Impacts of Climate Variability on Livestock Resources and Pastoralist Adaptation Responses in Dollo Ado Woreda, the Case of Ethio-Somali National Regional State.

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ABSTRACT

This study was conducted in Dollo Ado Woreda of Ethio- Somali-National-Regional State. The general objective of this study was to understand the impacts of climate variability on livestock system and pastoralist adaptation responses in DolloAddoWoredaEthio -Somali National Regional State. Rainfall and temperature data for 34 years were collected from three meteorological stations. Socio-economic data were collected using a structured esquestionnaire from150 randomly selected sample households from three kebeles. Data were organized in excel and analyzed using Statistical Package for Social Scientists (SPSS)and analyzed using descriptive statistics. Coefficients of variation (CV), Precipitation concentration index (PCI), and standardized rainfall anomalies (SRA) were calculated for the period 1983 - 2019. Livestock-related information was gathered from Dollo Ado Woreda Animal Science Department. Then regression and correlation were computed between annual rainfall amount and temperature total over the study period. The findings for this study indicated that both rainfall and temperature over the study area had shown high spatial and temporal variability. The average annual precipitation concentration index (PCI) showed an irregular distribution of annual rainfall for all stations. The results also indicated that the study area has experienced several drought events and flood years with different magnitudes. The number of livestock population was positively associated with annual rainfall. While most livestock populations (except Camel and Goat) were negatively associated with mean annual temperature over the study area. Adaptation practices included mobility, destocking, livestock diversification, shifting from pastoralist to agro-pastoralist, and external support. Factors affecting pastoralist adaptation decisions were; age and sex of household head, family size, educational background, access to credit, and access to extension services training. Based on the results, it is recommended that households should use the most drought tolerant animals and as well as diversify their income. It is also better to use small-scale irrigation with the two rivers (Dawa and Genalle) instead of rearing only livestock.

Keywords: Keywords: Adaptation practice, Climate variability, Coefficients of variation, destocking, mobility, ,

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1. INTRODUCTION

Climate variability is defined as the variation in the mean state and other statistics of the climate on all temporal and spatial scales, beyond individual weather events (IPCC, 2014). Globally, many regions are experiencing greater climate variability which has emerged as one of the most serious environmental and international development challenges of the twenty-first century. Climate variability can influence peoples' decisions on their social, economic, political, and personal conditions (UNFCCC, 2007). Climate variability is one of the serious challenges to sustainable development in Africa. The recent famine that occurred between July 2011 to mid-2012 is the result of several droughts that affect the entire East Africa region which is the worst in 60 years. Drought caused a severe food crisis across Somalia, Djibouti, Ethiopia, and Kenya. The droughtthreatened the livelihood of 9.5 million people in the Greater Horn of Africa which is one reminder of how fluctuations in the climate affecting a large number of people in the area (WMO, 2017). In Ethiopia, climate variability is not a new phenomena. According to the National Meteorological Agency, Ethiopia is one of the countries which has been suffering from climate fluctuations for decades. Recent drought episodes, flash floods, and disease outbreaks in the different parts of Ethiopia are stark reminders of how food, water, and livelihood strategies are still largely dependent on the climate system..Over the past three decades, Ethiopia has experienced countless localized drought events and seven major droughts, five of which resulted in famines. The major drought of 1984 resulted in over 300,000 deaths and affected over 7.5 million peoples, while the drought in 2003 affected over 12.6 million peoples (ECSNCC, 2011). The 2015/16 drought was labeled as the worst drought in decades and resulted in failure of two consecutive rainy seasons, poor harvested in the eastern part of the country, and led to a sharp increase in humanitarian requirements with more than 10 million Ethiopians in need of food aid (NDRMC, 2016). Major floods also occurred in different parts of the country in 1988,1989,1991,1993, 1994, 1995, 1996, 2006, 2007,2008, 2013 and 2016.

Ethiopian pastoralist areas are widespread in six federal regions of Somali, Afar, Oromyia, Southern Nations Nationalities and People's Region, Gambela, and Benishangul-Gumuz. The area converge accounts for more than 61 % of the total national area (PFE, 2016). The pastoralists raise a large portion of the national herd, estimated at 42 percent of the cattle, 25 percent of the goats, and 70% of camels (CSA, 2007). Ethiopian pastoralist livestock production plays an important role in the economy of the country. Ethiopia produces 1.5 million tonnes of milk and 0.331 million tonnes of meat annually (FAO, 2015). The scarcity of rain contributed to the death of livestock, hunger, and famines in Ethiopian pastoralist areas (Oxfam, 2008). In Somali National Regional State, Pastoral households who are reliant on livestock for their livelihoods, also suffer from severe asset losses through drought (RPPACC, 2011). Many pieces of research were conducted on the impact of climate change in arid and semi-arid areas of Ethiopia. Forinstance, Enyew (2015) conducted a study on the impact of climate change and adaptation in the South Omo Zone of Ethiopia. This study reported that evapotranspiration increased because of the rise of temperature that leads to more severe drought. However, the relation between rainfall and livestock production in the area has not yet been well studied. Tewodros (2011) also conducted a research to investigate the adaptation strategies of pastoralists to overcome the effects of climate change and variability in AmibaraWoreda, Afar National RegionalState. He found an extensive reduction in rainfall amount and increased temperature in the study area. He noted that these observed changes brought about challenges to pastoralist livelihoods by creating water shortage and the spread of new human and livestock diseases.

Wassie (2015) whose study focused on climate variability and household adaptation strategies in Southern Ethiopia found that climate variability was the root cause for the pastoral crisis in the area. Jatani (2011) also conducted a study on the impact of climate variability and change on the livelihood of pastoralists in Dire District of Borana Zone, Oromia National Region State. This study reported that climate change and variability caused negative impacts on natural resources such as pasture, water source, and vegetation cover. As stated above, different studies were carried out on the impact of climate change and variability on pastoralist areas. However, few studies deal with the impact of climate change and variability in Somali-National Regional State at the regional level. Moreover, understanding the impacts of climate variability and their adaptation responses at the woreda level was needed. The aim of this study, therefore, was to analyze the current climate variability and its impacts on the livestock system as well as pastoralists' adaptation responses in Dollo Ado Woreda, Somali National Regional State. This study site was selected because of the absence of previous studies on the impacts of climate variability and pastoralists adaptation.

The general objective of this study was to understand the impact of climate variability on livestock system and pastoralist adaptation responses in Dollo Ado Woreda Ethio -Somali National Regional

State.The specific objectives of this study were to:Analyze climate variability and identify climate-related hazards in Dollo Addo Woreda; Examine the impact of climate variability on livestock rearing in Dollo Ado Woreda; Assess pastoralists' response to the impact of climate variability in Dollo Ado Woreda, and Analyse factors affecting pastoralists' decision to adopt and implement various adaptation strategies to withstand the impact of climate variability.

2. MATERIALS AND METHODS

2.1. Overview of the Study Area

This study was conducted in DolloAddoWoreda, Liben Zone, Somali National Regional State. The climatic condition of the study area is semi- arid with an annual temperature between 35°C and 40°C. Dollo Addo Woreda is located in the Somali Regional State of Ethiopia, is prone to disaster. Rural communities heavily depend on natural resources. There is increasing awareness about the role that ecosystems play in reducing the impacts of climate change. This includes restoring and protecting vegetation on slopes to reduce hazards such as soil erosion. Ecosystem-based Disaster Risk Reduction (Eco-DRR) approaches include more inclusive natural resources management (NRM) in a water catchment area.

The approach recognizes the connectedness between human activities and natural resources management across landscapes while including disaster risk reduction (DRR) and climate change adaptation activities such as early warning and prevention. In parallel, ecosystem degradation is closely linked to decreased resilience, especially in regions vulnerable to climate change.

2.1.1.Geographical Location

Dollo Addo Woreda is located between 4˚24'N latitude, and 41˚38'E longitude (DWWO, 2016). The total area of the woreda is estimated to be about 30,5258 hectares (Figure 1). The topography of the study area is plane with altitude ranging from 200 to 1000 meters above sea level. The climate of Dollo Addo is arid and semi-arid. Meteorological station data is only available from one station within the project area, namely from Mandera in Kenya, which is located 35km southwest of Dollo Addo town. The average yearly rainfall is 270 mm/year (without the extreme rainfall of 1997). The rainfall pattern is bimodal whereby Dollo Addo Woreda experiences two rainy seasons per year: the Gu rain, major wet season, from March to June, and the Deyr rain, minor wet season, from October to December. The communities reported that because of climate change, over the past few years the Gu rains often started in April contrary to what it used to be in March historically. The Gu rains are important for local livelihoods as they mark the end of the long dry season (Jilaal) replenishing river flow, beginning of agricultural production, and regeneration of pasture grasslands(PWO, 2016).

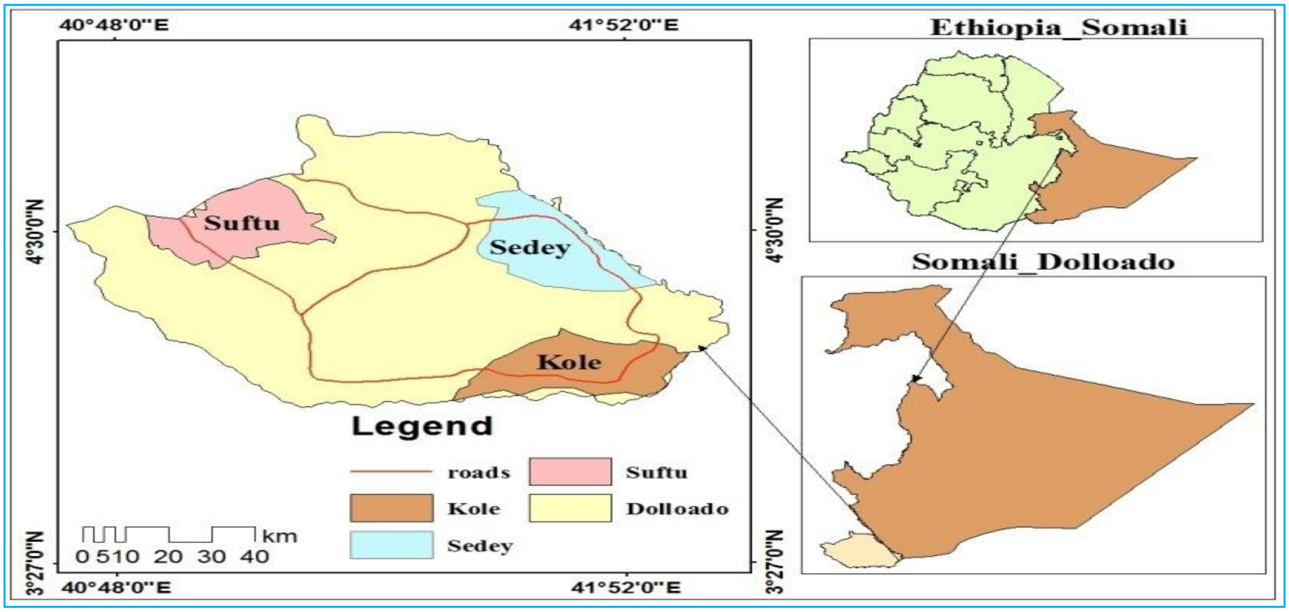

Figure 1. Map of the study area

Pastoralism is the most dominant livelihood system in the woreda. It involved wandering through the desert and living on meat, milk, and blood of camels. Some households engage in trading activity. Genale-Dawa River is the main source of water for the livestock (WDPPB, 2016).

2.1.2.Socio-Economic Condition of the Study Area

Dollo Addo Woreda (also referred to as "DoloAddo" or "DolloAdo") is a woreda in the Somali Regional State of Ethiopia and part of the Liben Zone. Towns in Dolo Ado Woreda include Dolo Ado town and Softu. Dolo Ado town is located at the confluence of the Ganale River and Dawa River and bordered FiltuWoredaon northwest, Afder Zone on the northeast, Somalia on the southeast, and Kenya on the south. The total population of Dolo Ado Woreda in 2011 was 150,100, of which 37,000 live in Dolo Ado town (Woreda census data, 2011). This population census does not include the refugee settlements mostly situated along the Genale River: Bur-

Amino, Bokolmayo, Melkadida, Kobe, and Hilaweyn. According to the United Nations High Commissioner for Refugees (UNHCR) operational portal, there are currently 157,000 refugees living in the refugee settlements in Dolo Ado woreda. The arrivals mostly from the Bay, Gedo, Middle Juba, and Bakool regions and have been moving to the refugee settlements since 2009 because of the conflicts exacerbated by the droughts in Somalia (Betts *et al*., 2019). Most refugees remain poor and dependent upon food aid. Humanitarian non-governmental organizations (NGOs) and international organizations have served as a source of employment for these communities. There are approximately 40 different NGOs active in the Woreda, including the WFP, UNHCR, UNICEF, RACIDA, Cordaid, ZOA, Save the Children, World Vision and COOPI. Most of the host communities live on subsistence from farming and their livestock. Mandera (Kenya) is a major town of trade and only 37 km away from Dolo Ado town through Softu. Dolo Ado town hosts many businesspeople. The town also hosts the major livestock market and provides seeds for agricultural activities. Some kebeles reported poor access to Dolo Ado town market because of poor road conditions (Risk Mitigation Adaptation plan, 2019).

2.2. Data Type and Sources

Daily and monthly temperature and rainfall data for the period 1983-2019 were collected from the National Meteorological Agency of Ethiopia to analyze the Spatio-temporal climate variability of the study area. These data were collected from three recording stations (Dollo Ado, Filtu, and Boqolmayo). Some pre-analysis activities such as handling of missing data values, outlier trimming, and homogeneity checking/correction were performed on monthly temperature and rainfall data for each kebele in the study area. Any missing data were checked and estimated by using average and normal- ratio methods. Outliers were identified using the formula $P_{out} = q_{0.75}+3IQR$ which checked values trans-passing a maximum threshold for each time series. In the formula $q_{0.75}$ is referred to the third quartile while IQR to the interquartile range. The IQR was used in quality control of climate data because it is resistant to outliers(Peterson, 2008a).

Standard normal homogeneity test (SNHT) was applied for both temperature and rainfall data to improve the quality and homogeneity of the time series.

2.3. Methods of Data Collection

The data collection methods for this study were household surveys using questionnaires, focus group discussions, key informant interviews, document analysis, and personal observation. A multi-stage sampling technique was used to select the sample households in the study area. Dollo Ado woreda was selected purposively based on the researcher's experience and accessibility for data collection. Then three Kebeles (i.e Suftu, Kolo, and Sedy) out of 22 kebeles in the woreda were selected using a simple random sampling technique. The size of the sample households from each kebele was selected using a proportional sampling method.Using Kothari's method of sample size determination, the total number of households (n) to be surveyed was (Kothari, 2004):

$$N= \frac{Z^2pqN}{e^2(N-1)+Z^2pq} \quad (1)$$

Where n was the sample size. N: was the number of population/households.Then, the total number of households from five villages was (1572) P: population reliability=0.1 (10%). q= 1-p=0.9. e: margin of error considered:5% for this study, Z was 1.96 at 95% confidence level. Hence, the total sample size was determined as:

$$n = \frac{1.96^2 x 0.1x\ 0.9x1572}{0.05^2 x(1572-1)+1.96^2 0.1x\ 0.9} \approx 150. \quad (2)$$

Eventually, 150 households were selected for the questionnaire in the study villages by employing a systematic random sampling.

2.4.Methods of Data Analysis

Both qualitative and quantitative data analysis methods were used in this study. Temperature and rainfall variabilities were analyzed using mean, standard deviation, precipitation concentration index(PCI), and coefficient of variation (CV). Coefficient of variation was calculated as the ratio of the standard deviation to the long-term mean rainfall and temperature datasets. The standardized rainfall anomalies (SRA) were calculated and graphically presented to evaluate inter-annual fluctuations of rainfall in the study area over the period of observation, which is described as:

$$SRA = \frac{Rt-Rm}{\sigma} \quad (3)$$

Where SRA-standardized rainfall anomaly Rt - the annual rainfall value in year t; Rm is a long-term mean annual rainfall over the period of study, while σ is the standard deviation of annual rainfall for the whole study period. Standardized rainfall anomalies were also used to examine drought risks. As described by Bewket, W. and Conway, D. (2007), the drought severity classes were extreme drought (SRA < -1.65), severe drought (-1.28 > SRA > -1.65), moderate drought (-0.84 > SRA > -1.28), and no drought (SRA > -0.84). Based on the daily rainfall and temperature data both rainfall and temperature indices were calculated for each of the three stations. The rainfall related indices used for this study were: rainy days (R days), maximum 1-day rainfall (RX1 days), maximum 5 days rainfall (RX5 days), number of heavy rainfall days (R10), Number of very heavy rainfall days (R20), Consecutive Dry Days (CDD), Consecutive Wet Days (CWD), Very wet day rainfall (R95p), Extremely wet day rain (R99p), and annual total wet-day rainfall (Rainfall TOT). However, the temperature-related indices calculated for this study were: Summer days (SU25), Tropical nights(TR20), Cold days (TX10p), Warm days (TX90p), Cool nights (TN10p), and warm nights per year(TN90p).

The multi-nominal logit regressions model was also used to analyze factors affecting pastoralists' decision to implement various adaptation strategies. The MNL model is given as follows;

$$Yi = In\ (Pj/P1) = \beta0 + \beta1\ X1 + \beta2\ X2 + \beta3\ X3 + \beta4\ X4 + \beta5\ X5 + \beta6\ X6 + \beta7\ X7 + \beta8\ X8 + \beta9\ X9 + \beta10\ X10 + \beta11\ X11 + \beta12\ X12 + ei. \quad (4)$$

Where Yi = adaptation strategy and Xi, where i = 1, 2,…11, are explanatory variables(sex, age, education, marital status, family size, experience, climate information, access to credit, market access, livestock extension service, and non-livestock income).To describe the MNL model, let Y denote a random variable taking on the values {1,2….j} for choices j, a positive integer, and let X denote a set of conditioning variables. In this case, y representing the adaptation measure chosen by any household in the study area. It assumes that each household faces a set of discrete, mutually exclusive choices of adaptation measures (that means a person chooses exactly one of the options, not more and not less) and these measures are assumed to depend on factors of X. Therefore, X represents several climate attributes, environmental, socioeconomic characteristics of households and other factors. The question is how, ceteris paribus, changes in the elements of x affect the response probabilities P(Y=J/X), J = 1, 2…. J. Since the probabilities must sum to unity, p (Y=J/X) is determined once we know the probabilities for J = 2…J.. The MNL model has response probabilities:

$$P(Y = J/X) = \frac{\exp\ (X\beta j)}{1+\sum_{h-1}^{j} \exp(x\beta h) j=1,\ldots J} \quad (5)$$

3. RESULTS AND DISCUSSIONS

3.1. Climate variability in the study area

3.1.1. Monthly temperature and rainfall variability in the study area

The mean monthly rainfall in the study area was relatively very low. It varied between 0.00 mm and 112.74 mm. The highest rainfall occurred in December at Kole station, while the lowest rainfall has occurred in March and April at Sedey station. The maximum monthly rainfall occurred in January (199 mm) in Suftu, in December (194mm) in Kole, and in July (235 mm) at Sedey. On the other hand, March and April are the driest months both at Suftu and Sedey stations (Table 1). The highest (5.83) and lowest (0.30) rainfall variability occurred in April month at Suftu station and December at Kole station, respectively.

The coefficient of variation (CV) showed that the monthly rainfall variability was higher in September both at Suftu and Sedey station (4.15) and (4.14) respectively while in February at Kole station (1.33). The mean monthly temperature varied between 37.7°C and 28.9°C.

The warmest temperature has occurred in October, while the lowest temperature was observed in March. As shown in the CV the highest temperature variability was observed in December and July (0.05) at Suftu station, in August (0.38) at Sedey, and (0.07) at Kole stations.

Table 1. Monthly rainfall and temperature variability for the period 1983-2019

Station	Data type	Statis	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Suftu	Tem.	Mean (0^{C})	34.6	32.6	32	32.8	35.4	34.4	33.4	34.5	36.3	37.7	37.5	34.7
		SD	1.3	1.0	1.1	0.8	1.3	1.5	1.2	1.2	0.6	0.7	1.6	1.7
		CV	0.04	0.03	0.03	0.02	0.02	0.04	0.05	0.04	0.02	0.02	0.04	0.05
	Rainf	Mean(mm)	58	4.59	0.5	0.44	3.3	45	41	5.6	0.59	2.56	20.6	88.3
		SD	39	8.41	2.3	2.57	8.2	38	46	7.1	2.44	5.43	27	39.3
		CV	0.7	1.8	5.1	5.8	2.45	0.85	1.13	1.28	4.15	2.12	1.31	0.44
Sedey	Tem	Mean	32.5	32.5	31.7	33.2	35.8	33.9	32.5	34.4	36.2	37.2	36.6	33.5
		SD	1.07	0.97	1.09	0.81	0.83	1.36	1.38	0.04	0.78	0.74	1.47	1.41
		CV	0.03	0.03	0.03	0.02	0.02	0.04	0.04	0.38	0.02	0.02	0.04	0.04
	Rainf	Mean	54.2	4.8	0.00	0.00	2.56	36.7	42.4	4.44	3.65	3.35	17.9	86.9
		SD	44.1	9.8	0.00	0.00	7.03	36.1	48.4	7.03	0.88	7.72	23.1	49.4
		CV	0.81	2.04	0.00	0.00	2.75	0.98	1.14	1.58	4.14	2.30	1.29	0.57
Kole	Tem	Mean	30.6	29.5	28.9	30.0	31.5	31.7	30.3	31.2	33.0	33.8	32.6	30.9
		SD	1.35	1.59	1.35	1.46	1.28	1.13	1.67	2.24	1.74	1.66	1.86	1.69
		CV	0.04	0.05	0.05	0.05	0.04	0.04	0.06	0.07	0.05	0.05	0.06	0.05
	Rainf	Mean	63.0	10.2	22.9	17.8	21.8	58.2	62.0	33.9	21.2	24.5	73.1	112
		SD	34.3	13.5	21.0	20.0	20.2	37.8	47.2	35.2	17.2	21.9	38.5	34.0
		CV	0.54	1.33	0.92	1.12	0.93	0.65	0.76	1.04	0.81	0.89	0.53	0.30
Areal Average	Tem	Mean	32.6	31.6	30.9	32	34.24	33.4	32.1	33.5	35.2	36.3	35.6	33.1
		SD	1.24	21	1.18	1.02	1.14	1.33	1.41	1.16	1.04	1.03	1.64	1.6
		CV	0.04	0.03	0.03	0.02	0.03	0.04	0.05	0.05	0.03	0.02	0.03	0.05
	Rainf	Mean	58.4	6.53	7.8	6.08	9.22	46.6	48.5	14.6	8.48	10.1	37.2	95.7
		SD	39.1	10.6	7.77	7.5	11.8	37.3	47.2	16.4	6.84	11.7	29.5	40.9
		CV	0.68	1.72	2.00	2.3	2.04	0.83	1.01	1.3	3.03	1.77	1.04	0.44

3.1.2. Seasonal temperature and rainfall variability in Dollo Ado

Seasonal rainfall and temperature variability were generated based on information obtained from the Dollo Ado Woreda Agriculture Office report. In the woreda, four seasonal calendars were used for pastoral activities. The main rainy seasons in the area locally known as Dayr (October, November, and December) has 47.78mm areal average rainfall from 1983 to 2016. The short rainy season is known asGuGahas occurs in April, May, and June which receives a total of 24.03 mm areal average rainfall during the period of 1983-2016. July, August, and September is locally known as Hagaa characterized by a windy climate and is taken as a dry season. Similarly, January, February, and March locally known as Koreheed was considered a hot dry season. The main rainfall has varied from station to station. Hence, the total rainfall amount for the main rainfall season was 70.14mm at Kole, 37.17mm at Suftu, and 36.04mm at Sedey stations. The CV for the main and small rainfall season varied between 0.7 and 42.5 and 0.90 and 51.7, respectively. The CV for the windy dry season and hot dry season were also varied between 2.18 and 51.6 and 0.93 and 110.4, respectively (Table 2).

Table 2. Seasonal rainfall variability in the study area

Recording station	Oct, Nov and Dec		Apr, May and Jun		Jul, Aug and Sep		Jan, Feb and Mar	
	Total amounts	CV	Total amou	CV	Total a.	CV	Total a.	CV
Suftu	37.17	1.29	16.32	3.04	15.56	2.18	21.02	2.56
Kole	70.14	0.57	32.61	0.90	39.08	8.7	32.07	0.93
Sedey	36.04	1.38	23.08	1.24	16.83	2.28	19.64	0.95
Reg. average	248.1	42.5	235.0	51.7	159.8	51.6	48.2	110.4

Source:Researcher,2018

3.1.3. Annual rainfall and temperature variability

The highest total annual rainfall was observed at Kole station (43.56 mm) while the lowest total annual rainfall was recorded atSedey station (20.44mm). The highest mean annual temperature observed at Suftu station was 34.6°C while the lowest mean annual temperature recorded at Kole station was 31.2°C. The result of coefficient of variation also showed that there was high rainfall variability at Sedey station (1.76) while Kole station showed lower annual rainfall variability than the other station (0.96).On the other hand, Suftu station showed high mean temperature variability (0.64) while Sedey station showed low mean temperature variability as indicated by the coefficient of variation (0.06). Inter-annual variability of rainfall in the study area was evaluated by using standardized rainfall anomalies with respect to the long-term mean for a specific time scale. The standardized rainfall anomalies of annual rainfall at the 3 stations, during the periods between 1983 and 2019 showed the presence of rainfall occurrences under and above normal amounts that might have caused drought and flood events in the study area. Positive rainfall anomalies occurred for 18 years at Suftu, for 15 years at Sedey, and for 12 years at Kole station. On the other hand, negative rainfall anomalies have occurred for 16,19, and 22 years at Suftu, Sedey, and Kole stations, respectively (Table 3). The negative rainfall anomalies at Kole and Sedey stations were large. Extremely dry weather was observed in 1999 and 2000 at Kole station, while extremely dry weather was observed in 1984 and 2001 at Sedey station. Severe drought event at was observed in

1984 and 2001 at Suftu station. On the other hand, 1984, 1991, 1992, 2006,2007, 2011, and 2012 were major drought years at a regional level. In contrast, 1997 was the wettest year in the three stations. Wet rainfall events were also observed in 2006, 2007, and 2011 in Kole station.

Table 3. Annual temperature and rainfall variability in Dollo Ado

Recording station	1983-2019			1983-2019	
	Total annual rainfall/mm	CV	PCI	Mean temperature (0^{C})	CV
Suftu	22.51	1.64	29.1	34.6	0.64
Sedey	20.44	1.76	33.7	34.2	0.06
Kole	43.56	0.96	16.1	31.2	0.07
Areal average	28.84	1.45	26.3	33.4	0.25

Source:Researcher, 2018

3.2. Climate-related hazards in Dollo Ado woreda

The maximum precipitation in one day (Rx1day) was below 50 mm in all of the stations (Suftu 32 mm, Sedey 34 mm, and Kole 35 mm). Similarly, maximum consecutive 5-day rainfall (Rx5 days) was highest at Sedey (61 mm) and lowest at Kole (35 mm) (Table 4). This indicated the scarcity of rain in most of the days in several months.

The average number of rainy days per year varied between 17.42 at Sedeyand 41.85 at Kole station. On average, wet days with at least 20 mm of rainfall varied between about 2.8 days per year at Suftu and about 1.8 days per year at Sedey. While average wet days with at least 10mm of rainfall ranged from 16.4 days per year at Kole, 5.23 years per year at Sedey, and 6.44 years per year at Suftu. On other hand, the ninety-five percentile of daily (R95p) precipitation varied between 19.81 at Sedey and 49.55 at Kole stations. Similarly, the extremely wet day precipitation (R99p) varied between 37.93 in Sedey station and 77.82 in Kole station.

In addition to rainfall-related indices, temperature-related indices were also calculated for all three stations. The Summer Days (SU25) index showed an increase of 359.96, 359.46, and 349.96 days per year at Suftu, Sedey, and Kole stations, respectively. This means that the number of days was very high when the maximum daily temperature was higher than 25 ºC. The average number of warm nights per year (TN90) was 2.19, 2.45, and 2.16 at Suftu, Sedey, and Kole, respectively. On the other hand, the monthly minimum value of daily minimum temperature (TN) was very low (2.58, 2.08, and 1.58) at Suftu, Sedey, and Kole.

Table 4. Extreme rainfall variability

Stations	Rdays	Rx1 Day	Rx5 Days	CD D	CWD	Rainfall TOT	R10 mm	R20 Mm	R95p	R99p
Suftu	22.52 days	32 mm	41mm	30 Days	11day s	5736 mm	6.44	2.8	22.21	40.471
Sedey	17.42 days	34 Mm	61mm	30 Days	12day s	4732 mm	5.23	1.8	19.81	37.934
Kole	41.85 days	35 Mm	35mm	30 Days	18day s	15758m m	16.41	2.82	49.55	77.827

Source: Researcher, 2018

3.3. The impact of climate variability on livestock rearing in Dollo Ado Woreda

The average livestock was regressed on two important climatic variables; annual maximum temperature and annual rainfall. Thus, mean annual temperature (X1) and rainfall (X2) from 2010 to 2016 were independent variables, and average annual livestock population for the dominant animal species (cattle, camel, goat, sheep, and donkey) for the same period was used as a dependent variable (Table 5). Livestock population data for the past period since 1983-2019, meat and milk productivity for major animals and fodder were not available.

Table 5. Regression and correlation between livestock species and climate elements

		Unstandardized Coefficients		Standard. Coefficient.		95.0% Confidence Interval for B		Correlation
Livestock's		B	Std. Error	Beta	Sig.	lower Bound	upper bound	Partial
Goat	(Constant)	762.2	28.52		0.819	-13.51	11.12	
	Rainfall	841.2	76.34	0.992	0.008	51.74	16.72	0.992
	Temperature	132.1	85.96	0.014	0.891	-35.25	38.41	0.109
Sheep	(Constant)	8094.9	13.066		0.617	52.88	67.71	
	Rainfall	776.9	36.89	0.996	0.002	61.16	93.66	0.998
	Temperature	-594.2	412.702	-0.068	0.287	-26.87	11.55	-0.713
Donkey	(Constant)	-15.74	441.34		0.975	-19.70	18.22	
	Rainfall	8.11	1.180	0.975	0.021	3.03	13.18	0.979
	Temperature	8.63	13.196	0.093	0.580	-48.14	65.41	0.420
Cattle	(Constant)	-129.8	23.04		0.996	-10.48	10.89	
	Rainfall	222.23	62.68	0.929	0.071	-47.48	49.94	0.929
	Temperature	-10.12	701.17	-0.004	0.990	-32.01	30.76	-0.010
Camel	(Constant)	1206.53	464.66		0.819	-18.61	21.66	
	Rainfall	162.78	12.04	0.680	0.320	37.93	69.47	0.680
	Temperature	2.065	13.466	0.001	0.999	-59.72	59.85	0.001

Source: Researcher, 2018

Independent variables: Rainfall and Temperature, Dependent variable: Cattle, sheep and goats, donkey and camels.

The Pearson correlation coefficient was used to test the significant relationship between livestock population and climate data at 0.05. The results of the analyses revealed that cattle, camel, goat, sheep, and donkey animals positively related with annual rainfall. The r-values indicated that: goat with mean annual rainfall ($r = 0.992$, $P < 0.05$), sheep ($r = 0.998$, $P < 0.05$), donkey($r=0.979, P< 0.05$), cattle ($r=0.929, P < 0.1$) and camel ($r=0.680$).

The result yielded a higher r-value which indicated a very strong positive relationship between all livestock species and rainfall amounts. Thus, the livestock population increased with increasing mean annual rainfall. This was illustrated by a positive association observed between all livestock populations and mean annual rainfall in the study area (Table 6). This indicated that livestock populations increased with increasing rainfall. A possible explanation could be that sufficient rainfall facilitated feed availability which subsequently minimized mortality and increased births, leading to increased livestock populations.

The result also indicated that the relationship between temperature and sheep was strong but negative (r= -0.713). This may be because extreme temperatures negatively affected the sheep population. On the other hand, the sheep population seemed to be more sensitive. The association between annual temperature and annual cattle population in the study area had a correlation coefficient value of-0.010. This was an indication of a very low and negative association between annual temperature amount and cattle population. However, the relation between temperature and goat, donkey, and the camel was weak and positive. This implied that temperature had a slight effect on these animals.

Table 6. Regression analysis between climate and livestock

Model	R	R Square	Adjusted R^2	Std.Error of the Estimate
Goat	0.992[a]	0.984	0.968	892.48567
Sheep	0.998[a]	0.996	0.991	431.31588
Donkey	0.980[a]	0.960	0.920	13.79113
Cattle	0.929[a]	0.863	0.725	732.79419
Camel	0.680[a]	0.463	-0.075	1450.04503

Source: Researcher, 2018

Regression analysis was also generated to determine the degree to which annual temperature and rainfall at the station explained livestock numbers. This showed that rainfall and temperature observations explained cattle production. Multiple regression analysis showed that 98.4%, 99.6%, 96%, 86.3%, and 46.3% of the total variability in goat, sheep, donkey, cattle, and camel production can be explained to be as a result of the effect of the climatic parameters (rainfall and temperature variability).

3.3.1.Households response to the impact of climate variability on livestock

The majority of households (76.67 %) in the study area indicated that animal productivity in terms of milk and meat production had decreased over time as a result of climate variability. There was greater variation in livestock productivity between the current time and thirty years ago. About 43.34% of respondents indicated that the quality and quantity forage had reduced during the last few decades. Similarly, 44.67% of the respondents confirmed the reduction of income generated from the livestock sector.

3.3.2. Climate variability and incidences of livestock diseases in the study area

65.34% of the household livestock production was negatively affected by increased incidences of livestock pests and diseases. The prevalence of diseases and pests caused severe damage to livestock production because of the shortage of veterinary services and the low financial capacity of people to get heath services for their livestock.

3.3.3. Livestock mortality in the study area

Climate variability in the study area also caused the death of livestock (animal mortality) as 73.34% of households attributed drought to livestock mortalities. According to an official in Dollo Ado Woreda, the vulnerability of pastoralists and livestock to climate variability is currently increasing.

3.3.4. Livestock milk reduction due to climate variability in the study area

About 93.3% of the households reported that milk production is decreasing over time. Households reported that livestock health problems (89.65%) were the main reasons for the reduction of livestock milk production over time in their villages.

3.4. Adaptation strategies used by pastoralists to climate variability in the study area

As the result of climate variability and uncertainties faced with climate-related hazards such as drought, livestock disease, erratic rainfall, heat stress, and flood, the sampled households in the study area reported that they employed various adaptation strategies. As evidenced from their responses provided below, they exerted efforts to cope up with climate-related hazards. Out of the total sampled households, almost 93.3% of them used adaptation strategies to overcome the impact of climate variability. This indicated that only a few households (6.7%) did not undertake any adaptation strategies to overcome the impact of climate variability and related hazards on their livelihoods.

3.5. Factors affecting pastoralists' decision to implement various adaptation strategies

The multinomial logit model (MNL) was used to analyze factors affecting households' choice of adaptation strategies to climate variability in the study area. The likelihood ratio statistics from the MNL model indicated by χ^2 statistics was significant. Therefore, the model suggested all the independent variables influenced the dependent variables.

Sex of the household head (Gender)

In this study, sex of household head showed positive and significant correlation with harvesting flood and rain water, growing of pasture by using irrigation and external support at $p < 5\%$. It also correlated with shifting from pastoralists to agro-pastoralists and get veterinary service at $p < 5\%$ and to small-scale trading at $p < 10\%$, respectively. The model indicated that male-headed households' increased the probability of using harvesting rain and flood water by a factor of (6.59) growing of pasture by a factor of (4.020) small scale trading by a factor of (15.570) veterinary services and livestock vacation by a factor of (6.771). Shifting from pastoralist to agro-pastoralist also correlated by a factor of (17.583) and external support by a factor of (8.661) times greater than the references category (not use any adaptation).

Age of the household head

The results of the MNL model showed that the age of the household was found to be positively correlated with receiving food aid, income diversification, growing of pasture by using irrigation, small-scale trading, and external support. On the other hand, age of the household head showed a negative and significant correlation with animal health training and harvesting rain and flood water at $p < 10\%$. In this case, a one-unit increase in the age of the household increased the probability of using harvesting flood and rain water by a factor of 0.242, animal health training, and extension services by a factor of 0.009. This implied that the older households' were less likely to take animal health training and vacation rather they might use their indigenous knowledge to treat their animals at home instead of taking them to vacation.

Education of the household head

For this study household's level of education was positively and significantly related to livestock diversification, harvesting flood, and rain water, and getting veterinary services at ($p < 1\%$) while it related with shifting from pastoralist to agro-pastoralist at ($p < 5\%$). This implied that educated households were more likely to respond to climate variability by making the best adaptation option based on their preference and influential decision making. The result of the model also indicated that as the household access to education increased the probability of choosing livestock diversification by a factor of 4.173, harvesting flood and rain water by a factor of 0.990, and getting veterinary services by a factor of 5.134 adaptation strategies at $p <1\%$ and shifting from pastoralist to agro-pastoralist by a factor of1.097 at $p <5\%$ keeping the value of other variables constant.

Household's livestock production experience

The years of livestock production experience of the households have a positive and significant correlation with income diversification at ($p < 1\%$), receiving food aid ($p < 5\%$), small scale trading ($p < 5\%$), religious belief, and praying at ($p < 1\%$) and external support at ($p <5\%$). This revealing that as households advance in years of livestock production experience, they preferred to use these strategies as an adaptation method to climate variability in the study area.

Access to climate information

The result of the model further showed that households that had access to climate information increased the use of livestock diversification at ($p < 10$ %) getting livestock veterinary services and livestock mobility at ($p < 1$ %). Being well informed about rainfall and temperature variability increased the likelihood of getting livestock veterinary service by a factor of0.041, livestock mobility by a factor of 11.6, and livestock diversification by a factor of 2.024.

Access to credit

The results suggested that access to credit increased the probability of households using income diversification by a factor of 0.021, harvesting flood and rain water by a factor of1.255, small-scale trading by a factor of 0.736, and external support by a factor of 6.144. It also reduced the probability of households using or receiving food aid as adaptation responses to climate variability by a factor of 0.011, compared to the references category not using any adaptation responses.

Access to market

Distance from the market center was negatively related to receiving food aid. However, the result indicated that market access was positively and significantly correlated with livestock veterinary service and livestock mobility p <5% and livestock diversification at p <10%. Access to the livestock market increased the probability of using livestock veterinary services and livestock diversification by a factor of12.026 and by a factor of 7.179, respectively. It also increased the probability of households using livestock migration by a factor of15.323.

Access to livestock extension service

Results of the MNL models showed that extension contact had a positive and significant correlation with six adaptation strategies such as livestock diversification, income diversification, religious belief, growing of pasture using irrigation, and small scale trading at $p < 1\%$ and with livestock mobility at $p < 5\%$. It had a negative and significance correlation with external support at $p < 1\%$. A one-unit increase in the extension contact was likely to increase the probability of the households to choose six adaptation strategies: livestock diversification by a factor of 3.190, income diversification by a factor of3.770, religious belief by a factor of 0.008, growing of pasture using irrigation by a factor of 1.862, and small scale trading by a factor of 2.307, and livestock mobility by a factor of 32.065 higher than those households' who did not access extension services.

Access to non-livestock income

Non-livestock income was positively and significantly related to livestock diversification and mobility at 1% level. Non-livestock income also increased the likelihood of shift from pastoralist to agro-pastoralist, getting veterinary services and livestock vacation, small scale trading, growing of pasture by using irrigation, and income diversification. But -non-livestock income decreased the probability of receiving food aid, external support, and animal health training and extension service. This indicated that when households had options for non-livestock incomes, they might not prefer to receive food aid and external support rather they preferred to diversify their income. The result of the model showed that a unit increase in household non-livestock income could increase the use of livestock diversification by a factor of 90.787 at $p < 1\%$.

4. CONCLUSIONS

The long-term monthly, seasonal and annual analysis of rain fall and temperature data showed considerable variability in the study area. The result of coefficient of variation (CV) also indicated inter annual variability of rainfall and temperature from 1983 to 2019 for all the stations in the study area. The average annual precipitation concentration index (PCI) showed an irregular distribution of annual rainfall in all stations. As a result of increased climate variability, the pastoralists faced different climate-related risks and were still adversely affected. Some of the climate-related risks identified by the households included drought, flood, extreme events, livestock pests, and diseases. The analysis of temperature and rainfall anomalies indicated that there were many extreme deviations above and below the mean annual totals. Above all 65%, 56%, and 47% negative rainfall anomalies (below) the mean were recorded in Kole, Sedey, and Suftu respectively. These spatial variations in climate affect the livestock production including feed shortage, shortage of water, livestock genetic resources loss, reduced productivity, and decreased mature weight as it was explained by the respondents. Positive anomalies, (above) long-term mean annual temperature, were obtained in all of the stations.The result further showed many warm and cold extremes. The maximum one-day precipitation (Rx1day) was below 50 mm in all of the stations. The maximum number of consecutive dry days (CDD) per month was very high (30 days) for all station in most of the months. The household's believed that the variability of climate patterns affected livestock production negatively because of its impact on grazing and forage quality. The fluctuation in these parameters (reducing rainfall and increasing temperature) had negatively impacted on pasture and water quality and availability, reducing livestock production in the area. Indeed the result from correlation and regression between livestock population and annual rainfall and temperature supported this conclusion as livestock numbers declined. Pastoralist households in the study area employed several adaptation strategies: the most common ones were: being mobile at the time of drought to find pasture and water for their animals, livestock diversification, seeking relief food, income diversification, harvesting rain water, growing pasture by using irrigation, getting veterinary services, shifting from pastoral life to agro-pastoral, and selling livestock. However, many constraints hindered the pastoralists from implementing adaptation strategies to reduce damages. These were lack of skills to implement the strategies, lack of climate-related information, lack of sufficient financial resources, and lack of awareness about climate variability issues.

The dilemma with climate variability was the uncertainty surrounding it and its timeframes. It was uncertain which areas, regions, and countries would be affected by the result. Livestock production in Africa and Eastern Africa, especially its developing component, is vulnerable and at high risk of being severely affected by climate variability. Constant research, education, and sensitization are needed to adapt to and combat the possible effects of climate variability at the local, national and regional levels.

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