon et al. 2007).

Although there is agro-pastoralism in a few districts, pastoralism is the dominant livelihood, and the people are generally referred to as cattle herders, even though they also keep sheep, goats, and camels (Bassi and Boku, 2007; Tiki et al. 2010). The people are known for their strong bondage and social security networks of helping each other during hard times, including droughts (Tache and Espen 2008; Anbacha and Kjosavik 2018). According to the Central Statistical Agency's (CSA) projection, the current total population of Dirree district is 88,622 (male: 44,523, female: 44,099), while that of Moyale district is 37,073 (male: 19,140, female: 17,933), and the total population of the Borena zone is 165,838 (CSA (Central Statistical Agency) 2013). The study area map is depicted in Fig. 1.

Mixed approaches—quantitative and qualitative methods—of the research along with the

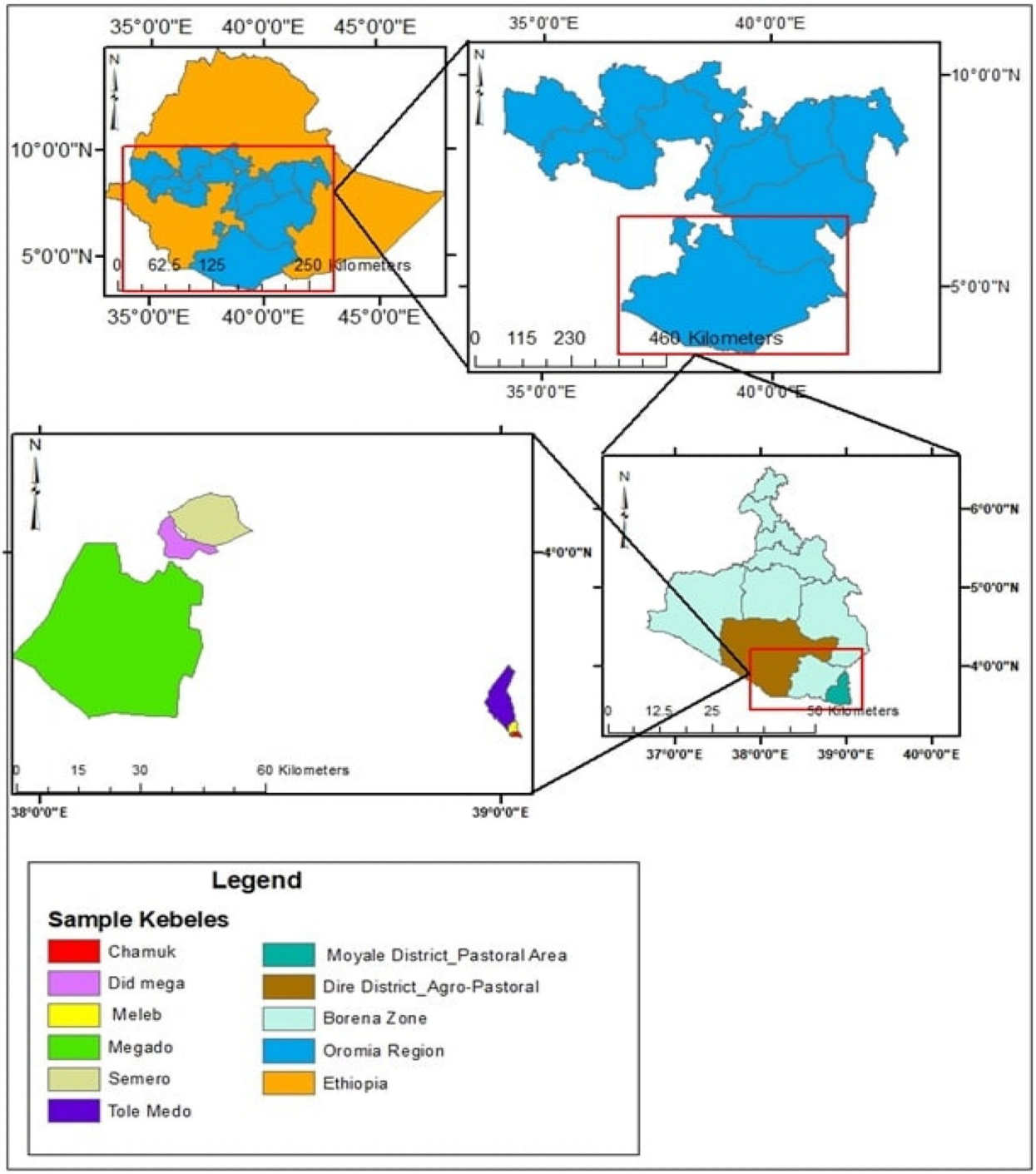

Fig. 1 Map of the study area. Research approach and design

descriptive design were used. The method employs both approaches iteratively or simultaneously to create a stronger research outcome because the combined quantitative and qualitative methods enable exploring more complex aspects and relations of the human and social world (Malina et al. 2010). Besides, it is a very suitable approach to any given research project. Its use would yield positive benefits in that the use of different approaches has the potential to provide a greater depth and breadth of information than is possible by

utilizing singular approaches, qualitative or quantitative, in isolation (Almalki 2016).

Sampling procedures

Both purposive and random sampling procedures were used for this study. First, the study area was purposefully selected considering the vulnerability of households and communities to the impacts of climate change-induced risks and the severity of drought in the area (i.e. two livelihood-based districts, Moyale (pastoral) and Dirree (agro-pastoral)). Second, a total of six kebeles (the lowest government administrative structure in Ethiopia), three from the livelihood-based district, were randomly selected. Finally, while respondents for quantitative data were included using randomized proportional sampling procedures, discussants for qualitative data were considered purposively. For quantitative data, 204 respondents were determined using Yemane's (1967) formula: $n = N/1 + N(e^2)$, *at a P-value of 0.07 from the total household (N = 271,468). We set the P-value at 7%, aiming to have manageable amounts of data because we gathered sufficient amounts of data using qualitative data collection methods and tools. However, because of incompleteness in the nine questionnaires, we dropped them and analysed the 195 households' reports.*

Methods and tools of data collection

A sampled household survey was used to collect quantitative data, while focus group discussions (FGDs), expert group discussions, and field observations were used to gather qualitative data. A semi-structured questionnaire was used to collect objective data, whereas an unstructured or open-ended questionnaire and/or discussion guide checklists were used to gather qualitative data.

Six pastoralist and agro-pastoralist focus group discussions and four expert group discussions were conducted to substantiate the information obtained from the survey method. When the total number of respondents for a survey was determined by using a formula (Yamane 1967), the total number of FGDs and expert group discussants was determined based on the level of data saturation. Enumerators with diplomas and first degrees were chosen and trained from district-level expertise, and the actual data was collected by them under the researchers' close supervision. However, qualitative data were gathered by the researchers themselves with the help of the facilitators. Voice recorders and a photo camera were used during the discussions to reduce the omission of relevant data, and each discussion group comprised 8–12 participants. In addition to the primary data from the field, district- and zonal-level offices were visited to collect secondary data. Disaster risk prevention and preparedness, agriculture (i.e., livestock production, health, and crops), natural resources, environment and climate change protection, and pastoral affairs offices were sectors visited to collect secondary data.

Method of data analysis

For the quantitative types of data analysis, descriptive statistics such as frequency, percentage, and mean are used. Besides, a multivariate model called principal component analysis (PCA) was used for analyzing the collected data from the sample pastoralist and agro-pastoralist households. At the same time, PCA is an important technique often used to reduce the dimensionality of large datasets, increase interpretability, and minimize information loss from the datasets (Jolliffe and Cadima 2016). PCA is a multivariate technique that analyses a data table in which observations are described by several inter-correlated quantitative dependent variables (Abdi et al. 2010). In general, PCA was used to generate the resilience capacity. The Statistical Package for Social Science (SPSS) version 23, Excel sheet, and STATA version 14 software were used for the analysis.

In order to analyse the qualitative data, voice data was transcribed and transformed into verbal or text form. A classification was made of the transcribed data. Then, reading and re-reading the text or transcribed data in order to identify themes or patterns of ideas, concepts, behaviours, and interactions and the creation of coherent categories that enable the summary of the whole data set were conducted (Tofu et al. 2022b). Finally, content analysis was used to present the qualitative information in harmony with the quantitative results.

Measurement of climate resilience of pastoral and agro-pastoral livelihood

The concept of resilience is used in different fields, but its definition is mainly associated with disaster resilience as well as the ability to cope with longer-term climate change, including transformative change (DFID (Department for International Development) 2013).

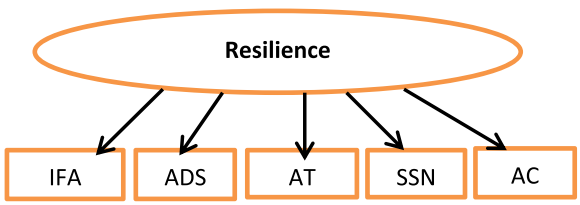

Fig. 2 Analysis of the resilience structure according to RIMA

Existing disaster risks are increased (in scale, frequency, and variability) by climate change, as well as by slow-onset impacts such as temperature increase and sea-level rise (UNDP (United Nations Development Programme) 2011). Here, disaster resilience is defined as the ability of individuals, communities, organizations, and states to adapt to and recover from hazards, shocks, or stresses without compromising long-term prospects for development (Combaz 2014). In order to understand the ability to absorb and recover from climate change-induced risks while positively adapting and transforming their structures and means for living in the face of long-term changes and uncertain climate change, a composite index of climate resilience was used by many scholars.

Among many studies, determining the resilience of rural households to food insecurity during drought conditions by Nahid et al. (2021), exploring households' resilience to climate change-induced shocks using the climate resilience index in the Dinki watershed by Asmamaw et al. (2019), factors affecting rural households' resilience to food insecurity by Boukary et al. (2016), adaptation and resilience to climate change and variability by Tambo (2016), understanding the resilience of pastoralists to climate change and variability in the Afar Region by Mekuyie et al. (2018), and dynamic analysis of resilience in Uganda (d'Errico et al. 2016) were the most widely referenced empirical studies in the area. Moreover, to determine the resilience index, many of them employed principal component analysis (PCA) by using different variables (Keil et al. 2008; Demeke and Tefera 2013; Lokosang et al. 2014).

In the same fashion, to determine the resilience levels of pastoral and agro-pastoral livelihoods in the Borena zone, a composite climate resilience index (CRI) was employed. The RCI was calculated as a function of five pillars or resilience building blocks employing principal component analysis (PCA) (Keil et al. 2008; Demeke and Tefera 2013; Lokosang et al. 2014). The major components that are presented in Fig. 2 include income and food access (IFA), access to basic services (ABS), assets (AST), social safety networks (SSN), and adaptive capacity (AC) (FAO (Food and Agriculture Organization) 2016). The formula is:

$$\mathrm{CRI} = f(\mathrm{IFA}i, t, \mathrm{ABS}i, t, \mathrm{AST}i, t, \mathrm{SSN}i, t, \mathrm{AC}i, t)$$

The Climate Resilience Index is the function of the *i*th household depending on the levels of IFA, ABS, AST, SSN, and AC at time *t*, plus the error term. Higher values of the resilience index show more resilience in households and vice versa (Boukary et al. 2016). The indicators of each component are measured on different scales; hence, they were standardized to fall in the range of 0 to 1 (Tambo 2016; Nahid et al. 2021). The functional relationship between resilience and the major components or pillars of resilience was taken into account by ensuring that resilience increases with an increase in the value of each component.

On the other hand, to identify the factors influencing pastoral and agro-pastoral households' resilience to climate change-induced risks, the structural equation modelling approach was applied by using a revised version of the methodology proposed by Alinovi et al. (2010). During this factor extraction, the shared variance of the variables is partitioned from their unique variance and error variance to reveal the underlying factor structure; only the shared variance appears in the solution. Sufficient numbers of factors are considered in order to make sure that they account for at least 95% of the explained variance (Preacher et al. 2013).

Moreover, the computed composite index of pastoralists' and agro-pastoralists' determinants of resilience capacity was explained as the given components having positive or negative relations with the resilience capacity of the households, and the relationship could also be significant or insignificant.

Table 1 Socio-economic characteristics of the respondents

Socio-economic variables		Percentage (%)	Descriptive statistics			
			Minimum	Maximum	Mean	SD
Sex	F	17				
	M	83				
Age	–	–	21	88	46.95	14.67
Education	Illiterate	46	0	1	0.54	0.50
	Read and write	54				
Family size	–	–	2	18	6.72	2.65
Livelihood	Pastoral	69	1	2	1.31	0.46
	Agro-pastoral	31				
	$N = 195$					

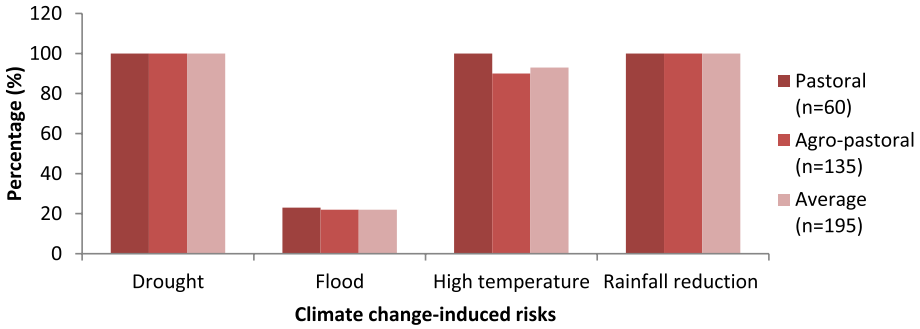

Fig. 3 Commonly experienced climate change-induced risks in the study area

Result and discussion

Socio-economic characteristics of the respondents

The survey results in Table 1 show the socio-economic characteristics of the respondents. Of the total surveyed, 83% of the respondents were male-headed households, whereas the remaining 17% were from female-headed households. Regarding household size, while the minimum number of family members was two, the maximum number was 18, with an average family size of 6.72 (SD = 2.65). This was relatively higher than the national average for rural households. According to the Central Statistical Agency (CSA (Central Statistical Agency) 2013) and the World Bank (2013), the average household size in rural areas of Ethiopia was 5.1%. The average age of household heads was 46.95 years (SD = 14.67), with a minimum and maximum age of 21 and 88 years, respectively.

Concerning educational status, about 46% of the sampled households are illiterate, whereas 54% are drawn from households able to read and write. The results showed that about 69% of the sampled households are pastoralists, whereas 31% of the sampled households are agro-pastoralists.

Measuring commonly experienced climate change-induced risks

Figure 3 shows the frequently experienced climate change-induced risks that were perceived by pastoralists and agro-pastoralists in the study area. Drought and reduction in rainfall were the most commonly experienced climate change-induced risk and were reported by 100% of pastoralists and agro-pastoralists. Similarly, around 93% of the pastoralists and agro-pastoralists reported that an increase in the local temperature was also the third most serious climate change-induced risk affecting their livelihood. On the other hand, a temperature increase was reported by 100% of pastoralists and 90% of agro-pastoralists, in contrast to drought and rainfall. Last but not least, the climatic shock that was noted by 22% of the respondents was flooding, implying a low trend of flood hazards.

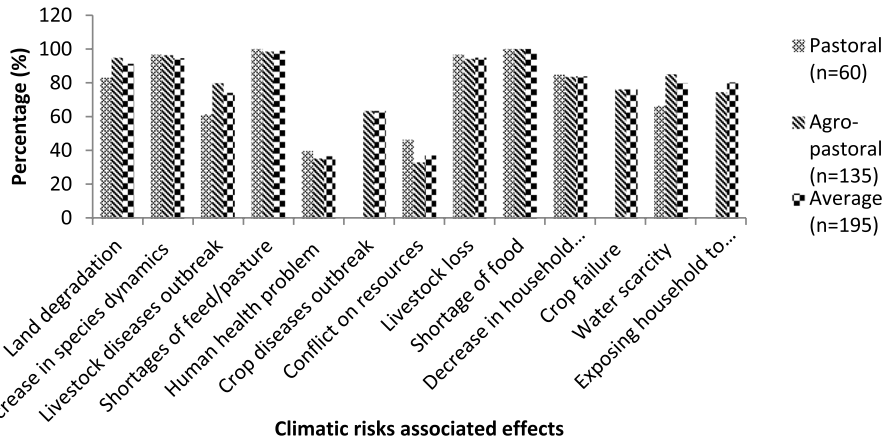

Fig. 4 Associated effects of climate change-induced risks in the study area

Table 2 Resilience indicator and component/index values for the districts

S/N	Major and sub-components	Moyale	Dirree
1	**Income and food access (IFA)**		
	Monthly income of the households	0.517	0.458
	Percentage of income used for buying food	0.713	0.629
	Consumption from own production	−0.475	0.629
	Sub-average index	**0.252**	**0.572**
2	**Access to basic service (ABS)**		
	Access to river water	−0.493	0.299
	Access to health service	0.349	0.656
	Access to veterinary service	−0.340	0.653
	Access to clean water	0.721	0.233
	Sub-average index	**0.059**	**0.460**
3	**Social safety net (SSN)**		
	Loan received	0.718	0.707
	Formal transfer	0.597	−0.035
	Informal transfer	0.117	0.706
	Social network	0.338	0.019
	Sub-average index	**0.443**	**0.349**
4	**Asset (AT)**		
	Mobile	0.535	−0.026
	Car	–	0.550
	Bicycle	0.583	0.383
	Television	0.131	0.415
	Radio	0.582	0.324
	TLU	−0.133	0.477
	Motorcycle	0.025	0.215
	Sub-average index	**0.287**	**0.334**
5	**Adaptive capacity (AC)**		
	Means of living	0.510	0.701
	Ability to read and write	0.597	0.203
	Diversity of crops grown	–	0.679
	Access to informal credit	−0.619	0.085
	Sub-average index	**0.163**	**0.417**

Effects of climate change-induced risks

Figure 4 depicts the associated effects of the above-discussed climate change-induced risks on the livelihoods of pastoral and agro-pastoral communities. Due to climatic change-induced effects, a shortage of food during the emergency period was a major problem for the communities and was reported by 100% of those surveyed. Loss of livestock (95%) and crop failure (76%) were noted as the major reasons. This resulted in a decrease in household income (84%) and played an important role in exposing households to external support (81%). In addition to the climatic risks (i.e., drought, temperature increment, and severity of drought), shortages of feed or pasture (99%) and water scarcity (80%) were reported as the next major effects affecting the livelihoods of pastoralists and agro-pastoralists in the study area.

Moreover, the degradation of agro-pastoral land (91%) and a decline in the overall productivity of pasture land (95%) were the most frequently mentioned effects of climate change-induced risks. These are the major resources of the pastoral community besides water, and the severely observed on it severely affected the productive capacity of the pastoral and agro-pastoral communities. This was also confirmed by the researchers during the fieldwork through the transect walk with the community facilitators. Similarly, livestock and crop diseases or pest outbreaks were reported by 74% and 64% of respondents, respectively, as the other constraining factors of pastoral and agro-pastoral livelihoods. Apart from their livelihood, climate change-induced risks advanced their dimension of effects on human health (37%) and drove them to conflicts (37%) due to competition for scarce natural resources.

Table 3 PCA results of the resilience score for the study area

Major components	Pastoral	Agro-pastoral	Overall CRI of Borena zone
Income and food access (IFA)	0.252	0.572	0.412
Access to basic service (ABS)	0.059	0.460	0.260
Social safety net (SSN)	0.443	0.349	0.396
Asset (AT)	0.287	0.334	0.311
Adaptive capacity (AC)	0.163	0.417	0.290
Overall Borena zone CRI	**0.249**	**0.407**	**0.328**

Measuring pastoralists' and agro-pastoralists' livelihood resilience

To measure resilience, the computed climate resilience index is based on five major components and 22 subcomponents. Table 2 depicts the resilience indicators and component or index values for study districts in particular. The resilience scores of agro-pastorals and pastorals are 0.407 and 0.249, respectively. As compared to the two livelihood areas, the result of the resilience score is low among pastoral livelihoods. Having poor access to basic services (CRI = 0.059) is the main cause of the observed relatively poor resilience capacity in the pastoral community, whereas it is the second most important factor (CRI = 0.460) for the resilience capacity of agro-pastoral livelihood. In addition to this, the presence of poor adaptive capacity (CRI = 0.163) played the second-largest role in the extremely poor resilience of pastoralists, while it is (CRI = 0.417) the third most important component for the relatively

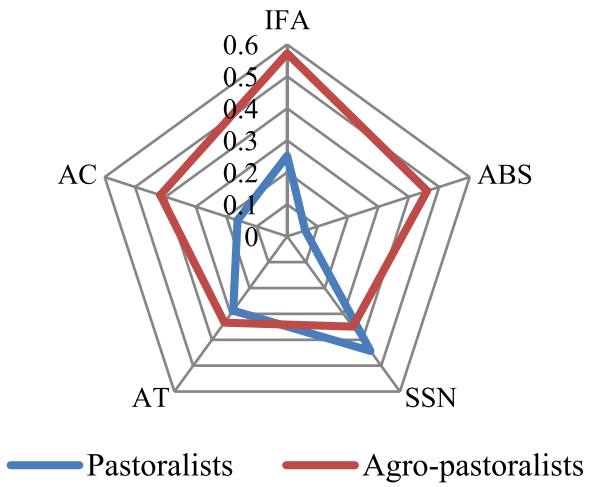

Fig. 5 Resilience components by livelihood

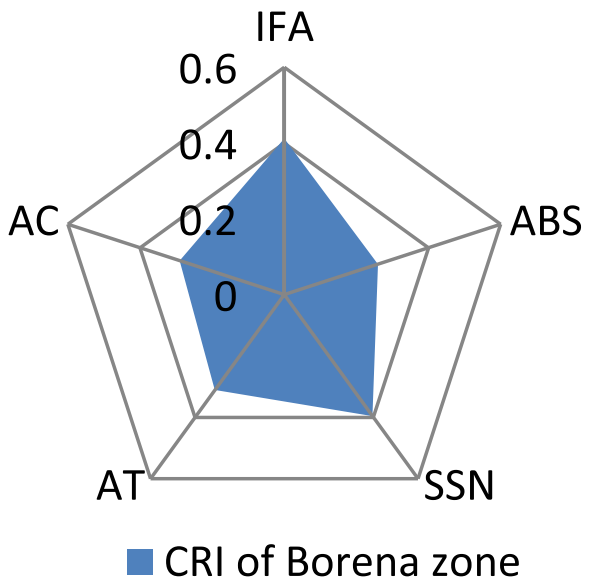

Fig. 6 Resilience components of the Borena

better resilience capacity of the agro-pastoral community in the study area.

The next major components that have a low contribution to the resilience capacity of the pastoral household are income and access to food (CRI = 0.252). In addition to this, access to assets is another sub-component that has a very poor role in the resilience of the pastoral households, with a very low score of 0.287. The total livestock unit (score = −0.133) and lack of commodities like cars as compared to the agro-pastoral area were other factors that contributed to the observed poor contribution of the component to the resilience capacity of the pastoral district and their livelihood. As compared

Table 4 Results of the determinants of pastoralists' and agro-pastoralists' resiliency estimation model

Variables of the model	Coefficient
Structural model	
RCI <--- ABS	−0.084 (0.064)
RCI <--- AST	−0.348 (0.084)[a]
RCI <--- SST	0.015 (0.063)
RCI <--- ADC	0.843 (0.153)[a]
Measurement model	
FEI <--- RCI	0.821 (0.142)[a]
FDI <--- RCI	−0.191 (0.079)[b]

Numbers in parenthesis are robust standard errors

"[a]" and "[b]" refers to significance at 1% and 5%, respectively

to this, the asset-holding capacity of households in the agro-pastoral community is relatively good. The last but not the least building block of resilience is the social safety net, which has the highest score (0.443) among all other major components of pastoralists. With regard to agro-pastoralists, this component has recorded a relatively low score (0.349) as compared to pastoralists.

In general, the overall climate resilience score of both pastoralists and agro-pastoralists is 0.328 (32.8%) (Table 3). For the observed low resilience capacity of pastoral and agro-pastoral communities in the Borena zone, having limited access to basic services played the first role compared to other major building blocks of resilience, with a very low CRI score of 0.26. For this reason, limited access to basic services by pastoral households in Moyale (CRI = 0.059) district compared to Dirree district (CRI = 0.460) contributed the highest share to the low resilience capacity observed in the Borena zone.

Similarly, poor adaptive capacity, with an average low CRI score of 0.29 in the pastoral community, is also another reason for having low resilience capacity in the study area. On the other hand, although the average score of CRI for the Borena zone is below 50%, the scores of income and food access (CRI = 0.412), social safety net (CRI = 0.396), and livelihood strategies (CRI = 0.311) were better than those of access to basic services and adaptive capacity. The results of the major component calculations for the two districts and the zone of the Borena zone are presented collectively in a spider diagram (Figs. 5 and 6).

The scale of the diagram ranges from 0 (less resilient) at the centre of the web, increasing to 0.1 (more resilient). Figure 5 shows that pastoralists are more resilient in terms of the social safety net, while agro-pastoralists are more resilient in terms of income and food access. In addition to this, Fig. 6 shows that Borena is in the worst situation of resilience in terms of access to basic

services and adaptive capacity, although all other major components are below the minimum resilience threshold. Despite the low resilience capacity of the Borena zone in general, compared to agro-pastoral livelihood, pastoral livelihood (depending only on livestock rearing) is the least resilient.

Determinants of livelihood resilience

The structural model result in Table 4 shows that pastoralists' and agro-pastoralists' assets and adaptive capacity are significantly related to the resilience capacity index (RCI). Moreover, the result shows pastoralists' and agro-pastoralists' adaptive capacity is positively influencing their resiliency capacity index. This implies that households with more adaptive capacity are more resilient to the impacts of climate change-induced risks. On the other hand, pastoralists' and agro-pastoralists' asset endowment is negatively influencing their resiliency capacity index. This is also what the focus group discussants and key informants critically noted.

In the same vein, results of the measurement model show that pastoralists' and agro-pastoralists' resiliency capacity index significantly influences their food expenditure index and food diet index. As reported in Table 4, pastoralists' and agro-pastoralists' resiliency capacity index is significantly and positively influencing their food expenditure. The result might imply that pastoralists and agro-pastoralists with a higher resiliency capacity index are expending more to meet the demand for live cost expenditure. On the other hand, the results show that the resiliency capacity index is negatively related to the food dietary index. The result might imply that the food dietary pattern of the study area is limited to some specific food items irrespective of their resiliency capacity.

Discussion

Cattle rearing is the main source of food and income in the study area, and a few of them also make a living through mixed farming, particularly in the Dirree district, where agro-pastoralism is common. Their livelihood, however, was frequently threatened by severe climatic shocks or risks. The recent severe east African drought in 2021, for example, was the most prominent risk for both pastoralists and agro-pastoralists. The absence of rainfall, i.e. rain from both short and long rainy seasons, was the cause of the severe drought in the area at the time. Given the recurrence of drought in the Borana zone in recent years, researchers agree that drought occurs every 1–2 years (Reid et al. 2013). Of course, the community's severe drought had a serious impact on the livelihoods of both pastoralists and agro-pastoralists. The severe drought has had a variety of consequences in the area, including livestock losses particularly due to a severe scarcity of water and grass. Similarly, Herrero et al. (2016) discovered that climatic risks have a negative impact on herd dynamics, stocking density, and pastoral production system productivity.

Following the severe drought and its effects on their resources, many of the households faced food shortages and were forced to seek external assistance because the shocks they were subjected to were beyond their ability to cope. According to Ludi et al. (2011), climate change, characterized by changing rainfall and temperature, increases contests for poor Ethiopians whose survival is dependent on rain-fed agriculture (crop and/or livestock rearing). The findings are also consistent with reports from Tanzania's Kilosa district (Kitasho et al. 2020). They reported that climate change has resulted in food shortages, decreased access to water and pasture, and reduced the number of and altered the patterns of pastoral feeding habits. A similar study by Coppock et al. (2014) also noted that in the Borana zone, pastoralists and agro-pastoralists have been suffering from the loss of their traditional production systems and modes of life due to several factors, including climate change, rangeland degradation, food insecurity, and a drop in livestock productivity.

Extended dry seasons and drought very often result in a critical decline in the quantity and quality of feed and a shortage of water, leading to decreased productivity and increased mortality of animals, and a consequent collapse of livelihoods (Tolera and Abebe 2021). This is consistent with Mohamed's (Mohamed 2019) report. He revealed that pastoralists have been facing new problems in recent years, including competition for water and pasture, being unrepresented in socio-economic and political activities, ethnic-based conflicts, poverty, an uneven drought, and climate change. Pastoralists commonly live in marginalized regions, are often food insecure and are allied with high levels of vulnerability (AU 2010).

The negative consequences of climate impacts on these vulnerable livelihoods present the most pressing challenges for these communities and hinder their ability to withstand impacts. Therefore, the adaptive capacity or resilience of pastoralists and agro-pastoral livelihoods was low due to the frequent occurrence of climate risks and livelihood vulnerability. However, people in the two spheres of life were less resilient. Those dependent on pastoral livelihoods, relatively speaking, have the worst resilience compared to those dependent on agro-pastoral livelihoods.

Of the five components of resilience, poor access to basic services played an important role in the relatively low resilience of pastoralists. Of course, there is no river water at all for this particular community, which has such a great need for water, as it relies only on a pastoral way

of life. Additionally, the lack of clean water for human consumption is a major problem for people in pastoral communities. Moreover, the presence of low capacity is another factor contributing to the observed low resilience of pastoralists. Here, the overwhelming reliance of households on raising livestock solely for their livelihood is a major limiting factor for pastoral communities. The same finding by Bekele et al. (2021) noted that households practising pure pastoral farming were also proven to be less resilient than those practising mixed farming (livestock and crop farming). This is because severe climate change-related risks such as drought and other related shocks are directly impacting livestock, causing shortages of the natural resources (such as pasture and water) upon which livelihoods depend. The resulting impact on the community is devastating. Such shocks usually result in the loss of livestock, affecting income and nutrition. However, the dependence of agro-pastoral livelihoods on crop production and self-sufficiency in household consumption through home production are positive factors for better adaptability (CRI = 0.679) observed among agro-pastoralists.

Moreover, poor access to assets is another sub-component that played a very minor role in the resilience of pastoral households. Thus, the lower ability of pastoral to own assets such as cars compared to agro-pastoral households was another factor in the observed smaller contribution of the (asset) factor to pastoral resilience. In contrast, the financial capacity of households in agro-pastoral communities is relatively good. Household resilience remains low, but high scores for this particular factor indicate that agro-pastoral households have a better ability to own assets compared to other households. On the other hand, the lack of rivers and the added weight of climate-related hazards such as drought and associated risks like livestock disease, diminishing productivity of rangeland or grazing, and loss of livestock may reduce the resilience capacity of the pastoral sector. In addition to this, usually, the devastating effects of severe seasonal droughts tend to erode the wealth and livestock of pastoralists. After an emergency, they most often try to replace lost livestock rather than focus on owning cars and other climate-insensitive assets, exposing them to possess the adaptive capacity.

In contrast, social safety nets are the last resilience component that played an important role over other components of pastoral livelihoods and even more so than the scores of communities dependent on agro-pastoral livelihoods. Loans received by agro-pastoralists in the last 12 months, formal transfers (e.g. food aid, cash aid, safety net programmes), and ministry to various social networks (e.g. farmers' groups, women's groups, unions) participation were the major factors that donated to a component's relative resilience score. On the other hand, the limited formal relocation of agro-pastoralists and their low participation in various social networks adversely affected the reduced resilience of communities dependent on agro-pastoral livelihoods. The greater resilience of the agro-pastoral sector compared to the pastoral sector may be due to the availability of essential facilities such as river water, clean water, and mixed farming systems, rather than relying solely on livestock as pastoralists do.

In general, average climate resilience index values for pastoralists and agro-pastoralists are below the minimum threshold of 0.5 (i.e. 0.33), indicating very low resilience in the region (Nahid et al. 2021). The observed low resilience of pastoral and agro-pastoral communities in the study area is primarily due to the limited access to basic services compared to other major components of resilience and had a very low CRI score of 0.26. Thus, the limited access to basic services by pastoral households in the Moyale district (CRI = 0.059) is a significant predictor of resilience in the Borana zone compared to agro-pastoral households in the Dirree district (CRI = 0.46). It accounted for the highest proportion of the observed low values. Besides, poor adaptive capacity in both study areas is another cause and one of the major determining factors for the low resilience capacity of the people in the study area.

On the other hand, in the face of severe drought, owning a large number of assets, mainly livestock, can itself become a problem. This means that households with a large number of livestock may be more severely affected than poorer households. A possible reason for this is that pastoralists and agro-pastors faced more competition from a large number of livestock and had to use different coping strategies such as such as temporary migration, feeding with purchases, and managing with water and feed rationing provided by the government and non-government, in comparison with households with fewer livestock. World Bank (2017), when people in vulnerable environments depend on vulnerable assets for their livelihoods due to climate shocks, the share of their wealth affected by climate shocks is two to three times greater than the percentage of households relying on diversified or non-vulnerable livelihood.

In general, due to the severe drought in 2021, the Borana Zone was severely affected by the loss of lifeline livestock. This means that the impact of severe drought in the study area exceeds the coping capacity and assets of households, limiting their ability to withstand the impact and exposing the households to look for external assistance. Most communities and sectors can cope or adapt to normal mild climate anomalies, but there are extreme event-related exposures in the most vulnerable sectors

(Smit and Wandel 2006). This suggests that households' ability to cope with climate risks often depends to some extent on the community's environment and that a community's adaptive capacity reflects aspects of local resource (including climate) processes (Yohe and Tol 2002; Smit and Pilifosova 2003). In addition to the natural resources, there should be one alternative strategy like diversification of the livelihood to minimize the impacts of climate change-induced risks. Because when households have diversified livelihoods, damage from extreme events in one livelihood sector may be offset by others that were not affected by the shock. The argument is also supported by a study conducted in pastoral communities in the Afar region of Ethiopia (Mekuyie et al. 2018). Their findings showed that pastoralists were less resilient than agro-pastoralists. This is due to the low adaptability and wealth of pastoralists, who lack the means to support their livelihood from other sources just as agro-pastoralists subsist from small-scale irrigated crops alongside raising livestock.

Conclusion and recommendations

Pastoralism and agro-pastoralism are the lowland livelihood systems in Ethiopia in particular and in East Africa in general. The Borena zone is one of the lowland areas where pastoralism and agro-pastoralists are practised as the main sources of income and livelihood. However, the pastoral and agro-pastoral livelihood systems, which were believed to be the most viable to systems to depend on before a few years ago, are becoming highly vulnerable. The current climate change and variability-induced risks are the major reasons for the high vulnerability of the livelihood systems in the area. Among others, recurrent drought was the most common climatic risk that posed severe impacts on the income and livelihood systems of the pastoralists and agro-pastoralists in the study area.

The recurrent drought, particularly the severe drought of 2021 that was caused by the abortion of two consecutive rainfall seasons, had severe impacts on the community. Extreme shortages of animal feed or pasture, scarcity of water, the decline in household income, and outbreaks of livestock and crop diseases and pests resulted in livestock loss and crop failure in pastoral and agro-pastoral communities and led the household to starvation. This is a situation that has exacerbated the previously vulnerable and degraded rangeland and species dynamics, pasture land, and water resource scarcity.

As a result of this, the adaptive capacity of the pastoralists and agro-pastoralists was reduced, resulting in the low resilience capacity of the livelihoods. The result also shows that in addition to the climatic factors, the resilience of pastoralists' and agro-pastoralists' livelihoods was highly influenced, positively and significantly, by adaptive capacity and negatively and significantly by the asset endowments of the households.

Therefore, policymakers should provide pertinent attention to reduce the effects of climatic risks and increase the resilience of pastoral and agro-pastoral livelihood systems. Policymakers therefore need to pay due attention to reducing the impact of climate risks and increasing the resilience of pastoral and agro-pastoral livelihood systems. The specific actions may include developing inclusive policies that focus on improving socio-economic services such as education, health, credit, and market access. In addition, governments can help by improving adaptability (i.e. increasing rangeland productivity to obtain sufficient fodder or pasture, improving access to water and diversifying income sources) and developing mechanisms to increase the resilience of pastoral and agro-pastoral livelihoods and the factors that hinder their livelihoods.

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Authors' contributions
DAT (Ass.Prof.), CF (PhD), and TD (MDV) designed the data collection tools, undertook the fieldwork and most of the analysis, and developed the manuscript. NB (PhD) and GT (PhD) contributed by reading and editing the manuscript. Accordingly, all the authors read and approved the final manuscript.

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Availability of data and materials
The first author will provide data upon reasonable request.

Declarations

Ethics approval and consent to participate
Ethical clearance was obtained from the Research Ethical Review Committee (RERC) of Ambo University, Director of Research and Community Services, and permission and supporting letter from the Oromia Disaster Risk Management Commission Borana zone and study districts. Verbal informed consent from each participant was obtained during data collection. The pastoralists and agro-pastoralists were given the right to refuse to take part in the study as well as to withdraw at any time during the study. All participants, pastoralists, agro-pastoralists, and experts, were assured of confidentiality.

Consent for publication
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Competing interests
The authors declare that they have no competing interests.

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