

Climate variability, perceptions of pastoralists and their adaptation strategies

Implications for livestock system and diseases in Borana zone

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Abstract

Purpose – Climate variability and extremes adversely affect the livestock sector directly and indirectly by aggravating the prevalence of livestock diseases, distorting production system and the sector profitability. This paper aims to examine climate variability and its impact on livestock system and livestock disease among pastoralists in Borana, Southern Ethiopia.

Design/methodology/approach – Data were collected through a combination of quantitative and qualitative methods using household questionnaire, field observations, focus group discussions and key informant interviews. Areal grid dikadal rainfall and temperatures data from 1985 to 2014 were collected from national meteorological agency. The quantitative and qualitative data were analyzed and interpreted using appropriate analytical tools and procedures.

Findings – The result revealed that the study area is hard hit by moisture stress, due to the late onset of rainy seasons, decrease in the number of rainy days and volume of rainfall. The rainfall distribution behavior coupled with the parallel increase in minimum and maximum temperature exacerbated the impact on livestock system and livestock health. Majority of the pastoralists are found to have rightly perceived the very occurrence and manifestations of climate variability and its consequences. Pastoralists are hardly coping with the challenges of climate variability, mainly due to cultural prejudice, poor service delivery and the socio-economic and demographic challenges.

Research limitations/implications – Pastoralists are vulnerable to the adverse impact of climate variability and extreme events.

Practical implications – The finding of the study provides baseline information for practitioners, researchers and policymakers.



Originality/value – This paper provided detailed insights about the rainfall and temperature trend and variability for the past three decades. The finding pointed that pastoralists' livelihood is under climate variability stress, and it has implications to food insecurity.

Keywords Climate variability, Disease, Drought, Pastoralists

Paper type Research paper

1. Background and justifications

The livestock sector has a key role in alleviating poverty in developing countries, and it is the mainstay of the economy for pastoral communities (Seo and Mendelsohn, 2006). For pastoralists, livestock is the source of livelihood, providing food, income, manure and draught power, in addition to being a mark of social status (Watson and Cutley, 2008; Randolph *et al.*, 2007). Socially, livestock is used to support and maintain relationships through gifts, exchanges and fines (Watson and Cutley, 2008). In most cases, access to credit for pastoralists depends on their livestock resource (Vandamme *et al.*, 2010). Therefore, the sector is rightly regarded as social and economic insurance for pastoralists (Thornton *et al.*, 2011; Vandamme *et al.*, 2010).

The current climate variability and extreme events are adversely affecting the livestock sector, directly and indirectly by aggravating the prevalence of diseases, distorting production and minimizing the sector's profitability (Thornton and Gerber, 2010). The experience in Borena lowlands is part of the norm than the exception. Evidences from empirical and theoretical studies come up with the finding that temperature is rising while the rainfall is decreasing and becoming more erratic in its distribution and amount (Ayal and Mulneh, 2014; Aklilu and Alebachew, 2009). Ever rising temperatures coupled with unpredictable rainfall amount and distribution behavior has become a bottleneck for the livestock production (Thornton *et al.*, 2010; IPCC, 2007).

Other effects of climate change and variability on the livestock system manifest in terms of disease outbreak and declining pasture and water availability (Coppock *et al.*, 2008; FAO, 2001) that results in poor growth performance, extended reproduction period and decreasing market prices of the livestock (Ayal *et al.*, 2015; Coppock *et al.*, 2008; Rowlinson, 2008). Climate variability and extremes also create favorable conditions for parasites and pathogens, thereby decreasing their reproduction and increasing mortality rate (Nkedianye *et al.*, 2010; Huho *et al.*, 2011; Scoones, 1992).

Major livestock diseases in pastoralist areas include those caused by trypanosomiasis, endoparasites particularly *Haemonchus contortus* and the highly zoonotic hydatidosis caused by *Echinococcus granulosus*. Other diseases include dermatitic, ectoparasite-related ailments such as orthopox, and tick-borne diseases caused by *Hyalomma*, *Rhipicephalus* and *Amblyomma* species are very common. As Ayal *et al.* (2015) and Luseno *et al.* (2003) pointed out, the sensitivity of pastoralists to climate extremes is increasing partly because their traditional system of weather forecasting is becoming less reliable and partly because of lack of climate change adaptation governance system (Ayal *et al.*, 2015). The cumulative effect of these problems undermines the resilience and sustainability of coping mechanisms and worsens the already precarious food security.

Given the above, the Borena lowland of Ethiopia, that is known to have supported veritable pastoral economy in the past (ESAP, 2000), exhibits deteriorating conditions of rangeland with a marked decrease in grass species and increase in shrubs (Terefe *et al.*, 2012). The grazing systems over the Borena plateau have become increasingly unsustainable in recent decades (Coppock *et al.*, 2008; Wassie *et al.*, 2007; Getachew *et al.*, 2006). This is because the area has been affected by cyclical and prolonged drought with a

heavy toll on livestock that deepens the level of poverty (Coppock *et al.*, 2008) and food insecurity Ayal *et al.* (2017). More catastrophe is predicted for the years to come (Fana and Asnake, 2012) due to poor infrastructure (veterinary services and facilities, market, school, health center, road, etc.), decades-long neglect, inappropriate development intervention and economic and political marginalization that would increase the vulnerability of pastoralists (Busby *et al.*, 2012; Fana *et al.*, 2012; Thornton *et al.*, 2010; Cooper *et al.*, 2008; IPCC, 2007). The livestock system among the Borena pastoralists is highly susceptible to climate variability and extremes to which they have limited adaptive capacity (Ayal *et al.*, 2017; Fana and Asnake, 2012; Coppock, 1994).

The livelihood of pastoralists in Borana is adversely affected by climate change and extremes (Hurst *et al.*, 2012; Desta *et al.*, 2011; Carswell and Jones, 2004). The efficacy of their coping and adaptation strategies are compromised by climate extremes and associated risks (Hurst *et al.*, 2012; Aklilu *et al.*, 2009; Boku, 2000). There is a need for a new and deeper understanding of the impact of climate extremes in pastoralist regions for an accurate appreciation of their environmental and socio-economic trajectories.

Currently, although there is a consensus about the magnitude of climate variability at national and global levels and its adverse effect on livestock production and local area specific empirical evidence is lacking for Borena. Thus, examining the current situation of climate variability in Borena and its impacts on the livestock system is highly important. To effectively use indigenous knowledge and to develop practical and realistic adaptation strategies to climate extremes, it is crucial to understand the perceptions of pastoralists about the existence of climate variability and its causes and consequences on their livestock system (Thomas *et al.*, 2007). This study analyzes the degree of climate variability and its adverse impact on the livestock system and the pros and cons of the coping mechanisms and forwarding ideas that can inform remedial interventions.

2. Materials and methods

2.1 The study area

Borena zone is located in southern Ethiopia between 3° 36'-6° 38' N and 36° 43'- 41° 40' E. Although the region has bimodal annual rainfall ranging from 400 mm in the south to 600 mm in the north, it is mainly characterized by semi-arid climate. The study was conducted in Yabello and Arero woredas, which is one of the learning sites of Climate Change Agriculture and Food Security (CCAFA) in East Africa.

2.2 Research design and methodology

2.2.1 Research design. The study used mixed research approach. Using qualitative and quantitative research methods enables the researchers to explore a research problem better (Creswell, 2008). In this study, the qualitative method focused on in-depth data collection on behaviors of temperature and rainfall and its effect on livestock system and disease. The quantitative method deals mainly with the behavior of temperature and rainfall and pastoralists' perceptions on climate situation and its effect on the livestock system and livestock diseases. Triangulation data collection method and analysis was applied to increase the validity and reliability of the results.

2.2.2 Research method.

2.2.2.1 Sampling technique and sample size. For this study, Dikale and Alona peasant associations (PA) in Yabello district and Arero district respectively were selected purposively. The study sites were selected in consultation with district veterinarians and PA development agents due to their physical accessibility and the occurrence of climate variability with direct and indirect impacts on the livestock system and livestock diseases.

Accordingly 32 heterogeneous focus group discussion (FGD) participants, two veterinarians in Yabello laboratory center, two veterinarians in respective district Pastoralist Development office, two PA development agents in each site, four traditional veterinarians and two community key informants were selected purposively. A total of 180 households were randomly selected for interview through questionnaire.

2.2.2.2 Data sources and collection instruments. The study used PRA, individual interview and questionnaire survey to collect relevant data from experts, DAs, key informants and sample households. PRA (as a tool overt observation, FGD) used to collect data. A total of four FGD sessions having an average of eight participants' of male-headed and female-headed households were organized. FGD sessions were organized to collect data on pastoralists' perception of the trend and variability of temperature and rainfall, adverse impact of climate change and variability on livestock system and livestock diseases as well as coping and adaptation mechanisms. Data on the availability and accessibility of water, pasture land and seasonal pastoralists' activity were also documented using the same method.

Using individual key informant interview, data on the nature of climate variability impact on the asset base of pastoralists (social, economic, psychological and biophysical), trends of perceived climate variability and extremes, challenges and opportunities to adapt and cope with climate variability were collected.

A detailed questionnaire was designed to collect data on the socio-economic and demographic features of respondents, perceptions of pastoralists of climate variability and its impact on livestock production system and livestock diseases and their coping and adaptation practices. The questionnaires were translated into the local language (*Oromeffa*), pretested and modified before implementation.

2.2.2.3 Meteorological data. The areal (4×4 km) grid dikadal maximum temperature, minimum temperature and rainfall data from 1985 to 2014 were collected from Ethiopian National Meteorological Agency (NMA) to determine seasonal and annual anomalies and trends of temperatures and rainfall in the study sites. Areal satellite grid data have no missing values and avoid distribution variations caused by topographic factors. The validity of areal grid rainfall and temperature data is tested and confirmed from scientific point of view by NMA.

2.2.2.4 Retrospective animal health survey. Additional data were collected from Yabello veterinary laboratory center records of the sites for the period between 2006/2007 and 2015/2016. This was to determine the most prevalent climate related livestock diseases over the past 10 years.

2.2.2.5 Data analysis. Qualitative and quantitative data analysis techniques were used to analyze the data. Analysis of temperature and rainfall data involved characterizing long-term mean values, and calculations of indices of variability and trend at seasonal and annual time steps. Standard anomaly was calculated to assess rainfall and temperature variability. Mann-Kendall test as described by Sneyers (1990) was used to detect trends. The significance level of the slope was estimated using Sen's method. Nonparametric Mann-Kendall test and Sen's method are less affected by outliers (Salmi *et al.*, 2002). Descriptive statistics such as mean scores, percentages, coefficient of variation and standard deviations were used as part of data analysis methods. The total weighted scores were used to give the final ranking of the livestock diseases. For the quantitative analyses, SPSS 16 and Microsoft excel 2007 were used. The qualitative data collected from interviews, individual household and FGDs and observation were analyzed thematically. In the analytical procedure of qualitative data identification of themes, paraphrasing and characterization of the recurring themes was performed.

3. Results and discussions

3.1 Trend and variability of rainfall and temperatures

It has become conventional wisdom among scientists and ordinary people alike that there is a marked variability in the amount of rainfall and temperature over the years. However, empirical figures on the actual change in the amount and distribution behavior of rainfall and temperature are highly aggregated to national, continental and international level. This study has analyzed the trends and variability of rainfall and temperature in Borena, to evaluate the extent to which pastoralists' perceptions correspond to actual climatic variability and to provide local specific phenomenon of climate situation in ways that can inform the design and development of local coping and adaptation mechanisms. The analysis used rainfall and temperatures data recorded over the past 28 years from 1987 to 2014.

3.1.1 Annual and seasonal rainfall trends. Figure 2 shows a decrease in the annual and main rainy season rainfall by 42.00 and 31.28 mm per decade, respectively, and an increasing trend for the small rainy season rainfall by 15.34 mm per decade for the study site. The trend of annual and main rainy season rainfall reduction was found to be statistically significant ($p < 0.1$) level. However, the increase in small rainy season rainfall was not statistically significant.

At decadal level, significant reduction in the annual volume of rainfall was registered during the first ($p < 0.05$), second ($p < 0.01$) and third ($p < 0.1$) decades. Likewise, the main rainy season rainfall reduction was witnessed across three ($p < 0.1$) decades. Unlike the 28 years trend, the decade-based small rainy season trend showed statistically insignificant decreasing trend across three decades. The results from this study contributes to the wider argument of the general decreases of rainfall; and with the small rainy season shows no a regular trend across different time intervals. This findings is inconsistent with previous studies in Africa and Ethiopia (see, for example, Deressa *et al.*, 2011; Aklilu *et al.*, 2009; Woldeamlak, 2007; Slegers, 2008; Maddillson, 2007) which stated no significant difference in the long-term annual rainfall trend. A rising of temperature and declining rainfall trend, evident in the study site, is create favorable condition for the prevalence of livestock diseases and reduce resistance of livestock through adversely affecting pasture and water availability.

3.1.2 Annual and seasonal rainfall variability. Figure 3 shows that the long-term average mean for annual rainfall, main rainy season rainfall and small rainy season rainfall was 640.7, 290.2 and 196.9 mm with standard deviation of 139.3, 96.3 and 104.7 and coefficient of variation 0.21, 0.33 and 0.53, respectively. With the highest coefficient of variation, the small rainy season rainfall exhibits the highest fluctuation of rainfall distribution followed by the main rainy season and lastly annual rainfall. This is consistent with previous studies, for example, Nicholson (1996) and Pohl and Camberlin (2006), that conclude that greater rainfall variability is experienced during the small rainy season than the main rainy season and annual rainfall. As depicted in Figure 3, the area experienced 15 annual, 15 years of main rainy season and 15 small rainy season rainfall below the long-term average mean.

Table I summarizes the long-term annual and seasonal mean rainfall, standard deviation, coefficient of variation, the highest and lowest amount of rainfall from 1987 to 2014. According to NMA (1996), a rainfall amount with CV of less than 0.20 is less variable, CV between 0.20 and 0.30 is moderately variable and CV greater than 0.30 is highly variable. The study site experienced moderate and high rainfall variability. Small rainy season and main rainy season rainfall distribution were highly variable. Besides, Table I illustrates the presence of very high differences of annual and seasonal rainfall amount between the long-term mean, the highest and lowest years within each category. For instance, the highest records of annual and seasonal rainfall amount (e.g. 925.13, 555 and 458 mm) were more

than double of the lowest records (442.3, 201.2 and 96.3). As reported by [Ayal and Muluneh \(2014\)](#) and [Woldeamlak \(2007\)](#), extreme high and low rainfall values within the study period could influence the rainfall trend. The increasing and decreasing trend of small rainy season across 28 years and at decade level respectively could be evidence for the extreme rainfall value influence on the annual and seasonal rainfall trends (Section 3.1.1). Therefore, the study site rainfall distributions behaviors were variable and the trend of annual and main rainy season rainfall steadily decreased. However, the aggregated 28 years and disaggregated decadal small rainy season rainfall trend lacks consistency. [Dinar and his associates \(2008\)](#) also observed the presence of inter-annual climate variability in Ethiopia. In general, the rainfall volume trend and distribution behavior could create conducive environment for livestock diseases and adversely affect the livestock system.

3.1.3 Trends of minimum and maximum temperature. [Figure 4](#) illustrates significant (0.1 level) increases in both maximum and minimum temperature. The increase in maximum temperature (0.41°C) per decade was much higher compared to the minimum temperature (0.33°C) per decade, and it confirms the NMA report (2001). While the second decade showed the highest increase in the minimum temperature, the highest maximum temperature increase was observed during the first decade. During the first decade, the highest decrease in rainfall volume was accompanied by the highest increase in temperature, which makes the situation more sever ([Figures 2 and 4](#)). The second decade was characterized by an increase in the amount of annual rainfall, compared to the first decade, and an increase in minimum and maximum temperature. The unevenness of the trend of temperatures rising reinforces the view that the dryness and wetness conditions in the study site were unpredictable. This could undermine pastoralists' preparation for livestock diseases aggravated by extended dryness and wetness conditions. Similarly, the ever-rising temperatures facilitate evapotranspiration and worsen moisture deficiency. This would bring about shortage of water and pasture availability for the livestock and weaken livestock resistance to diseases.

Assessing the seasonal maximum and minimum temperature trend offers insights on the level of stress the livestock system of pastoralists suffer from climate variability and extremes. The seasonal increase in the amount of maximum temperature for the hot dry season, main rainy season, small rainy season and cool dry season was 0.47°C ($p < 0.01$), 0.43°C ($p < 0.1$), 0.29°C ($p < 0.5$) and 0.39°C ($p < 0.5$), respectively.

Station									
Annual (total)			Main rainy season			Small rainy season			
Mean	SD	CV	Mean	SD	CV	Mean	SD	CV	
654.29	139.03	0.21	308.18	104.35	0.34	194.34	89.2	0.46	
<i>Two wettest years</i>									
Year	Rainfall amount (mm)		Year	Rainfall amount (mm)		Year	Rainfall amount (mm)		
2010	925.13		2010	555.6		1997	458		
1997	846		1987	471.1		2011	414		
<i>Two driest</i>									
2014	413.09		2014	171.39		2013	86.8		
1994	442.25		2012	201.15		2014	47.00		

Notes: SD = Standard deviation; CV = coefficient of variation

Table I. Annual and seasonal rainfall (mm), longer-term mean, standard deviation and coefficient of variation (1987-2014)

3.1.4 Trends of seasonal maximum temperature. The situation of main rainy season and hot dry season maximum temperature implies that a year of better rainy season does not necessarily result in better moisture. The maximum temperature increase during the rainy season preceded by highly increasing trend of hot dry season compromises pastoralists' ability to manage pasture and water for the weak livestock and control livestock diseases manifested in hot and wet conditions. The significant rises of maximum temperature during the cool dry season and the small rainy season have its own share to deplete water, pasture and erode the resilience of livestock.

3.1.5 Trends of seasonal minimum temperature. Figure 6 illustrates that the significant increase in the minimum temperature of the main rainy season, hot dry season, small rainy season and cool dry season was 0.37°C ($p < 0.1$), 0.31°C ($p < 0.01$), 0.34°C ($p < 0.5$) and 0.32°C ($p < 0.5$), respectively. The result is consistent with Figure 4 where a marked increase in the annual minimum temperature is noted. FGD participants and key informants also noted that the temperatures are increasing, while the annual and seasonal rainfall and the numbers of rainy days are decreasing. Substantial delays of the onset as well as early cessation of rainfall and unpredictable rainfall amount were reported at the FGD and KI interview sessions. The ever-rising temperatures and state of rainfall amount and distribution behavior lead to the shortage of water and pasture for livestock as well as proliferation of livestock diseases.

Previous studies in Ethiopia showed an increase in the average maximum and minimum temperature by 0.1 and 0.25°C , respectively (NMA, 2001), while the minimum and mean temperature increased by 0.37°C and 0.28°C every decade. The annual volume of rainfall is reported to be constant (Daniel, 2008; NMA, 2001), while it is predicted to have an increasing trend in some part of the country (Dinar *et al.*, 2008; NMA, 2001). In this study, the trend of maximum and minimum temperature increases exceeded the national average (Figures 4 and 5). The average annual rainfall reduction in Borena is far greater than the national average and the experience of highland Ethiopia (see Daniel, 2008; Woldeamlak and Conway, 2007).

The combined effect of reduction and variability of rainfall and the unbearable temperature favors outbreak of livestock diseases and depletion of pasture and water resources. Consequently, the Borena pastoralists are more vulnerable to climate variability. Hence, it is possible to affirm the view that temperature is increasing (Aklilu *et al.*, 2009; Maddison, 2007) which promotes livestock diseases (Rötter and van de Geijn 1999), reduces grass palatability (Minson, 1990) and reduces intake (Erickson *et al.*, 2011) and resistance to livestock diseases (Ayal and Muluneh, 2014). The resultant livestock morbidity and loss of body weight affects the market price of livestock and entails added cost in terms of money, time and energy for treatment and management. Hence, it reduces the household income and worsens food insecurity among the Borena pastoralists.

4. Socio-economic and demographic characteristics of respondents

To study the perceptions of respondents about the existence of climate variability and associated consequences, it is necessary to grasp their level of education, annual income, family size, sex and age. This enables us to differentiate how socio-economic and demographic differences lead to varying perceptions on climate change and variability. The empirical data help to evaluate the validity of previous studies about the difference between the literate and the illiterate, male-headed households and female-headed households, old and young, rich and poor, etc., in perceiving the manifestations climate variability and its impact on the livestock sector.

Table II shows that the socio-economic and demographic condition of respondents is a typical reflection of pastoral societies in the Horn of Africa. Economically, the sample households earn an average annual income of about US\$435.5 which divided by the average family size gives us an annual per person income of US\$64, far below the national average of US\$377 (MOFED, 2012). This exactly feeds into the conclusion that enormous proportion of pastoralists earn below the income of the national average in East Africa (Oxfam, 2005). The income of female-headed households is far below that of male-headed ones, as more than 66.6 and 90 per cent of female-headed household respondents earn between US\$50 and US\$250 and US\$50 and US\$350, respectively. The precarious condition of female-headed households is exacerbated by high family size (6.93) which is above the total average. Conversely, male-headed households enjoy a relatively better wealth because of their greater income and lower family size. However, it appears that the main cause of gender income disparity is related to the number of domestic livestock where the average possession of male-headed and female-headed households is about 122 and 21, respectively. The number of household heads with early grades of primary education is negligible where the proportion of educated female-headed households is practically nil. With this socio-economic profile, the data from respondents are reliable enough to understand how pastoralist society is affected by and manages to cope with the impact of climatic variability and extremes induced livestock diseases. Researchers have shown that differences in literacy and wealth creates a big divide in accessing basic infrastructures, which in turn means different levels of vulnerability to climate related risks (UNDP, 2011; Alebachew, 2011; Morrow, 2008; Enarson, 2007).

Items	M	F	No.	
			Total	(%)
Sex	150	30	180	100
<i>Age</i>				
30-40	48	11	59	32.8
41-60	69	18	87	48.3
>60	33	1	34	18.9
<i>Educ. level</i>				
Illiterate	136	30	166	92.25
1-4	10	1	11	6.7
5-8	2	0	2	1.1
9-10	1	0	1	0.6
<i>Annual income from the livestock sector</i>				
US\$50-150	28	8	36	20
US\$151-250	35	12	47	26.1
US\$251-350	44	7	51	28.3
US\$351-450	6	2	8	4.4
US\$451-550	8	0	8	4.4
US\$551-650	15	0	15	8.3
US\$651-750	7	1	8	4.4
>US\$750	7	0	7	3.9
Average family size			6.8	
Average age of the respondent			50	
Average livestock number			11.9	
Average annual income from the livestock sector			US\$435.5	

Table II.
Pastoralists'
socio-economic and
demographic
characteristics

5. Pastoralists perceptions of the climatic variability and its impact on the prevalence of livestock diseases

The majority of participants (78 per cent) perceived the increasing trend of indicators of temperature from time to time in their localities. As depicted in Table III, participants felt the highest temperature increase during the hot dry season followed by the main rainy season. During FGD and key informant interview sessions, participants underscored the increase in temperatures during the day and night time in all seasons. The result is consistent with annual and seasonal minimum and maximum temperature meteorological data analysis (Figures 4-6). Pastoralists perception of the increasing trend of annual and seasonal temperatures are supported by previous researchers (Ayal and Muluneh, 2014; Alebachew, 2011; Woldeamlak, 2012).

The majority of respondents perceived that seasonal and annual rainfall amount and number of rainy days has been decreasing, while drought frequency and severity increased from time to time in their localities. Likewise, Table III illustrates that most of the respondents observed seasonal and annual rainfall distribution were erratic in its onset and cessation. The perceived reduction of seasonal and annual rainfall volume and erratic behavior of rainfall distribution matches with the instrumental record (Figures 2-3 and Table I). Except for the three decade aggregated small rainy season record, our result is divergent with previous findings (Woldeamlak, 2012; Slegers, 2008; Meze-Hausken, 2004) which stated that the local peoples' perception of the trends of rainfall is not in agreement with instrumental record. The sampled households' perceptions about the volume and timing of annual and seasonal rainfall, annual and seasonal minimum and maximum temperatures and impact on the prevalence of livestock disease are consistent with FGD and key informants observation.

In general, the majority of respondents are aware about the existence of climate variability. They explain their experience on climate variability using the rising of seasonal and annual temperature, reduction of the volume of annual and seasonal rainfall, increment of drought frequency and severity. FGD and key informants underscored the changing climatic conditions in their localities particularly in the last two decades, which in part triggered the proliferation of

Item	Mean scores
<i>Perception of temperature variability</i>	
Temperature increases	4
Hot dry season temperature increased	4.7
Cool dry season temperature increased	3.6
Main rainy seasons temperature increased	4.1
Small rainy season temperature increased	3.1
<i>Temperature mean</i>	3.9
<i>Perception of rainfall variability</i>	
Rainfall amount decreases	4.4
The onset of rainfall becomes more unpredictable	4.7
The cessation of rainfall become more unpredictable	4.5
Number of main rainy season days decreased	4.2
Number of small rainy season days decreased	2.6
Drought occurrence frequency increase	4.5
Drought severity increase	4.4
<i>Rainfall mean</i>	4.2
<i>Grand mean</i>	4.1

Table III.
Mean score of
pastoralists'
perception of climate
variability indicators

livestock diseases. Due to the changing climatic condition, the scale of diseases prevalence and its adverse impact is increasing. New livestock disease types have also emerged in their localities. Our finding reinforces Ogalleh's *et al.* (2012) report that local people usually express their perception of climate variability in light of observed impacts on their livelihood. As Hope (2009) observed, climate disturbance increases the prevalence of vector borne diseases and creates favorable conditions for the vector breeding and new transmission of disease. For instance, Coenurosis is reported as a newly emerged disease which affects the brain of goats in the study sites; it is prevalent in wet and dry seasons. Key informants explained that more frequent drought, rising temperature, reduction in the volume of rainfall and the unpredictability in the onset and cessation of rainfall coupled with non-climate stressors such as population pressure, rangeland deterioration and weakening of traditional rangeland management system; remain responsible factors for depletion of water and pasture resources in the study sites. The cumulative effect is mass death of livestock because the conditions create favorable condition for vectors. This in turn debilitates the physical condition of livestock due to water and pasture shortage.

6. The prevalence of livestock diseases in the study area

Climate variability and extreme events have a profound effect on livestock diseases and the well-being of the pastoralists. Increasing temperature and changes in the behavior of rainfall lead to changes in the spatial and or temporal distribution of climate-change sensitive livestock diseases. Sample households, key informants and FGD participants were asked to rank common livestock diseases in their localities. Accordingly, Coenurosis, PPR, CBPP, camel sudden death, Tick and FMD were listed as the most frequent and were reported to cause mass death of livestock in Dikale. The prevalence of Coenurosis and CCPP has increased particularly during the past decade. Relatively, the prevalence of LSD was less than the other livestock disease types. There were variations from place to place in Alona Diarrhea followed by FMD, trypanosomiasis, sudden death, coenurosis, black leg, anthrax and tick infection were the most prevalent livestock diseases. In addition to the above top eight livestock diseases, the study site pastoralists' livestock were affected by diseases such as Salmonellosis, liver diseases, Tumma, bleeding and bloating.

Table IV demonstrates a summary of livestock diseases, their local name and prevalence period as described by pastoralists. As depicted in Figures 1-6, the trends and variability of annual and seasonal temperature and rainfall have created favorable condition for the proliferation of vectors, pathogens and parasites and hence the incidence and distribution of livestock diseases. FGD and key informants underscored that most of the livestock diseases are highly sensitive to seasonal temperature and rainfall extremes. For instance, they observed that the increased incidence and distribution of livestock diseases such as Trypanosomiasis is attributable to high temperature, while extended dryness creates conducive environment for diseases such as Anthrax and black leg. Their observation matches with the scientific view that higher temperature has the effect of increasing the occurrence and distribution of livestock diseases by intensifying vector activities (Baylis and Githeko, 2006).

On the other hand, the high mobility of livestock caused by shortage of pasture and water aggravates the spread of contagious diseases, such as bovine pleuropneumonia, Pasteurellosis and camel respiratory complex disease, due to contact between animals from different regions, including wild animals. Moreover, the livestock in the study area are exposed to emergent disease, e.g. Coenurosis which previously was only confined to Tsemaco area (Taffese and Samson, 2009). In times of pasture abundance, animals avoid eating poisonous grass species. However, during drought, due to scarcity

No.	Livestock disease		Type of livestock affected	Livestock disease occurrences as described by FGD participants and key informants
	Scientific name	Local name		
1	Foot and Mouth Disease*	Ooyyalee	Cattle	It occurred in dry and wet seasons. It affects all age groups
2	Black leg*	Harkaa	Cattle, sheep, goat	Its pervasive time is rainy season when adequate pasture is available and cattle are in good body condition. It is soil born in dry season. It affects all age group
3	Anthrax*	Citaa	Cattle, equine	Soil born in dry season and affect all age groups
4	Contagious Caprine Pleuropneumonia (CCPP)*	Sombeessa Re'ee	Sheep and goats	Outbreaks of the disease often occur after heavy rains, after cold spells or after transportation over long distances. All age group are sensitive
5	Coenurosis *	Sirgoo	Goats	It happens in dry and wet seasons. All age group are sensitive
6	Sudden death		Cattle and camel	Extended dry years are more conducive for the outbreak of the disease. It is newly emerged and most killer diseases in the study site
7	CBPP		All	Its prevalence time is both dry and wet seasons
8	Trypanosomiasis*	Dhukkaanaa	Cattle and Camel	Frequently occurs and favored by high temperature. Its abundance is very high especially at fly pick season i.e. immediately after wet season. It affects only the adult cattle and all age groups camel
9	Ticks*	Silmii	All	It occurs in all year round but its burden increases during rainy season and cool dry season. In the area cattle are the most vulnerable that the rest livestock species. Common in early wet season, ticks usually occur in brushy pastures and woodlands
10	Lumpy Skin Disease (LSD)*	Suukii	All	Its prevalence time is both dry and wet seasons. It is the list prevail disease. Its effect is high on the cattle. Affect all age groups

Table IV.
Summary of livestock diseases, their local name and prevalence period as described by pastoralists in Dikale and Alona

of feed and hunger, grazing animals are forced to consume poisonous plants, exposing themselves to Phyto-poison. Moreover, due to the increasingly deteriorating conditions of the rangeland, grazing on degraded pasture can expose the animals to the risk of soil-borne bacterial diseases. In fact, the problem was experienced in the study area during 1997, 2005 and 2010.

The livestock diseases severity and prevalence was reported to increase during periods of stress, particularly drought-induced problems such as lack of water and pasture. The livestock diseases seasonal prevalence rate and level of severity was identified with the help of participants as illustrated in Table V. Participants observed that the severity of all livestock diseases was high during the hot dry season (*Bonna*) except Bloat. The prevalence rate and severity of Coenurosis, PPR, CCPP, trypanosomiasis, diarrhoea and sudden death were also high during *Bonna* and cold dry season (*Adolessa*). Unlike other livestock diseases, the severity of tick was medium during the main rainy (*Ganna*), *Adolessa* and

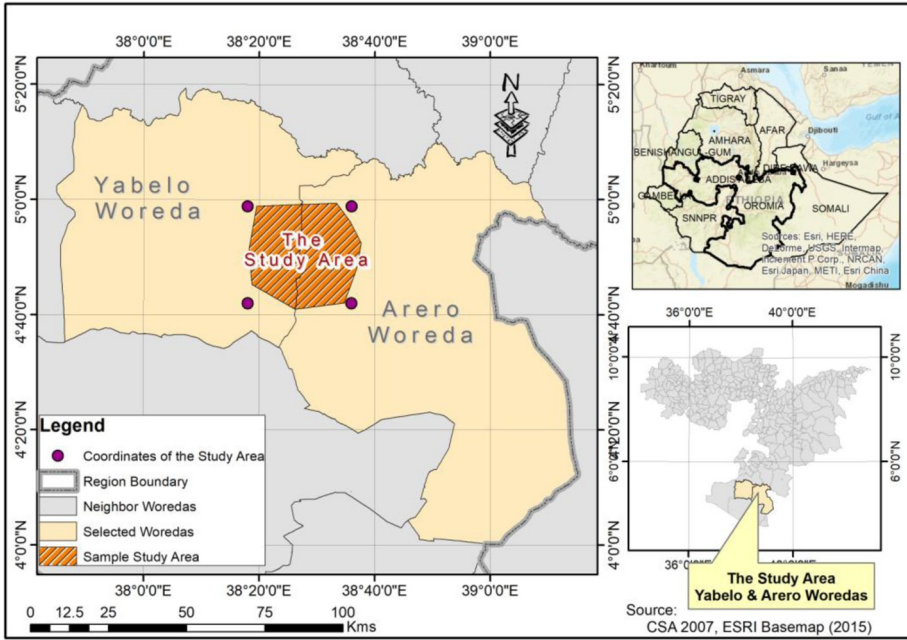


Figure 1. Study area map

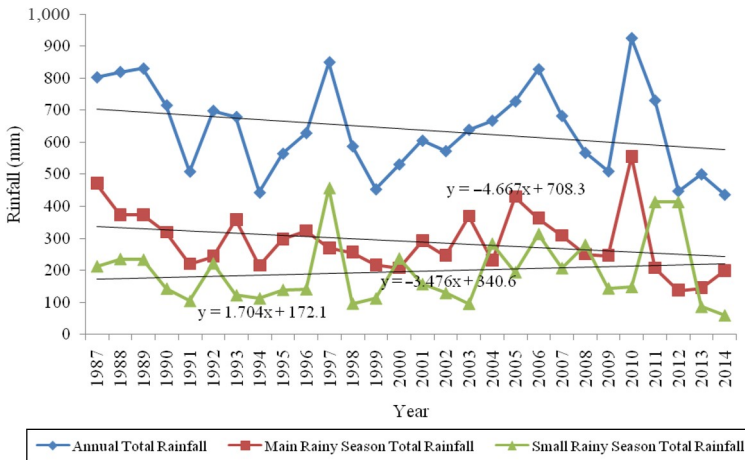


Figure 2. Trends of annual and seasonal rainfall, 1987-2014

Bonna seasons. In general, the type, severity and impact of livestock diseases vary from season to season.

In conclusion, the local people understand the type, seasonality and prevalence of old and newly emerging diseases acute during the drought period. The livestock diseases attain acute prevalence during the dry season, while the lowest incidence was observed during the

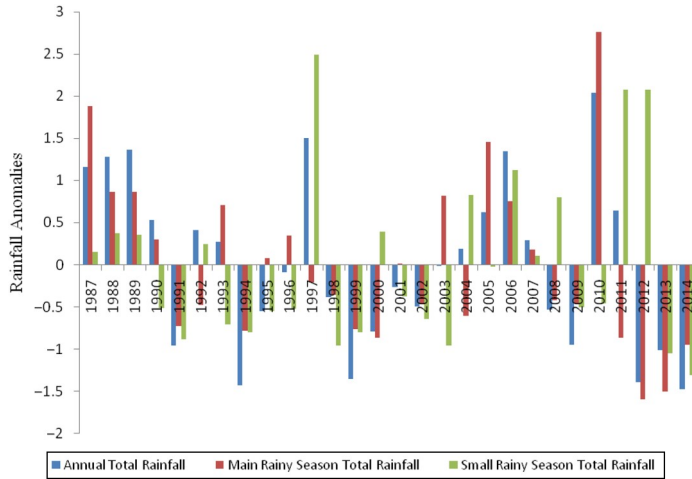


Figure 3.
Rainfall anomalies
(1987-2014)

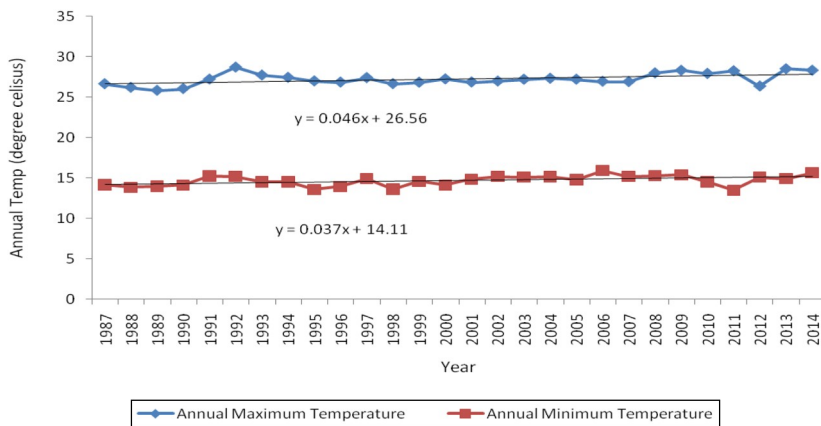


Figure 4.
Trends of maximum
and minimum
temperature
(1987-2104)

wet season (Table V). This shows that the occurrence and catastrophic impact of old and emerging livestock diseases is mostly felt during times of moisture stress and shortage of feed. The disappearance of medicinal plants especially during the dry season and drought time further worsens the impact of the prevailing livestock diseases. The relative vulnerability of livestock to climate extremes and concomitant prevalence of livestock diseases is shown in Table VI.

7. Retrospective livestock health survey

Data were collected from veterinary clinic records of the area for the period between 2006/2007 and 2015/2016. This was to determine the more prevalent climate change sensitive livestock diseases in the past 10 years.

The death toll on livestock brought about by the above diseases has been critical. The exaction of diseases on cattle and shoat was far more than the case

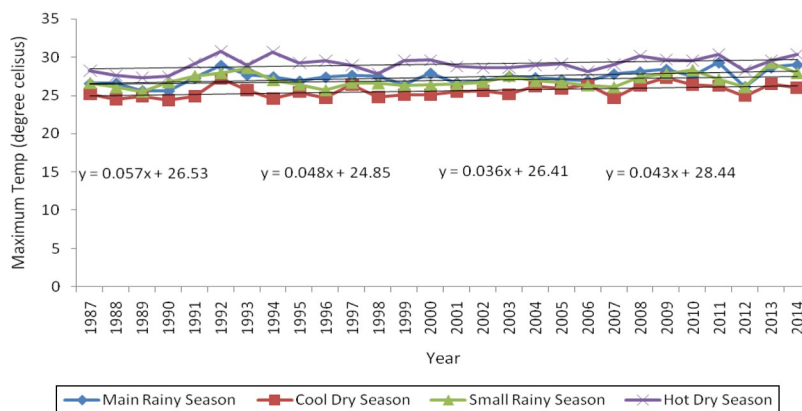


Figure 5. Trends of seasonal maximum temperatures (1987-2014)

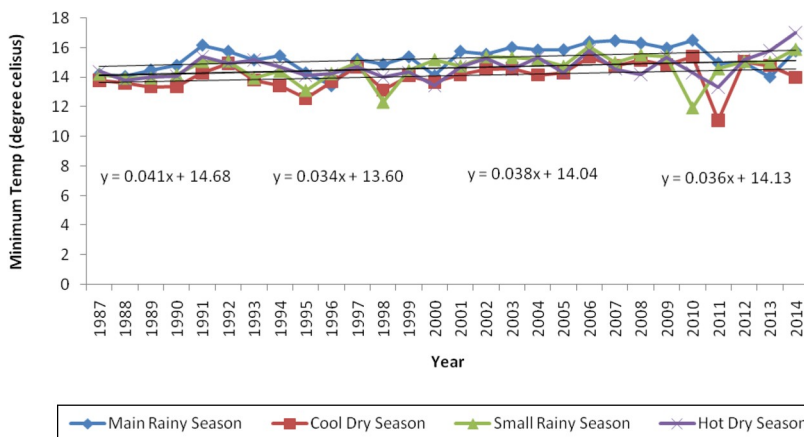


Figure 6. Trends of seasonal minimum temperatures (1987-2014)

of equine and camel (Table VI). Because the Borena mostly relies on cattle, the economic loss caused by the death of 1637 cattle is self-evident. As can be learnt from a retrospective study of the summery of clinic record at the Yabello Zonal Livestock Laboratory Center, despite the occurrence of more number of diseases attacking camels and equines compared to cattle diseases, the camel and equine population suffered relatively lower causality (Table VI). Economically, loss of livestock deprives pastoralists of their primary assets. The remaining livestock due to poor physical conditions will reduced milk productivity and low market demand. Drought further depletes the livestock population by impacting growth and reproductive rates. Consequently, a once better-off household turns poor and destitute, thereby resorting to charcoal trade and sedentary agriculture and aggravating rangeland deterioration.

Annually reported livestock disease types in Yabello and Arero districts during the past 10 years to Yabello laboratory center were summarized in Table VII. As discussed in the above sections, almost all reported livestock diseases are climate sensitive and

Table V.
Summary of participants' responses on the severity and prevalence of livestock diseases in different season

Disease types	Severity of diseases during different seasons			
	Ganna	Adolessaa	Hagayaa	Bonna
CCPP	*	****	**	****
Coenurosis	****	****	***	****
Sudden death	*	****	**	****
CBPP	*	****	**	****
FMD	*	***	**	****
Salmonellosis	*	***	**	****
Bloat	****	*	****	*
Tick	***	****	**	****
PPR	***	****	**	****
LSD	**	*	*	****
Diarrhoea	***	*	*	****
MCF	***	*	*	****
Trypanosomiasis	****	*	**	****

Notes: **** = High; *** = Medium; ** = Moderate; * = Low

Table VI.
Comparative impact of disease on livestock in 2014

Districts	Livestock type							
	Total	Cattle No. of death	Total	Shoat No. of death	Total	Camel No. of death	Total	Equine No. of death
Alona	28,000	439	20,000	2,076	700	32	1,394	0
Dikale	23,800	1,198	19,000	2,385	800	127	1,480	0
Total	51,800	1,637	39,000	4,461	1,500	159	2,874	0

Table VII.
Summary of the veterinary record on the major health problems during the last 10 years (2006/2007-2015/2016)

Cattle disease	Camel disease	Shoats disease	Equine disease
Blackleg**	Respiratory complexisease**	CCPP**	AHS
CBPP**	Coughing**	Coenurosis**	Pneumonia**
Pasteurellosis**	Trypanosomosis**	General septicemia**	Bone illness**
Trypanosomiasis**	Caseous lymph adenitis**	Diarrhoea**	Epizootic**
LSD**	Hemorrhagic septicemia**	Foot-and-Mouth Disease (FMD)**	Cancer**
Ticks**	Camel pox**	Mange mite**	Rectal prolapse**
Cowdriosis/heart water**	Nervousness**	Foot rot**	Phyto-poison (Poisoning plant)**
Liver disease (diseases that affect liver)**	Wry neck syndrome**	Orf (Contagious ecthyma)**	
Anthrax**	Lameness**	Peste-des petits ruminants**	
	Abscess**	Sheep or goat pox**	

Note: ** Annually reported for the past 10 years

become severe during the occurrence of climate extremes such as drought and extended dryness.

8. Local responses to impact of livestock diseases

Pastoralists' used various direct and indirect responses to cope with old and newly emerging livestock diseases. Use of traditional medicine (branding, plants), vaccination, buying medicine from private sources, isolating sick livestock, strengthening enclosure, diversifying livestock types, diversify livelihood, destocking and risk sharing in their decreasing order.

8.1 Traditional medicine

The Borena herders treat livestock using traditional medicine which is said to be preferred to modern veterinary solution. Traditional veterinarians claim able to effectively treat livestock diseases (Black leg, FMD, CCPP, Pasteurellosis, Cowdriosis/Heart water, bovine) using various plant roots, leaves and burning (blotting) the swollen part. Informants even held that diseases that could not be treated with repeated modern medication were easily treated with traditional medicine. The diseases, however, being prevalent during drought, are hardly treated for lack of medicinal plants. Besides, the effectiveness of traditional medicine or its experts has been decreasing, possibly due to adaptation of diseases to traditional medicine and the disappearance of medicinal root plants caused by rangeland degradation. However, traditional veterinary experts have no idea of treating emerging livestock diseases.

8.2 Government veterinary services

The government has established veterinary centers in both study sites to eradicate livestock diseases and enhance the community adaptive capacity. However, the government veterinary centers in Alona and Dikale have not been giving service over the past two years due to the absence of veterinary drugs. Experts complain that the government has not given attention to the livestock sector in general and pastoral community in particular. Thus, government veterinary centers are devoid of medicine storage infrastructures and facilities (e.g. store, different size refrigerators, electricity/generator, etc.), laboratory equipment and facilities and logistic. These factors made unable to provide timely, effective and efficient intervention against disease outbreak.

8.3 Vaccination

The government has regular livestock vaccination campaign. There is also experience of surveillance on the outbreak of livestock diseases. Lacking portable refrigerator to keep vaccines at room temperature coupled with poor logistic facility undermining vaccination programs. Zonal medicine stores keep vaccine medicines in a room without proper temperature conditions and protection against termites and rats. The largest cold room in Yabello is not functional for the past three years due to maintenance problem. The absence of refrigerator could have adverse effect on the quality and effectiveness of vaccine. Some vaccines such as FMD, PPR, LSD, SGP should be kept at -21°C . It is crucial to establish infrastructure such as solar power and different size refrigerator. There is an also poor functional linkage between the NGOs (who usually have financial resources) and the government veterinary/laboratory technicians. The zonal administration needs to work closely with local and international NGOs to ensure that the veterinary laboratories are equipped well with a reliable power sources, and remain functional.

8.4 Buying veterinary drugs from private vendors

Private drug stores and illegal markets are the two major source of livestock drug for pastoralists. In the study area, where there is no government veterinary service provision, pastoralists attempt to mitigate the challenge by buying modern drug at private drug stores. The price of these drugs is high and unregulated, and at times the drugs are past their expiry date. The majority of pastoralists who cannot read and write are liable to buy the expired drugs and at a high cost. Purchasing high-cost drugs frustrates poor pastoralists.

8.5 Isolating sick livestock

Pastoralists practiced isolation of sick livestock to avoid wide transmission of diseases to the healthy.

8.6 Strengthening enclosure

This helps to minimize the risk of livestock diseases transmission from the neighboring locality and also increases the resistance of livestock for the diseases.

8.7 Livestock type diversification

Livestock species vary in their different production characteristics and abilities to handle stresses related to nutrient deprivation, climate change and diseases (Western and Finch, 1986). The Borena pastoralists keep various types of livestock species, including cattle, goats, sheep, camels and donkeys. To the Borena pastoralists, maintaining diversified herd has many purposes, and one of these is its contribution to climate change. Herd species diversification also reduces risk associated with different diseases. Participants underscored that all livestock are not equally sensitive for various diseases and pests. Diverse herds also enable them to use different ecological niches and enhance the ecological services. Various species also have different production attributes. While the camels give income value in addition to milk, goats due to their rapid reproduction rate can recover quickly post-drought. Cattle, over and above their economic value, also give prestige and social status in Borena communities. Participants' explained that recently, the number of camels have increased because of the camel's high market value and drought-resilient.

8.8 Risk sharing

Pastoralist communities have well-established risk sharing experience (Webb *et al.*, 1992; Messer, 1989). Risk sharing experience could contribute for quick recovery and increase motivation to take action (Ayal and Muluneh, 2014). Social bond through collective action appears high during the initial stage of the shock and decline under prolonged stress. Thought, the declining of the Borena risk sharing experience has been reported, participants mentioned as one response to the impact of old and newly emerged diseases. In Borena, pastoralists who lost their livestock by direct and indirect impact of drought sought support from clan members, relatives and friends. The support *Busa Gonofa* could be in the form of livestock transfers in the case of clans, or sharing milk herds in the case of friends and relatives.

8.9 Livelihood diversification

Pastoralists in livestock trading, crop production, real estate, etc., use livelihood diversification strategy that reduces the nature of vulnerability to climate-related risks (Devereux, 2000). Participants explained that income from different sources enable them to buy medicine for their livestock.

8.10 Destocking

Pastoralists observed that the number of cattle at household level has decreased. Although the best bet for pastoralists is to sell animals during normal marketing, when climate extremes begin to hit, they engage in commercial emergency destocking, thus helping them salvage all they can before the animal dies. Such action of reducing livestock number helps manage climate-related risks.

9. Conclusions

Pastoralists' perceptions about the trends and variability of annual and seasonal rainfall and temperature were consistent with meteorological records. The extent of temperature increase and rainfall decrease is higher than the national average. As a result, pastoralists in Borena have found it difficult to sustain their livestock-based livelihood for the reasons that the current climate situation favors the prevalence and increasing severity of livestock diseases and on the top poverty is structurally well entrenched. The problem of pastoralists' *vis-à-vis* climate variability and its attendant adverse consequences is not due to lack of awareness. However, effective and efficient responses to the livestock diseases have been constrained by services and facilities, buying ability of the ever-rising medicinal prices and disappearance and less effectiveness of traditional medicines. Even though, pastoralists were not passive victims, currently practiced coping and adaptation practices are found far from instrumental to the realization of the desired outcome, fast economic growth and development. At this moment, neither traditional medicine nor modern veterinary services could mitigate the harm the Borena pastoralists are suffering. More intensive and broad effort should be made to develop a typology of emerging livestock diseases and tackle them. Animal health programs need to integrate efforts with climate change and environmental rehabilitation institutions to check pastoralist victimization by drought and drought-induced livestock diseases.

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