Veterinary and Animal Science 16 (2022) 100240

Contents lists available at ScienceDirect

Veterinary and Animal Science

journal homepage: www.elsevier.com/locate/vas

Effects of climate variability on livestock productivity and pastoralists perception: The case of drought resilience in Southeastern Ethiopia

Matiwos Habte [a,b,*], Mitiku Eshetu [c], Melesse Maryo [d], Dereje Andualem [b], Abiyot Legesse [e]

[a] Africa Center of Excellence for Climate Smart Agriculture and Biodiversity Conservation, Haramaya University, P.O.Box 138 Dire Dawa, Ethiopia
[b] Department of Animal and Range Sciences, Dilla University, P.O.Box 419 Dilla, Ethiopia
[c] School of Animal and Range Sciences, Haramaya University, P.O.Box 138 Dire Dawa, Ethiopia
[d] Ethiopian Biodiversity Institute, Addis Ababa, Ethiopia
[e] Department of Geography and Environmental studies, Dilla University, P.O.Box 419 Dilla, Ethiopia

ARTICLE INFO

Keywords:
Climate variability
Drought
Livestock
Pastoralist
Resilience

ABSTRACT

This study examines the perception of the pastoral community on climate change and performance, resilience and adaptive capacity of livestock under climatic stress in southeastern Ethiopia. The study used a mixed research approach whereby quantitative and qualitative data were gathered from multiple sources to address the impacts of climate variability on livestock production and livelihood of pastoral-agro-pastoral communities of Guji zone. Data about pastoralist perception on climate change were collected from 198 randomly selected households using a semi-structured questionnaire. Furthermore, climate data were obtained from the national meteorological agency, and climatic water balance was assessed. The household survey result indicated increasing patterns of temperature (82.8%)and drought intensity (84.8%). Majority of respondents perceived decreasing trends of rainfall and feed availability. Similarly, the trend analysis of rainfall showed declining trends of annual (-4.7 mm/year), autumn (-4.5 mm) and winter (-0.54 mm). Rainfall Anomaly Index identifies 13 drought years over the past 32 years, of which 53.85% occurred between 2007- 2017. Significantly higher ($p<0.01$) cattle and small ruminants than camel per household died during the disastrous drought occurred in 2008/9 and 2015/16. Nonetheless, the result indicated significantly higher ($p<0.01$) amounts of milk yield (3.32 litre/day) of dairying camel during dry periods than cattle and small ruminants. Camel and goats are perceived as drought-resistant livestock species and cattle keepers shifting to have more camel and goat in response to prevailing drought in the study area. Poor attention is given to identify climate-smart/resilient livestock species and strains. Therefore, extensive investigations are required to select and identify purpose-specific camel and goat strains for drought-prone areas.

Abbreviations

FAO	Food and Agriculture Organization
HH	Household
NMA	National Meteorological Agency

1. Introduction

Most Africans depend on agriculture for their livelihoods, which is the backbone of national economies for almost all countries in Africa. The sector employs 70-90% of the total labour forces, supports about 50% of feed demands and 50% of the income of the households. Among the agricultural sub-sectors, livestock rearing supports the income and livelihood for about one-third of African populations and provides 30-50% of agricultural GDP (AU-IBAR, 2016). Livestock is the principal asset of the poor in most pastoral and agro-pastoral communities, though the sector is highly susceptible to extreme climatic events (Fereja, 2016). Climate extremes are having a significant impact on livestock productivity in Eastern and Western Africa. 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 & Sessa, 2013; Ulrichs, Slater, & Costella, 2019). Climate change is threatening the productivity of agricultural land, by shortening growing periods and decreasing crop/pasture yields (UNFCCC, 2007).

* Corresponding author.
E-mail address: matiwosh@du.edu.et (M. Habte).

https://doi.org/10.1016/j.vas.2022.100240
Received 29 April 2020; Received in revised form 23 February 2022; Accepted 23 February 2022
Available online 1 March 2022

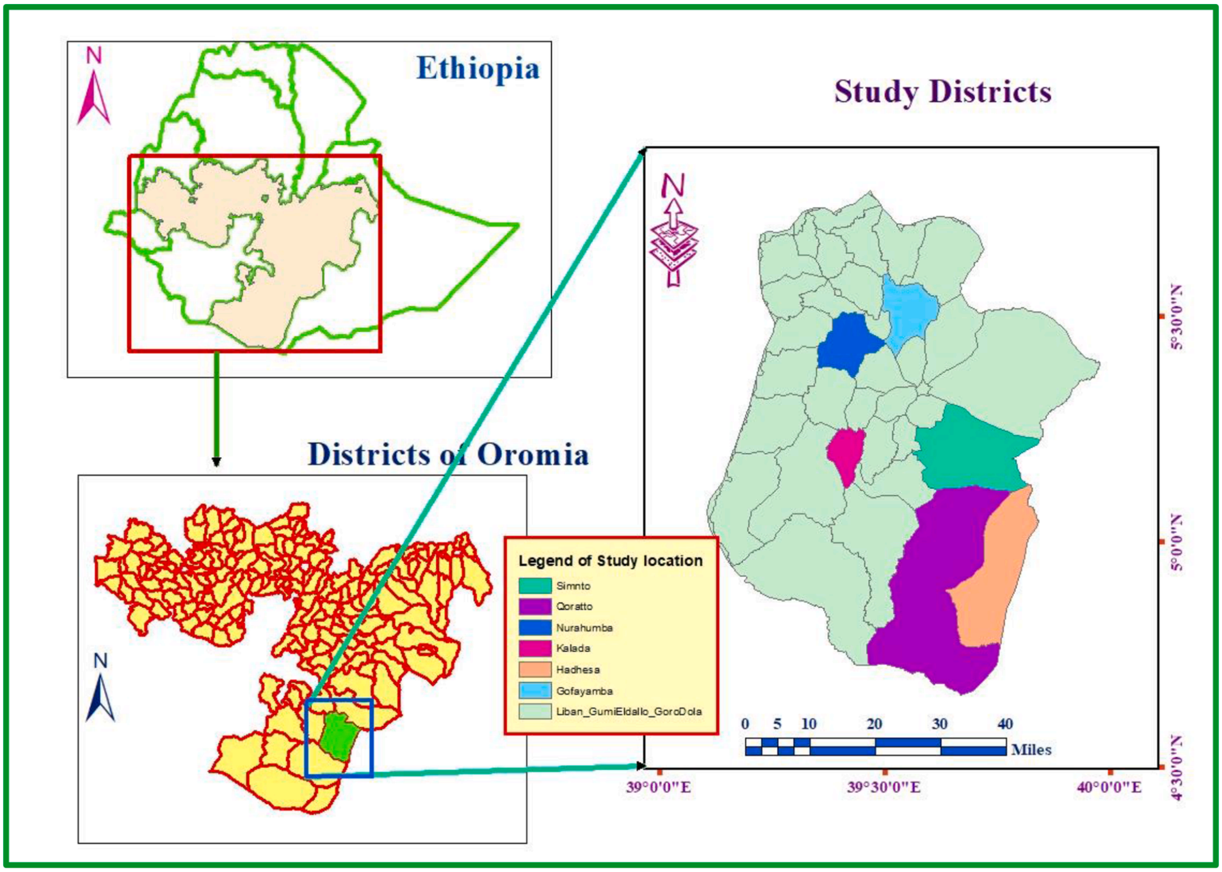

Fig. 1. Location map of the study area

In Ethiopia, climate variability and change has triggered frequent droughts, floods, heat waves, heavy rains, and strong winds (FDRE, 2007). The country is suffering from the impacts of climate change such as an increase in average surface temperature, changes in rainfall patterns, recurrent drought, El Niño southern oscillation (ENSO), floods and La Nina (Melees & Samuel, 2017; Melkamu, 2017). The country necessarily needs to switch to a new sustainable development strategy to cope with and adapt to the changing climatic condition (Anita, Dominic, & Neil, 2010; FDRE, 2011).

The vulnerability of livestock to climate variability varies across species based on their adaptive mechanism (Fereja, 2016). According to Wako, Tadesse, and Angassa (2017), a significantly higher number of cattle and sheep death were recorded during drought condition, while the death of goat and camel were eventually low. Loss of animals is associated with drought and the cumulative impacts of rainfall and surface temperature variability. The climate variability alters plants' growth potential, deterioration of livestock feed resources 56 and livestock's physiological response. Increasing patterns of temperature and decreasing rainfall trends is a global phenomenon, pastoral and agro-pastoral communities who rely on natural resources for livestock production rigorously feel its adverse effects. Climate variability alters the niche of forage species and may modify animal feed resources. The rising surface temperature may increase fodder and pasture browse species' productivity while the productivity of grassland is severely declined (Thornton, Herrero, & Ericksen, 2011). Changes in grassland composition lead to inadequate grassland serving capacity and the areas left with browse feed resources (Fereja, 2016; Yilma, Haile, Guerne-Bleich, & Ababa, 2009).

Climate change is affecting livestock productivity by altering ecosystem services like water availability, forage quality and quantity (Gashaw, Asresie, & Haylom, 2014; Hidosa & Guyo, 2017; Kefyalew & Tegegn, 2012), diseases outbreak, and animals stress due to heat shock (Bagath et al., 2019; Morand, 2015), and eroding livestock species diversities (Yilma et al., 2009). Ecosystem health and animal health are directly linked to the impacts of climate change (Al-Amin & Alam, 2011). The incidence and distributions of livestock diseases are currently increasing, which is assumed that these might have emerged due to climate change. The distribution of vectors and pathogens are positively correlated to wind and its blowing direction (Lubroth, 2012; Van den Bossche & Coetzer, 2008; Yatoo, Kumar, Dimri, & Sharma, 2012). Climate change diminishes available feed resources and creates conducive environment to survive, complete cycle and transfer of disease which directly leads to increase the susceptibility of livestock species and distributions to vectors and pathogens (Desalegn, 2016; Lubroth, 2012; Morand, 2015; Yilma et al., 2009).

Although, the interest of camel research increased from time to time in the current era, according to Tefera and Abebe (2012) most of the past research findings concentrated on assessing morphology and anatomy (34%), veterinary aspect (16%), general physiology (12%) and reproduction (10%). Those of which recently conducted were based on either short period observation or one-time survey and restricted to Somali and Afar Regional States in Ethiopia and almost all studies failed to assess impacts of climate change on livestock production potential (Mebrahtu, Asgedom, & Hadush, 2017; Simenew et al., 2013; Yosef et al., 2014).

According to IPCC (2014), global surface temperature increases, rainfall patterns become uneven, and heat waves events are the potential consequences of the climate variability and changes. Effects of climate change will directly impact the livestock sector and rangeland resources, directly linked to pastoralists livelihoods and food security. The loss (death) of livestock has been observed by climate-driven impacts such as recurrent drought, which negatively impacts pastoralists' livelihood security. The pastoral and agro-pastoral communities are particularly vulnerable to climate variability and changes due to their livestock dependence for food and livelihood. For preparing people to face these challenges, decision-makers and policy planners need information on climate change. Pastoral and agro-pastoral communities in Ethiopia have become vulnerable to the effects of recurrent drought. However, pastoralists have gradually developed mechanisms to survive in a risky environment. The communities lived in drought-prone regions, adapted to fragile environments, and sustainably conserved the natural resources. A comprehensive assessment of the pastoralists perceptions on climate change and vulnerability, i.e., the degree to which livestock species is susceptible to climate variability and extremes, is needed to reduce its impacts and respond effectively. Pastoralists in the study area are rainfall dependent, and any variation in its pattern affects livestock productivity and survivability. Some livestock species are more vulnerable than others, depending on their resilience and adaptive capacity. Assessing community perception of climate change and livestock production potential under climatic stress is valuable in addressing livestock herder vulnerability to climate extremes. Therefore, this study examines the perception of the pastoral community on climate change and performance, resilience and adaptive capacity of livestock under climatic stress in southeastern Ethiopia.

2. Material and Methods

2.1. Study area Description

East Guji Zone is located in southeastern parts of Ethiopia (Fig. 1), enclosing 13 districts, of which five of them host pastoral and agro-pastoral communities. Three neighbouring pastoral and agro-pastoral districts, namely Liben, Gumi Eldallo and Goro Dola have been selected for the study. The chosen areas are located 5°02′ to 44'N and 39°28′ to 42′E and cover about 742,644.14 ha. The altitude of the study districts ranges between 1370 and 1560 m.a.s.l . The agro-climatic condition of pastoral and agro-pastoral areas of the East Guji zone is mostly arid and semi-arid with an average annual rainfall of 526.75 mm. The pattern of the rain is bimodal with the main rainy season (Ganna) contributing about 60% of yearly rainfall which extend from March to May while minor season (Hagayya) providing approximately 40% of annual rainfall ranges from September and November. Meteorologically, there are four-seasons in east Guji zone; autumn (Ganna), summer (Adolessa), spring (Hagayya) and winter. Autumn (March-May) is the long rainy season while spring (September – November) is short and erratic rainfall period in the study area. Winter (December – February) is the driest season of the year and summer (June – August) is moderately dried period between the long rainy season (autumn/Ganna) and the short rainy season (spring/Hagayya) in east Guji zone (Abate, 2016; Alhamshry, Fenta, Yasuda, Kimura, & Shimizu, 2020; NMA, 2015). The annual mean temperature of the pastoral and agro-pastoral districts of the Zone ranges from 24 to 30°C (Adi & Swoboda-Reinhold, 2003). The area is prone to drought every five to ten years (Abate, 2016).

The pastoral and agro-pastoral districts of east Guji zone are homes to 192,121 populations, of whom 97,062 are males, and 95,059 are females (CSA, 2007). The pastoral districts of the Zone have a total population of 1,285,392 cattle, 282,302 camels, 1,247,484 goats, 231, 523 sheep, 163,015 donkeys and 777,402 chickens. Rain-fed based livestock rearing is the main livelihood supporting the economy of pastoral community of the study area under the mercy of nature. Pastoralism in the study area is constrained by drought, erratic rainfall, poor livestock productivity, grassland degradation, eroding forage species, and increasing livestock disease occurrences and livestock death. As a result, most people of the study area chronically face food insecurity (Abebe et al., 2012; Kebebew, Synnevaag, & Tsegaye, 2001; Mirkena et al., 2018).

2.2. Data types and source

This study primarily focused on collecting information related to camel resilience ability to climate variability influence on pastoral communities livelihood options such as livestock production and productivity. Qualitative and quantitative data were gathered using semi-structured questionnaires from the selected districts. The survey encompasses the economic benefit of camel including socio-economic characteristics**,** intensities of drought and disease prevalence, effects of drought on livestock, mainly camel production in the face of climate change. Furthermore, data on camel keepers' indigenous knowledge and practices, potential milk production under hostile environmental condition, benefits, challenges and opportunities of camel production over cattle, goat, and sheep were collected.

Thirty-two years (1986-2017) of time series daily precipitation and temperature data were obtained from National meteorological agency collected at "Negelle" station to analyze rainfall and temperature trends. The daily record of climate data was missed with about 5.8% (673 values) of rainfall and 4.6% (534 values) of temperature. However, the missed values were assumed based on the estimation method of climatological data where the missing values equal to the mean of the same period of non-missing years.

2.3. Sampling procedures and design

Three study districts namely Liben, Gumi Eldallo and Goro Dola were randomly selected from the five pastoral and agro-pastoral districts of East Guji Zone by using drawing lots procedure indicated in (Gomez & Gomez, 1984). The study considered two traditionally classified geographical locations namely Golba (covers the altitude below 1450 m.a.s.l) and Dida (the altitude up-to 1650 m.a.s.l). Two kebeles (the smallest administrative area of Ethiopian Government) were randomly selected from each districts; Hadhessa and Qoratti from Gumi Eldallo, Siminto and Kalada from Liben and Gofi Ambo and Nura Umba from Goro Dola district. Accordingly, Hadhessa, Qoratti and Siminto kebeles from Dida and Kalada, Gofi Ambo and Nura Umba from Golba study location. The wealth status of participating respondents was classified based on livestock number owned following Gemedo-Dalle, Isselstein, and Maass (2006). Up-to-date list of camel owners was obtained from the zonal and Districts pastoralism offices, from which 198 sample respondents were chosen using systematic random sampling methods. The required sample size was determined based on an adopted formula following Yamane (1967) and Israel (1992) at a 95% confidence interval and 7% precision level (sampling error).

$$n = \frac{N}{1 - N(e)^{z}}$$

where n is sample size, N = total household of selected kebels, e = precesion level, z= 1.96 (at 95%).

$$\textbf{Sample Size} = \mathbf{n} = \frac{2441}{1-2441(0.07)^{1.96}} = \mathbf{198}$$

The sample size for each kebeles was allocated according to Bowley (1925) formula as follows.

$$ni = n\frac{Ni}{N}$$

where ni = assigned sample size of kebeles or wealth rank, n = Total sample size, Ni = Household size of single kebeles or single wealth group, N = Total household size

2.4. Method of Data Collection

2.4.1. Household Survey

The survey was conducted through exploring the discussion points listed in the questionnaires by moving on the respondent's perception, opinions and experience on climate change, rainfall and temperature trends, livestock trends, livestock resilience abilities and camel production. The discussion was primarily focused on the perception of pastoralists/agro-pastoralists on climate change and its effects on livestock productivity and livelihood strategies by asking the questions and

Table 1
SPEI and CV value to characterize conditions drought and variability.

SPEI value	Climatic water Balance	CV	Variability level
2.0+	Extremely wet	<20%	less Variable
1.5 to 1.99	Very wet	20 to 30%	Moderately variable
1.0 to 1.49	Moderately wet	>30%	Highly variable
-0.99 to 0.99	Near normal		
-1.0 to -1.99	Moderately dry		
-1.5 to -1.99	Severely dry		
-Two and less	Extremely dry		

Source: McKee, Doesken, and Kleist (1993) and Hare (1983)

recording the response. The assessment was conducted by explaining the significance of the study and maintaining the comfortable atmosphere through appealing the instincts of pride of respondents. Furthermore, prepared questionnaires were translated into the local language (Afan Oromo) since the study locations are solely Oromo's ethnic group. The enumerators assured not to reveal the respondent's identity and only used the data in aggregate form.

Enumerators were recruited and trained to have better knowledge on the questionnaires. The questionnaires were pre-tested before the actual data collection, and appropriate components were modified and corrected as per the feedback obtained. Respondents were interviewed following face-to-face survey method using the door-to-door approach.

2.4.2. Key informant Interviews

Key-informant interview was conducted to obtain a general overview of the climate change situation and its impacts on livestock production as well as socio-economics of the community following (Geilfus, 2008). Accordingly, eight key-interview questions were developed using semi-structured dialogue methods. Eight key informant elders (4 male and two female pastoralists, and two male government experts) were selected and interviewed.

2.4.3. Focus group discussion

Thirty six participants from both sexes representing all wealth groups, locations and education level were purposively selected to obtain relevant information on climate variability and camel resilience ability following (Geilfus, 2008). Six FGDs, one in each kebeles consisted of eight participants were employed.

2.5. Data analysis

All collected data were subjected to Kruskal-Wallis test using R-software (version 3.6.0) to test against normality to manage the outliers. Mean differences among variable were determined using Duncan's multiple range test (Duncan, 1955). A General Linear Model (GLM) and multivariate linear model procedure were used for analysis of quantitative variables.

Analysis of Variance was used to examine the variance of the quantitative variables with Standard deviation (SD). Descriptive statistical tests were also used to analyze qualitative variables. Furthermore, the non-numeric data such as key informant interviews, notes, focus group discussions, images and audio recordings were analyzed using narrative and discourse methods of qualitative data analysis following the procedure indicated in O'Connor and Gibson (2003) and Bernard and Bernard (2013).

Linear trend analysis was used to compute trends of temperature and rainfall. The intra- seasonal, annual variabilities and drought conditions were characterized using standard precipitation evapotranspiration index (SPEI) using SPEI package in R-software (Vicente-Serrano, Beguería, & López-Moreno, 2010), rainfall anomaly index and coefficient of variation were also analyzed. The significance of trend analysis was tested using Mann-Kendall's test of time series significance. Hydrological and agricultural drought was quantified using SPEI for 1986-2017 period (Table 1). Moreover, Sen's slope of estimator applied

Table 2
Pastoralist/agro-pastoralist Perception of temperature, rainfall and drought change (Frequency (%))

Compering to 1980s with 2010s		Golba	Dida	Total	p
Onset of Rainy season	Early	2 (2.1)	2 (2.0)	4 (2.0)	0.088
	Late	17 (64.6)	10 (80.4)	27 (72.7)	
	On time	17 (17.7)	10 (9.8)	27 (13.6)	
	Irregular	15 (15.6)	8 (7.8)	23 (11.6)	
	p	0.0064	0.1253	0.0005	
Temperature pattern	Increasing	77 (80.2)	87 (85.3)	164 (82.8)	0.746
	Decreasing	2 (2.1)	2 (2.0)	4 (2.0)	
	No Change	12 (12.5)	8 (7.8)	20 (10.1)	
	Don't Know	5 (5.2)	5 (4.9)	10 (5.1)	
	p	<.0001	<.0001	<.0001	
Drought intensity	Increasing	81 (84.4)	87 (85.3)	168 (84.8)	0.481
	No Change	12 (12.5)	9 (8.8)	21 (10.6)	
	Don't Know	3 (3.1)	6 (5.9)	9 (4.5)	
	p	<.0001	<.0001	<.0001	
Hot day trend over the years	Increasing	82 (85.4)	83 (81.4)	165 (83.3)	0.662
	No Change	10 (10.4)	12 (11.8)	22 (11.1)	
	Don't Know	4 (4.2)	7 (6.9)	11 (5.6)	
	p	<.0001	<.0001	<.0001	
Duration of rainfall	Too Short	80 (83.3)	88 (86.3)	168 (84.8)	0.564
	No change	16 (16.7)	14 (13.7)	30 (15.2)	
	p	<.0001	<.0001	<.0001	
Amount of rainfall	Enough	32 (33.3)	29 (28.4)	61 (30.8)	0.455
	Too little	64 (66.7)	73 (71.6)	137 (69.2)	
	p	0.0011	<.0001	<.0001	

to quantify gradient of temperature and rainfall over the years and across seasons. Pettitts test was also computed to show the period at which significant change observed (Mann, 1945). The frequency and intensity of drought was quantified using Rainfall anomaly index taking the record of the dry and wet years of historical precipitation data following Van Rooy (1965) and the modified equation by Hänsel, Schucknecht, and Matschullat (2016).

$$RAI = -3 * \left(\frac{N - \overline{N}}{\overline{X} - \overline{N}}\right)$$,For negative anomalies

$$RAI = 3 * \left(\frac{N - \overline{N}}{\overline{M} - \overline{N}}\right)$$, For Positive anomalies

Where

N = current monthly/seasonally/yearly rainfall when RAI generated (mm)

$\overline{N}$ = Yearly average rainfall of historical (32 years) series (mm)

$\overline{M}$= average of the ten highest yearly precipitation of historical series (mm)

$\overline{X}$= average of the lowest ten yearly/seasonal precipitation of historical series (mm)

Historical series = 1986-2017

== Positive anomalies have the value above average and negative anomalies have their values below average.

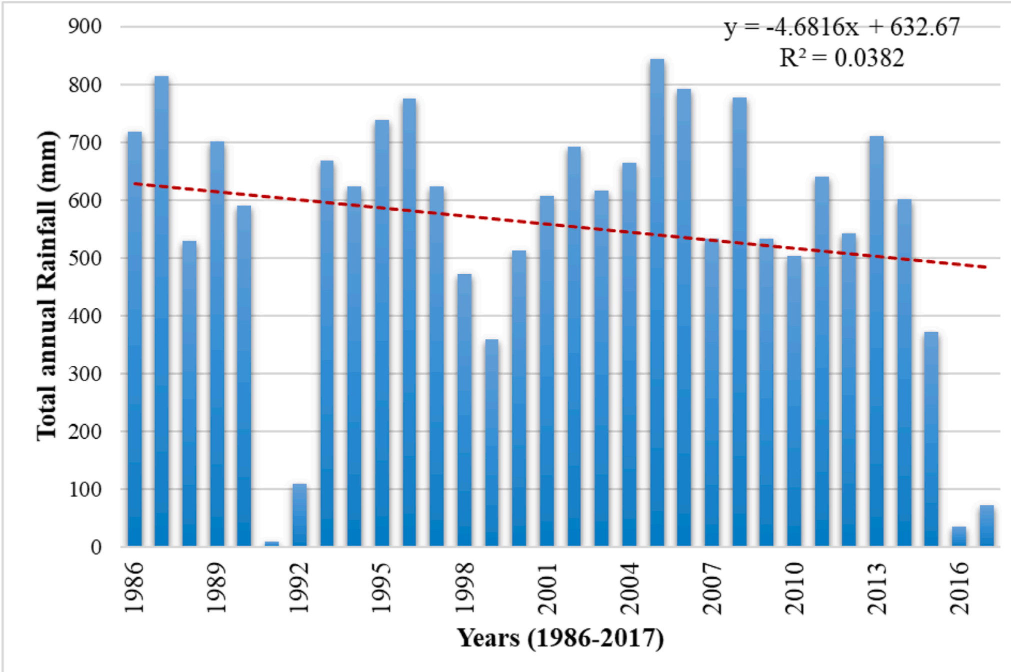

Fig. 2. Total annual trends of rainfall in East Guji zone

3. Result and Discussion

3.1. Perception of climate variability among pastoralists

East Guji pastoralists perceived the changing climatic condition in terms of temperature, rainfall and intensity of drought (Table 2). There is no statistically differ between the perception of pastoral and agro-pastoral communities at both study location regarding onset of rainy season, temperature pattern, drought intensity, duration and duration of rainfall. Significant ($p< 0.05$) proportion of the pastoralists in the study area perceived the late onset of the rainy season ($p = 0.0005$, 72.7%) and increasing patterns of temperature ($p <.0001$, 82.8%) as compared with constant rainfall and temperature over years. In agreement to this finding, revealed significant increasing trends of mean maximum and minimum temperature as well as increasing frequency of drought in recent years in Ethiopia. Similarly, Nicholson, Funk, and Fink (2018) revealed the decreasing patterns of annual and seasonal rainfall in Ethiopia. According to ATPS (2013), pastoral and agro-pastoral communities are perceived decreasing patterns of rainfall, late onset of rainy season and increasing trends of temperature and heat stresses.

The result of this finding extrapolates the increasing trends of temperature patterns of the 2010s as compared to 1980s. As indicated in Table 2, significant number of pastoralist and agro-pastoralist from Golba ($p <.0001$, 80.2%) and Dida ($p <.0001$, 85.3%) locations thought an increasing rate of temperature patterns. In some occasions, the temperature trend may decrease when precipitation and amount of rainfall increase as well as when la Nina climatic condition appears. In line with this finding, Ayal and Leal-Filho (2017) reported an increasing trend of temperature farmers perception in Ethiopia. Similarly, Afar and Somali pastoralists are well aware of increasing trends of temperature from time to time as reported by ATPS (2013).

Drought intensity increased in the 2010s compared with 1980s (Table 2). The result of the current finding revealed that significantly higher ($p < 0.05$) proportions of pastoral and agro-pastoral communities perceived increasing trends of drought intensity ($p <.0001$, 84.8%) over the years. According to Getachew (2018), drought affected geographic coverage were being increasing in Ethiopia. Furthermore, Ververs (2012) and Osborn, Barichivich, Harris, Van Der Schrier, and Jones (2018) reported the declining trends of rainfall and increasing rate of drought affected communities in eastern African and all over the globe since 1950/51.

3.2. Historical Climate Data Analysis

3.2.1. Rainfall trends

The analysis of precipitation data over the past 32 years (1986-2017) showed a decreasing trend of annual rainfall in the study area (Fig. 2). Similarly, the majority of respondents perceived that the amount of rainfall has being decreasing from year to year and becoming too little in its amounts. Meteorological record of precipitation data of the study area corroborates the perception of most respondents. In contrary to this finding Tsige (2018) revealed a lack of congruence of meteorological data with farmers perception of rainfall trends. The analysis of linear trend during the historical period of 1986-2017 showed that decreasing (4.68mm) pattern of the annual rainfall. In agreement to this study, Nicholson et al. (2018) and Asfaw, Simane, Hassen, and Bantider (2018) reported decreasing patterns of annual rainfall in African continent and in Ethiopia, respectively. Similarly, Pachauri and Reisinger (2008) reported the declining trends of rainfall patterns over the dry region and southeastern parts of Ethiopia Chris et al. (2012). also discussed 15-20% declining rate of summer rainfall in some parts of Ethiopia since the mid-1970s.

Data source: NMA, 2018

The result of rainfall anomaly index of the current study revealed that there are an increasing intensity and frequency of drought years during the 1986-2017 historical periods. The rainfall anomaly index resulted in 13 driest years (1991, 2016, 2017, 1992, 1999, 2015, 1998, 2010, 2000, 1988, 2009, 2007 and 2012) within 32 years (1986-2017). Of which, 46.2% (6 driest years) were recorded during 1986-2006 (within 21 years) while about 53.8% (seven driest years) noted during 2007 – 2017 (within 11 years), indicating increasing trends of drought years in the last 11 years. Similarly, the majority of pastoralist perceived an increasing trend of drought intensity (84.8%) in the recent decade (Table 2).

The rainfall anomaly index of east Guji zone during the historical period of 1986-2017 ranges from -6.34 in 1991 (the driest years) to 4.31

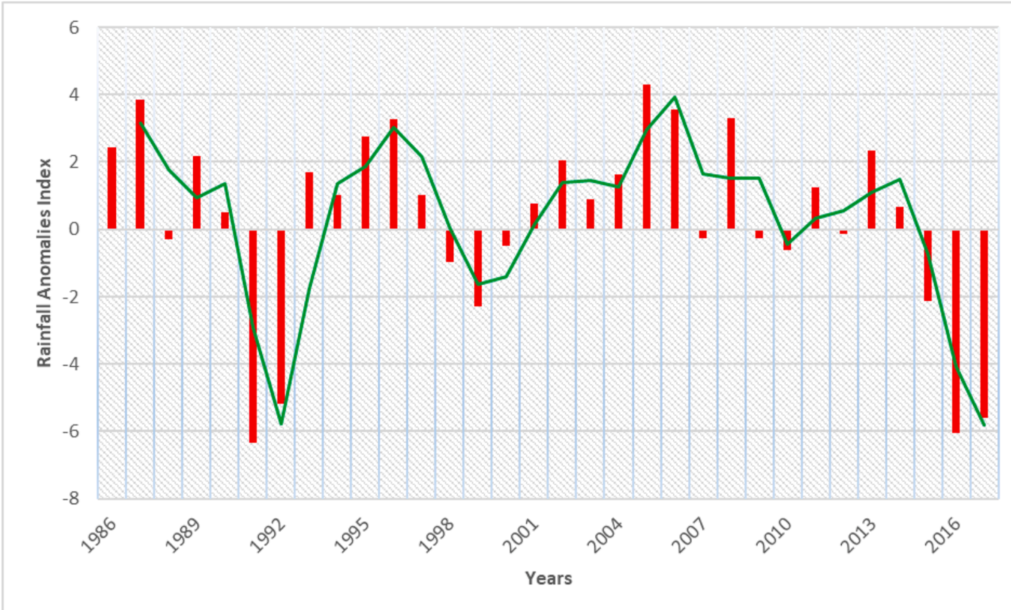

Fig. 3. Annual rainfall anomaly Index in East Guji zone

Table 3
Mean Seasonal and annual rainfall amount along with the coefficient of Variation

Meteorological season	Rainfall (mm)		Mean (mm)	SD (mm)	CV
	Max	Min			
autumn (Ganna)	633.5	172.4	368.3	109.1	29.6
Summer (Adolessa)	451.9	78.8	20.9	16.4	78.2
Spring (Hagayya)	124.5	0	216.7	84.5	39.0
Winter	80.4	3.6	31.6	29.7	94.0
Annual	843.8	358.8	637.6	109.3	17.2

in 2005 (the wettest year) (Fig. 3). The mean annual rainfall of the historical period (1986-2017) is about 637.6 with standard deviation of 109.3 and coefficient of variation of 17.2% CV value (Table 3), indicating less inter-annual variability over the past 32 years. Changes in distribution, regularity and seasonality of rainfall in the study area was a major concern than amounts of rainfall overall historical period (1986-2017). The long rainy season progressively becomes shortening, which is in line with the perceptions of large proportion of respondents who have perceived amounts of rainfall receive over the years to be too little. In agreement with this finding, Tsige (2018) reported higher seasonal variability of rainfall in Sidama Zone of the southern Ethiopia. Similarly, Herrero et al. (2010) revealed a remarkable inter-annual variability of precipitation across Ethiopia, Kenya, Tanzania and Somalia.

Data source: NMA, 2018

3.2.2. Seasonal rainfall patterns and variability

The maximum and minimum rainfall of the long rainy season (autumn /Ganna) over the last 32 years (1986 – 2017) was 633.5 mm and 172.4 mm, respectively. The mean autumn season rainfall was 368.3 mm with about standard deviation of 109.1 and CV of 29.6%, indicating moderate inter-seasonal variability of rainfall over the last 32 years. The patterns of autumn rainfall have shown a declining trend from 1986-2017 (Fig. 4). The trend result of autumn season rainfall showed a declining pattern by 5.4 mm per year during the historical

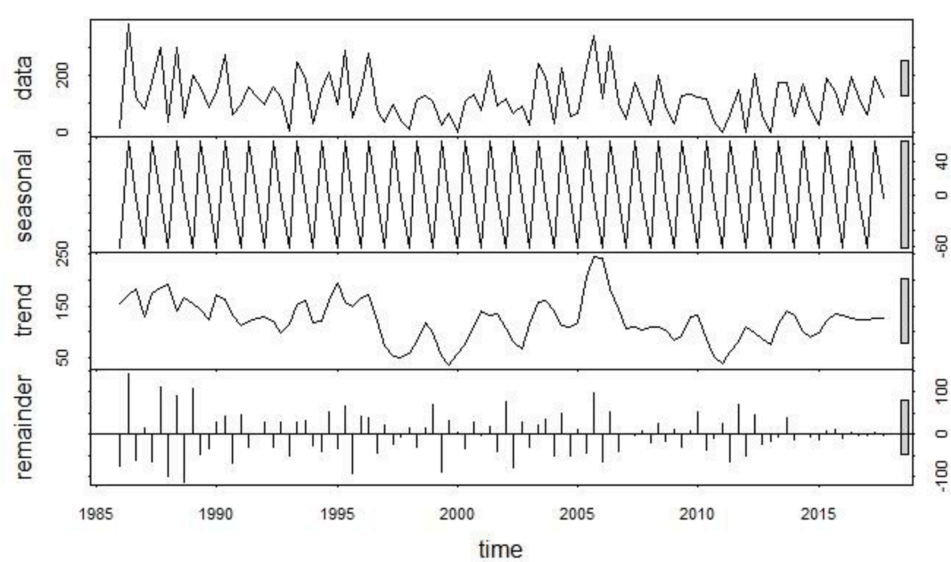

Fig. 4. Autumn season (March – May) rainfall (mm) trends of East Guji Zone

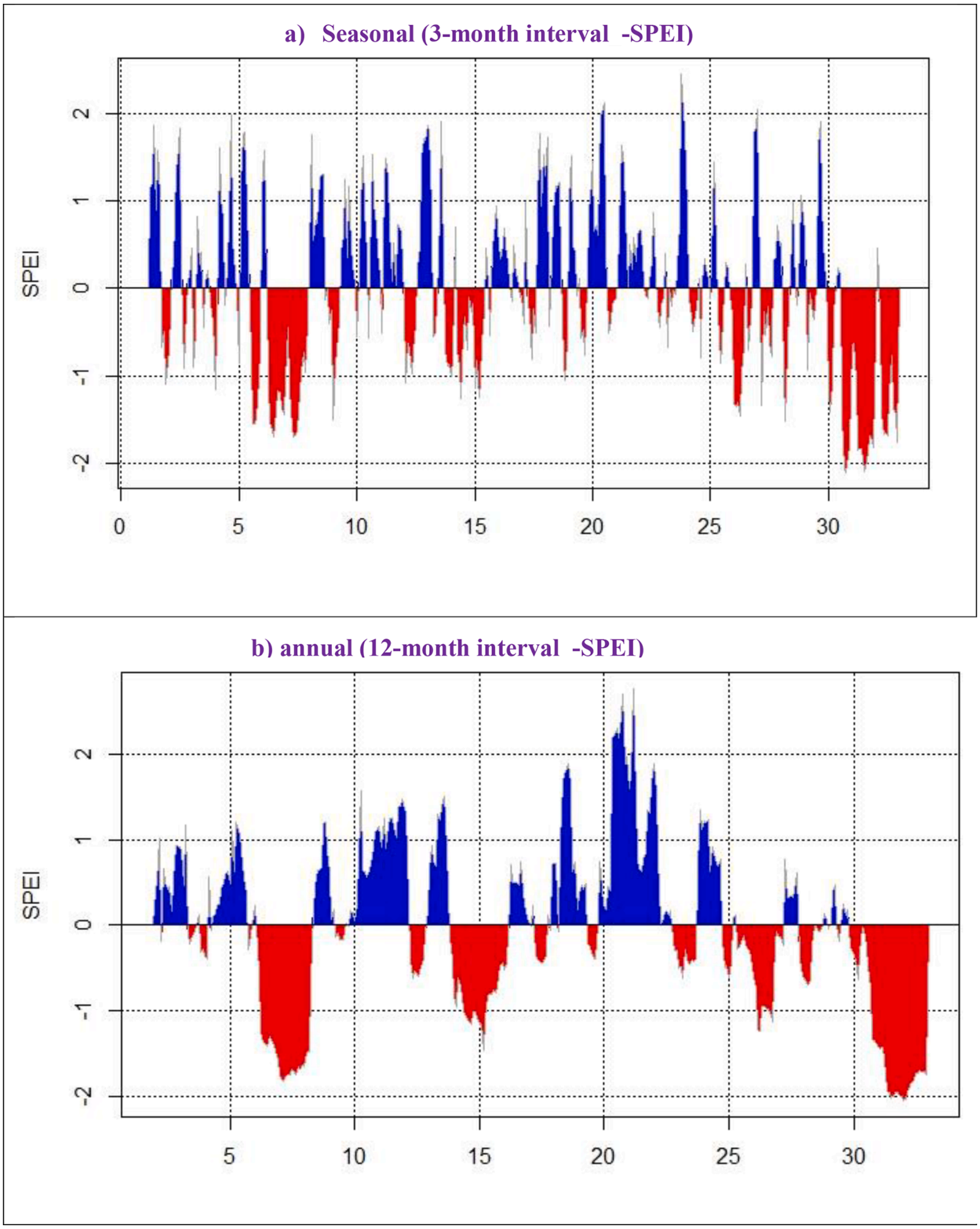

Fig. 5. Rainy a) season and b) annual standardized precipitation Evapotranspiration Index (SPEI) of East Guji Zone

period. The current finding revealed that higher seasonal variability in summer (CV = 78.2%), spring (CV = 39.0%) and winter (CV = 94.0%) with a non-significant decreasing trend of winter and slightly increasing trends of spring rainfall by 1.16 mm (Fig. 4; Table 3). The CV values of rainfall of summer, winter and spring season lie within the highly variable category while the autumn season lie within the moderate variable category. Thus, the trend analysis of the autumn season rainfall indicates declining patterns from year to year over the past 32 years. Therefore, the decreasing trends of the long rainy season (autumn/Ganna) could be the primary reason for the declining annual rainfall patterns. However, minor rainy season (spring) and summer meteorological season trend line of rainfall showed an increasing amount of rainfall over the historical time series of the past three decades.

Note: The Autumn season showed in Fig. 3 includes March, April and May months (mm). The data panel shows the raw rainfall data in the autumn season. The seasonal panel shows the seasonality of rainfall data. The trend panel shows rainfall trends of the autumn season from 1988 to 2018. The remainder panel shows the residual of the rainfall data.

Similarly, NMA (2016), Bekele (2017), Asfaw et al. (2018) & Teshome and Zhang (2019) revealed decreasing trends of autumn, summer and spring (short rainy season) amounts of rainfall in east and southeast parts of Ethiopia. The analysis of rainfall data collected from meteorological stations located in Rift Valley areas indicates high variability and erratic nature of rainfall in amount and distribution in the last four decades (Regassa, Givey, & Castillo, 2010). In contrary to the current finding, Tsige (2018) revealed increasing trends in rainfall during the long rainy season (June to September) and decreasing pattern during the short rainy season (February to May). According to IPCC (2014), climate change might alter the distribution, frequency and duration of precipitation in general . The observed historical data in this study depicted significant variability of rainfall across the study area. This variability became a bottleneck of livestock productivity and household's livelihood in the study area.

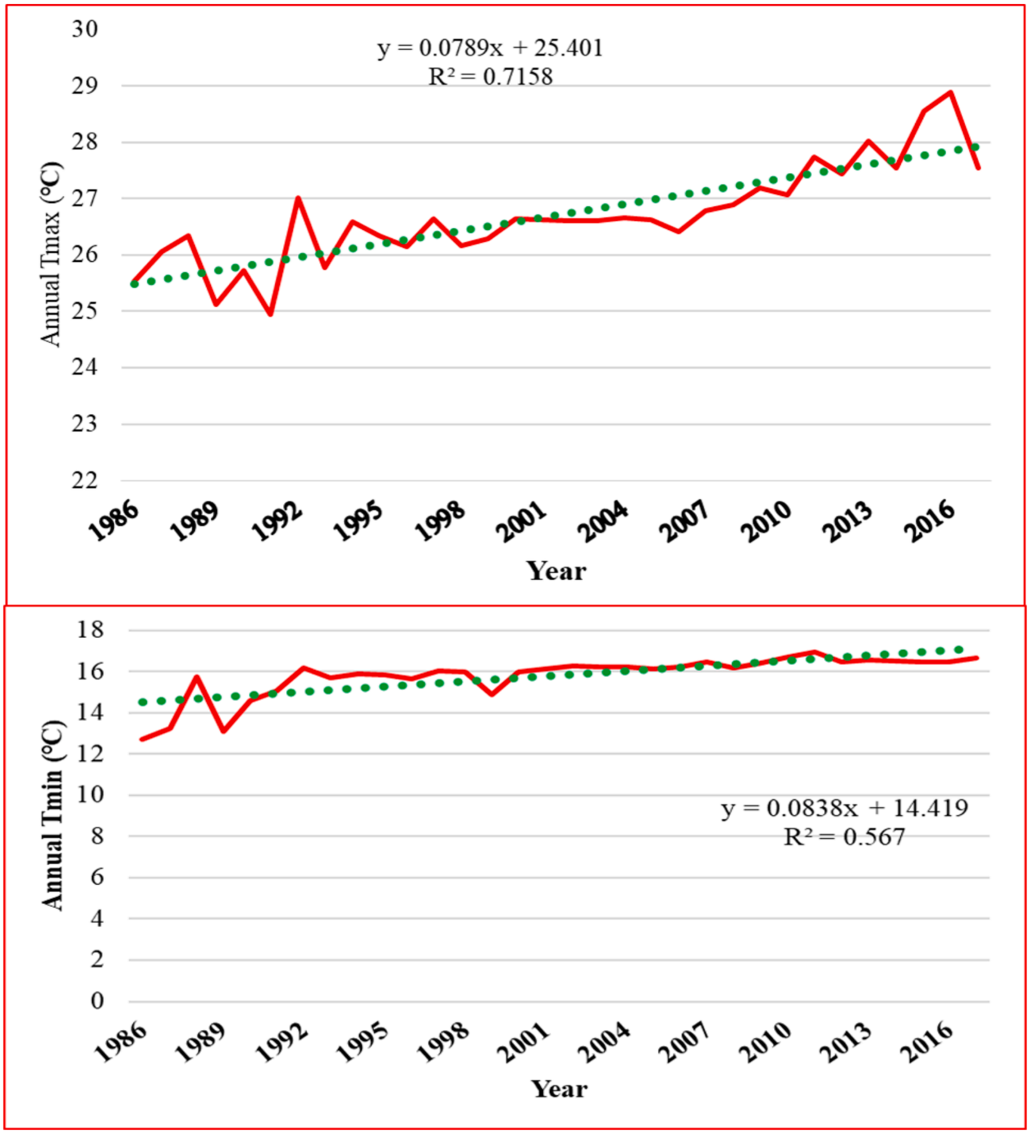

Fig. 6. Trends of annual maximum and minimum temperature

3.2.3. Standardized Precipitation Evapotranspiration Index (SPEI)

East Guji Zone experiences hydrological drought during the years of 1991, 1992, 1999, 2015, 2016 and 2017 (Fig. 5). However, the rainfall anomaly index showed 13 years (1988, 1991, 1992, 1998, 1999, 2000, 2007, 2009, 2010, 2012, 2015, 2016 and 2017) of the below-average annual rainfall of historical period (1986 – 2017). Of which 1991, 1992, 2015, 2016 and 2017 years were characterized as severely dry years while the SPEI value of 1991 lies within the moderately dry category. The SPEI results of the long rainy season (autumn) indicated the agricultural drought during 1990, 1991, 2003, 2015, 2016 and 2017. The SPEI result of the spring season in 1990 (-1.04), 1992 (-1.37), 2003 (-1.05) and 2017 (-1.42) lies within a moderately dry category while 2015 (-1.93) and 2016 (-1.73) lies within the severely dry category of agricultural drought (Fig. 5 (a)).

Fig. 5a indicated severe agricultural drought in 1991 (SPEI = -1.53), 1992 (SPEI = -1.70) and 2016 (SPEI = -1.84) in autumn rainy season. Thus, the study area has been suffering from agricultural and hydrological drought over the last 32 years (1986-2017). According to Teshome and Zhang (2019), the chronology of extreme events compiled from international disaster database showed, increasing frequency of drought in the last 32 years in Ethiopia and 11 drought years (1984, 1985, 1987, 1988, 1990, 1991, 1992, 1997, 2002, 2009, 2015, 2016) has recorded during the recent four decades of the historical period (1980 - 2016). Similarly, Temam, Uddameri, Mohammadi, Hernandez, and Ekwaro-Osire (2019) reported an increasing intensity and frequency of agricultural and meteorological drought over the last century in Ethiopia. According to Kebebew et al. (2001), acute drought (a long period of abnormally low rainfall) covered the whole Borana during the years of 1984, 1990, 1991, 1992, 1993, 1994, 1999 and 2000, which has resulted scarcity of grazing feed resources, drinking water and human food. During these periods, animals were unable to provide milk and produce adequate meat for household consumption, and a large number of animal died.

3.2.4. Trends of temperature

Mean maximum and minimum temperature record of the last 32 years were 26.7 °C and 15.8 °C, respectively Fig. 6. shows an increasing trend of annual maximum and minimum temperature by 0.08 °C and 0.084 °C per year, respectively. Over the past three decades, indicating a slightly faster increasing rate of minimum temperature than maximum. The mean annual maximum temperature steadily increasing from 25.53 °C (1986) to 28.88 °C (2016) while minimum temperature increased from 12.71 °C (1991) to 16.93 °C (2012). In agreement to this finding, Tsige (2018) reported steadily increasing minimum and maximum

Table 4
Significance test using Mann-Kendall's

Variable	Mann-Kendall's tau	p	Sen's slope estimator	Z	Pettitt's test for change value
Spring	0.02	0.83	0.02	0.22	October 2014
Winter	-0.02	0.80	0.00	-0.26	February 2010
Autumn	-0.09	0.21	-0.41	-1.26	March 2010
Summer	0.07	0.32	0.01	0.99	June 1994
Total Annual rainfall	-0.01	0.76	0.00	-0.31	September 1993
Tmax	0.19	< 2.22e-16	0.01	5.60	November 2006
Tmin	0.37	< 2.22e-16	0.01	10.68	January 2000

temperature during the historical period of 1987-2017 in Sidama Zone of Southern Ethiopia. Similarly, Asfaw et al. (2018) discussed increasing trends of mean maximum and minimum annual temperature by 0.067 °C and 0.026°C per decades, respectively, during the historical period of 1901-2014. A report from NMA (2016) depicted increasing trends of mean minimum temperature by 0.36°C per decades in Ethiopia Teshome and Zhang (2019). Also showed increasing trends of mean maximum and minimum temperature in Ethiopia with 0.04 and 0.05°C, respectively during 1980-2010. Moreover, Hussen-Ahimed, Biru, and Yadessa (2011) reported that the mean annual maximum and minimum temperature has been increasing with one and 0.25°C per decades throughout the country. At global level, Bindoff et al. (2013) and Huang et al. (2017) indicated significant increasing patterns of mean annual temperature and surface warming by 0.6-1.3 °C at almost all location during the historical period of 1951 – 2010.

Increasing trends of mean annual temperature may cause heat stress in livestock species, and loss of animal may be the consequence. Increasing trends of mean annual temperature are consistent with the perception of the majority of the pastoralist who indicated increasing patterns of temperature and warming situation (Table 2). According to Sejian, Gaughan, Bhatta, and Naqvi (2016), a substantial decline in domestic animals performance inflicting heavy economic losses when animals are subjected to heat stress. Climate change especially increases in temperature, has a direct impact on increasing heat stress in animals (Coffey, 2008; Valtorta, 2002). Similarly, Robinson, Strzepek, and Cervigni (2013) reported that surface Warming is expected to alter the feed intake, mortality, growth, reproduction, maintenance, and production of animals. Heat stress due to high temperature accompanied by excess humidity cause infertility in most of the farm species and adversely affecting the reproductive performance of farm animals (Desalegn, 2016). Furthermore, comfortable environmental temperature ranges 20-25°C for sheep (Khalek, 2007), 25-30°C for goat (Lu, 1989), 5-20°C for cattle and 15 to 42°C for camel (Barnes et al., 2004; DeShazer, 2009; Kerr, 2015; Khan, Arshad, & Riaz, 2003). According to (Peters & Peters, 1986), small animals cool and loss heat faster than large animals, and they are sensitive to climate change. In this scenario, weather plays a significant role in determining the thermoneutral zone (TNZ) of livestock, which determines livestock productivity since adverse weather condition can yield production loss (Kerr, 2015; Valtorta, 2002; Vining, 1990).

3.2.5. Trend analysis using Mann-Kendall's/ MK test

The level of significance, the magnitude of trend and change point of time series data detected using Mann-Kendall's, Sen's slope estimator and Pettitt's test, respectively (Table 4). The Mann-Kendall's trend analysis applied to all seasons of the year (summer, autumn, winter and spring) and the entire years of the historical period. The MK test result for spring (the minor rainy season of the study area) and summer season

Table 5
Time period at which pastoralist starts to raise camel in the study area(Frequency (%)) as per wealth

Variable	Variable	Poor	Medium	Rich	P
Gada period at which pastoralist starts rearing camel	Jilo Aga (1976-1984)	15 (23.4)	11 (17.2)	6 (8.6)	0.1486
	Boru Guyo (1984-1992)	23 (35.9)	23 (35.9)	21 (30.0)	0.942
	Boru Madha (1992-2000)	16 (25.0)	18 (28.1)	14 (20.0)	0.7788
	Liben Jaldessa (2000-2008)	9 (14.1)	11 (17.2)	14 (20.0)	0.57
	Guyo Goba (2008-2016)	1 (1.6)	1 (1.6)	13 (18.6)	<.0001
	Kura Jarso (2016-present)	–	–	2 (2.9)	
	p	0.0003	0.0002	0.0017	

rainfall data indicated non-significant increasing trend ($p< 0.05$). The result of Pettitt's test suggested that higher rainfall value recorded after October 2014 for spring and June 1994 for the summer season than before. The current finding revealed statistically non-significant decreasing trends of winter, autumn (the long rainy season of the study area) and annual rainfall ($p< 0.05$). According to the test made with Pettitt's change value, insignificant downward rainfall change value was recorded after February 2010, March 2010 and September 1993 for winter, summer and total annual rainfall, respectively. This finding is in line with a report from Asfaw et al. (2018) who discussed significant decreasing trends of annual long rainy season at 5 and 10% significance levels. In contrary to this finding Tsige (2018) reported significantly increasing annual main rainy season patterns of the rainfall.

The MK test result for minimum and maximum temperature in this study showed significantly increasing ($p< 0.05$. The result of Pettitt's test indicated that significant change of maximum and minimum temperature after November 2006 and January 2000, respectively. Similarly, studies by Asfaw et al. (2018) and Tsige (2018) revealed significant increasing patterns of maximum and minimum temperature during the last three to four decades. According to IPCC (2019), the changes of global surface air temperature over the land has considerably risen above 1.5 °C. According to FAO (2007), nearly 20 to 30% of animal and plant species are at risk of extinction when the surface temperature increases by 1.5 to 2.5 °C.

3.3. Camel raising and its history among pastoral and agro-pastoral communities of East Guji Zone

Table 5 depicts the period at which they start to raise a camel as a farm animal. The result showed that most pastoralists (P<.0001, 33.93%) included the camel in their farm animal stock during the Boru Goyo Gada period (1984 – 1992) followed by Boru Madha (1992 - 2000) Gada Period (24.37%). Declining trend of rainfall, increasing patterns of temperature and intensified drought condition may be forced to shifting to camel rearing. Drought is one of the climate driven impacts and it is the primary determinant factor of livestock feed quality and availability. Climate change is the reason for increasing level of the invasive bush, poisonous (Xanthium, Parthenium hysterophorus L and Prosopis hysterophorus) and thorny plant species (Acacia mellifera and Acacia Senegal). Decreasing trends of palatable grass and browse species such as elephant grass and Acacia brevispica was also the primary factor of climatic change. Therefore, the factors that motivated pastoral communities to rear or owning camel during 1984-1992 was the high death rate of cattle, sheep and goat species during severe Ethiopian famine condition of 1983 – 84. Worst drought that occurred in 1983-85 significantly reduced livestock population and the death rate was as

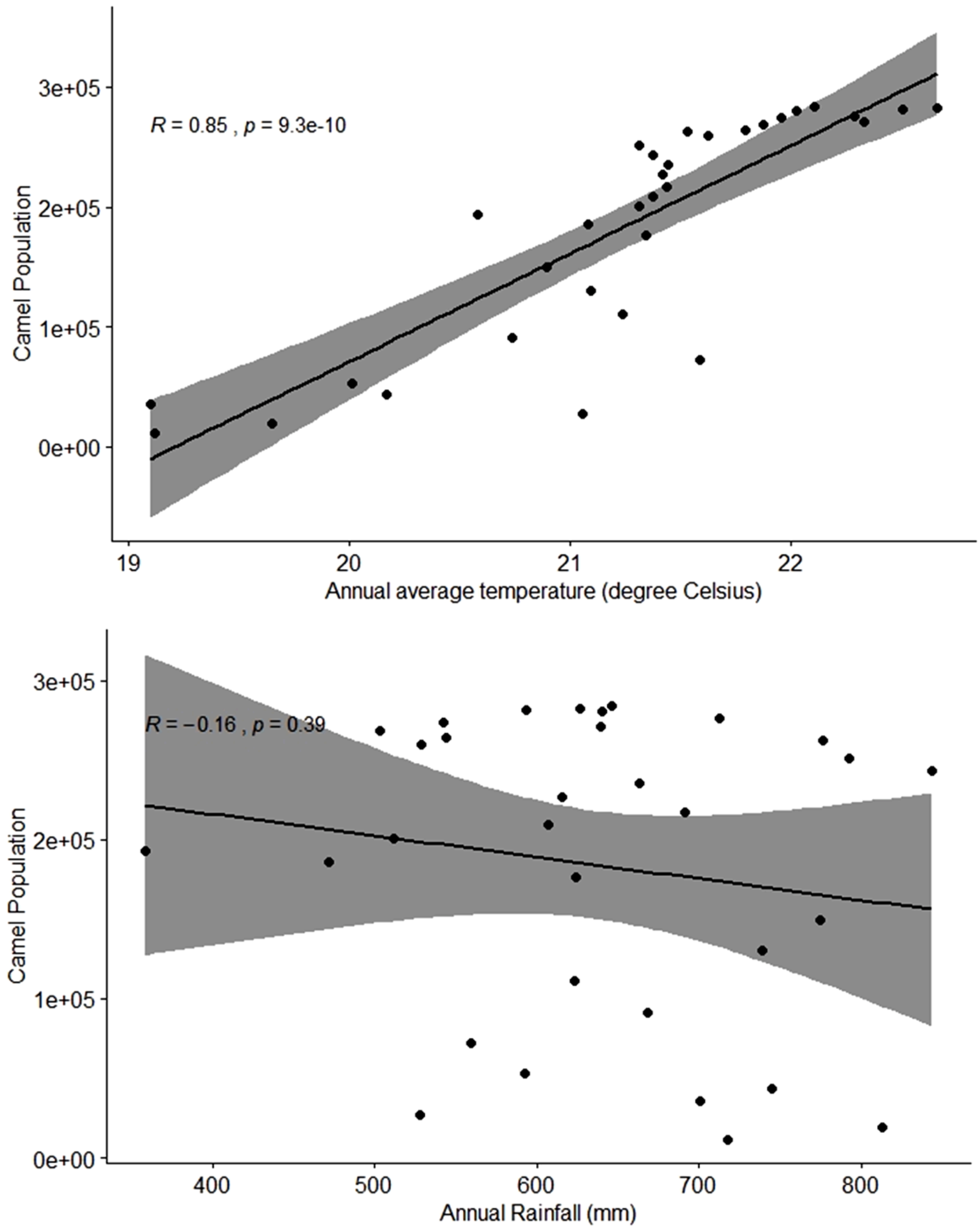

Fig. 7. The relationship between climate variability and camel population

high as 90% (Kebebew et al., 2001). According to Abebe et al. (2012), increasing rate of poisonous, thorny and invasive bush and declining trends of grass plant species due to drought and erratic nature of rainfall in Borana rangeland forced pastoral and agro-pastoral communities to have more drought resistant browse livestock species like camel and goat.

Similarly, Sandford and Habtu (2000) reported significant decreasing rate (78%) of cattle population during 1985-87 in the Borana and Ethiopian Somali alongside Ethio-Kenyan border. For this reason, Guji and Borana pastoralists started to raise camels to cope with recurring drought condition. The Borana and Guji pastoralists still prefer raising cattle than camel. However, they also want to keep more camels and goat as they are safely supported by the changing ecological condition and have drought-resistant capacity (Abebe et al., 2012). Similarly, Boru, Schwartz, Kam, and Degen (2014) showed significantly decreasing trends of cattle population due to drought and land desertification. As a result, Borana pastoralists are shifting to drought-resistant livestock species such as camel and goat.

Moreover, the key informant interviewee was confirmed that the result revealed through quantitative development. One of the interviewees expressed his emotion and experience in the face of drought challenge as follow

“I am Doyo Guyo, 61 years old, living in Liban woreda. We are Borana; Boranas are mainly cattle keeper. Before 1984, we had cattle, 325 goats, 34 sheep and no camel in our herd. We lost more than 200 cattle, 150 goat and 28 sheep during the severe drought in 1984. Our neighbour Ethio-Somali pastoralists are mainly camel herder who was rescued when we lost most of our assets during the drought period. At that time, we decide to exchange two cattle with one camel and owned at least two camels in 1984. The livestock death rate is now increasing than before because of drought caused by a decline in rainfall (amount, intensity and duration), limited grazing feed resources caused by bush encroachments, land degradation (loss of land productivity), new emerging livestock diseases and heat stresses. Our cattle number has

Table 6
Drivers for livestock decline in the study area

Purpose	Golba			Dida		
	Frequency	Index	Rank	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

been decreasing from 306 to 16 over the last six years. However, our camel population increased to 53; the camel is considered as a drought-resistant animal, can browse on thorny plant species, give us milk at least for household consumption, and our livelihood is now shifting from cattle to the camel raising."

The relationship between climate variability and camel population in the study area over the years have showed an increasing pattern as per indicated in Fig. 7. Average annual temperature and camel population are strongly correlated as annual temperature increases; camel population also tends to increase positively with correlation coefficient of 0.85 and p-value <0.001. Whereas, non-significant ($p < 0.05$) weak negative relationship between annual rainfall and camel population with correlation coefficient of -0.16 and p-value of 0.36 was observed. The camel population is being increasing with raising annual average temperature. The increasing pattern of camel population is attributed to decreasing patterns of rainfall and increasing trends of temperature, which in turn depresses grazing lands, increasing bush encroachments and browse feed resources. Therefore, herders decided to have more camels than cattle and small stocks to adapt to changing ecological condition. Current finding revealed that camel population is consistently increasing from 1984 to 2017 (from Jilo Aga to Guyo Goba Gada Periods).

"I am Naji Abdullah, 49 years old, living in Goro Dola Woreda. We inherited raising camel from our parent. Before 1984 we had more than 200 cattle, 184 goats, 20 sheep and three camels. It is heartbreaking, most of our cattle, sheep and goat lost because of drought and livestock diseases occurred in 1984. We have recovered, and our livestock population turn back just before 15 years, but in 2011 afterwards, we lost most of our cattle and goat once again. In 2008 we had 27 cattle, but now it declined to 13 head, and our goat population was decreased from 117 to 10 head within the last ten years. However, our camel population is being increased and now supporting us as food and income source. Nevertheless, our camel population and its productivity declined in the last four years due to disease and extreme desertification. We had 47 head of camel before six years, but now we have 16. Before 20 years, our family has one of the rich men but now am one of the low-income family and regimen for safety net program."

Respondents declared that the main drivers for livestock decline in the study area is drought and drought-driven impacts (Table 6). In general, the ranking of livestock decline drivers in Dida and Golba study locations showed that drought received high ranking. Respondents of the study area believed that diseases and shortage of grazing feed resources associated with drought incidence. Drought condition attributed to the shortage of available feed resources, leading to poor in body condition, which in turn diminish body immune system and make the animal easily exposed to the disease. The primary climate stresses in dryland areas are drought, inadequate water, heat and inadequate feed resources, which lowers immunity system of livestock and exposed them to new pathogens and vectors. The result of the current study agreed with the finding of (Boru et al., 2014) who reported drought and land fragmentation drove livestock death and declining cattle population in eastern Guji zone.

3.4. Effects of Drought on livestock production

3.4.1. Livestock mortality

People, plants and animals depend on the ecosystem services.

Table 7
Reason for Livestock death summary (mean ± Std.D)

Death factors	Camel	Cattle	Small ruminant	p
Drought	0.045 ± 0.52^{b} (c)	$43.57 \pm 55.27^{(a)}$	28.52 ± 29.01^{b} (b)	<0.001 ***
Disease	11.03 ± 21^{a} (b)	33.65 ± 47.53 (a)	40.11 ± 35.53^{a} (a)	<0.001 ***
p	<0.001 ***	0.0562	<0.001***	

*** indicates statistical significance at 1% level, letter superscript in parenthesis indicates statistical significance across the row and out of parenthesis shows column comparison.
H_0: drought is the major determinant factors for death of all livestock species

Table 8
Drought resilience ability of camel (mean ± Std.D)

Camel milk yield (lit/day)	Camel	Cattle	Goat	p
Dry season	$3.32 \pm 1.70^{b(a)}$	$0.43 \pm 0.43^{b(b)}$	$0.12 \pm 0.17^{b(c)}$	< 0.001 ***
Wet season	$7.19 \pm 3.17^{a(a)}$	$1.27 \pm 0.64^{a(b)}$	$0.29 \pm 0.27^{a(c)}$	
p	< 0.001 ***			
	Dida	**Golba**		
staying and producing without water (days)	9.49 ± 4.46	11.00 ± 4.81		0.0228 *

* indicates statistical significance at 5% level; *** indicates significance level at 1%; Means within the same row $^{(abc)}$ and column ^{abc} bearing different superscripts are significantly different at $p<0.01$

However, climate change disrupting the provisioning and regulation services such as shrinking of food and water supply, and unable to control the diseases. Drought and drought-driven factors are the most common climate change impacts and chief the reasons for livestock death of the study areas Table 8. indicates significantly higher ($p < 0.01$) number of camel (11 head/HH) death due to the emerging disease prevalence while drought was the major death factor of cattle. However, it was not statistically significant ($p < 0.05$) (Table 7). Total number of 8627 cattle, 5648 goat and 9 camel were died during drought event at different periods and significantly differ across the livestock species ($p < 0.001$). Similarly, a significantly higher number of goats (40 head/HH) and cattle (34 head/ HH) died due to several disease occurrences than camels (11 head/HH) and statistically significant among the species ($p \leq 0.001$).

The result indicates that significantly resilience ability of camel towards drought and emerging disease conditions. Nearly 11 camel/HH and 40 goat/HH died in average due to the disease while 1 camel/HH and 28 goat/HH died because of drought within the last ten years and there significantly differ among the death factors ($p \leq 0.001$). However, the cattle death rate is not significant for both death factors (Table 7). Cattle is the only livestock species that tends to have weaker resilience ability (high death rate) for both death factors. The result shows that camel is relatively the most resilient farm animals for both drought and disease among the livestock species. The mean drought livestock loss observed in this study is in line with the report of Dirriba Mengistu (2016) who showed a significant number of cattle death (68%) as compared to goat (5%) and camel (2%) during disastrous drought condition. This result is agreed with the report of Coppock (1994); Sandford and Habtu (2000); Kebebew et al. (2001) who reported decreasing cattle population by 90% in 1984-85, 60% in 1983-85 and 78% in 1995-97 drought events, respectively.

3.4.2. Milk production

The camel milk production potential was significantly influenced by the season of the year in the study area (Table 8). Camel provides significantly higher amounts of daily milk yield during the wet season ($\approx$ 7.2 litres/day) as compared to the dry season (3.32 litre/day) and

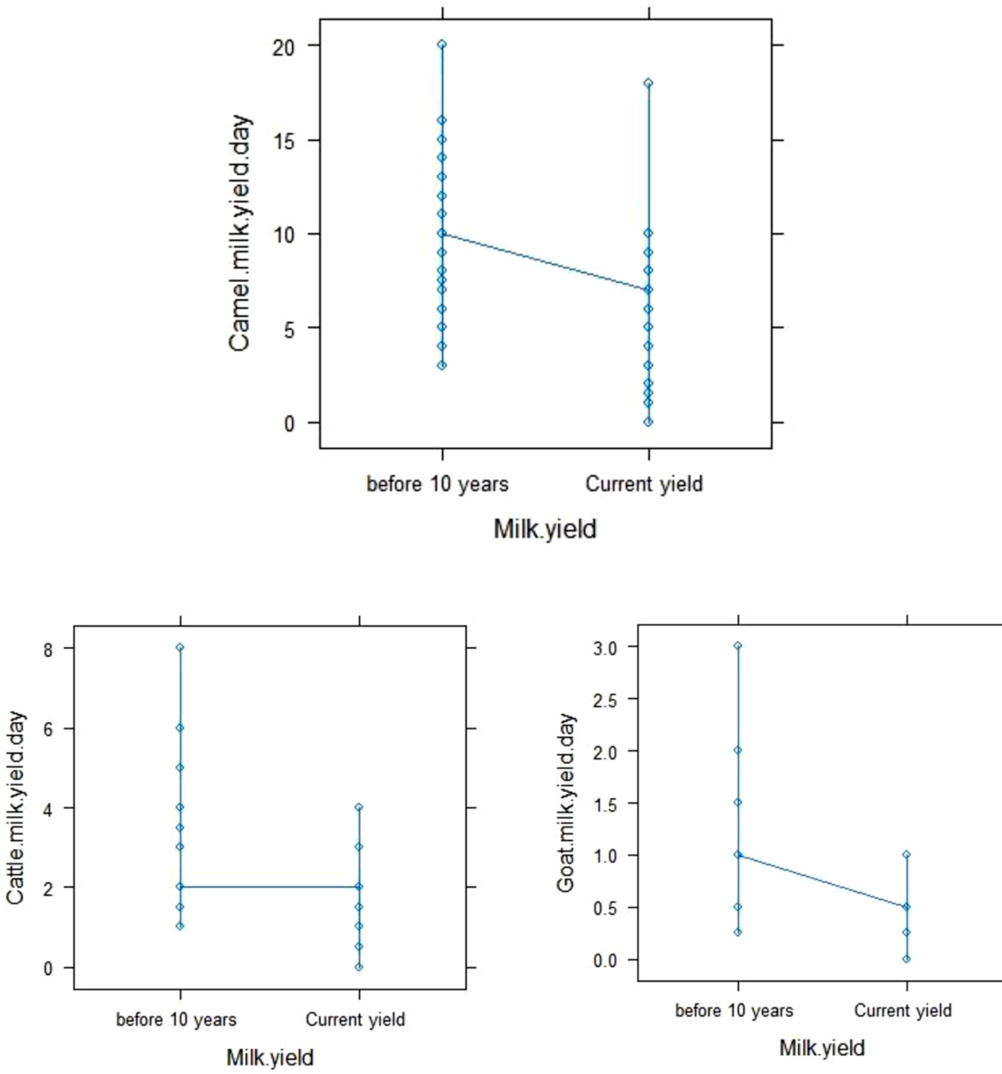

Fig. 8. milk yield trends of camel, cattle and goat before ten years and currently in East Guji Zone (0.5L)

significantly differ across the production seasons ($p<0.01$). Higher daily milk yield record during the wet season is associated with availability of better drinking water and feed. The result of the current study showed that significantly higher ($p<0.01$) milk yield of dairying camel at both dry periods. Daily milk yield of Camel > cattle > goats at both dry and wet season. Similarly, Kedija-Hussen, Tegegne, Kurtu, and Gebremedhin (2008) reported significantly higher mean daily milk yield of a camel across production seasons and dairying species (camel, cattle and goat).

This study found that lower daily milk yield of camel, cattle and goat during the dry period as compared to the wet season and significantly vary across species and season ($p<0.01$). Only camels continue to survive and produce milk in drought-stricken areas where drought decimate goat, cattle and sheep populations and hinder milk yielding capacities (Alhadrami & Faye, 2016). Similarly, CSA (2018) reported 3.91 and 1.4 litres of mean daily milk yield of camel and cattle, respectively. The significant variation of mean daily milk yield across dairying livestock species in this study is convenient with the finding of Kedija-Hussen et al. (2008) who revealed that better milk yield potential of the camel at both dry and wet season. However, cattle's mean daily milk yield recorded in this study is lower than the report of Kedija--Hussen et al. (2008) who reported about 3.26 and 1.63 litres per day during the wet and dry condition, respectively. Location effect, climatic stress, genotypic variations, feeding and physiological status of the cattle might be the reason for the variation. The variation of mean daily milk yield of the camel as per the production season recorded in this study is in agreement with the finding of Zeleke (2007).

The current finding revealed that the milk yield potential of dairy livestock in the study area shows the significant decreasing trends (Fig. 8). The camel milk yield before 2008 is more than ten lit/day/head, showing decreased to about four lit/day/head in 2019. Similarly, cattle milk yield declined from about three lit/day/head to one lit/day/head. The reason for decreasing in milk yield may be related to intensive climatic stresses such as water scarcity, expanding desertification, recurring drought and heat stress. The focal group discussants underline that camel is better a milking animals and good milk yield at both dry and rainy season than cattle and goat. It is the camel, which can mainly support the family nutrition and household's livelihood during drought condition.

"I am Tari Dita, 33 years old, living in Gumi Eldallo Woreda near to Somali regional state border. We start raising camel about 17 years ago. In the beginning, we bought three camels from Somali pastoralists when the drought takes off most of our cattle. Just before 2005, we had more than 137 cattle, 42 goats, 28 sheep and three camels. However, our livestock population is dramatically decreasing to 31 cattle, 27 goats and 16 sheep, but our camel population is increasing, and now we have 47 head. We believe that the main driving factor of decreasing cattle, sheep and goat population is drought and drought-driven impacts such as conflict lack of water, heat stress and feed resources. Our cattle milk

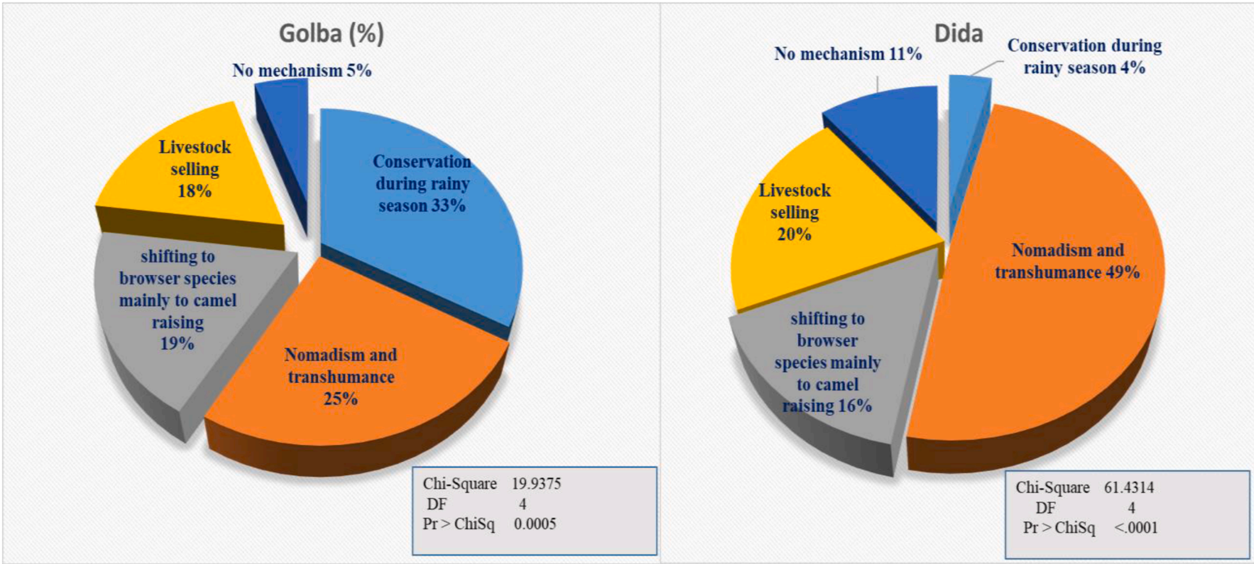

Fig. 9. Drought coping strategies used by pastoralist in East Guji Zone

yield is not worthwhile; however, the camel milked up to two litres/day/head during surplus feeding resources and under suitable environmental conditions, which could be zero during the drought conditions. However, the camel milk yield is estimated to be 4-5 litre/day/head under the good environmental condition and pleasant feed availability. However, the milk yield potential declined during the drought condition. Nevertheless, the dairying camel can still give milk up to 2-3 litre/day under the harsh environmental condition and poor quality feed availability."

3.5. Climate change coping strategy

The Fig. 9 displays farmers coping strategic measures taken to reduce the impacts of recurring drought. As a result, conservation of feed resources through circumscribing with a fence during the rainy season, and ample feed availability preferred as a primary coping mechanism as it indicated by 33% followed by herd mobility (25%) and shifting to browse livestock species (19%) in Golba study location. Whereas, herd mobility and migration during the disastrous drought period to where feed and water available area is the most preferred drought coping strategy as it indicated by 49% ($p<0.01$) followed by reducing livestock number through selling (20%) and shifting to camel raising (16%) in Dida study location.

The primary coping strategy observed in this study is in line with the result of Dirriba Mengistu and Haji (2016) and Opiyo, Wasonga, Nyangito, Schilling, and Munang (2015) who reported herd mobility and migration as a mutual drought coping strategy of Ethiopian Borana and Northern Kenyan pastoralists. In contrary, Tsige (2018) reported that reducing livestock number through selling is the leading climate change coping measures taken by the farmers of Hawassa Zuria woreda. Although Kebebew et al. (2001) in his report indicated that selling of cattle and other animals does not encourage by Gadaa system, this study shows that east Guji pastoralist attempt to sell some animals in good condition when they observe early stages of drought. In agreement to this study, Sandford and Habtu (2000) reported none of the pastoral groups in Ethiopia diversifies their livelihood option as a measure of drought coping strategy. However, Kebebew et al. (2001) revealed the attempt of income diversification in Borana pastoralists in order to avert the severe consequences of drought.

4. Conclusion

Pastoral/agro-pastoral communities in the study area had a perception of decreasing patterns of rainfall, increasing trends of temperature and drought intensities between 1986 and 2017 likewise there is strong meteorological evidence of the same climate trend direction during that period. This study revealed that increasing trends of intensities and frequency of drought occurrence in the study area. Accordingly, RAI identifies 13 drought years within the historical periods of 1986-2017, of which 54% (seven drought years) occurred within the last ten years (2007-2017).

Pastoralists/agro-pastoralists in the study area have encountered climate-related problems like rainfall/water accessibility, feed quality and availability, risk of animal disease, heat stress and hence, reduced livestock performance. Temporary migration/nomadism to areas with better pasture is the most commonly practicing coping strategy so far to address feed and water shortage. Moreover, reducing livestock number, reserve grazing/standing hay and shifting to browse livestock species (camel and goat) are also preferred coping mechanism to tackle climate-related problems. Camel and goats are perceived as drought-resistant livestock species and Boranas cattle keepers shifting to have more camel and goat in response to prevailing drought. Pastoral and agro-pastoral communities in the study area are well aware of climate change, variability, its trend direction, and its potential pessimistic impacts on their livelihood in the future. Cooperating adaptation programs of intended beneficiaries is very critical to develop the traditional coping mechanism of pastoralists/agro-pastoralists in response to pessimistic impacts of climate change. Moreover, extensive investigation is required to select and identify purpose-specific camel and goat strains for drought-prone areas.

Funding

This research was supported by Africa center of excellence for Climate Smart Agriculture and Biodiversity Conservation, Haramaya University in collaboration with World Bank Group.

Etical Statement

No potential Ethical Statement for this piece of work

Conflict of Interest Declaration

No potential conflicts of interest to declare

Acknowledgment

We thank Nigussie Zeray (PhD) for assistance with statistical analysis of some parameters of this research. We would also like to show our gratitude to Mr. Liban Boru (Dilla University), Mr. Mieso Kaweti (Haramya University, Climate Smart Agriculture PhD candidate), Mr. Guye Aga (East Guji Zone livestock and fisheries office), Dr. Wako Bonaya (Gumi Eldallo District Livestock health office) and Mr. Birhanu Admassu (Dilla University) for sharing their pearls of wisdom with us during the course of fieldwork.

References

Abate, T. (2016). Indigenous ecological knowledge and pastoralist perception on rangeland management and degradation in Guji Zone of south Ethiopia. *Sustainable Development*, (15), 192–218.
Abebe, A., Eik, L. O., Holand, Ø., Ådnøy, T., & Tolera, A. (2012). Pastoralists' perceptions of feed scarcity and livestock poisoning in southern rangelands. *Ethiopia. Journal Tropical animal health, 44*(1), 149–157.
Adi, S., & Swoboda-Reinhold, M. (2003). The Borana Pastoral production and Livelihood system (BPPLS), BLPDP/GTZ, Addis Ababa and Negelle/Borana. Retrieved from Addis Ababa:.
Al-Amin, A. Q., & Alam, G. M. (2011). The impacts of climate change on animal health and economy: A way forward for policy option. *Asian J. Anim. Vet. Adv, 6*, 1061–1068.
Alhadrami, G., & Faye, B. (2016). Animals that produce dairy foods: Camel. In Reference Module in Food Science (pp. 1-12): Academic Press Amsterdam.
Alhamshry, A., Fenta, A. A., Yasuda, H., Kimura, R., & Shimizu, K. (2020). Seasonal Rainfall Variability in Ethiopia and Its Long-Term Link to Global Sea Surface Temperatures. *J Water, 12*(1), 55.
Anita, W., Dominic, M., & Neil, A. (2010). Climate change and agriculture impacts, adaptation and Mitigation: Impacts, adaptation and Mitigation: OECD publishing.
Asfaw, A., Simane, B., Hassen, A., & Bantider, A. (2018). Variability and time series trend analysis of rainfall and temperature in northcentral Ethiopia: A case study in Woleka sub-basin. *Weather, 19*, 29–41.
ATPS. (2013). Rationale and Capacity of Pastoral Community Innovative Adaptation to Climate Change in Ethiopia. African Technology Policy Studies Network. *ATPS Research Paper, 25*(25). Nairobi, Kenya.
AU-IBAR. (2016). Livestock Policy Landscape in Africa: A Review. Reinforcing Veterinary Governance in Africa. Nairobi, Kenya.
Ayal, D. Y., & Leal-Filho, W. (2017). Farmers' perceptions of climate variability and its adverse impacts on crop and livestock production in Ethiopia. *Journal of Arid Environments, 140*, 20–28.
Bagath, M., Krishnan, G., Devaraj, C., Rashamol, V., Pragna, P., Lees, A., & Sejian, V. (2019). The impact of heat stress on the immune system in dairy cattle: A review. Research in veterinary science, 126, 9. doi:10.1016/j.rvsc.2019.08.011.
Barnes, A., Beatty, D., Taylor, E., Stockman, C., Maloney, S., & McCarthy, M. (2004). Physiology of heat stress in cattle and sheep. *Meat Livestock Australia, 209*, 1–36.
Bekele, F. (2017). Analysis of current rainfall variability and trends over Bale-Zone, South Eastern highland of Ethiopia. *SF J Global Warming, 1*(2).
Bernard, H. R., & Bernard, H. R. (2013). Social research methods: Qualitative and quantitative approaches: Sage.
Bindoff, N. L., Stott, P. A., AchutaRao, K. M., Allen, M. R., Gillett, N., Gutzler, D., & Jain, S. (2013). Detection and attribution of climate change: from global to regional, 2013 *The Physical Science Basis, TF IPCC, 2013 report*.
Boru, D., Schwartz, M., Kam, M., & Degen, A. A. (2014). Cattle reduction and livestock diversification among Borana pastoralists in southern Ethiopia. *Nomadic Peoples, 18* (1), 115–145.
Bowley, A. L. (1925). Measurement of the precision attained in sampling: Cambridge University Press.
Chris, F., Jim, R., Gary, E., Emebet, K., Nigist, B., Libby, W., & Gideon, G. (2012). Climate Trend Analysis of Ethiopia: Famine Early Warning Systems Network-Informing Climate Change Adaptation Series. *Fact Sheet*, 3053.
Coffey, S. G. (2008). A Systems Approach to Climate Change Impacts on Livestock Production. Retrieved from.
Coppock, D. L. (1994). The Borana plateau of southern Ethiopia: Synthesis of pastoral research, development, and change, 1980-91 (Vol. 5): ILRI (aka ILCA and ILRAD).
CSA. (2007). Central Statistical Authority population estimates in Ethiopia, Addis Ababa. 2010. Agriculture Sample Survey 2009/2010 (2002E. C.) Volume I Report on Area and Production of Crops (Private Peasant holdings Meher Season). *Statistical Bulletin*, 446. Addis Ababa.
CSA. (2018). Agricultural Sample Survey 2017/18 [2010 E.C.]. Retrieved from ADDIS ABABA:.
Desalegn, K. (2016). The climate change impacts on livestock production: A Review. *Global Veterinaria, 16*(2), 206–212.
DeShazer, J. A. (2009). Livestock energetics and thermal environmental management: American Society of Agricultural and Biological Engineers.
Duncan, D. B. (1955). Multiple range and multiple F tests. *Biometrics, 11*(1), 1–42.
FAO. (2007). Adaptation to Climate Change in Agriculture, Forestry and Fisheries: Perspective, Framework and Priorities. Food Agriculture Organization. In. FAO Rome: Food Agriculture Organization.
FDRE. (2007). Climate change adaptation programme of action (NAPA) of Ethiopia.
Fereja, G. B. (2016). The impacts of climate change on livestock production and productivities in developing countries: a review. *International Journal of Research-Granthaalayah, 4*(8), 181–187.
Gashaw, T., Asresie, A., & Haylom, M. (2014). Climate change and livestock production in Ethiopia. *Adv Life Sci Technol, 22*, 39–42.
Geilfus, F. (2008). 80 tools for participatory development: appraisal, planning, follow-up and evaluation (9290399104). Retrieved from.
Gemedo-Dalle, Isselstein, J., & Maass, B. L (2006). Indigenous ecological knowledge of Borana pastoralists in southern Ethiopia and current challenges. *The International Journal of Sustainable Development World Ecology, 13*(2), 113–130.
Getachew, A. M. (2018). Drought and its impacts in Ethiopia. *Weather and Climate Extremes, 22*, 12. doi:doi.org/10.1016/j.wace.2018.10.002.
Gomez, K. A., & Gomez, A. A. (1984). Statistical procedures for agricultural research: John Wiley & Sons.
Hänsel, S., Schucknecht, A., & Matschullat, J. (2016). The Modified Rainfall Anomaly Index (mRAI)—is this an alternative to the Standardised Precipitation Index (SPI) in evaluating future extreme precipitation characteristics? *Theoretical applied climatology, 123*(3-4), 827–844.
Hare, F. K. (1983). Climate and desertification: a revised analysis (Vol. 44): World Meteorological Organization.
Herrero, M., Thornton, P. K., Notenbaert, A. M., Wood, S., Msangi, S., Freeman, H., & van de Steeg, J. (2010). Smart investments in sustainable food production: revisiting mixed crop-livestock systems. *Science, 327*(5967), 822–825.
Hidosa, D., & Guyo, M. (2017). Climate Change Effects on Livestock Feed Resources: A. *Review. Fish. Livest Prod, 5*, 259.
Huang, J., Zhang, X., Zhang, Q., Lin, Y., Hao, M., Luo, Y., & Wang, L. (2017). Recently amplified arctic warming has contributed to a continual global warming trend. *Nature climate change, 7*(12), 875–879.
Hussen-Ahimed, Biru, D., & Yadessa, B. (2011). Oromia National Regional State Program of plan on Adaptation to climate change Finfinne, Ethiopia: Oromia National Regional State Program.
IPCC. (2014). Climate Change 2013: The physical science basis: Working group I contribution to the fifth assessment report of the Intergovernmental Panel on Climate Change: Cambridge University Press.
IPCC. (2019). Summary for Policymakers. In: Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems. *Summary for Policymakers, In press, 36*. https://www.ipcc.ch/srccl/.
Israel, G. D. (1992). Determining sample size.
Kebebew, F., Synnevaag, G., & Tsegaye, D. (2001). Traditional coping strategies of the Afar and Borana pastoralists in response to drought: Drylands Coordination Group.
Kedija-Hussen, Tegegne, A., Kurtu, M. Y., & Gebremedhin, B. (2008). Traditional Cow an Camel Milk Production and Marketing in Agro-Pastoral and Mixed Crop-Livestock Systems: the Case of Mieso District, Oromia Regional State, Ethiopia: ILRI (aka ILCA and ILRAD).
Kefyalew, A., & Tegegn, F. (2012). The effect of climate change on ruminant livestock population dynamics in Ethiopia. 24(10), 185.
Kerr, S. R. (2015). Livestock heat stress: recognition, response, and prevention.
Khalek, T. (2007). Thermoregulatory responses of sheep to starvation and heat stress conditions. *Egyptian Journal of Animal Production, 44*(2), 137–150.
Khan, B. B., Arshad, I., & Riaz, M. (2003). Production and management of camels: University of Agriculture, Faisalabad, Department of Livestock Management.
Lu, C. (1989). Effects of heat stress on goat production. *Small Ruminant Research, 2*(2), 151–162. https://doi.org/10.1016/0921-4488(89)90040-0
Lubroth, J. J. B. (2012). *Climate change and animal health, 23*, 63.
Mann, H. B. (1945). Nonparametric tests against trend. *Econometrica: Journal of the Econometric Society*, 245–259.
McKee, T. B., Doesken, N. J., & Kleist, J. (1993). The relationship of drought frequency and duration to time scales. *Paper presented at the Proceedings of the 8th Conference on Applied Climatology*.
Mebrahtu, S., Asgedom, K., & Hadush, A. (2017). Camel Milk Production and Marketing: Challenges and Opportunities in Afar Regional State, Ethiopia.
Melees, W., & Samuel, S. (2017). Review on the Impact of El Niño-Southern Oscillation (ENSO) Climate Changes in Ethiopia.
Melkamu, B. N. (2017). The Effects of El Nino on Agricultural GDP of Ethiopia. *American Journal of Water Science and Engineering, 3*(4), 45–49.
Mengistu, D. (2016). Impacts of Drought and Conventional Coping Strategies of Borana Community, Southern Ethiopia. *Research Journal on Humanities Social Sciences, 6*(23), 37.
Mengistu, D., & Haji, J. (2016). Traditional Coping Strategies of Borana Pastoralists for Climate Extremes: A case of Yabello District, Borana Zone, Ethiopia. *International Journal of Engineering Innovation & Research, 5*(3), 7.
Mirkena, T., Walelign, E., Tewolde, N., Gari, G., Abebe, G., & Newman, S. (2018). Camel production systems in Ethiopia: a review of literature with notes on MERS-CoV risk factors. *Pastoralism, 8*(1), 30.
Morand, S. (2015). Impact of climate change on livestock disease occurrences. In Climate Change Impact on Livestock: Adaptation and Mitigation (pp. 113-122): Springer.
Nicholson, S. E., Funk, C., & Fink, A. H. (2018). Rainfall over the African continent from the 19th through the 21st century. *Global planetary change, 165*, 114–127.
NMA. (2015). Seasonal agro meteorological bulletin. Kiremt Seasonal Outlook for Ethiopia.

O'Connor, H., & Gibson, N. (2003). A step-by-step guide to qualitative data analysis. *A Journal of Indigenous Aboriginal Community Health, 1*(1), 63–90.

Opiyo, F., Wasonga, O., Nyangito, M., Schilling, J., & Munang, R. (2015). Drought adaptation and coping strategies among the Turkana pastoralists of northern Kenya. *nternational Journal of Disaster Risk Science, 6*(3), 295–309.

Osborn, T., Barichivich, J., Harris, I., Van Der Schrier, G., & Jones, P. (2018). Drought: Monitoring global drought using the self-calibrating Palmer Drought Severity Index [in" State of the Climate 2017"]. In B. o. t. A. M. Society (Ed.), Bulletin (Vol. 99, pp. S36-S37). USA: American Meteorological Society.

Pachauri, R., & Reisinger, A. (2008). Climate change 2007. Synthesis report. Contribution of Working Groups I, II and III to the fourth assessment report. Retrieved from Cambridge University Press, Cambridge:.

Palombi, L., & Sessa, R. (2013). Climate-smart agriculture: sourcebook. Rome, Italy: Food and Agriculture Organization of the United Nations.

Peters, R. H., & Peters, R. H. (1986). The ecological implications of body size (Vol. 2): Cambridge University Press.

Regassa, S., Givey, C., & Castillo, G. (2010). The rain doesn't come on time anymore: Poverty, vulnerability, and climate variability in Ethiopia. Oxfam Policy Practice: Climate Change Resilience, (6, 1).

Robinson, S., Strzepek, K., & Cervigni, R. (2013). The cost of adapting to climate change in Ethiopia: Sector-wise and macro-economic estimates. Retrieved from.

Sandford, S., & Habtu, Y. (2000). Emergency response interventions in pastoral areas of Ethiopia.

Sejian, V., Gaughan, J., Bhatta, R., & Naqvi, S. (2016). Impact of climate change on livestock productivity. *Feedipedia-Animal Feed Resources Information System-INRA CIRAD AFZ, FAO*, 1–4.

Simenew, K., Dejen, T., Tesfaye, S., Fekadu, R., Tesfu, K., & Fufa, D. (2013). Characterization of camel production system in Afar pastoralists. *North East Ethiopia. Asian Journal of Agricultural Sciences, 5*(2), 16–24.

Tefera, M, & Abebe, G. (2012). The Camel in Ethiopia. M. Tefera & G. Abebe Eds *Ethiopian Veterinary Association*.

Temam, D., Uddameri, V., Mohammadi, G., Hernandez, E. A., & Ekwaro-Osire, S. (2019). Long-Term Drought Trends in Ethiopia with Implications for Dryland Agriculture. *Water, 11*(12), 2571.

Teshome, A., & Zhang, J. (2019). Increase of Extreme Drought over Ethiopia under Climate Warming. *Advances in Meteorology*, 2019.

Thornton, P. K., Herrero, M. T., & Ericksen, P. J. (2011). Livestock and climate change. *Livestock Thematic Papers Tools for project design (pp. 20): International Fund for Agricultural Development (IFAD)*.

Tsige, F. (2018). Impact of Climate Change on Livestock production and its Adaptation Strategies in Hawassa Zuria and Hula Districts of Sidama Zonen, Southern Ethiopia. (MSc Thesis submitted to the Program of climate change and sustainable agriculture), Hawassa University Unpublished.

Ulrichs, M., Slater, R., & Costella, C. (2019). Building resilience to climate risks through social protection: from individualised models to systemic transformation. *Disasters, 43*. S368-S387.

UNFCCC. (2007). Climate change: impacts, vulnerabilities andadaptation in developing countries.

Valtorta, S. E. (2002). *Animal production in a changing climate: impacts and mitigation*, 1–12.

Van den Bossche, P., & Coetzer, J. (2008). Climate change and animal health in. *Africa. Rev Sci Tech, 27*(2), 551–562.

Van Rooy, M. (1965). A Rainfall Anomally Index Independent of Time and Space, Notos.

Ververs, M.-T. (2012). The East African food crisis: did regional early warning systems function? *The Journal of nutrition, 142*(1), 131–133.

Vicente-Serrano, S. M., Beguería, S., & López-Moreno, J. (2010). A multiscalar drought index sensitive to global warming: the standardized precipitation evapotranspiration index. *Journal of climate, 23*(7), 1696–1718.

Vining, K. C. (1990). Effects of weather on agricultural crops and livestock: an overview. *International journal of environmental studies, 36*(1-2), 27–39.

Wako, G., Tadesse, M., & Angassa, A. (2017). Camel management as an adaptive strategy to climate change by pastoralists in southern Ethiopia. *Ecological Processes, 6*(1), 1–12.

Yamane, T. (1967). Statistics: An introductory analysis. Retrieved from.

Yatoo, M., Kumar, P., Dimri, U., & Sharma, M. (2012). Effects of climate change on animal health and diseases. *International Journal of Livestock Research, 2*(3), 15–24.

Yilma, Z., Haile, A., GuerneBleich, E., & Ababa, A. (2009). Effect of climate change on livestock production and livelihood of pastoralists in selected pastoral areas of Borana, Ethiopia. ESAP Proceedings.

Yosef, T., Kefelegn, K., Mohammed, Y., Mengistu, U., Solomon, A., Tadelle, D., & Han, J. (2014). Morphological diversities and eco-geographical structuring of Ethiopian camel (Camelus dromedarius) populations. *Emirates Journal of Food Agriculture*, 371–389.

Zeleke, Z. (2007). Non-genetic factors affecting milk yield and milk composition of traditionally managed camels (Camelus dromedarius) in Eastern Ethiopia. *Livestock Research for Rural Development, 19*(85), 97.