Journal of Environmental and Agricultural Studies
Website: www.al-kindipublisher.com/index.php/jeas/index
Al-Kindi Center for Research and Development

JAES

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

Degu Zewdu
Department of Geography and Environmental Studies, College of Social Science and Humanities, Arba Minch University, Arba Minch, Ethiopia
Corresponding Author: Degu Zewdu, E-mail: Zewdu.belhu@gmail.com

ARTICLE INFORMATION

Received: October 17, 2020
Accepted: December 09, 2020
Volume: 1
Issue: 2

KEYWORDS

Climate variability, Coefficients of variation, mobility, destocking, Adaptation practic

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 impact of climate variability on livestock system and pastoralist adaptation responses in Dollo Addo Woreda Ethio -Somali National Regional State. Rainfall and temperature data for 34 years were collected from three meteorological stations. Socio-economic data were collected using structured quationnaire from150 randomly selected sample households from three kebeles. Data were organized in excel and analyzed using Statistical Package for Social Scientists (SPSS) and analysed using descriptive statistics. Coefficients of variation (C.V), Precipitation concentration index (PCI) and standardized rainfall anomalies (SRA) were calculated for the period 1983 - 2016. Livestock related information were gathered from Dollo Ado Woreda Animal Science Department and regressed and correlated against annual rainfall and temperature totals over the study period. The findings for this study indicated that both rainfall and temperature over the study area have shown high spatial and temporal variability. The average annual precipitation concentration index (PCI) shows irregular distribution of annual rainfall for all stations. The results also indicated that the study area has experienced a number of drought events and flood years with different magnitudes. The number of livestock population was positively associated with annual rainfall. While most livestock population (except Camel and Goat) were negatively associated with mean annual temperature.Adaptation practices included mobility, destocking, livestock diversification, shifting from pastoralist to agro pastoralist and external support. Factors affecting pastoralist adaptation decision were; age and sex of household head, family size, educational background, access to credit and access to extension services training. From the results, it is recommended that households should use most drought tolerant animals, as well as diversifying their income and better to use small scale irrigation with the two rivers (Dawa and Genalle) instead of rearing only livestock.

1. Introduction

Climate variability is one of the serious challenge to sustainable development in Africa. The recent famine in Greater Horn of Africa is one of reminder of how fluctuations in the climate affecting large number of people in the area (WMO, 2017). In Ethiopia, climate variability is not a new phenomenan. 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 largly dependent on the climate system and vulnerable to its seasonal and annual variability and long term changes. 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 drought in 2003 affected over 12.6 million peoples (ECSNCC, 2011). 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 region, Gambela, and Benishangul-Gumuz. The area converge accounts 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 economies of the country. It produces a total of 1.5 million tonnes of milk and 0.331 million tonnes of meat annually (FAO, 2005). Despite the important role pastoralists plays in supporting local livelihoods in contributing to national and regional economies in the country, its capacity to adapt climate variability is facing many challenges. Rain failures have contributed to deathof livestock , hunger and famines in Ethiopian pastoralist areas(Oxfam, 2008). Pastoral households in Somali National Regional State, which are reliant on livestock for their livelihoods, also suffer severe asset losses through drought (RPPACC, 2011). Many researches were conducted on the impact of climate change in arid and semi-arid areas of Ethiopia. For instance, Enyew (2015) conducted a study on the impact of climate change and adaptation in South Omo Zone of Ethiopia. This study reported that evapo-transpiration increased due to 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 clarified. As stated above different studies were carried out on the impact of climate change and variability on pastoralist areas. However, there are very few studies dealing with the impact of climate change and variability for Somali-National Regional State at the regional level. Moreover, understanding the impacts of climate variability and their adaptation responses at the woreda level is needed. The aim of this study therefore was to analyse of the current climate variability and its impacts on livestock system as well as pastoralists' adaptation responses in Dollo Ado Woreda, Somali National Regional State. This study site is selected due to the absence of previouse studies on the impacts of climate variability and pastoralists adaptation.

1.2. Objectives of the study

The general objective of this study was to understand the impact of climate variability on livestock system and pastoralist adaptation responses in Dollo Addo Woreda Ethio -Somali National Regional State. The specific objectives of this study were to:

- Analyse climate variability and identify climate related hazards in Dollo Addo Woreda,
- Examine the impact of climate variability on livestock rearing in Dollo Addo Woreda,
- Assess pastoralists' response to the impact of climate variability in Dollo Addo Woreda, and

Analyse factors affecting pastoralists' decision to adopt and implement various adaptation strategies to the impact of climate variability.

2. Materials and Methods

2.1 Study Area

This study was conducted in Dollo Addo Woreda, Liben Zone, Somali National Regional State. It located between 4˚24'N latitud, and 41˚38'E longitude (DWWO, 2016). The total area of the woreda is estimated about 30,5258 hectars. The topography of the study area is plan with altitude ranges from 200 to 1000 meters above sea level (PWO, 2016).

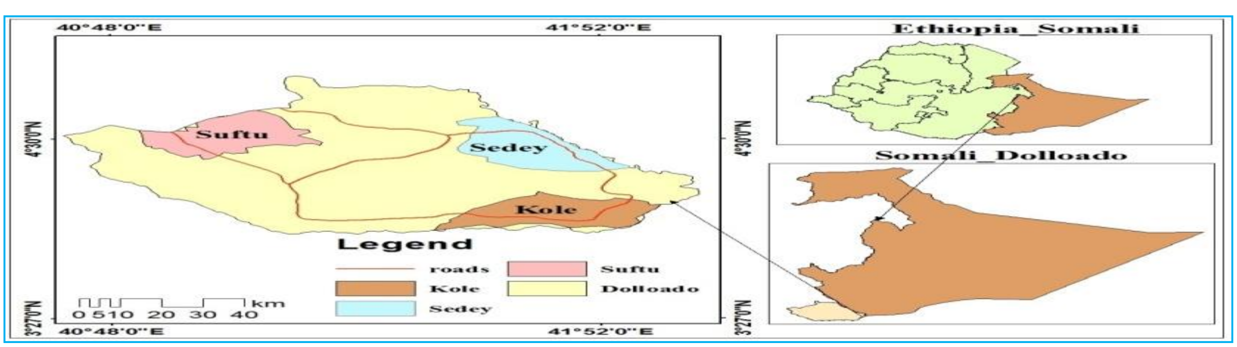

Figure 3.1. The study area

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

2.2. Data type and sources

Daily and monthly temperature and rainfall data for the period 1983-2016 were collected from National Meteorological Agency of Ethiopiato analyse the spatio-temporal climate variability of the study area. These data were collected for 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 was checked and estimated by using average and normal- ratio methods. Outliers was identified as those values trans-passing a maximum threshold for each time series by a formula $P_{out} = q_{0.75}+3IQR$. Where $q_{0.75}$ is the third quartile and IQR the interquartilic range. The IQR has been 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 survey using (questionnaires), focus group discussions, key informant interview, 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 experience and accessibility for data collection. Then three (namely Suftu, Kolo and Sedy) out of 22 kebeles in the woreda were selected using simple random sampling technique. The size of sample households from each kebele were selected using proportional smpling method. By kothari method of sample size determination, the total number of households (n) to be surveyed was: n= $\frac{Z^2 \mathrm{pqN}}{e^2(N-1)+Z^2\mathrm{pq}}$ (Source: Kothari, 2004). Where: n is the sample size. N: is the number of population/household'for this study total households from five villages are (1572) P: population reliability = 0.1 (10%). q= 1-p = 0.9. e: margin of error considered:5% for this study, Z is 1.96 at 95% confidence level. So that, the total sample size was determined as: $n = \frac{1.96^2 \text{ x } 0.1\text{x } 0.9 \text{ x}1572}{0.05^2\ x\ (1572-1)+1.96^2 0.1\text{x } 0.9}$ ≈150. In the last stage 150 households were selected for questions in the study villages by employing a systematic random sampling.

2.4. Methods of data analysis

Both qualitative and quantitative data analysis were used in this study. Temperature and rainfall variabilities were analysed using mean, standard deviation, Preciptation concentration index (PCI) and coefficient of variation (CV). Coffcient 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:$\mathrm{SRA} = \frac{\mathrm{Rt-Rm}}{\sigma}$: 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 was also used to examine drought risks. As described by Bewket, W. and Conway, D. (2007), the drought severity classes are 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). Precipitation concentration index was applied for the rainfall data at the annual time scale. From the daily rainfall and temperature data different both rainfall and temperature indices were defined and 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 (RainfallTOT) while 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).

Multinominal logit regressions model was also used to analyze factors affecting pastoralists' decision to adopt and implement various adaptation strategies to the impacts of climate variability. The MNL model was as follows; Yi = In (Pj / P1) = β0 + β1 X1 + β2 X2 + β3 X3 + β4 X4 + β5 X5 + β6 X6 + β7 X7 + β8 X8 + β9 X9 +β10 X10 + β11 X11 + β12 X12 + ei. 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 a number of 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. Let x be a 1x K vector with first element unity. The MNL model has response probabilities: $P(y = j/x) = \frac{\exp\ (X\beta\ j)}{1+\sum_{h-1}^{j}\exp(x\beta h)\, j=1,\dots J}$ ... Where j β is K × 1, j = 1……., J

3. Results and Discussion

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 that varied between 0.00 mm and 112.74 mm. The highest rainfall has 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 (194 mm) in Kole and (235 mm) in July at Sedey. On the other hand, March and April are the driest months at both Suftu and Sedey stations (Table 4.1). The highest (5.83) and lowest (0.30) rainfall variability have occurred in April month at Suftu station and December at Kole station respectively. The cofficent of variation (CV) has showed that monthly rainfall variability was higher in September in at both 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. Warmest temperature has occurred in October, while the lowest temperature observed in March month during the study period. As shown by CV that the highest temperature variability observed in December and July (0.05) at Suftu station, in August (0.38) at Sedey, and (0.07) at Kole stations.

3.1.2. Seasonal temperature and rainfall variability in Dollo Ado

Seasonal rainfall and temperature variability were generated based on information obtained from Dollo Ado Woreda Agriculture Office report. In the woreda there are four seasonal calendar as they used for pastoral activities. The main rainy seasons in the area locally known as *Dayr* (October, November and December) which receives a total of 47.78mm areal average rainfall during period1983-2016. Short rainy season known as *GuGa* has occurs 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 locally known as *Hagaa* and characterized by windy climate and is dry season. Similarly, January, February and March locally known as *Koreheed* are hot dry season. The main rainfall varied from station to station. Hence, the total rainfall amout for the main rainfall season were 70.14mm at Kole, 37.17mm at Suftu and 36.04mm at Sedey station. 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 slso varied between 2.18 and 51.6 and 0.93 and 110.4, respectively.

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 at Sedey station (20.44mm). The highest mean annual temperature observed at Suftu station were 34.6°C while the lowest mean annual temperature was recorded at Kole station 31.2°C. The result of cofficent of variation also showed that there is high rainfall variability at Sedey station (1.76) while Kole station showed low 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 cofficent 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 2016 showed the presence of rainfall occurrences under and above normal amounts that have caused drought and flood events in the study area, respectively. Positive rainfall anomaies have 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. The negative rainfall anomalies at Kole and Sedey stations were large. Extremely dry weather was observed 1999 and 2000 at Kole station, while it was in in 1984 and 2001 at Sedey station. Severe drought event at Suftu station observed in 1984 and 2001.On the other hand, 1984, 1991, 1992, 2006,2007, 2011 and 2012 were major drought years at regional levele. In contrast, 1997 was the wettest year at all the three stations.Wet rainfall events were also observed in 2006, 2007 and 2011 in Kole station.

3.2. Climate related hazards in Dollo Ado woreda

Maximum one-day precipitation (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). This indicates that there were many days in several months which have not get any rain in the study area. The average number of rainy days per year varied between 17.42 at Sedey and 41.85 at Kole station. On average, wet days with at least 20 mm of rainfall vary 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 10 mm of rainfall ranges from 16.4 days per year at Kole, 5.23 years per years at Sedey and 6.44 years per year at Suftu. On other hand the nithty 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) was varied between 37.9 3 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 shows 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 when the maximum daily temperature is higher than 25 ºC was very high. 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) is very low (2.58, 2.08 and 1.58) at Suftu, Sedey and Kole.

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

The average livestock is regressed on two important climatic variables; annual maximum temperature and annual rainfall. Thus, mean annual temperature (X1) and rainfall (X2) from 2010 to 2016 are independent variables and average annual livestock population for the dominant animal species (cattle, camel, goat, sheep and donkey) for the same period is used as the dependent variable. The functions are fitted separately for each animal. Livestock population data for the past period since 1983-2009, meat and milk productivity for major animals and fodder availability were not available.The occurrence droughtin 1983 to 2016 at Kole 22 years and at Sedeythe total livestock population in study area showed greater fluctuation.

Table 3.1: Regression and correlation between livestock species and climate elements

		Unstandardized Coefficients		Standard. Coefficient.		95.0% Confidence Interval for B		Correlation
						lower	upper	
Livestock's		B	Std. Error	Beta	Sig.	Bound	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

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

The Pearson correlation coefficient is used to test the significant relationship at 0.05. The results of the analyses revealed that cattle, camel, goat, sheep and donkey animals are positively related with annual rainfall. Where 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 indicates a very strong positive relationship between all livestock species and rainfall amounts. In general, the livestock population increased with increasing mean annual rainfall. This is illustrated by a positive association observed between all livestock population and mean annual rainfall in the study area.

This indicates that livestock populations generally increased with increasing rainfall. A possible explanation could be that sufficient rainfall facilitates feed availability which subsequently minimizes mortality and increases births, leading to increased livestock populations. The result also indicated that relationship between temperature and sheep is strong and negative (r= -0.713). This may be because extreme temperatures do negatively affect sheep population. On the other hand, 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 camel are weak and positive. This implies that temperature have slight effect on these animals.

Table 3.2: 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. 2108

To determine the degree to which annual temperature and rainfall at the station explained livestock numbers, a regression analysis was generated. It showed that rainfall and temperature observations explained cattle production.The result obtained from the multiple regression analysis shows that 98.4%, 99.6%, 96%, 86.3% and 46.3% of 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 has decreased over time as result of climate variability. According to there was greater variation inlivestock productivity between the current time and thirty years ago. About 43.34% of respondents indicated that the quality and quantity forage has reduced during the last few decades. Similarly, 44.67% of the respondents confirmed the reduction of income generated from livestock sector.

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

As indicated by 65.34% of the household's livestock production have been negatively affected by increased incidences of livestock pests and diseases. The prevalence of diseases and pests have caused severe damage due to shortage of veternary service and low financial capacity of people to get health services for their livestock.

3.3.3. Livestock mortality in the study area

Climate variability in the study area also resulted death of livestock (animal mortality), as 73.34% of households stated that drought cause livestock mortalities. Mr. IbrahimMohamed DPPO officer in Dollo Ado Woreda explained that pastoralists and livestock the vulnerabilities to climate variability currently increased.

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 decreased over time. Households were also requested the main reasons for reduction of livestock milk production over time in their villages, livestock health problems (89.65%) were the major reasons.

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, there are efforts towards adapting climate related hazards. Out of the total sampled households, almost 93.3% of them were used adaptation strategies to overcome the impact of climate variability. This indicates that only 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 x^2 statistics was significant. Therefore, the models suggesting all the independent variables are 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 is also correlated with shifting from pastoralists to agro pastoralist and get veterinary service at $p < 5\%$ and to small scale trading at $p < 10\%$ respectively. The model indicates that, being male headed households' increase the probability of using harvesting rain and flood water by (6.59)**,** growing of pasture by (4.020), small scale trading by (15.570), get veterinary services and livestock vacation by (6.771), shift from pastoralist to agro pastoralist by (17.583) and external support (8.661) times greater than the references category (not use any adaptation).

Age of the household head

The results of the MNL model shows that age of the household is 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 shows 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 increases the probability of using harvesting flood and rain water by 0.242, animal health training and extension services by 0.009. This implies that the older households' are less likely to take animal health training and vacation rather they might be used 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 is positively and significantly related to livestock diversification, harvesting flood and rain water and get veterinary service at ($p < 1\%$) while it is related with shifting from pastoralist to agro pastoralist at ($p < 5\%$). This implies that educated households are more likely to respond to climate variability by making 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, the probability of choosing livestock diversification increase by 4.173, harvesting flood and rain water by 0.990 and get veterinary service by 5.134 adaptation strategies at $p < 1\%$ and shifting from pastoralist to agro pastoralist by 1.097 at $p < 5\%$ holding the value of other variables constant.

Household's livestock production experience

The years of livestock production experience of the households have 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 household's advances 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 have access to climate information, increase the use of livestock diversification at ($p < 10\%$), get livestock veterinary service and livestock mobility at ($p < 1\%$). Being well informed about rainfall and temperature variability increased the likelihood of get livestock veterinary service by 0.041, livestock mobility by 11.6 and livestock diversification by 2.024.

Access to credit

The results suggest that access to credit increase the probability of households using income diversification by 0.021, harvesting flood and rain water by 1.255, small scale trading by 0.736 and external support 6.144. It also reduces the probability of households using or receiving food aid as adaptation responses to climate variability by 0.011 compared to the references category not using any adaptation responses.

Access to market

Distance from the market centre is also negatively related to receiving food aid. Moreover, the result indicates that market access is positively and significantly correlated with livestock veterinary service and livestock mobility p <5% and livestock diversification at p <10%. Easy access to livestock market increases the probability of using livestock veterinary service and livestock diversification by 12.026 and 7.179 respectively. It also increased the probability of households to use livestock migration by 15.323.

Access to livestock extension service

Results of the MNL models shows that extension contact has positive and significant correlation with six adaptation strategies such as livestock diversification at, income diversification, religious belief, growing of pasture using irrigation and small scale trading at p < 1% and with livestock mobility at p < 5%. It was also negative and significance correlation with external support at p < 1%. A one unit increase in the extension contact is likely to increase the probability of the households to choose six adaptation strategies: livestock diversification by 3.190, income diversification by 3.770, religious belief by 0.008, growing of pasture using irrigation by 1.862 and small scale trading by 2.307 and livestock mobility by 32.065 higher than those households' who do not access extension services.

Access to non livestock income

Non livestock income is positively and significantly related to livestock diversification and mobility at 1% level. Non livestock income also increases the likelihood of shift from pastoralist to agro pastoralist, get veterinary services and livestock vacation, small scale trading, growing of pasture by using irrigation and income diversification. But non livestock income decreases the probability of receiving food aid, external support and animal health training and extension service. This indicates that when households have options for non livestock incomes, they can unlikely afford to receive food aid and external support rather they are expected to be busy to diversify their income. The result of the model also shows that a unit increase in household non livestock income can increase the use of livestock diversification by 90.787 at p < 1%.

4. Conclusion

The long term monthly, seasonal and annual analysis of rain fall and temperature data shows considerable variability in the study area. The result of coefficient of variation (CV) also indicated that inter annual variability of rainfall and temperature during 1983 to 2016 for all the stations in the study area. The average annual precipitation concentration index (PCI) showed irregular distribution of annual rainfall in all stations. As a result of increased climate variability the pastoralists have been facing different climate related risks and still adversely affected. Some of the climate related risks identified by the households include drought, flood, extreme events, livestock pests and diseases.The analysis of temperature and rainfall anomalies indicated that there are 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. Positive anomalies (above) long term mean annual temperature were also found for all of the stations. The result further showed many warm and cold extremes. 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 many months. Furthermore, frequencies of warm days and nights increased strongly and decrease in the number of cold days and cold nights in all the stations. The household's believed that the variability of climate pattern affected livestock production negatively due to its impact on grazing and forage quality. The fluctuation in these parameters (reducing rainfall and increasing temperature) has negatively impacted on pasture and water quality and availability thus reducing livestock production in the area. Indeed, the result from correlation and regression between livestock population and annual rainfall and temperature support this conclusion as livestock numbers declined. Pastoralist households in the study area were employ 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 service, shifting from pastoral life to agro pastoral, and selling livestock. However, there were also many constraints that hinder 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 on climate variability issues.

The dilemma with climate variability is the uncertainty surrounding it and its timeframes. It is uncertain which areas, regions and countries will be affected by the result and to what extent. This may lead to a reluctant approach to the initiation of mitigating measures. 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 in order to adapt to and combat the possible effects of climate variability at local, national and regional level.

Acknowledgment

The author would like to thank Mis. Andrea Spinner manager of Pharo Foundation, Dollo Ado Woreda DPPO officers, PWO and PYDO managers, Kebele chairman's who were most helpful and cooperative in the study area and strong supporters during the field survey. The author is also thanking the reviewers for their valuable comments and suggestions which helped in improving the article. The authors are also grateful to Dr.Mekonne Adnew researcher of Addis Ababa University in Department of Geography and Environmental Studies for his suggestions on statistical analysis. Finally, the author need to express his heartfelt thanks go to the Dollo Ado Woreda Communities and my enumerators' for their patience, encouragement and support during data collection.

References

[1] Amundson, J. L., Mader, T. L., Rasby, R. J., & Hu, Q. S. (2006). Environmental effects on pregnancy rate in beef cattle. *Journal of animal science*, *84*(12), 3415-3420.

[2] Tache, B. (2000). Changing Patterns of Resource Control among the Borana Pastoralists of Southern Ethiopia: A lesson for development agencies. *Pastoralists and Environment: Experience from the Greater Horn of Africa*, 51-73.

[3] Calvosa, C., Chuluunbaatar, D., & Fara, K. (2009). Livestock and climate change. In *Livestock and climate change*. International Fund for Agricultural Development (IFAD).

[4] CSA (Central Stastical Agency) (2007). The 2007 Population and Housing Census of Ethiopia, results for Somali Central statistical report. Addis Ababa, Ethiopia.

[5] Daniel G (2009). Impact of climate change and variability on smallholders livelihoods and their adaptation: The case of central rift valley area of Ethiopia, M.A. Thesis, college of development studies, Addis Ababa University.

[6] Davies J (2007). Livelihood adaptation to risk: Constraints and opportunities for pastoral development in Ethiopia's Afar region. Journal of Development Studies.

[7] ENMA (Ethiopian National Metrological Agency) (2006). Climatic and agro-climatic resources of Ethiopia. National Meteorological service Agency of Ethiopia, Meteorological Research

[8] FAO (Food and Agricultural Organization) (2005). Impact of climate change, pests and diseases on Food Security and Poverty Reduction, Rome.

[9] IFAD (International Fund for Agricultural Development) (2004). Livestock and climate change livestock thematic paper, Rome, Italy.

[10] IPCC (Inter Governmental Panel on Climate Change) (2007b). Climate change 2007: The physical science basis. Contribution of working group I to the fourth assessment report of the intergovernmental panel on climate change.cambrige University Press, Cambridge, UK and New York: NY, USA.

[11] IPCC (Inter Governmental Panel on Climate Change) (2007). Fourth Assessment Report. Intergovernmental Panel on Climate Change Secretariat. Geneva, Switzerland.

[12] IPCC (Inter Governmental Panel on Climate Change) (2013). Climate Change 2013: The Physical science basis. Contribution of working Group l to the fifth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp.

[13] NRC (National Research Council) (2006). Effect of environment on nutrient requirements of domestic Animals. Committee on Animal nutrition. Subcommittee on environmental sress National Academy Press Washington DC.

[14] OXFAM (Oxford Committee for Famine Relief) (2008). Survival of the Fittest: Pastoralist and climate change in East Africa. Briefing Paper, UK, PP.116.

[15] UNDP (United Nation Development Program) (2009). Climate Change in African Dry lands: Adaptive Livelihood Options.

[16] UNFCCC (United Nation framework Convention on Climate Change) (2007). Climate Change 2007: Impacts, Vulnerabilities and Adaptation in Developing Countries, Bonn, Germany.

[17] World Bank (2006). Ethiopia: Managing Natural resources to maximize sustainable growth. Report No. 36000-ET: The World Bank. Washington, DC.

[18] WMO (World Metrological Organization) (2012). Climatic Change in Africa. World Metrological Agency. No. 195. WMO, Geneva.