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Climate Change, Its Effect on Livestock Production and Adaptation Strategies in Hawassa Zuria and Hula Districts of Sidama Region, Southern Ethiopia

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Abstract: Climate change remains the major threat for livelihood of smallholder farmers in Ethiopia. This study reviews the effects of climate change on livestock production and adaptation measures employed by the farmers from two districts in Sidama Region. The data was collected from 189 sample households. The climate data were collected from National Meteorological Agency. The results revealed that the trend of RF was increasing by the rate of 0.79mm in Hawassa Zuria and 11.62mm in Hula per annum and there are tendencies indicating a future with warmer climate. The effects of climate change were reduced quality and quantity of feed, increased incidence of diseases, reduced quality and quantity of water and reduced production and reproduction performance of animals. From the total households 27% of the sample households were practicing reducing the number of animals in Hawassa Zuria and income diversification adaptation strategies in Hula. Adaptation strategies considered in the Multinomial logit model analysis were income diversification, supplementary feed, reducing number of animals and diversifying animals. Education, age, labor size, farm size of household and livestock holding are among the factors that might contribute to explain different levels of adaptive capacity within these two communities. Therefore, future policy should focus on improving the quality of meteorological data, water supply, enhancing innovations in livestock production system and enhancing research on use of new improved forage species.

Keywords: Adaptation, Climate Change, Multinomial Logit Model

1. Introduction

Climate change is one of the biggest environmental challenges and it has become a major concern to society because of its potentially adverse impacts worldwide. There are already increasing concerns globally regarding climate change is threatening the livelihoods of the vulnerable population segments [58, 59].

According to the climate change vulnerability index in 2014, Ethiopia ranks 10th in the list of countries most at risk of climate change. The low-level of development and dependence on agriculture are the main reasons for the vulnerability [60]. Climate variability and extreme events are causing significant damage to life, property, natural resources and economy in Ethiopia; making the most important economic systems highly vulnerable [16].

Climate affects livestock production directly and indirectly [28]. Direct impacts of climate change on animals are: Heat stress [54] milk yield reduction and poor reproduction performance [44, 60]. The indirect effects are on: quality and amount of fodder [8, 42], availability and quality of water [5, 61], animal health [28, 38, 61] and genetic diversity of animals [8, 18, 26, 42, 49].

To minimize the impact of climate change on smallholder farmers, adaptation strategies are vital instruments [12, 15, 25, 47]. Therefore, efforts should focus on finding mechanisms in which livestock keepers can reduce these problems and improve smallholder farmers' adaptation strategies to climate change in order to enhance resilience of the sector.

Climate change will have far-reaching consequences for animal production, especially in vulnerable parts of the world. The impact of climate change can heighten the vulnerability of livestock systems and exacerbate existing stresses upon them, such as drought [19].

Animals are the means of asset building, insurance, savings, and important source of food for Sidama people [34]. Sidama's rural livelihoods are at risk due to several factors, an important one being climate change. Weather conditions in the highlands are gradually converting to midland conditions while the lowlands tend to transform into semi-desert [45]. Sidama experienced food insecurity, diminishing water resources, drought, erratic and torrential rainfall causing flood and the constellation of marginality all worsened by climatic stress [32].

Livestock production system is sensitive to climate and responding to the challenges requires formulation of appropriate adaptation options for the sector [37]. This study, therefore, identifies the effects of climate change on livestock production and possible adaptation measures taken by farmers in highlands and lowlands of Sidama region.

2. Methodology

2.1. Description of the Study Area

The study was conducted in Hawasa Zuria and Hula woredas (districts) of Sidama region (Figure 1). The dominant agricultural production system in the study area is smallholder mixed crop-livestock systems. Hawasa Zuria district is found in the great rift valley of Ethiopia and bordered on the south by Shabadino and Boricha, on the west and north by the Oromia Region, and on the east by Wondo Genet. This district almost surrounds Lake Hawasa on all sides. Based on the Census conducted by the CSA, this district has a total population of 124,472, of whom 62,774 are male and 61,698 females.

Hula district is found in the highlands of Sidama Regional State at 98 km South of Hawassa city. It is bordered by Oromia Region on the South, Bursa district on the North and Bona zuria on the East. The district has population of 129,263 of whom 64,551 are men and 64,712 women.

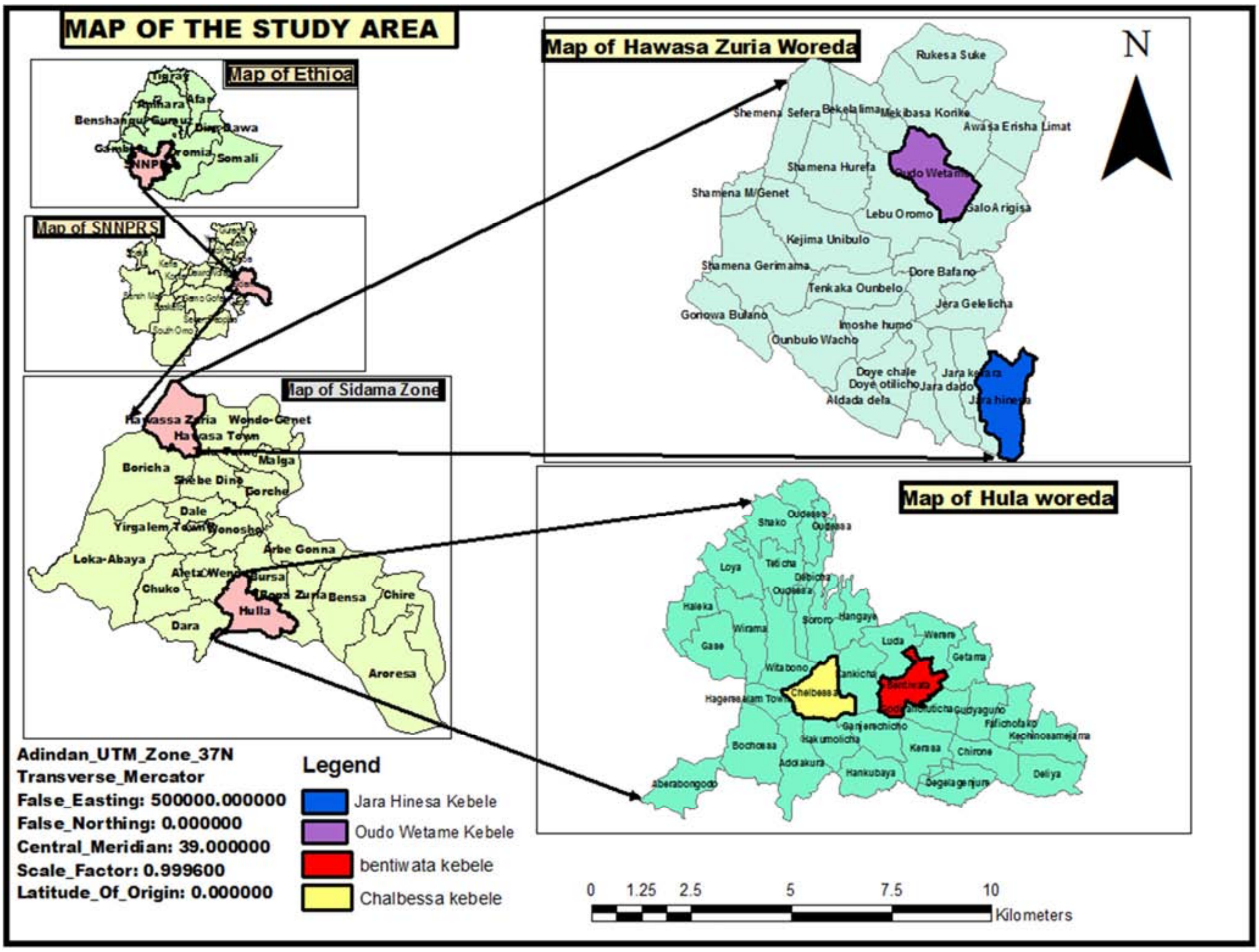

Figure 1. *Location map of the study areas.*

2.2. Sampling Procedure

The selection of study area is predicated on spatial difference, which links to the fact that vulnerability and impacts of climate change and hence adaptation measures vary from place to place. Altitude is the key influence on livelihood systems, farming practices, human settlement, rainfall distribution and temperature. Accordingly, two AEZs were selected representing lowlands, and highlands. Thus, Jara Hi'nessa and Udo Wotate *kebeles* from Hawassa Zuria district (representing lowland) and Bantiwata and Chalbessa *kebeles* from Hula district (representing highland) were selected randomly out of 23 and 31 *kebeles* respectively. Then, sample households were selected using systematic random sampling technique. Lists of total households were acquired from each *kebele* administers. Simplified formula provided by Yamane was used to determine the required sample size at 95% confidence level and 7% level of precision as shown below.

$$n = \frac{N}{1+N(e)^2} = \frac{2475}{1+2475(0.07)^2} \approx 189$$

Where n is sample size, N is total households of selected kebeles and e is precision level.

Both primary and secondary data sources were used. The data on effects of climate change on livestock production, adaptation strategies and determinants were collected through questionnaires directly from sample households, focus group discussions and key informants. Metrological data were gathered from National metrological agency Hawassa branch directorate.

At the Hula (Hagereselam) meteorological station's recording system is poor; from 31 years' records, some years have missed records for two to six months. Years that have such restrictions of records have been fulfilled based on the climatological data estimation method which assumes that a missing value equals the average of measurements taken at the same time in other years.

Climate change can be observed by the long term weather elements like temperature and precipitations. In this regards based on data from National Meteorology agency maximum and minimum temperature and precipitation data of the study districts were analyzed to observe the trends in climate change [58].

2.3. Data Collection Procedure

Household survey: - Semi-structured questionnaires were prepared and the sample households of both AEZs were interviewed about the climate change, its impact on livestock production and the adaptation measures. Data collection was carried out by applying face to face interview of researcher with farmers.

Key informant interviews (KII): - The interview was carried out with a total of 10 key informant interviewees which have included 4 DAs (one from each *kebele*), 4 elder informants (one from each *kebele*) and 2 *woreda* livestock office expert (one from each district).

Focus group discussions (FGDs): - Both male and female farmers representing different age groups, with different education level and wealth groups were selected from each sample *kebeles.* Local, relative wealth status ranking method was used to identify wealth groups; which suggest that a household is poor or rich in the context of its village. Total of eight FGDs were conducted on (two focus group discussions in each *kebele* with 6 participants in each FGD).

2.4. Methods of Data Analysis

Both descriptive statistics and econometric model were used to analyse collected data. Tables, percentages, frequency, graphs and mean values were used to present the analysed data. Data collected from the two different AEZs were analysed separately in order to contrast the results. Independent samples t- test was used to compare the observation of the two districts.

To analyse data type of adaptation measures and its determinants, multinomial logit model (MNL) was used. Trends of rainfall and temperature were analysed by undertaking linear trend analysis and also Mann-Kendall test for trend significance was used. Rainfall data were analysed by Standard Precipitation index (SPI) and Coefficient of Variation. SPI is used to quantify the precipitation deficit for multiple timescales.

$$SPI = \frac{X-\bar{X}}{SD}$$

Where SPI is Standardized Precipitation Index, X is discrete precipitation data, $\bar{X}$ is mean and SD is Standard Deviation

SPI is drought index which is a powerful, flexible and simple to calculate. In addition, it is just as effective in analysing wet periods as it is in analysing dry periods. It indicates the moisture level from extremely wet (SPI ≥ 2) to extremely dry (SPI ≤ -2) [35]. SPI is based on the probability of precipitation for any time scale. The probability of observed precipitation is then transformed into an index. It is being used in research or operational mode in more than 70 countries [62].

Intra seasonal rainfall variability was analysed using the coefficient of variation (CV).

$$CV = \frac{SD}{\bar{X}} \times 100$$

Where CV is Coefficient of Variation; SD is Standard Deviation

The non-parametric Man-Kendall test used to determine whether there was a positive or negative trend in weather data with their statistical significance [36] Therefore, Mann-Kendall trend test was applied to detect the presence of trends in the precipitation and temperature records for Hawassa Zuria and Hula districts.

The test statistic (S) for the Mann-Kendall test is given as:

$$S = \frac{\sum_{i=1}^{N}\sum_{j=i+1}^{N-1} sgn(Y_j - Y_i)}{\sigma_s}$$

$$\sigma_s = \frac{\sqrt{N(N-1)(2N+5) - \sum_{i=1}^{n} ti(i-1)(2i+5)}}{18}$$

Where: N is the number of data, Yj and Yi are the data values in two consecutive periods; ti is the number of ties, i.e. equal values, of extent i and N is the number of tied groups.

The function sign(Y_j-Y_i) =1 if Y_j- Y_i >0; sign (Y_j- Y_i) =0 if Y=0 and sgn(Y_j- Y_i)=-1 if Y_j- Y_i<0.

MNL model is appropriate to the model of climate change adaptation practice of smallholder farmers. To describe the model, let Y denoted vector of adaptation options for climate change to chosen by farmer household. Assuming the adaptation option farmers' choice are depending on climatic factors, institutional factors and socioeconomic characteristic of the farmers. The MNL model for the adaptation choice can be specified in the following relationship between the probability of choosing option and a set of explanatory variables [24].

$$Prob(Y_i = j) = \frac{e^{\beta'_j x_i}}{\sum_{k=0}^{5} e^{\beta'_k x_i}}, \ j=0, 1, 2\ldots5 \qquad (1)$$

Equation (1) is normalized to remove indeterminacy in the model by assuming $\beta_0 = 0$ and the probabilities can be estimated as: -

$$Prob(Y_i = j/x_i) = \frac{e^{\beta'_j x_i}}{1+\sum_{k=0}^{J} e^{\beta'_k x_i}}, \ j=0, 1, 2\ldots j \qquad (2)$$

Maximum likelihood estimation of equation (2) yields the log-odds ratio

$$\ln\left(\frac{P_{ij}}{P_{ik}}\right) = x'_i(\beta_j - \beta_k) = x'_i\beta_j, \text{ if } k = 0 \qquad (3)$$

The dependent variable of any adaptation option is therefore the log of odd in relation to the base alternative. MNL coefficients are difficult to interpret and associating the β_j with the j^{th} outcome is tempting and misleading. Therefore, Marginal effect is useful to interpret the effect of independent variable on the dependent variable in terms of probabilities [24].

$$\frac{\partial P_j}{\partial x_i} = P_j\left(\beta_j - \sum_{k=0}^{J} P_k\beta_J\right) = P_j(\beta_j - \beta), \qquad (4)$$

The marginal effects, measure the expected change in probability of a particular choice being made with respect to a unite change in explanatory variable [24].

Excel sheets, Statistical Packages for Social Scientists (SPSS) version 20 and STATA version 14.2 were used to raw data entry, analysing the data and present the findings.

3. Results and Discussions

3.1. Climate Data Analysis of Hawassa Zuria and Hula

Climate of a region is determined by temperature, precipitation, wind and cloud. Among these temperature and precipitation are major elements.

3.1.1. Rainfall

The trend analysis of the Meteorological data of rainfall over the past 31 years shows that there was slightly increasing trend in annual rainfall in the study areas, despite the perception of the majority of respondents. The recorded data of the areas showed in contrary of the most farmers' perception and indicated an increasing trend in rainfall in 31 years' period. The trends results show an increase of 0.79mm and 11.62mm of rainfall annually in Hawassa Zuria and Hula respectively from the year 1987 to 2017.

A research report indicated that observations on Meteorological station lack congruence with farmers' perception of trend in changing of climate elements. This lack of congruence could be due to the fact that farmers assess rainfall in relation to the needs of particular crops at particular times; small change in quality, onset and cessation of rain over days or even hours can make a big difference, whereas Meteorological data is more likely to measure total and large events [41]. The amount of rainfall has been decreasing in many areas of Ethiopia, but increasing in some areas [56].

According to IPCC there was an increasing of rainfall in parts of east Africa and the historical observed data also revealed which is similar with the results obtained in the study over Hawassa Zuria and Hula districts. Trend analysis of annual rainfall in Ethiopia shows that rainfall remained more or less constant when averaged over the whole country while a declining trend has been observed over the Northern and Southwestern Ethiopia [29].

The annual rainfall of Hawassa Zuria district in the years 1987-2017, ranges from 670.9 mm in 2015 (the driest year) to 1197.9mm in 2006 (the wettest year). The mean annual rainfall of those years is about 959.3mm with SD=141mm. Likewise the annual rainfall of Hula district, ranges from 973.6 mm (in 2003) to 1756.6mm (in 2010). The mean annual rainfall was also about 1326.82mm with SD=205.5mm.

Rainfall of the districts show inter annual variability over the past three decades. According to the result, annual rainfall of Hula was more variable than that of Hawassa Zuria. The change in seasonality, distribution and regularity of rainfall were becoming more of concern than the overall amount of rainfall. Even the main rainy season progressively become shorter some times in some areas; it starts later and stops earlier than it accustomed to.

The present result was consistent with findings that in East Africa regions across Ethiopia, Kenya, Somalia and Tanzania while mean temperature varied with elevation, the more remarkable climate variation was with respect to precipitation in a given area [27]. This variability has also been indicated as a major problem to livestock production as felt by respondents.

The rainfall in Ethiopia does not show any definite trend; it shows high variability [3, 11, 17, 57]. Analysis of the annual total rainfall data of Ethiopia indicated a coefficient of variation ranging from 20 to 89% highlighting the extreme variability of rainfall over the country [3].

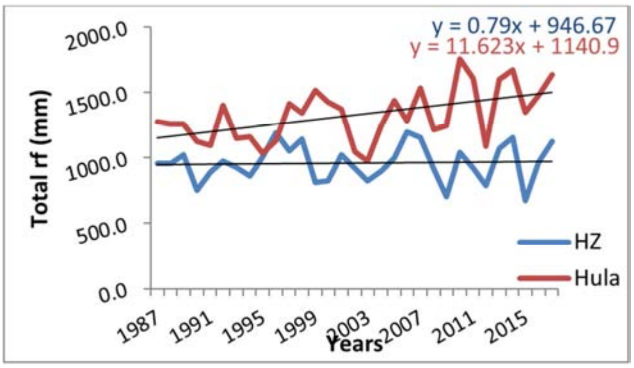

Figure 2. *Annual rainfall trend in HZ and Hula.*

Seasonal rainfall trends and variability

From meteorological point of view, there are three seasons in Ethiopia; *Belg, Kiremt* and *Bega. Belg* (February to May) is the small rainy season in Ethiopia. Much of the northeastern, central, southern, southwestern, eastern and southeastern parts of the country receive considerable amount of rainfall during this season. *Kiremt* (June to September) is the main rainfall season for most parts of the country except for the lowlands of southern and southeastern Ethiopia. *Bega* (October to January) is mostly a dry season for most parts of the country except for southwestern as well as the lowlands of south and southeast Ethiopia [39].

In Hawassa zuria district maximum and minimum rainfall of the main rainy season **(***Kiremt***)** in the last 31 years was 692.6mm and 280mm respectively. The mean rainfall was 460.3mm; with SD and CV of 105.46mm and 22.9% respectively. In Hula district maximum and minimum rainfall of *Kiremt* was 918mm and 316mm respectively. The mean rainfall was 533.9mm with SD of 137.93mm and CV of 25.83%.

In Hawassa zuria there was high inter-seasonal variability between the *belg* and *kiremt* rainfall. Rainfall of *belg* season has shown declining trend from 1987-2017. It has decreased by 0.67mm per year over the past three decades. On the other hand, *kiremt* rainfall was increased by 2mm per year. But in Hula both *belg* and *kiremt* rainfall has increased by 2.74mm and 5.96mm per year respectively.

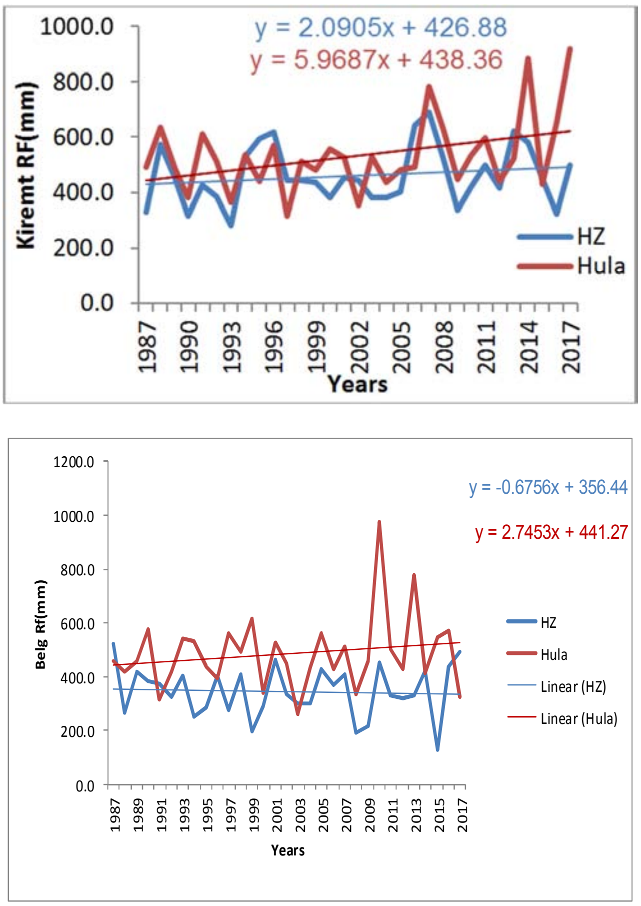

Figure 3. *Kiremt and belg season rainfall trend in HZ and Hula.*

On Figure 3 above, trend lines clearly indicate the increased pattern of rainfall in both districts. Thus, the seasonal rainfall during main rainy season revealed an increasing from time to time over the past three decades. The increasing trend of *Kiremt* rainfall could be the main cause for increasing of annual rainfall. Inversely, in case of short rainy season the trends analysis of the seasonal rainfall shows decreasing in rainfall amounts over time at Hawassa Zuria and slightly increasing at Hula district.

Short rainy season (*Belg*) rainfall extended from 125.7mm to 521.8mm in Hawassa Zuria and 260.5 mm to 975mm in Hula district. The mean rainfall of *Belg* was 345.6mm in Hawassa Zuria and 485.2mm in Hula with SD 94.15 and 137.58 in respective districts. CV of *Belg* season was 27.24% in Hawassa Zuria and 28.35% in Hula, which lie within moderately variable category.

In particular, rains have decreased during the *Belg* season in the East and Southeast with the largest percent reductions [39]. According to Oxfam International [41], the rainfall data gathered from rift valley of Oromia meteorological station showed, in the last three to four decades, rainfall has become highly variable and erratic in terms of amount and distribution in the area. The short rainy season *(Belg)* has failed repeatedly in the past 20 years.

As shown in table 1 below, the rainfall of Hula is more variable than that of Hawassa zuria and *Belg* rainfall has relatively higher CV than total annual and *Kiremt* rainfalls in both districts. The annual rainfall was less variable whereas *Kiremt* and *Belg* rainfall was considered as moderately variable.

Table 1. *Coefficients of variation.*

Districts	Rainfall	Mean rainfall (mm)	CV (%)
Hawassa Zuria	Total annual	959.31	14.69
	Belg	345.6	27.24
	Kiremt	460.3	22.91
Hula	Total annual	1326.82	15.48
	Belg	485.2	28.35
	Kiremt	533.9	25.83

Standard precipitation index (SPI) as a Measure of Drought

Drought indicators based purely on precipitation give a good overall view of the situation. Correspondingly SPI has been used to classify degree of drought. Drought begins when the standardized rainfall anomaly first falls below zero and ends with the first positive value [35].

In Hawassa zuria and Hula districts annual rainfall is below average in 16 years out of 31. Thus, this shows that both districts had been suffering from shortage of rainfall in the years more than a half out of the last three decades. Both districts had below average rainfall in the same 12 years out of 16. As indicated in figure 4 below, the droughts of 1990, 1999 and 2012 in HZ and 1991, 1995, 2002 and 2012 in Hula categorized as moderate drought; their SPI values are (-1.48, -1.06, -1.23, -1.12, -1.41, 1.36 and -1.16), respectively.

Moreover, drought of 2009 in Hawassa Zuria and 2003 in Hula, were categorized as severe drought, their SPI values are (-1.81 and -1.72), respectively. Based on the criterion Hawassa Zuria experienced extreme annual drought in 2015 (SPI = -2.04).

Generally, from 1987 to 2017 three classes of droughts were occurred in Hawassa zuria, (moderate, severe and extreme droughts) and moderate and severe droughts occurred in Hula district. The risk of livestock losses suffered during the occurrence of droughts associated with rainfall variability was one of the most serious threats to livestock herders. Drought is an extreme weather event, which results when rainfall is far below average.

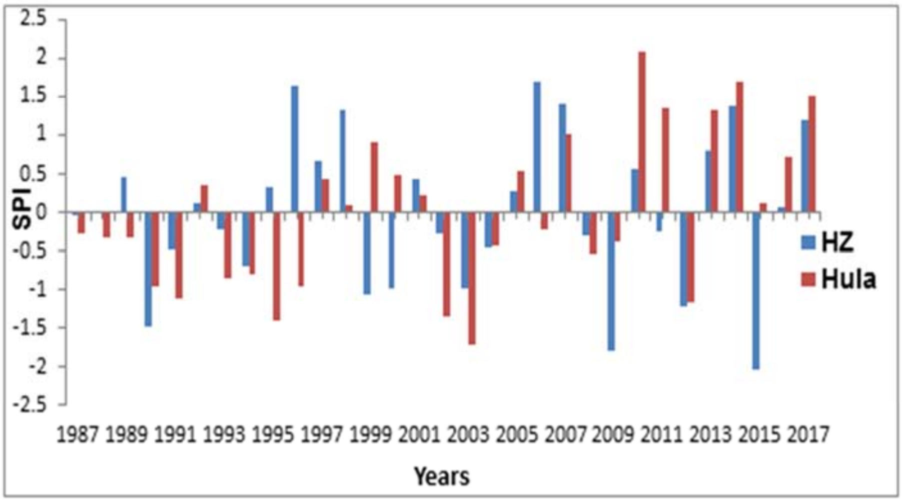

Figure 4. *Standardized precipitation Index at HZ and Hula.*

3.1.2. Temperature

Temperature is one of the elements that determine the weather condition and climate of an area. The average yearly maximum temperature of Hawassa Zuria and Hula districts were 27.5°C and 19°C respectively, while the average minimum temperature of respective districts were 13.1°C and 6.4°C in the last three decades. As indicated in figure 5 below the maximum temperature of Hawassa Zuria and Hula districts over the past 31 years were increased by about 0.03°C and 0.08°C annually respectively. This indicated that maximum temperature of Hula was increased by the faster rate than that of the Hawassa Zuria.

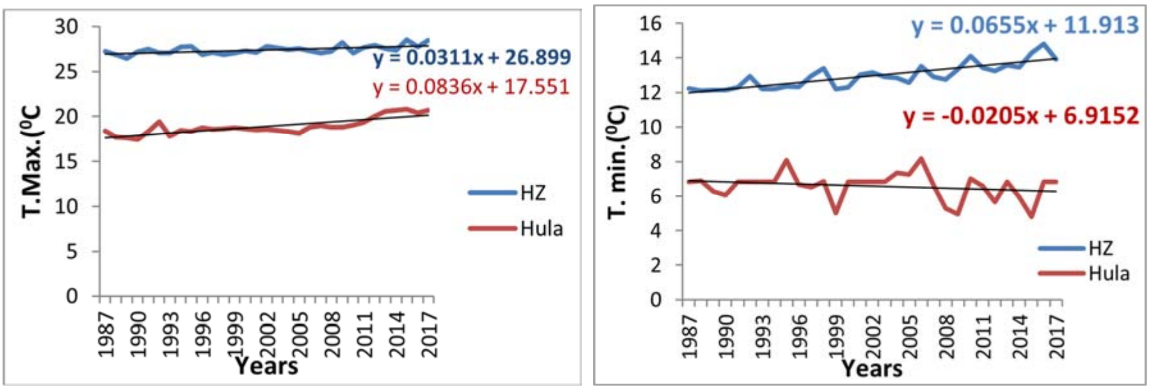

Figure 5. *Trends of maximum and minimum temperature.*

Average minimum temperature of Hawassa Zuria was increased by 0.06°C, while that of Hula district was decreased by 0.02°C annually (Figure 5). Since 1987 temperature has been steadily increasing reaching as high as 28.6°C (2015) and 14.9 (2016) as for annual mean maximum and minimum temperature, respectively in Hawassa Zuria and on the other hand in Hula district, the annual mean maximum temperature reached 21°C (in 2015) and minimum temperature reached about 8.3°C (in 2006).

In Ethiopia the average annual minimum and maximum temperature over the country has been increased by the rate of 0.25°C and 0.1°C every ten years, respectively [40].

3.1.3. Trend Analysis

Detection and attribution of past trends, and variability in climatic variables is essential for the understanding of potential future changes. The Mann-Kendall non parametric trend test was applied to time series of total annual rainfall and maximum and minimum temperature for Hawassa zuria and Hula districts. The test statistic follows the standard normal distribution. The higher the magnitude of the value of the Kendall's tau, the strong the trend is.

Table 2. *Mann-Kendall test of significance.*

Variable	Mann-Kendall's tau	Sig. level
Maximum temperature of HZ	0.4212*	0.00
Maximum temperature of Hula	0.6369*	0.00
Minimum temperature of HZ	0.6662*	0.00
Minimum temperature of Hula	-0.1140	0.36
Total annual rainfall of HZ	0.05	0.68
Total annual rainfall of Hula	0.3333*	0.01

* indicates statistical significance at 5% level

We obtained an increasing trend in the time series of in both maximum and minimum temperature in Hawassa Zuria and maximum temperature and total rainfall in Hula. Minimum temperature in Hawassa Zuria shows the strongest increasing trend.

The direction of the temperature trend in the study area was consistent with several other studies [14, 22] at various spatial and temporal scales have recognized warming trends in minimum and maximum temperature.

In Ethiopia, the average annual minimum temperature over the country has been increasing by 0.25°C every ten years while average annual maximum temperature has been increasing by 0.1°C every decade [39].

3.1.4. Farmers' Perceptions to Climate Change

The farmers were asked whether they had perceived changes in the pattern of rainfall and temperature in their locality. As indicated in table 3 below, about 92.2% and 75.6% of the respondents perceived decreasing amount of rainfall in Hawassa Zuria and Hula districts respectively, while all of the respondents in both districts perceived increasing trend of temperature in the past three decades. There is also statistically significance mean difference between the two local areas respondents' perception on the trends of rainfall at 5% significance level. Consequently, Hawassa Zuria community perceived decreasing rainfall trend more than that of Hula (t- value= 3.788).

The results showed that the respondents, who noted decreasing in amount of rainfall, replied that it led to decrease in pasture production, water availability and increase disease and parasite occurrence. The amount of rainfall might increase from time to time with its intensity increased. The rainfall might come late and withdraw early. Some variations in the rainfall pattern had been experienced in the area from one year to the other over the thirty-year period. As the study conducted by Oxfam International [41] in Oromia region indicated the total number of days were decreased from 73 rainy days in 1982 to 8 rainy days in 2007, whereas the of the total annual rainfall is more or less the same. However, when the rain comes, it is erratic leading to flooding without recharging ground water resources.

The result also indicated that the majority of the respondents noticed a change in the length of rainy season, specifically, 90.3% and 87.2% observed decreasing in length of rainy season in Hawassa Zuria and Hula respectively, whereas the remaining observed no change in the length of rainy season in respective districts.

Table 3. *Perception on rainfall and temperature trend.*

Variables		HZ (n=103)		Hula (n=86)		t-value (df=187)
		Frequency%		Frequency%		
RF Amount	Increasing	-	-	9	10.4	
	Decreasing	95	92.2	65	75.6	3.788*
	No change	8	7.8	12	14	
RF Pattern	Highly variable	54	52.4	42	48.8	
	Slightly variable	31	30.1	33	38.4	0.2807
	No change	18	17.5	11	12.8	
RF duration	Prolonged	-	-	-	-	
	Becoming Short	93	90.3	75	87.2	0.6686
	No change	10	9.7	11	12.8	
Onset of rainy Season	Early	3	2.9	-	-	
	Late	88	85.4	63	73.3	1.4131
	On time	12	11.7	23	26.7	
Temperature	Increasing	103	100	86	100	
	Decreasing	-	-	-	-	
	No change	-	-	-	-	

* indicates statistical significance at 5% level.

Various studies have demonstrated a good match with the result of perceptions of the local people in Ethiopia. Climate change and its impacts have also been perceived by local people, who express (from their indigenous knowledge and experiences) climate variability and change in that generally the temperature is increasing and the rainfall is decreasing [2, 10, 30, 43, 55, 56].

Generally, all the farmers in the study areas said that they were aware of climate change, mainly through their life time experiences. In general, this study presented farmers believe that the climate is changing for the bad and had led to changes in livestock productivity. Similarly, studies which assessed farmers' perception on climate change in Ethiopia have reported comparable findings.

The study conducted by Belachew and Zuberi on farmers' perception of climate change and their response in Central Oromia, indicated that farmers had a good understanding and perception of the impacts of climate change at the local level;

many negative impacts of the climate irregularity had been identified by the community, like reduced crop yield, heating/drying up of environment and soil loss affecting natural plant regeneration from the forest soil seed bank, drying up of streams and springs, disappearance of trees and plants, rarity of wild animals and increasing pests/diseases [9].

According to the study conducted in Sidama zone, farmers clearly perceive climate change based on their lived experience and knowledge of their local environment. They identify shifting seasons, increased aridity, drought, erratic rainfall, floods, extreme heat and the emergence/spread of diseases such as malaria as indicators of change. Yet their perception of the cause of climate change varied: deforestation, God’s wrath, abandonment of past traditions/practices and overpopulation [45].

3.2. Effect of Climate Change on Livestock Production

Climate change and its impacts on livestock was the most frequently mentioned problems by the herders of Hawassa Zuria and Hula districts. Respondent in the study areas indicated that climate change had its effect on their livestock production through various mechanisms. The importance of climate change observed on livestock production system in the study areas is demonstrated in tables 4 and 5.

Lack of feed due to drought, flood and unpredictable rainfall; increased disease incidence; and shortage of water due to drought were responded in varied degree between the households of Hawassa Zuria and Hula districts (74.75 vs 86.05; 9.5 vs 13.95 and 15.5 vs 0)% respectively. As a result of the observed changes and increased frequency of climate hazards, livestock feed availability has tremendously reduced.

Moreover, FGD participants in Hula suggested other factors for the increased shrinkage of rangeland area and deterioration of productivity. These include expansion of farming and overgrazing.

The amount and duration of rainfall is declining and the dry season is becoming longer, resulted in shortage of water and pasture that further led to the loss of livestock assets [7]. Furthermore, the effect of climate change on livestock production is measured through the effects on natural pastures, water sources, livestock diseases and biodiversity [5, 28, 38, 42].

Climate change and its impacts on livestock were the major problems to the herders of Hawassa Zuria and Hula districts. Most of the respondents agreed that the quantity and quality of the pastures was deteriorating. This is mostly because of shortage and variability of rainfall. Generally, farmers believe that the decreasing livestock production and reproduction trends were associated with shortages of feed and resulted in poor livestock performance. Changes in rainfall patterns affects pasture growth patterns thereby affecting the quality and quantity of both feed grains and fodder produced.

Similar results were obtained from the FGD from Hula decrease in amount of rainfall that it led to a decrease in pasture production, increase disease and parasite occurrence. Livestock feeds are desperately decreased in quantities and qualities. Areas which were earlier used to serve as pasture lands for livestock grazing and browsing of animals in farming communities have currently shrunk and converted into farmlands because of great pressure imposed from lands for crop cultivations.

Climate change is likely to bring about even more erratic and unpredictable rainfalls and more extreme weather conditions such as longer and frequent droughts. As a result, access to pastures becomes more difficult, leading to loss of livestock. The trends in inter-annual and inter-seasonal rainfall variability like declining in amount, increasing in intensity, varying in the length of growing seasons with increasing temperature are consequently negative effect on livestock productivity [23, 31].

The increased 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 and disease distributions. Reduction of quantity and quality of feed often results in declining the animal production [19, 28].

Table 4. *Factors affecting animal feed in HZ and Hula.*

Factors	HZ (n=103) Frequency%		Hula (n=86) Frequency%		t-value (df=187)
Drought	38	36.9	-	-	6.4752*
Flood	19	18.4	21	24.48	0.6958
RF Variability	20	19.4	53	61.62	5.6633*

* indicates statistical significance at 5% level.

As ranked by respondents, major effects of climate change on livestock production include reduced quality and quantity of feed, incidence of diseases, reduced quality and quantity of water and reduced production and reproduction performance of the animals (table 5). Changes in rainfall patterns affects pasture growth patterns thereby affecting the quality and quantity of both feed grains and fodder produced.

Perceptions of flooding were dominated by two divergent viewpoints. Majority of the respondents (table 3) felt that the amount of rainfall had decreased, whereas 18.4% in HZ and 24.48% in Hula claimed that flooding had actually become more frequent and affecting feed (table 4), as rainfall became more erratic and intense with short-lasting storms.

Generally, most of respondents ranked that reduction of quality and quantity of feed was the primary impact of climate change in both districts. Grazing livestock is negatively affected by climate change. The availability of pasture and water for livestock is determined by climate conditions and land use change. Natural grass was the main feed for cattle in the study areas. High temperature and lacking of water reduced grass development capacity or even made nature grass drier or died. The impacts of increased climate change on livestock production are likely to increase the risk of production and productivity losses.

Table 5. *Rank of major impacts of climate change on livestock production.*

Major impacts	HZ		Hula	
	Index	Rank	Index	Rank
Reduced quality and quantity of feed	0.2799	1st	0.4376	1st
Reduced production performance	0.2443	2nd	0.1564	4th
Increased incidence of diseases	0.2427	3rd	0.2475	2nd
Reduced quality and quantity of water	0.1602	4th	-	-
Reduced reproduction performance	0.0728	5th	0.1584	3rd

Climate change is likely to have major impacts on poor livestock keepers and on the ecosystem goods and services which they depend on. These impacts will include changes in the productivity of forage, reduced water availability, and changing severity and distribution of livestock diseases. Changes in the patterns of rainfall and ranges of temperature affect feed availability, grazing ranges, feed quality, quantity and quality of water, weed, and pest and disease incidence. The spatial distribution and availability of pasture and water are highly dependent on the pattern and availability of rainfall [6, 10, 20, 46, 52, 53].

Occurrence of diseases is one of the major problems ranked by the respondents. This is associated to increased susceptibility of livestock to diseases aggravated by shortage of feed. Drought affected livestock by drying water resources, pasture land and decreasing availability of drinking water to livestock.

The direct effect of extreme weather variability causes significant effect on animal health, growth and reproduction. The effects from feed resources causes were due to change in forage species composition that brought a significant effect on type of animal species or category feed on it and eventually modifies the feeding pattern this was due to the change in quality of forage by increased temperature and reduce the rate of degradability of species which further reduce nutrient availability to animals [44].

Although the direct effects of heat stress on livestock have not been studied in the study areas, increased heat alters feed intake, growth, reproduction and production of animals. Thus, the collective effects of these factors were likely to have a negative impact on livestock productivity in the areas.

3.3. Adaptation Measures

Farmers were asked which climate change adaptation measure they have been using so far. Thus, the result was shown using a pie chart below which indicates the farmers' adaptation strategies taken to reduce the impact of climate change (figure 6).

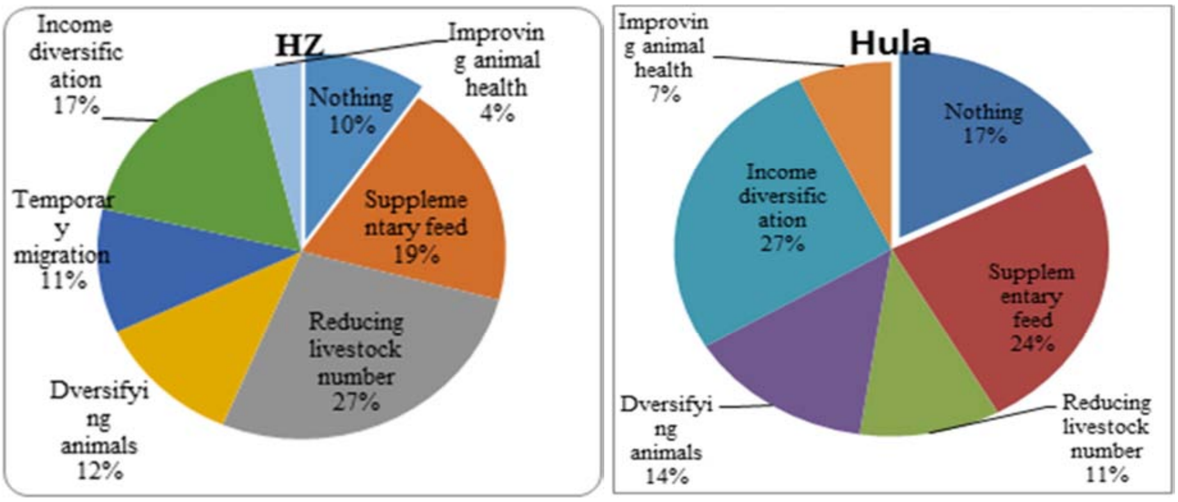

Figure 6. *Adaptation strategies used by the farmers in HZ and Hula.*

In this case, reducing the number of animals is preferred climate change adaptation strategy as it is indicated by 27%, followed by supplementary feed (by 19%) and income diversification (by 17%) in Hawassa Zuria. whereas, income diversification is the primary adaptation method (27%) followed by supplementary feed (24%) in Hula district.

In Central Oromia farmers were observed to diversify their livelihood options as part of responding to irregularities in the local weather and adopting a number of steps to change agricultural systems [9].

The above chart shows that, about 89.32% and 82.56% of the respondents from lowland (Hawassa Zuria) and highland (Hula) AEZ has taken different adaptation measures to climate change respectively, while the remaining 10.68% and 17.44% did not. As compared to the farmers between lowland and highland AEZs, the respondents who has taken adaptation measures from highland AEZ are relatively lower. This is may be due to the fact that the intensity of climate change effects gets lower and lower as one goes from lowlands to highlands. Therefore, this proportion could also be an indicator of where the climate change effects is more sever.

3.4. Factors Affecting Adaptation Choices

The results of MNL model shows how factors influence farmers' choice of adaptation measures in the study area. Therefore, tables 6 and 7 below presents the MNL results along with the levels of statistical significance.

MNL regression shows the determinant variables for each category versus the reference category. The reference category is the household who did not choose any adaptation strategy. The maximum likelihood method was employed to estimate the relative importance of predictor variables on the farmers' decision to choose adaptation measures.

Table 6. *Marginal effects from the multinomial logit climate change adaptation model; HZ.*

Explanatory Variable	Supplementary feed	Reducing livestock number	Diversifying animals	Temporary migration	Income diversification	Improving animal health	No adaptation
Gender	1.6515	-.5816	-.4155	-.4166	-.4169	.3909	-.2117
Education	.0698	.0104	.0145	.0081	.0217	-.0345	-.0902
Labour	.0365	-.0409	.0054	-.0648	.1560*	-.0438	-.0484
Farm size	-.0284	-.0754	.0787 **	-.0180	.0276	.0104	.0050
TLU	-.0593	.0331	-.0380	.1267*	.0279	-.0248	-.0656
Information	.2122	.3812	.2806	.1306	.1581	.0860	-1.249
Experience	-.0268	.3009*	-.0623	-.0420	-.0320	-.0743	-.0632
Saving	.5667	.2556	.2213	.2537	.2789	-.4415	-1.134

Notes: *, **= significant at 1% and 5%, probability level, respectively.

Table 7. *Marginal effects from the multinomial logit climate change adaptation model; Hula.*

Explanatory Variable	Supplementary feed	Reducing livestock number	Diversifying animals	Income diversification	Improving animal health	No adaptation
Gender	-.2926	-.1199	-.1382	-.0326	.8094	-.2260
Education	.2813*	.1125**	-.1303	-.0387	-.0213	-.2034***
Labour	-.0295	.0032	-.0429	.1874*	-.0624	-.0556
Farm size	-.0699	.0045	.1450*	-.0279	-.0330	-.0186
TLU	.0554	-.0575	.1082	.0202	-.0517	-.0745
Information	.0400	-.0547	-.0474	.1226	.0168	-.0773
Experience	-.0420	.1139	-.0054	-.0739	-.0344	.0419
Saving	.4406	-1.278	.3765	.5319	-.5679	.5690

Notes: *, **, *** = significant at 1%, 5%, and 10% probability level, respectively

Interpretation of significance from the marginal effect

Education level of the household head: When the education level of the household is increased by one, the probability of engaging supplementary feed and reducing number of animals as adaptation strategies increased by 28.14% and 11.25% at 1% and 5% significant level respectively in Hula district holding other variables constant. While, education level increases by one the probability of farmers' no to use any adaptation strategy decrease by 20.34% at 10% level of significance, keeping other variables constant in Hula.

Evidence from sources indicates that there is a positive relationship between the education level of the head of household and adaptation to climate change [13]. Therefore, farmers with higher levels of education are more likely to adapt better to climate changes

Active labour: Labour also has significant and positive effect on adaptation strategies to climate change in both districts. A unit increase of active labour in the family increase the probability of farmers to use income diversification adaptation methods by 15.6% and 18.74% in Hawassa Zuria and Hula districts respectively at 1% significant level, keeping other variables constant. Because larger household size enables the adoption of technologies by availing the necessary labour force in one hand and enabling the generation of additional income from extra labour invested in off-farm activities. The finding of this study was similar with the result of Tagel [50].

Farm size: Farmers' adaptation strategy to climate change is also significantly affected by the amount of farm size that the households owned. For instance, a one hectare increases in the farm size increases the probability of the farmers to use diversifying animal species and genetic resources adaptation strategies by 7.88% and 14.5% in Hawassa Zuria and Hula respectively, holding other variables constant.

Farm size may also associate with greater wealth and it is hypothesized to increase adaptation [1, 21, 51].

This indicates that the bigger the size of the farm, the greater the proportion of pasture land allocated for different animal species as some adaptation strategies that the farmers are likely to adopt.

Livestock holding: The number of the livestock owned by the farmer is significant explanatory variable in this study. It was positively influencing the farmers' decision of taking diversifying animal resources in Hula as well as temporary migration in Hawassa Zuria. A one TLU increase in the livestock owned by the household increases the probability of temporary migration by 12.67% in Hawassa Zuria and diversifying animal resource in Hala by 10. 82%.

In this case, livestock is considered as an asset for the farmers and plays a very important role by serving as a source of income. Therefore, having a large number of livestock can strengthen farmers' adaptive capacity to climate change. On the other hand, livestock rearing is one part of agricultural activities which is also subject to climate change impact. Consequently, as the number of the livestock increased the farmers will look for adaptation measures that safeguard their assets against climate related problems. This result is also similar with Legesse et al. [33]. When climate changes are getting more current in arid and semi-arid regions, temporary migration in search for livestock might become a valuable adaptation strategy [48]

Farm experience: It is one of a significant explanatory variable in which its coefficient has positive sign. A year increase in age of the household head increases the probability of farmers to use reducing animal numbers as adaptation measure by 30.09% at 1% significant level and 11.39% at 10% significant level in Hawassa Zuria and Hula districts respectively, other factors remain constant.

The likelihood of taking up climate adoption measures was higher among older farmers. Because as the age of the household head increases, the person is expected to acquire more experience in weather forecasting and that helps increase in likelihood of practicing different adaptation strategies to combat impacts of climate change on livestock production.

This might be attributed to the experience of older farmers perceiving changes in climatic attributes. This result is in line with the findings of Ajibefun and Fatuase [4] On the other hand, due to things like a weaker health, and consequently age and experience might give negative outcomes [48].

4. Conclusion

The study used cross-sectional data collected from 189 households in the production year 2017/2018, and applied descriptive and econometric approaches to analyze the data. In this study area, almost all of the livestock keepers have awareness about the change in the level of precipitation and temperature during the last 30 years in both Hawassa Zuria and Hula districts. Majority of the respondents, about 92.2% in Hawassa Zuria and 75.6% of Hula perceived reduction in amount of rainfall. Meteorological recorded data of the areas showed in contrary of the most farmers' perception and indicate an increasing trend in rainfall in 31 years' period in both districts. This lack of congruence between farmers' perception and Meteorological data is due to the fact that farmers assess rainfall in relation to the needs of particular crops at particular growing seasons. All of the respondents perceived increment in temperature over the last 20 years. Indicators of climate change have been observed in the study area includes: drought, flood, as well as rainfall variability.

Farmers in the study area have encountered climate related problems like feed quality and availability, water quality and availability, risk of animal diseases and hence, reduced performance of animals.

Majority of the livestock herders have been practicing different adaptation measures like income diversification, supplementary feed, reducing number of animals, diversifying animals in both districts. Education, age, labor size, farm size of household and livestock holding are the determents of adaptation measures in the study area.

5. Recommendations

Based on the findings of this study, the following recommendations were forwarded to help the livestock farmers in the highlands and lowlands of Sidama region to tackle climate change impacts and farm productively.

1. Improve the quality of meteorological data and increase the spatial distribution of stations.
2. The vulnerability of lowlands is a grave concern in future and intervention is needed to address water shortage in Hawassa zuria district.
3. Promote use of improved forage species with good nutritive value and which can resist the impact of climate change.
4. Facilitate research and extension services to provide adequate extension and information services to ensure that farmers receive up-to date information about rainfall and temperature patterns in the forthcoming seasons.
5. The study further suggests that the positive and significant variables (i.e. livestock ownership, education level, farm size, and active labor) which prompted the farmers to adapt to climate change be considered when adaptation strategies are implemented.

Acronyms and Abbreviation

AEZs	Agro-ecological Zones
CV	Coefficient of Variation
CSA	Central Statistical Agency
EPCC	Electric Power Control Centres
FAO	Food and Agriculture Organization
HZ	Hawassa Zuria
IPCC	Intergovernmental Panel on Climate Change
MNL	Multinomial Logit Model
NMA	National Meteorology Agency
ONRS	Oromia National Regional State
SD	Standard Deviation
SPI	Standardized Precipitation Index
SPSS	Statistical Packages for Social Scientists
TLU	Tropical Livestock Unit
WFP	World Food Program
WISP	World Initiative for Sustainable Pastoralism

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