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Contribution of Indigenous Knowledge to Climate Change and Adaptation Response in Southern Ethiopia

Teshome Abate*

School of Animal and Range Sciences, Hawassa University, Ethiopia

Abstract

The role of indigenous knowledge of pastoralists 'on climate change and adaptation response has been given less emphasis. This study was conducted to explore pastoralist's perception of climate change, its impacts, copping and adaption response in southern Ethiopia. The data were gathered through a multi-stage sampling process, a total of 211 households in three pastoral and agro-pastoral districts were selected and interviewed use of structured questionnaire, and key informants. A long-term (1986-2014) rainfall and temperature were analyzed use of Standardized Precipitation Index (SPI), Precipitation Concentration Index (PCI) and Mann-Kendall trend test. The study shows pastoralists' recognized the changes in climate and described use of many local indicators. Both household and empirical climate records indict a declining in rainfall amount, and an increasing in drought frequency. The changes in climate had led to recurrent drought, feed scarcity, crop failure and low yields leading to food insecurity were among other effects. Pastoralists' have many adaptation responses to climate change generally involved in adjusting of crop production strategies, grazing and herd management practices, shifting to non-pastoral livelihoods activities and use of social supporting system. The study shows communities' had a set of coping strategies frequent sale of livestock found be the primary responses. The study concludes pastoralists' had a many innovative adaptation responses and practices, integration of local knowledge and scientific should have a potential to limit the negative effects of climate change as well as to look at an alternative adaptation strategies.

Keywords: Adaptive capacity; Climate variability; Climate change; Drought; Guji

Introduction

Climate change has become a serious challenge across the world. The challenges have more serious in the developing countries like East Africa countries [1]. In East Africa, climate variability and change is linked to declining rainfall patterns, increased drought frequencies [2], floods, and extreme temperatures [3]. The changing patterns of climatic events in particular uneven distribution of rainfall and recurrent droughts have adversely affected the pastoralists and their dryland [4]. A studies by [5,6] have shown that dryland communities, especially pastoralists are vulnerable to climate-induced stresses due to their low adaptive capacity, over dependence on climate-sensitive livelihood activities and less resilient production environments [7,8]. The dryland of Ethiopia cover about 60% of the landmass of the country [9]. Pastoralism and agro-pastoralism is the dominant land use system where extensive livestock production is the main livelihood of the communities. In recent years, however, extreme climatic events attributed to drought-induced livestock mortality, food insecurity, poverty and putting enormous pressure on the livelihoods of the pastoralists [10,11].

Climate change has been reported as a major challenge to livestock production in the pastoral system through their impacts on forage production, water availability, disease risks and thermal stresses [12,13]. Consequently, causing declining in livestock production. Among the factors that amplify the effects of climate change droughts are perhaps as the most crucial as they adversely affect pastoral livestock production [14]. Droughts have frequently affected Guji-Borana pastoralists of southern Ethiopia, causing substantial livestock losses, declining agricultural production, and food insecurity [11].

A range of climate prediction models by [15] have shown that Ethiopia expects a 2°C to 4°C increase in temperature and 10% to 30% increase in precipitation by the end of the century. Use of a large-scale climate trends do not necessarily shows local conditions and has failed to address the local impacts, as well as capability of local communities' adaption to climate change [16]. Hence, understanding the perception of pastoralists' on climate change and adaptation response at local level is vital. Furthermore, the adaptive mechanisms suggested by the policy makers based on model output may not often favorable to the local communities' as it lacks the local and/or traditional human and ecological knowledge. This basic information of the pastoralist' that has been acquired through extensive observation and practices may easily match with time, location and cultural diversity of the people. This in turn helps the pastoralists better understand the climate change implications and respond to adverse effects strategically [17-19].

Pastoral communities have a traditional knowledge about their environment and have been implementing various adaption measures to cope with climate related risks [20-22]. Studies [23-25] have suggested that understand local climate knowledge of communities' can be valuable for decision-making processes. Additionally, traditional knowledge may provide new insights for improving existing scientific knowledge and a basis for designing appropriate research and development policies. Despite the existence of these knowledge researchers and development policy experts have given less emphasis to the adaptive mechanisms of pastoralists. Furthermore, the potential importance of local practices in enhancing socio-ecological resilience

***Corresponding author:** Teshome Abate, School of Animal and Range Sciences, Hawassa University, Ethiopia, Tel: 251915855551, Fax: 2510463312674; E-mail: teshome_abate@yahoo.com

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has been underestimated particularly in pastoral production system of Ethiopia including the Guji pastoral and agro-pastoral areas.

The Guji pastoral and agro-pastoral system inhabits large parts of the southern Ethiopia. The communities predominantly pastoralists and agro-pastoralists where livelihood is mainly dependent on livestock production. Until, 1980, the rangelands were in good condition and the production system was viewed as one of the most productive in East Africa [26]. In recent years, however, extreme climatic events (e.g. recurrent drought, and rainfall variability), attributed to food insecurity, poverty and exacerbate the existing vulnerability [27]. Therefore, this study aimed at exploring the communities' perception on climate variability, its effect, and adaptation responses in pastoral system.

Materials and Methods

Description of the study area

The study was conducted in three districts of Guji Zone in Oromia Regional State of south Ethiopia (Figure 1). The Guji zone bordered on the North with Gedeo and Sidama zone, on the South with Somali Regional state, on the East with Bale zone and on the West with Borena zone. The total land area of the zone is 18,577 square kilometers. The human population size of the Guji zone is estimated about 1,590,225 [28]. The zone lies within the altitude range of 700-3500 meter above sea level (m.a.s.l). The zone has 13 districts, out of these five were categorized as pastoral and agro-pastoral districts. This study was conducted in three neighboring districts of pastoral and agro-pastoral namely Wadera, Gorodola and Liben districts. The climate of pastoral and agro-pastoral region of Guji zone is mostly arid and semi-arid. The inter-annual rainfall was varied with an average annual rainfall of 526.75 mm. The rainfall pattern is bimodal the major season (*Gana*) which extend from March to May and received 60% of the annual rainfall, the minor season (*Hagaya*), which extend from September and November received 40% of the annual rainfall. The mean annual temperature range is 24°C to 30°C [29]. Drought is common in the study area every five to ten years. The Guji Oromo are numerically the dominant ethnic group in the study area living in peaceful coexistence with other ethnic groups. The main livelihood system in the area is pastoral and agro pastoral where the communities are predominantly dependent on livestock production and in some area's agriculture. They are predominantly pastoralists, agro pastoralists and farmers. The Guji and Borena communities had a well-established indigenous system in the management of grazing lands and other natural resources. Furthermore, they had an organized social institution the 'Gada' system (Figure 1).

Methodological approach

Data were gathered using a multiple visit formal survey method [30,31]. Prior to the actual survey, visits were made to the districts and secondary information relevant to the study was gathered. Informal surveys and group discussions were made to gather information about the districts and to get insights from community members who were directly or indirectly involved in the production system. Group discussions were held with key informants, development agents and district agricultural officers. A structured questionnaire was designed to obtain data on household demography characteristics, climate change indictors, impacts, adaption and copping strategies. The questionnaire included both closed (single response) and open (multiple responses) questions. We define adaptations as adjustments in ecological, social, or economic systems in response to actual or/and expected climatic stimuli and their effects or impact, as well as to the changes in processes, practices, and structures to moderate potential damages and/or to benefit from opportunities associated with climate change [16]. Adaptations are of longer-term in nature [32]. Coping strategies, on the other hand, consist of household practices used as short term measures when confronted with unexpected events such as droughts [32,33]. A pre-test of the questionnaire was made before the actual data collection, and appropriate modifications and corrections were made. Interviewers were recruited and trained in an attempt to improve the accuracy of answers to questions. Out of five pastoral and agro-pastoral districts of the zone, three districts (e.g. Wadera, Gorodola and Liben) were purposely selected. In each district, representative Pastoral Associations (PAs) were purposely selected based on accessibility, representativeness of grazing land, livestock potential, crop cultivation potential, agro-ecologies, drought condition and food security status. A total of 211 households head (HH) that consists of 91 households from Wadera district, 60 households from Gorodola and 60 households from Liben district were randomly selected and interviewed. Furthermore, to understand the communities' perception a long-term daily rainfall, minimum and maximum temperature data were gathered from the Ethiopia National Metrological Agency (ENMA) for Liben district [Negele Borena station, (1985-2015)] and only daily rainfall data of Wadera district (1986-2007). Time series of rainfall data were summarized as rainy days, monthly, seasonal, annual, and decadal averages for comparison. A rainy day is defined as a day with at least 1 mm of precipitation. Annual and seasonal rainfall variability was determined use of Standardized Precipitation Index (SPI), Precipitation Concentration Index (PCI), coefficient of variation and rainfall trend analysis [34,35]. Standardized Precipitation Index (SPI) was calculated as the difference between the annual total of a particular year and the long term average rainfall records divided by the standard deviation of the long term data.

$$SPI = \left(X - \frac{\sum_{i=1}^{3} P_i^2}{\left(\sum_{i=1}^{3} p_i\right)^2} \times 25\right) / s,$$

Where X *is* the annual average, while $\bar{x}$ and s is the long-term mean and standard deviation, respectively [36].

This index used to examine the nature of the trends, and to determine the drought and wet years in the record. Annual rainfall variability was assessed by the coefficient of variation (CV) as $CV = 100(s / \bar{x})$. Precipitation Concentration Index (PCI) was calculated as was proposed by Oliver in 1980 [37]. Precipitation Concentration

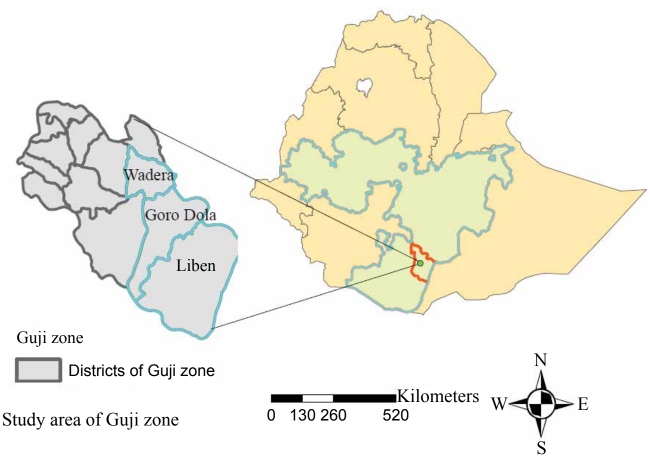

Figure 1: Map of the study areas in Guji zone of south Ethiopia.

Index (PCI) was calculated use the following equations for annual and seasonal scale.

$$\text{PCI annual} = \frac{\sum_{i=1}^{12} P_i^2}{\left(\sum_{i=1}^{12} p_i\right)^2} \times 100$$

Where pi is the monthly precipitation in month i.

$$\text{PCI seasonal} = \frac{\sum_{i=1}^{3} P_i^2}{\left(\sum_{i=1}^{3} p_i\right)^2} \times 25$$

This index gives the advantage of getting information on the long-term variability of the precipitations within the yearly, monthly and seasonal regime [38,39]. The values index ranges from 8.3 to 100. For PCI values below 10, there is uniform monthly precipitation distribution over the year variability in precipitation amounts. Values from 11 to 15 denote a moderate seasonality in precipitation distribution, and PCI values from 16 to 20 denote a seasonal distribution. Values above 20 correspond to climates with substantial monthly variability in precipitation amounts [40]. Trend analyses of rainfall and temperature data were carried out use of nonparametric Mann-Kendall (MK) test for a monotonic trend [41]. The slopes were estimated using Theil-Sen's equation [42]. The trend statistical analysis was carried out in [43]. Furthermore, time series of mean, minimum and maximum temperature data were summarized as monthly, standardized temperature anormality and trend analyses was determined. The collected household data were summarised and analysed using Statistical Package for the Social Sciences (SPSS, Version 19, 1996) [44].

Results

Household demographic characteristics

The survey shown that an average family size of study area of 10.4 ± 7.0 (± SD) people. Of the total respondents, 10.4% were female headed households and the remaining were male as males were the head of the family and strong cultural practice prevented females responding on behalf of the family. Among the total respondents, 71.6% were Guji ethnic group followed by the Borena (16.1%) the remaining were Arsi (7.6%), Somali (0.5%) and others (4.3%). The mean age of respondents was 45.2 ± 11.4 years with the age range of 26-88 years. Among respondents 46.4% had no formal education with only 5.7% of respondents being educated past 8th grade.

Pastoralists perception on local indictor and impact of climate change

Local communities'percived climate change as environmental change locally described as *qilenssaa jijjirame*. The local indicators to explain climate variability is presented in Table 1. The majority of respondents (56.9%) perceived amount, pattern and unpredictable (e.g. onset, cessation time of rainfall and length of crop growing days) of rainfall had declining over the past 40 years. However, most respondents indicated an increased in occurrence of drought (82.5%), temperature (79.1%) described in warming days, and dry spell. Furthermore, most respondents indicated the increase of strong wind (46.0%) with a lot of dust in the air, incidence of frost (27.8%) and flood (20.5%) were increased (Table 1). Local communities' recognise occurrence of drought as when there is no rain during the main rainy season (March-May), or below-average of both the short and the long rains. In three sample districts, respondents reported drought had the primary indicator for changing of climate. However, some respondent's failure to give response on the incidence of strong wind (28.4%), frost (20.3%) and flood (42.5%) as climate change indicators (Table 1). The effect of climate change is presented in Table 2. The influences of climate change had varied among the study districts. Majority of respondents (66%) indicated drought had an adverse effect

Variables	Status	Wadera %	Gorodol %	Liben %	Mean %
Rainfall status (Include rainfall amount, onset, cessation and length of growing period)	Increase	27.5	20	40	28.9
	Decrease	70	48.3	45	56.9
	No change	2.2	3.3	0	1.9
	I don't known	0	28.3	15	12.3
Incidence of drought	Increase	84.6	88.3	73.3	82.5
	Decrease	12.1	11.7	10	11.4
	No change	3.3	0	0	1.4
	I don't known	0	0	16.7	4.7
Temperature	Increase	75.8	70	93.3	79.1
	Decrease	19.8	16.7	0	13.3
	No change	4.4	0	0	1.9
	I don't known	0	13.3	6.7	5.7
Incidence of frost	Increase	43.3	10	28.3	27.8
	Decrease	40.3	75	8.3	41.2
	No change	16.4	15	0	10.7
	I don't known	0	0	63.3	20.3
Incidence of strong wind	Increase	37.4	63.3	42	46
	Decrease	33	21.7	0	20.4
	No change	2.2	15	0	5.2
	I don't known	27.5	0	58.3	28.4
Incidence of flood	Increase	6.6	30	42	20.5
	Decrease	46.2	65	23.3	9.3
	No change	0	0	0	0
	I don't known	47.3	5	35	42.4

Table 1: Local indicators used to describe climate change in Guji zone of South Ethiopia (n=211).

Parameters	Wadera %	Gorodola %	Liben %	Mean %
Recurrent droughts (rainfall)	42.9 [1]	85 [1]	83.3 [1]	66.4 [1]
Incidence of crop disease	3.3 [10]	2.3 [7]	15 [11]	5.7 [9]
Incidence of food insecurity	19.8 [2]	21.7 [2]	11.7 [6]	0.9 [7]
Incidence of crop failure or poor harvest	26.4 [3]	6.7 [6]	30 [3]	25.1 [3]
Incidence of human disease	3.3 [9]	3.3 [10]	1.7 [12]	1.9 [11]
Incidence of livestock disease	24.2 [4]	8.3 [8]	25 [2]	23.2 [5]
Livestock death	24.2 [5]	8.3 [9]	11.7 [8]	10.9 [8]
Shortage of water for human and livestock	6.6 [6]	26.7 [3]	30 [4]	40 [6]
Shortage of forage for animals	20.9 [4]	36.7 [4]	15 [7]	26.5 [2]
Incidence of land dispute	2.2 [11]	3.3 [11]	31.7 [5]	2.4 [8]
Change in vegetation cover	5.5 [8]	2.3 [12]	1.7 [10]	24 [10]
Deforestation	5.5 [7]	48.3 [5]	15 [9]	15.2 [4]
Food aid	5.5 [13]	3.3 [13]	1.7 [13]	3.8 [12]

Table 2: Community perception on impact of climate variability in Guji zone of South Ethiopia (n=211).

on pastoral production led to declining of forage (26.5%), crop failure and poor harvest (25.1%), and deforestation (15.2%) were among the effects (Table 2).

Seasonal and annual rainfall and temperature variability

Table 3 is depicted rainfall amount, rainy days and coefficient of variability in the study districts. The study areas had a bimodal rainfall pattern, the majority of annual rainfall falling in long rainy season (*Gana*), which extend from March to May and Short rainy season (*Hagaya*), which extend from September and November. Wadera district had high mean annual rainfall amount (979.02 mm) and rainy days (86.41 days) than Liben district (Table 3). Annual and long season rainy days at Wadera in 65% of the studied period (13 years) had below the long term average. On contrary at Liben, over half of the studied period, annual, long and short season rainy days had above the long term average. Percent coefficient of variation shows mean total annual rainfall amount, rainy days seasonal and inter-decadal rainfall had high variability (Table 3). High decadal rainfall variability had occur in 1980's at Wadera (CV=39.0%) and in 1990's (CV=24.2%) at Liben than others (Table 3). Similarly, long season in 2000s' at Wadera (CV=38.3%) and 1990's at Liben (CV=36.2%) had high variability than others. Short rainy season in 1990s' at Wadera (CV=34.8%) and 2000s' at Liben (CV=45.3%) had extreme variability than others (Table 3). The Mann-Kendall trend had shows annual total rainfall amount at both districts shows a decreasing non-significant (P >0.05) trends (Table 4). Regarding to seasonality, rainfall amount in both long and short season at Wadera showed significantly (P<0.05) an increasing trends (Table 4). Furthermore, rain days in long season at Liben and short season at Wadera reveled significantly (P<0.05) an increasing trend (Table 4).

Standardized Precipitation Index (SPI) revealed over the studied period, 50% of them at Liben and 35% at Wadera of annual rainfall amount had below the long term average. Nearly half of the droughts events in Liben had manifest by sequential failures in the short and long rains whereas the remaining drought had occur either failure in long rainy (21%) or short rainy (29%) (Figure 2). Regarding to seasonality, the study showed both long and short rainy seasons had higher drough than wet years (Figure 2). These drought events had seriously affected the pastoral production system. Among a drought events that occurred in the region in 1998 and 1999 at Liben, and in 1999 and 2000 at Wadera were found to be the worst incidences.

The study areas had high monthly rainfall variability (e.g. CV of 92.6% at Wadera, and CV of 112.7% at Liben) and highest amount of rainfall had occurred in April in a long season and October in short

Variables measured	Wadera		Liben	
	Rainfall (mm)	CV %	Rainfall (mm)	CV %
Mean annual rainfall (mm)	979.0	19.8	646.6	23.5
Long rainy season (*Gana*) rainfall	473.4 (48.4%)	11.81	367.8 (56.9%)	12
Short rainy season (*Hagaya*) rainfall	378.2 (38.6%)	12.56	225.8 (34.9%)	13.5
Long dry season (*Bona*) rainfall	71.9 (7.3%)	97.7	31.9 (4.9%)	100.5
Short dry season (*Adolessa*) rainfall	55.6 (5.7%)	68.1	17.5 (2.7%)	82.4
Annual rainy days (day)	86.4	17.23	66.3	14.9
Long season rainy days (day)	35.2	26	32	21.1
Short season rainy days (day)	34.2	24.2	25.5	27.7
Decadal rainfall amount				
1980s' (mm)	1080	39	691.9	17.2
1990s (mm)	979	21.8	633.6	24.2
2000s' (mm)	911.7	17.7	657.8	17.8
2015s' (mm)	--	--	614.9	12
Decadal long rainy season (mm)				
1980s' (mm)	537.7	19.7	474.9	15.9
1990s (mm)	507.9	32.6	357.1	36.2
2000s' (mm)	372.9	38.3	376.2	33.4
2014s' (mm)	--	--	296.8	18.7
Decadal short rainy season (mm)				
1980s' (mm)	428.9	22.9	179	23.2
1990s' (mm)	341.6	34.8	213.6	41.5
2000s' (mm)	405.2	30.4	224.3	45.3
2014s' (mm)	--	--	274.7	27.4
CV: Coefficient of variability.				

Table 3: Mean annual, seasonal, decadal rainfall amount, rainy days, and coefficient of variation in southern Ethiopia.

Time series variables	Wadera		Liben	
	P value	Sen's slope estimate	P value	Sen's slope estimate
Annual rainfall amount (mm)	0.167	-2.66	0.173	-7.028
Long rainy season rainfall amount (mm)	0.030*	0.778	0.082	-5.335
Short rainy season rainfall amount (mm)	0.033*	3.042	0.487	0.896
Annual rainy days (days)	0.143	0.265	0.097	-1
Long season rainy days (days)	0.324	-0.074	0.046*	-0.716
Short season rainy days (days)	0.007*	0.333	0.461	0.087
Mean maximum temperature (0^c)	--	--	0.000**	0.053
Mean minimum temperature (0^c)	--	--	0.000**	0.069
Mean annual temperature (0^c)	--	--	0.000**	0.071
*: Significant (P<0.05); ** Significant (P<0.01).				

Table 4: Mann-Kendall trend and Sen's slope estimate for annual, seasonal rainfall and rainy days in southern Ethiopia.

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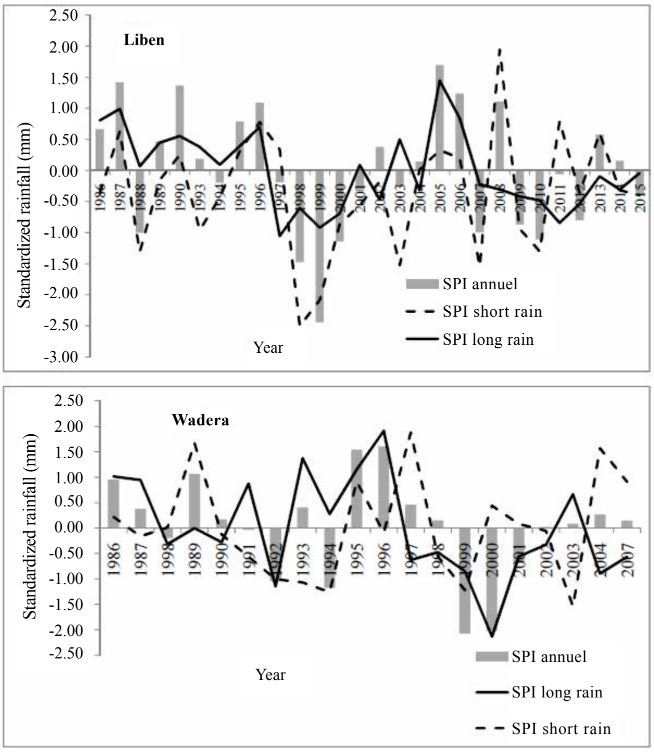

Figure 2: Standardized precipitation index for annual, long and short rainy season in Liben and Wadera districts of south Ethiopia.

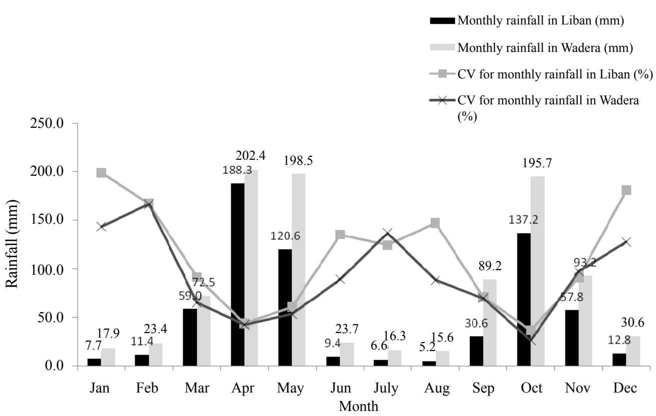

Figure 3: Monthly rainfall and coefficient of variation in Liben and Wadera districts of south Ethiopia.

rainy season (Figure 3). Furthermore, rain onset months for instance March for long and September for short season as well as rainfall cessation time (May for long and November for short rainy season) had extreme rainfall variability (Figure 3). This shows that rain onset and cessation time has variable.

Annual and seasonal Precipitation Concentration Index (PCI) values are presented in Figure 4. In general, mean annual PCI values was high at both districts and higher at Liben (23.3%) than Wadera district (19.77%), which shows there was inter annual precipitation variability (Figure 4). About 64.3% of annual PCI value at Liben had shows above 20 and the remaining 35.7% PCI values were between 16-20, which indicates the distribution of precipitation were an irregular and seasonal pattern. Regarding to seasonality, in study districts large proportion of PCI values in both seasons as well as annual rainy season had not show uniform precipitations distribution. At Liben only 39.2% in long rainy and 7.9% in short rainy season had PCI values under 11, which shows distribution of precipitations was uniform (Figure 4).

As depicted in Figure 5, the mean, maximum and minimum daily temperature of study area were 20.90°C, 26.32°C and 15.09°C, respectively. The highest mean monthly temperature was recorded in March while the lowest was in July. The standardized temperature anomalies indicated that among the studied periods (1985-2014) at Liben in about 66.67% of mean annual temperature had shown above the long-term average while the remaining 33.33% studied periods reveled below the normal average (Figure 6). Similarly, for about 21 years (77.78%) mean annual minimum and maximum temperature had above the long term average (Figure 6). Furthermore, the Mann-Kendall trend revealed that mean annual, minimum and maximum temperature showed significantly ($P<0.001$) an increasing trend (Table 4).

Aadaption and coping mechanisms of communities to climate change risks

Local communities' used a range of climate adaption strategies and their response is presented in Table 5 and Figure 7. Most respondents involved in adjustment in crop production practices. These practices include use of diversified crop varieties and expansion of farmland (72.8%), use early maturing and drought tolerance crop varieties and adjust agronomic practices (78.76%) include choices of crop varieties, altering planting date, use of minimum tillage, inter cropping, and use of input such as fertilizer. Local communities' diversify different crops use of small scale irrigation for producing of vegetables (mainly common at Wadera and Genale district of Liben), Today's, local communities shift

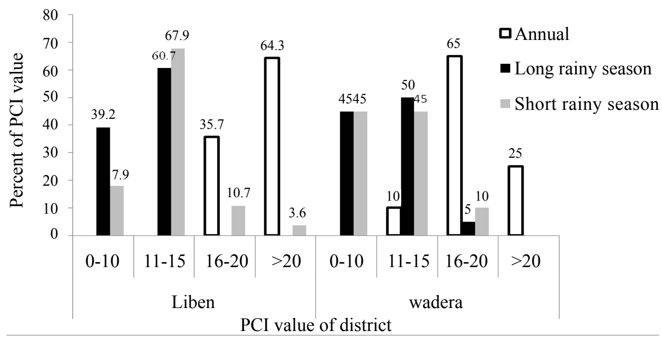

Figure 4: PCI for annual, long and short rain season in Wadera and Liben districts of South Ethiopia.

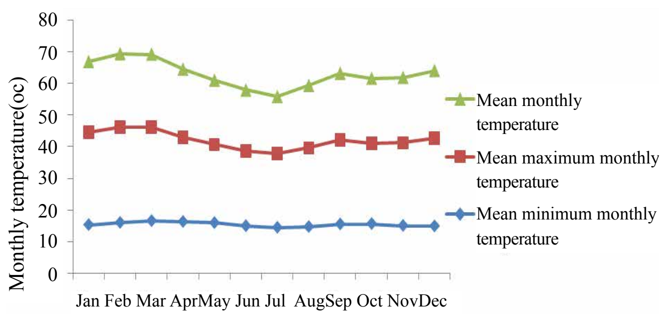

Figure 5: Monthly mean maximum and minimum temperature in Liben district (1985-2014) of South Ethiopia.

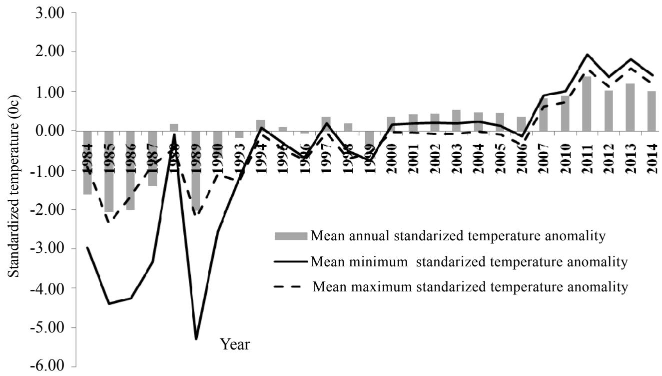

Figure 6: Standardized mean minimum, maximum and annual temperature anomalies of Liben district of South Ethiopia.

Parameters	Wadera %	Gorodola %	Liben %	Mean %
Accumulate livestock or other assets	64.8	43.3	60	56
Traditional mutual social supporting system	56	30	70	52
Divide livestock and family into separate places	62.6	53.3	66.2	60.7
Keep some animals with relatives as insurance	57.1	53.3	91.7	67.4
Expansion and diversification of crop production	68.3	78.3	71.7	72.8
Use drought resistant and early maturing crop varieties and adjusting agronomic practices	82.4	86.7	65	78
Seek alternative income sources	82.4	81.7	65	76.4
Avoid use of expensive agricultural inputs	53.8	40	63.3	52.4
Land management for soil and moisture conservation practices	54.9	75	35	55
Praying	48.4	45	73.3	55.6
Pay attention to climate forecasts/early warning systems	59.3	75	36.7	57

Table 5: Communities climate change response adaptation strategies in Guji zone of South Ethiopia (n=211).

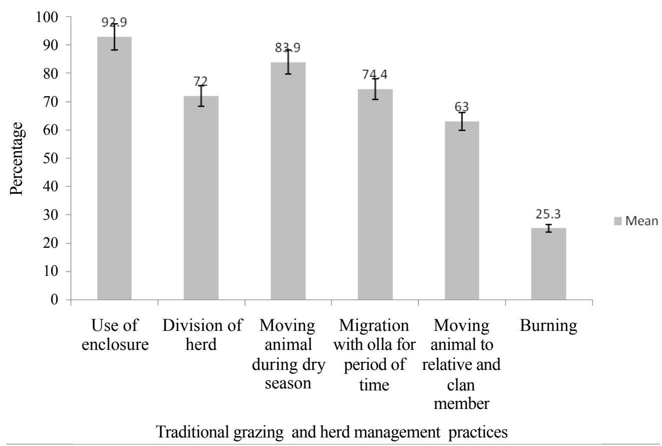

Figure 7: Traditional range land utilization and management practices in Guji zone of South Ethiopia (n=211).

to produce cash crops (e.g. haricot bean, khat, coffee, enset) and tree (eucalyptus tree) as well as practicing agro-forestry practices. Growing of haricot bean has been intensified and considered as emerging crops, before 10-15 years ago; haricot bean production is very low interims of yield and area cover. At present, it becomes among the dominant crop. The intensification of haricot bean could relate with high market demand, early maturing, and drought tolerance could grow under moisture stress condition. The intensification of this leguminous pulse crop would contribute to household food security, household income as well as enhance soil fertility and this might encourage communities' to integrate a crop with other food and forage crops.

The majority of respondents have been implimenting various grazing and herd management strategies in response of feed scarcity and droughts condition. These practices include use of enclosure (92.9%) and establish of drought reserve grazing lands way of responding to the scarcity of feed for vulnerable herd classes, seasonal herd mobility (74.4%), herd splitting (72%), moving animal during dry season (83.9%), partitioning of grazing lands into wet and dry season, adoption and diversification of herd composition (73%) mainly drought tolerance species (e.g. camel and goat), moving animal to relative and clan member (63%) to exploit areas remote from their permanent settlement sites and use of fire (25.3%) (Figure 7). Communities local keep more female dominated herd to facilitate rapid animal recovery after drought. Furthermore, some households use browse plant species, crop resides, and hay as copping strategies in response to drought and declined pasture were traditional grazing land practices which contribute to adaption of local climate change.

The majority of respondents accumulates livestock (57.3%), relying on savings (64.9%), involved in non-pastoral income generating activities (53.6%) (e.g. promotion of crop cultivation, petty trade, sale of charcoal, and fire wood), traditional mutual social supporting system (32.6%) were among main adaption strategies. These social systems are meant to support poor households or those who have lost many assets due to hazards such as droughts, conflicts or diseases. Additionally, communities used many coping mechanisms for short term strategies and the practices that have been used are presented in Table 6. Most respondents (81%) used frequent sale of livestock as the primary copping strategies to obtained grains to supplement their families followed by minimised daily food intake and eat less preferred food items (74.4%), use of traditional mutual social supporting system (66.8%) were among the copping strategies (Table 6).

Discussion

Local indictors of climate change

This study has provided a wealth of information on contribution of indigenous knowledge on climate change, its impacts, coping and adaption strategies of pastoral and agro-pastoral communities in Guji zone of south Ethiopia, which will be valuable for many stakeholders that focus on climate changes related issues. As observed in this study and in many pastoral areas e.g. Kenya [45], Uganda [21] and southern Ethiopia [46] have reported that local communities' perceive the existence of climate change and explain use of multiple indictors mainly declining precipitation amount, erratic on onset and cessation time of rainfall, and increasing frequency of drought as well as temperature. The change in amount of rainfall, rainy days, onset and cessation time rainfall, standardized precipitation index, rainfall trend, PCI and temperature could indicate climate change. This view is in agreement with the empirical climate data analysis for the study area. Other studies

Various coping mechanisms	Wadera %	Gorodola %	Liben %	Mean %
Relying on savings (money, grain)	57.1	68.3	73.3	64.9 (5)
Food aid, and other inputs from government	61.5	50.0	31.7	49.8 (14)
Food for work or cash	48.4	73.3	46.7	55.0 (10)
Traditional mutual social supporting system	69.2	66.7	63.3	66.8 (3)
Frequent sale of livestock or other assets	95.6	65.0	75.0	81.0 (1)
Reduce the quantity and frequency of daily food eating	92.3	36.7	85.0	74.4 (2)
Divide stock and family into separate places	56.0	31.7	70.0	53.1 (12)
Eating of wild fruit and other food type	45.0	51.7	26.7	41.7 (16)
Sale of forest product	45.5	40.0	41.7	42.7 (15)
Alternative income opportunity	49.5	60.0	53.3	53.6 (11)
Migration to gold mining and urban area	58.2	68.3	69.0	64.5 (7)
Herd mobility	52.7	55.0	93.3	64.9 (6)
Additional responsibilities for women	86.1	40.0	45.0	61.6 (8)
Remove children from school	69.2	35.0	66.7	58.8 (9)
Use water by sharing from clean and water management	70.3	52.0	28.3	53.0 (13)
*Number in bracket shows ranking order.				

Table 6: Coping mechanisms of communities' for climate variability in Guji zone of south Ethiopia (n=211).

have also shown a considerable decline in precipitation and increased drought recurrences in the East of African, and associated such trends to climate change [2,46].

Impact of climate change

Recurrent drought and rainfall variability has been a major cause of food insecurity and challenge in east Africa pastoral group (46). The perceived effects of drought on forage production, availability of water, livestock production and pastoral communities' in present study have been documented by many studies [47-49]. The decline of precipitation, increased drought and raising of temperature in Guji and Borana communities caused a declining of forage, water availability, and seriously affect the productivity (e.g. milk yield, body weight, growth and reproductive performance of livestock), and health [26]. Additionally, the periodic drought induces loss of crop yield, and local food insecurity [50], this view was supported in the present study. The increases drought and the rise in temperature adversely affect pastoral livestock production through pose thermal stresses on animals; impair feed intake, and thereby hindering their production and reproductive performances [13] and disease distributions [12]. Drought in Guji and Borana pastoral communities has resulted in a substantial change in livestock holding at the household level, while communities in general have lost their livestock asset and become destitute. Another consequence of drought is linked to food insecurity, poverty to the extent of food aid, expansion of aridity and the need for alternative livelihood income and diversification. The children dropout from school, incidence of human and livestock disease, land dispute, and more pressure on females described by local communities in this study is similar with other study documented in other pastoral area of Ethiopia [20].

As described in this study by local communities, the increased in drought directly pose on tree seedling germination and recruitments and indirect impacts on forest resources through putting enormous pressure on a resources, for example, during drought and pasture decline times forest serve as key refuge and communities' use sale of firewood, charcoal, timber and Gesho as alternative income generating activities. However, these households' strategies might be effective for short term, yet become unsustainable as droughts prolonged and sever which, leads to deforestation. Consequently, the deforestation can leads to loss of other ecosystem services, including local climate regulation, and biodiversity. In the past, in Guji communities had no individuals involved in charcoal making as a livelihood strategy and it has recent phenomena and poverty driven.

Adaptation and coping response of local communities

Local communities' have used several coping and adaption measure to reduce risks related to droughts and rainfall variability. The strategies described by communities on use of traditional grazing and herd management contribute to local climate change adaption. For example, use of enclosures and establish of drought reserve grazing lands way of responding to the scarcity of feed for vulnerable herd classes (calves, milking cows and weak animals) could help in reducing grazing pressure on communal lands, creating access to fodder banks, improving restoration of soil for rangeland development and restore carbon, which would enhance resilience and adaptive capacity of local communities [27]. In overall, traditional indigenous practice shows how local communities' adapt and mitigate risk in an unpredictable and changing environment. Considering the possible relation between increasing droughts and climate variability, enclosure could contribute to a local adaptation and mitigation to climate change. Furthermore, the use of browse plant species, crop resides, and hay in response to drought and declined pasture might further encourage communities to use animal feed preservation and supplementation. The observed herd diversification in this study implies one way of communities' adaptive respond to changing environmental condition and enhances climate resilience in the region, which was similar with other pastoral area [51]. However, the adoption of camel herding as production strategies requires the acquisition of different patterns of forage and water use, and new knowledge about animal management, market chain that allowed the poor household to own camel and some degree of institutional change. These kinds of rangeland and herd managements practice in the area were more or less similar with other pastoral area of East Africa [52], Southern Ethiopia [51].

Guji and Borena pastoralists had strict rules, regulation on water resources and controlled by elders in the village. The communities had developed strategies by digging, maintaining and rehabilitating ponds and wells to supply drinking water. The utilisation of water from the ponds and wells were regulated with traditional rules and regulations this kind of practice in this study is similar with document in southern Ethiopia [53] and in east African rangelands [52]. Additionally, regulating the frequency of watering livestock allows better utilisation of both water and forage resources. This, kind of traditional practice of water management could contribute to adaptation to local climate variability and change.

Even though communities had many adaption and copping response, however, it is vital to understand not all local coping and adaption strategies are appropriate for long term strategies. Some local level adaptation and copping strategies could used for short term, when used as long term plan might exacerbate environment degradation and thereby declining future adaptive capacity of communities'. For example, income generating activities based on sale of charcoal, fire wood, and some traditional mutual supporting system might be good coping strategies when drought occurs at long term intervals. However, when there is prolonged drought in short term interval, charcoal and firewood selling lead to degradation and deforestation, and ultimately intensified climate related risks. Hence, use of these kinds of strategies to long term plan might be unsustainable and destructive for pastoral production system. Additionally, use of continuous food aiding, reduce the quantity, quality and frequency of daily food consumption lead to malnutrition, and poor disease resistance. Withdrawal of children from school could influence further adaptive capacities of local communities.

Conclusion

The study shows local communities perceived existence of climate variability and explained use of multiple indictors mainly declining of precipitation amount, and change in pattern (rainy days; onset and cessation time of rainfall) and increasing frequency of drought. The long term empirical climatic analysis supports the communities' views and the existence of climate variability interims of Standardized Precipitation Index, Precipitation Concentration Index, trend analysis and coefficient of variability. Communities' influenced by numerous challenges that emanating from climate change include drought, scarcity of forage, livestock disease, crop failure, food insecurity and deforestation were among the effects. However, the communities' had many adaptation response the main were categorized as adjusting of crop production strategies, grazing and herd managements, look for alternative income and diversification options, and use of traditional mutual supporting system. The study shows communities' had a set of coping strategies frequent sale of livestock found be the main copping responses. Yet, some of the coping strategies are become less effective and cannot be scaled up easily to other areas. To adapt and limit the negative effect of climate change in the region, efforts should base on clear understanding of local context, practices and knowledge. Finally, it is vital to integrate local knowledge and scientific approaches should have a potential to develop and look an alternative adaptation strategies.

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