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Perception of Fogera Cattle Farmers on Climate Change and Variability in Awi Zone, Ethiopia

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Abstract

This study aimed at assessing perception of Fogera cattle farmers on climate change and variability in selected districts of Awi zone. The zone was classified as lowland (<1500), midland (1500 - 2500), and highland (>2500 m.a.s.l) based on altitudinal variation from which a total of three districts one per cluster were selected through random sampling. 150 households were selected through systematic random sampling targeting Fogera cattle owners for primary data collection. Over 36 years (from 1983-2019) of meteorological data were taken from the National Meteorological Agency. Meteorological data result confirmed that climate was changing across all the agro-ecological zones. Both the mean annual maximum and minimum temperature was considerably increasing for all agro-ecological zones whereas the mean annual rainfall was decreasing which is consistent with the farmers' perception. Meteorological data result also showed that the short rainy and dry season rainfall indicated high interannual variability at all agro-ecological zones. Survey result revealed that 97.13% of the farmers recognized climate change and variability impact in all agro-ecological zones. About 80.91% of Fogera cattle farmers reported the incidence of negative impacts of climate change and variability on cattle. Chi-square test values of survey results show that in all agro-ecological zones frequency of drought, duration of dry spell, wind, and floods were ever-increasing ($p < 0.001$). Moreover, about 84.48%, 65.3%, and 60.47% of farmers owning Fogera cattle in the lowland, midland, and highland, respectively perceived the prevalence of increasing ($p < 0.001$) cattle mortality. In response to climate change and variability, farmers were reducing number of livestock, diversification of livestock species, and replacing Fogera cattle with small ruminants as adaptation strategies. Thus, regular prediction of climate change and variability and designing pertinent response strategies is essential to reduce the adverse impacts of climate change for enhancing resilience capacity of the Fogera cattle farmers in the study areas.

Keywords

Climate Change and Variability, Fogera Cattle Farmers, Perceptions

1. Introduction

Livestock is an essential component of nearly all farming systems in Ethiopia and provides draught power, milk, meat, manure, hides, skins, and other products [1]. Currently, the population of livestock found in Ethiopia is estimated to be 60.39 million cattle, 31.30 million sheep, and 32.74 million goats [2]. Moreover, Ethiopia has a diversified climate ranging from the semi-arid desert type in the lowlands to tropical humid and sub-humid in the highland area [3]. The size and diversity of major agro-ecological zones render it suitable for the support of large numbers and classes of livestock [1]. However, many previous studies [4] [5] showed that the country has suffered from climatic variability and extremes. Climate-related hazards in Ethiopia include drought, floods, heavy rains, strong winds, frost, heat waves, and lightning [4]. The consequence of the long-term climate-related to changes in precipitation patterns, rainfall variability, and temperature has increased the frequency of droughts and floods [4] [6]. According to [7] and [8], climate change influences are more severely felt by poor people who rely heavily on the natural resource base for their livelihoods. Climate models show warming in all four seasons over Ethiopia, which may result in more frequent heat waves [9]. Climate change affects livestock production through competition for natural resources, quantity and quality of feeds, livestock diseases, heat stress, and biodiversity loss while the demand for livestock products is expected to increase by 100% by mid of the 21st century [10]. Cattle are generally the livestock species most susceptible to water and nutritional stresses engendered by climate change and variability, because they are strongly dependent on herbaceous pasture and frequent access to drinking water, which in turn are highly sensitive to variation in precipitation in dry Savannas [11]. Different studies have been conducted in Ethiopia so far [12] [13] [14] [15] but most of them were emphasized on crop production. Thus, little attention was given to cattle farmers. For instance, [16] reported that cattle population size has decreased by 19.8% from 2008 to 2017. Another study conducted in Borana area showed that recurrent droughts (89%) and associated livestock losses (72%) have increased from 1976 and 1984 to 2008 and 2016 while trends in rainfall (92.1%), milk production (93%), and milk and meat consumptions (90.1%) were declining [17]. Little is known about the perceptions of farmers on northern part of Ethiopia who rear Fogera cattle on climate change and variability. Currently, climate change and variability is affecting world population especially low-income countries whose economic activities are mainly dependent on Agriculture. In this regard, the study area is not exceptional. Moreover, the linkage between the perception of Fogera cattle farmers and meteorological data to assess climate change and variability is scarce in the literature. Thus, assessing and understanding the current status of the perceptions of farmers on climate change and variability has paramount importance in designing pertinent management interventions. Therefore, the overall objective of this study was to assess the perceptions of Fogera cattle farmer's on climate change and variability in three selected districts of Awi Zone.

2. Materials and Methods

2.1. Description of the Study Area

The study was conducted in the three districts (Guangua, Dangila, and Banja) of Awi Zone, Amhara National Regional State of Ethiopia. The Zone has a total of nine districts of which three (3) of them are town administrations. It is 445 km far from Addis Ababa and 113 km from the Regional capital city, Bahir Dar. The farming system practiced in the study area is a mixed crop-livestock production system. The area consists of different livestock composition. According to [18], the study site had 1.1 million cattle, 347,299 Sheep, 177,948 goats, and 66,834 horse, 85,488 donkey, 17,138 mules, 873,008 poultry, and 97,518 beehives while the dominant crops grown in the areas were maize, finger millet, wheat, potato, *teff*, and *nug*. According to [4], the area has three defined seasons; dry season (October to January), short rainy season (February to May), and the long rainy season (June to September). The three districts (Guangua, Dangila, and Banja) are selected based on their altitudinal variation as lowland (<1500), midland (1500 - 2500), and highland (>2500 m.a.s.l), respectively. The descriptions of the districts are as follows:

2.1.1. Guangua

Is located at 35˚50'0"E to 37˚30'0"E, longitude and 10˚20'0"N to 11˚10'0"N latitude, and 1583 m.a.s.l. and far 502 km northwest of Addis Ababa. The administrative center of this district is Chagni. The monthly mean minimum and maximum temperature is 13.37˚C, and 28.21˚C, respectively. The mean annual rainfall is 1130 mm. The area possesses extensive grassland coverage and perennial river flows, which is suitable for livestock grazing. The major feed resources for livestock in the study area comprise grasses, shrubs, and tree leaves [19]. Herbaceous and woody plants are the major vegetation types of this district. Among the herbaceous species, grasses accounted for 64.3% of the total herbaceous species with 57% of the grass species being highly desirable (palatable) *Cynodon dactylon*, *Digitaria ternata*, *Digitaria velutina*, *Brachiaria dictyoneura*, *Commelina benghalensis*, and *Panicum maximum* were the most palatable grass species [20].

2.1.2. Dangila

It is located between 36˚35'30"E to 37˚0'30"E longitude and 11˚05'30"N to

11˚25'30"N latitude at an altitude ranging from 1353–2454 m.a.s.l. Most of the landscape of the area is described as a flat surface with a small portion undulating [21]. The monthly mean minimum and maximum temperature is 10.75˚C, and 25.95˚C, respectively. The mean annual rainfall is 1434 mm. Most of the landscape of the district is described as being a flat surface with a small undulating portion. The production system is characterized by mixed farming in which crop and livestock productions are running side by side [22]. The vegetation of the study area is mostly plantation forest of Eucalyptus, and natural tree species *Cordia Africana* (*Wanza*), different Acacia species, and *Missana* are found in the district [23]. A variety of crops, such as annual and perennial crops, grow under rain-fed and irrigation systems. Most of the cereal crops grown in the area are maize, *teff*, wheat, barley, and finger millet. Besides cereal crops, a variety of vegetables (e.g., onion, tomato, pepper, and cabbage), cash crops (e.g., chat and coffee), and fruit crops (e.g., papaya and banana) are also grown [18].

2.1.3. Banja Shekudad

It is located between 36˚39'09" to 36˚48'25"E longitude and 10˚57'17" to 11˚03'05"N latitude with an elevation 2560 m.a.s.l. It is situated 122 km far from the regional city Bahir Dar to south, and 447 km north to Addis Ababa [24]. The administrative center of this district is Injibara, which is situated in a predominantly mountainous location. The hills and valleys receive high amounts of rain, especially in the rainy season. This high rainfall permits farmers to grow multiple crops in a year [18]. The monthly mean minimum and maximum temperature of the area was 9.12˚C and 24.65˚C, respectively. The mean annual rainfall was 1602 mm with the main wet season from June to September. The vegetation type was dominated by *Albizia gummifera*, *Croton macrostachyus*, *Prunus Africana*, and *Apodytes dimidiate* [24] (**Figure 1**).

2.2. Methods of Data Collection

The relevant data for this study were collected from both primary and secondary sources. The primary source was cross-sectional survey collected from households. The primary data majorly includes socioeconomic characteristics, demography, and farmers' perceptions of climate change and variability. To collect primary data from respondents' survey questionnaires, focus group discussions, and field observations were employed. Three focus group discussions were conducted, one per district, each comprising ten persons. The questionnaires were focused on five themes: 1) Socioeconomic characteristics; 2) Farmers' perception of climate change and variability; 3) Farmers' perception of rainfall patterns; 4) Farmers' perception of temperature trends; 5) Farmers' perception of climate change and variability over the last 30 years and their strategy to cope up with the change. Constraints of Fogera cattle production related to feed resources, water sources, and the prevalence of major diseases in the area were collected. The trend in feed availability, water availability, and occurrence of disease were collected over the last 30 years from Fogera cattle farmers. Questionnaires were

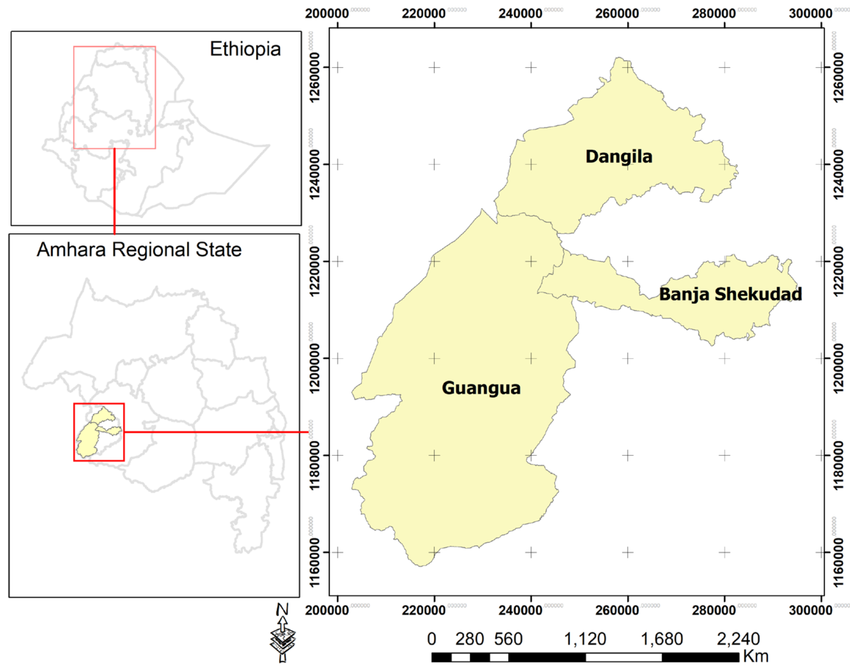

Figure 1. Location map of the study area.

designed, translated to the local language, pretested, and administered. Focus group discussions were held with model farmers and Fogera cattle owners while key informant interviews were held with extension workers, *Keble* leaders (lower administrative unit), and elderly female and male members of the society. The members of the discussion were known to have a better knowledge of the present and past social and economic status of the area to strengthen the reliability of survey questionnaires. Over 36 years (from 1983 to 2019) climate data of three observatory stations (Chagni, Dangila, and Injibara) were taken from National Meteorological Agency (NMA). The temperature and rainfall data over 36 year's period (1983-2019) were collected to link the trend of climate change with the perception of farmers [25].

2.3. Sampling Procedure

The sampling method employed for this study was a multi-stage cluster sampling technique, which was based on the agro-ecological classification of the zone. During this time, a rapid reconnaissance survey was made before the actual survey work to identify the agro-ecological classification. Discussions were held with zonal and district agricultural experts and development agents about agro-ecological classification. Finally, based on their altitude variation districts were clustered into three groups of similar agro-ecological zone as lowland, midland, and highland. According to [18], Awi zone has nine districts and three town administrations from which three districts (Guangua /lowland/, Dangila /midland/, and Banja /highland/) one per cluster were selected randomly. Then, from each district, three *kebeles* (total of nine *kebeles*) were selected following the same procedure while 150 households having at least three and above Fogera cattle were selected through systematic random sampling based on probability proportionate to the size of the *Kebeles*' number of households. At this stage, the selection of respondents was made with the local Ministry of Agriculture and Rural Development staffs and *Kebele* administrators. They have participated in the identification of sampling units and data collection activities.

Sample size for household survey was calculated by the [26] formula;

$$n = \frac{N}{1 + N\left(e^2\right)} \tag{1}$$

where, N is the population size (263) and e is the level of precision (0.05)

2.4. Method of Data Analysis

2.4.1. Perception of Farmers' Analysis

Pearson Chi-Square (χ^2) was used to test the association between the farmers' perception and changes in temperature and rainfall patterns [25]. Selected cattle farming attributes were analyzed using Statistical Package for Social Scientists [27]. A one-way analysis of variance was applied for quantitative dependent variables using agro-ecological zone as the independent variable. Tukey Cramer test was used for mean separation for one way analysis of variance. Descriptive statistics, including percentages and frequencies, were applied for summary and presenting the findings. Indices were calculated for perception of farmer's trait preference, and major Fogera cattle production constraints. The following formula was used to compute index as employed by [28]:

$$Index = \frac{R_n * C_1 + R_{n-1} * C_2 + \cdots + R_1 * C_n}{\left(R_n * C_1 + R_{n-1} * C_2 + \cdots + R_1 * C_n\right)} \tag{2}$$

where, R_n = the last rank (example if the last rank is 8th, then

$R_n = 8$, $R_{n-1} = 7$, $R_1 = 1$).

C_n = the number of respondents in the last rank,

C_1 = the number of respondents ranked first.

2.4.2. Rainfall Variability Analysis

The interannual variability of annual and seasonal precipitation pattern was analyzed as follows:

$$\text{CV}\left(\%\right) = \frac{\sigma}{\mu} \times 100 \tag{3}$$

where, CV = coefficient of variation σ = standard deviation and μ = mean.

According to [29], the degree of variability of rainfall events can be classified as low (CV < 20), moderate (20 < CV < 30), and high (CV > 30).

2.4.3. Trend Analysis

Unlike most of the tropics where two seasons are common (wet season and dry season), three seasons are known in Ethiopia, namely *Bega* (dry season) which extends from October-January, *Belg* (short rainy season) which extends from (February-May), and *Kiremt* (long rainy season) which extends from June-September [4]. Thus, the study areas were classified as dry season (October-January), short rainy season (February-May) and long rainy seasons (June-September) following [4]. Then the monthly mean rainfall and temperature data were classified and analyzed through the application of descriptive statistics technique that involved the calculation of maximum and minimum of both sets, calculation of annual averages. Trend analysis was conducted using the Mann-Kendall (MK) trend test and Sens's slope estimator [30] [31], as implemented in R-package *modifiedmk*. The nonparametric Mann-Kendall test (MK) was used for trend analysis as it is widely used to evaluate trends in agro-meteorological and hydrological time series [32] [33] [34]. The strengths of the MK are usually associated with its simple concept and with the fact that as a nonparametric procedure that does not assume a specific joint distribution of the data, it is minimally affected by departures from normality [35]. All-time series data were tested for serial autocorrelation using Durbin-Watson Test in R-*car* package. Where autocorrelation was not significant, a standard set of tests were applied (command *mkktest*) while when serial autocorrelation was found to be significant, a trend test was performed following a method proposed by [36] that applies a bias-corrected prewhitening (*bcpw*) tool found in the same R package. The rainfall and temperature trends were analyzed using R Software version 3.5.2. The Mann-Kendall test [30] [31] was applied to the long-term data to detect statistically significant trends. In this test, the null hypothesis (H_0) was that there has been no trend in temperature and precipitation over time; the alternate hypothesis (H_1) was that there has been a trend (increasing or decreasing) over time.

The Mann-Kendall test [30] [31] was applied using the formula:

$$S = \sum_{k=1}^{n-1} \sum_{j=i+1}^{n} \operatorname{sgn}\left(x_j - x_k\right) \tag{4}$$

where n = number of data points, x_k and x_j = data values in time series k and j ($j > k$), and $\operatorname{sgn}(x_j = x_k)$ is defined as:

$$\operatorname{sgn}\left(x_j - x_k\right) = \begin{cases} +1 & \text{if } \left(x_j - x_k\right) > 0 \\ 0 & \text{if } \left(x_j - x_k\right) = 0 \\ -1 & \text{if } \left(x_j - x_k\right) < 0 \end{cases} \tag{5}$$

The variance of S was calculated as:

$$VAR(S) = \left\{\frac{1}{18} n(n-1)(2n+5) - \sum_{p=1}^{q} t_p\left(t_p - 1\right)\left(2t_p + 5\right)\right\} \tag{6}$$

where q = the number of tied groups and t_p = the number of data points in the p^{th} group.

Whereas the values of S and $VAR(S)$ are used to compute the test statistic Z as follows:

$$Z = \begin{cases} \frac{s-1}{\sqrt{VAR(s)}} & \text{for } s > 0 \\ 0 & \text{for } s = 0 \\ \frac{s+1}{\sqrt{VAR(s)}} & \text{for } s < 0 \end{cases} \quad (7)$$

where, the positive values of Z indicate upward (increasing) trends in time series, and the negative values show downward (decreasing) trends. Trends are then tested against some critical values ($Z_{1-\alpha}$) to show that either they are statistically significant or not. For example, if $|Z| > Z_{1-\alpha}$, (e.g., $Z_{1-\alpha}$ at $\alpha = 0.05$); the null hypothesis of no-trend is rejected, and alternative hypothesis of significant trend is accepted.

2.4.4. Sen's Slope Estimator

Sen's nonparametric method [31] was used to estimate the magnitude of trends in the time series data as:

$$\beta = median\left(\frac{x_j - x_k}{j-k}\right), j > k \quad (8)$$

where, x_j and x_k represent data values at time j and k, respectively. β is Sen's slope estimate. $\beta > 0$ indicates an upward trend in a time series. Otherwise, the data series presents a downward trend during the time period.

3. Results and Discussions

3.1. Livestock Holding

In all the agro-ecological zones, about 100% of the interviewed households indicated that livestock keeping and crop production were their major farming activities. Out of the total livestock owned by 150 households, 42.33% were cattle whereas 32.42%, 13.90%, 6.73%, and 4.52% were chicken, sheep, goat, and equines, respectively. The higher proportion of cattle in this area might be attributed to the dominant mixed farming system in the study areas in which cattle are the main source of power for agricultural practices. Moreover, cattle, goat, and chicken holdings were higher in lowland than midland and highland (Table 1). The average numbers of Fogera cattle per household among agro-ecological

Table 1. Livestock holding (mean ± SE) by different agro-ecological zones per household.

Livestock species	Lowland ($n = 58$)	Midland ($n = 49$)	Highland ($n = 43$)	Overall
Cattle	17.91 ± 1.21^{a}	8.16 ± 1.32^{b}	14.67 ± 1.40^{a}	13.58 ± 0.76
Sheep	3.59 ± 0.62^{a}	3.76 ± 0.68^{a}	6.02 ± 0.72^{b}	4.46 ± 0.39
Goat	4.02 ± 0.53^{a}	0.08 ± 0.57^{b}	2.37 ± 0.61^{c}	2.16 ± 0.33
Chicken	12.10 ± 1.14^{a}	10.25 ± 1.23^{b}	8.86 ± 1.32^{b}	10.40 ± 0.71
Horse	0.05 ± 0.15^{a}	0.12 ± 0.16^{ab}	0.58 ± 0.18^{b}	0.25 ± 0.097
Donkey	1.72 ± 0.17^{a}	0.82 ± 0.18^{b}	0.52 ± 0.19^{b}	1.02 ± 0.11
Mule	0.04 ± 0.06^{b}	0.45 ± 0.06^{a}	0.07 ± 0.07^{b}	0.18 ± 0.04

Rows with different superscripts are significantly different at $p < 0.05$.

zones were significantly different. The highest number of cattle per household was recorded in lowland and the lowest one in the midland. Similarly, [37], reported that except for equine, livestock holdings of all types were higher in pastoral/agro-pastoral production systems than lowland crop-livestock systems and highland cereal-livestock systems. The second dominant livestock population in all agro-ecological zones was chicken. The highest mean population was also recorded in the lowland than both midland and highland. This might be because of societies living at lowland economic activities are relatively linked to the livestock rearing as compared to midland and highland farmers whose economic activities principally depend on crop-livestock farming. Goat population was the third reported in the lowland, whereas sheep population was third reported both in midland and highland. This difference might be due to the availability of goat feed resources and the suitability of environmental conditions at lowland than at midland and highland and vis-versa.

3.2. Perception of Fogera Cattle Farmers on Climate Change and Variability

The current result revealed that majority (97.13%) of the farmers perceived that the climate is considerably changing in the area across all the agro-ecological zones. On the other hand, 2.87% of Fogera cattle owners did not perceive it. About 86.21%, 100%, and 90.69% of the farmers in lowland, midland, and highland, respectively perceived that temperature was noticeably increasing. Moreover, about 72.40%, 89.79%, and 83.72% in lowland, midland, and highland, respectively reported that rainfall was significantly decreasing (**Table 2**). The

Table 2. Farmers climate change and variability perceptions in percentage at different agro-ecological zones.

Variables	Lowland (N = 58)	Midland (N = 49)	Highland (N = 43)	χ^2-value
Climate is changing				
Yes	91.38	100	100	
No	8.62	-	-	8.205**
Temperature trend				
Increased	86.21	100	90.69	
Decreased	13.79	-	9.3	108.351***
Rainfall trend				
Increased	27.59	10.2	16.28	
Decreased	72.40	89.79	83.72	71.665****
Amount of rainfall				
Increased	10.34	4.08	4.65	
Decreased	89.65	95.91	95.35	136.435***
Duration of rainfall				
Increased	22.41	20.41	-	

Continued

Decreased	77.58	79.59	100	107.010***
Intensity of rainfall				
Increased	32.76	14.29	-	
Decreased	67.24	85.71	100.00	88.905***

***, and **significant at 0.001, and 0.01 p level, respectively. *N* = number of respondents, χ^2: chi-square.

chi-square test values of survey results show that amount of rainfall, its duration and intensity were significantly declining ($p < 0.001$) along all the agro-ecological zones. Generally, the majority of households were aware of the occurrence of climate change. They revealed their local experience of climate change incidence using variability in onset and offset time of the rainy season, the decreased number of rainy days, increased drought severity, and the increased number of hot days. Respondents also indicated that short rainy season rainfall is important for the farming community for planting of long rainy season crops like maize and forage. They reported that the short rainy season is becoming irregular, unpredictable, and resulted in frequent Fogera cattle mortality due to a longer dry season, and a significant increase in livestock disease prevalence were happening in the area, as supported by the presented statistical analysis. Similarly, study conducted in the Tigray region of Ethiopia [38], showed that the majority of farmers perceived total rainfall decreased in the last fifteen years in their localities. Another study in northern Tanzania also indicated that farmers were experiencing a reduced amount of rainfall in their respective villages over the last 30 years [39] which is also consistent with this result.

3.3. Perceived Impact of Climate Change and Variability and Major Adaptation Strategies

3.3.1. Impact of Climate Change and Variability

The majority of Fogera cattle farmers (80.91%) reported experiencing water shortage as negative impacts of climate change and variability in the study areas. The chi-square test values of survey result indicated that frequency of drought, duration of the dry spell, wind, and floods were significantly increasing ($p < 0.001$) in all the agro-ecological zones. Moreover, about 84.48%, 65.3%, and 60.47% of Fogera cattle farmers in the lowland, midland, and highland, respectively perceived that there was significantly an increasing trend of cattle mortality in the study areas ($p < 0.001$) as shown in **Table 3**. Moreover, about 55.17%, 61.22%, and 55.81% of the Fogera cattle owners in lowland, midland, and highland reported that herd size of the Fogera cattle were decreasing in trend whereas 17.24%, 30.61% and 41.86% reported increasing trend, respectively. However, 27.59%, 8.16%, and 2.32% Fogera cattle owners in lowland, midland, and highland were reported that there was no significant change in cattle numbers due to climate change and variability, respectively over the last 30 years. Livestock production is likely to be adversely affected by climate change, competition

Table 3. Perceived impact of climate change and variability in percentage at different agro-ecological zones.

Impact of climate change	Lowland (N = 58)	Midland (N = 49)	Highland (N = 43)	χ^2-value
Water shortage				
Yes	87.93	57.14	97.67	
No	12.07	42.86	2.33	73.131***
Frequency of drought				
Increased	77.59	81.63	69.77	
Decreased	22.41	18.37	30.23	98.946***
Duration of the dry spell				
Increased	75.86	81.63	79.01	
Decreased	24.14	20.93	20.93	109.546***
Winds and floods				
Increased	70.69	59.18	90.69	
Decreased	29.31	40.82	9.30	62.475***
Forage availability				
Increased	27.59	34.69	23.26	
Decreased	72.41	65.3	76.74	5.703^{NS}
Fogera cattle mortality				
Increased	84.48	65.3	60.47	
Decreased	15.52	34.69	39.53	46.561***
Fogera cattle disease				
Increased	72.41	61.22	72.09	
Decreased	27.59	38.78	27.91	1.875^{NS}

***Significant at $p < 0.001$ level while Ns = non-significant N: number of respondent, χ^2: chi-square.

for land and water, and food security at a time when it is most needed [40]. The most important diseases reported by the Fogera cattle owners were ectoparasites (26.78), foot and mouth diseases (FMD) (15.84), lumpy skin disease (15.84), trypanosomiasis (15.32), endoparasites (13.50), and mastitis (12.72%). Group discussion with key informants and extension workers with Fogera cattle owners revealed that majority of these diseases have occurred during the short rainy season when there is no adequate feed and water supply. Participants of group discussion also reported that the emergence of new diseases during a severe drought when there was no adequate cattle feed and water sources. These constraints were one of the major problems of communities residing in lowland areas. Previous studies in Ethiopia also reported an increased incidence of diseases during the long dry season [41]. A similar study by [42] reported that FMD, blackleg, and contagious bovine pleuropneumonia (CBPP) were identified as the major diseases of cattle in Borana area. According to [41], decreasing water levels in rivers and low levels of water accumulation in community ponds have been observed in recent years in Ethiopia. A study conducted by [43], indicated that the negative impacts of heat stress would become more severe in the future, as a consequence of ever-progressing global warming and genetic selection for higher production continues. The same author also reported that even a minute increase in upper critical temperature might severely hamper the cattle production subjecting the farmers to be highly vulnerable to cope with the challenge. This finding is also in line with review work in India which indicated that climate change negatively impacted cattle production both directly and indirectly [44].

3.3.2. Major Adaptation Strategies

The present study revealed three dominant adaptation strategies in the study areas that were reducing the number of livestock, diversification of livestock species, and replacing Fogera cattle with small ruminants. Moreover, mixed farming (crop-livestock), night grazing during hot days, and water harvesting during long rainy season for livestock use were also reported as important adaptation strategies in the study areas (Figure 2). A significant number of Fogera cattle farmers were reported that currently replacing Fogera cattle with small ruminants was becoming an adaptation option because of the shortage of feed resources, especially in the lowland agro-ecological zones. Most of these respondents were reported that they were replacing with small ruminants as small ruminants need relatively small quantities and low-quality feed compared to cattle and equines. Diversification of livestock species is the second important adaptation option reported by the farmers because they believed that if one species fails, they would remain with the other one. In this regard, [17] also reported that due to differences in tolerance to water and feed shortage and resistance to drought among species, multispecies keeping is of vital importance in minimizing

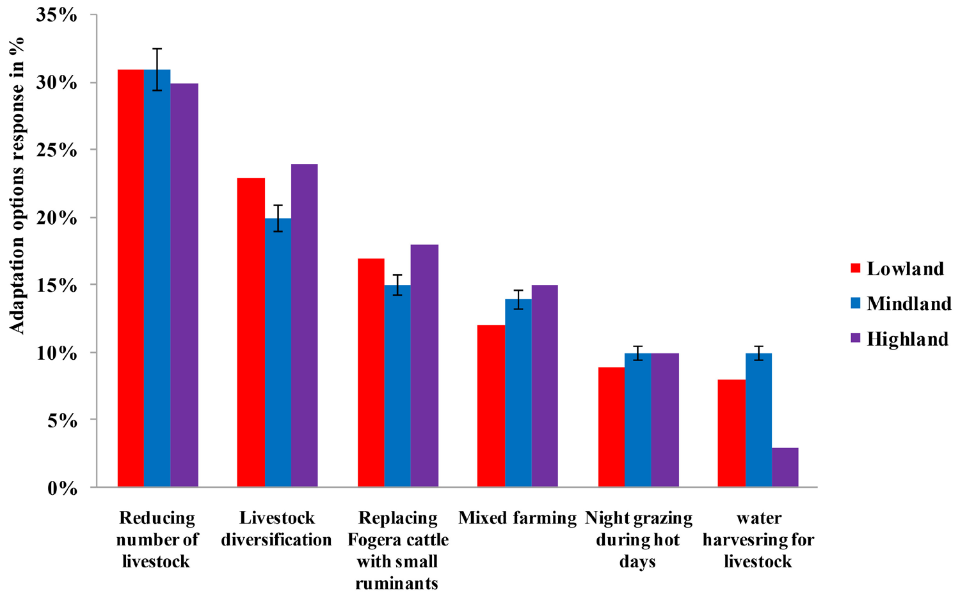

Figure 2. Perceived major adaptation strategies in response to climate change and variability.

climate-related risks. Similar study in the Borana area reported that recurrent droughts, bush encroachment, increased cattle herd vulnerability, and thus the growing demand for adapted animal species, were the major drivers of livestock diversification [11]. Another study conducted in the Afar region outlined that water harvesting, livestock diversification, cattle restocking, hay production, and purchasing of hay were utilized as among the major adaptation measures [45]. This finding is also in agreement with study conducted in Pakistan which reported that livestock farmers attempted to adopt conventional climate change in their areas using different strategies such as mixed farming, reduction of animals number, provision of more drinking water, use of tree shades, livestock diversification, use of muddy roof, and floor to cope with climate changes [46]. Reducing livestock numbers to match carrying capacity of grazing lands through increased commercial off-take rates and forage development such as elephant grass and fodder trees were potential practices for enhancing the adaptive capacity of communities in pastoral areas [41], which is also consistence with the present result.

3.4. Major Constraints of Fogera Cattle Farmers at Different Agro-Ecological Zones

The current result revealed that feed shortage was the dominant constraint with an index value of 0.36, 0.35, and 0.36 in lowland, midland, and highland, respectively (**Figure 3**). Moreover, the second most important constraint was disease prevalence with an index value of 0.27, 0.3, and 0.32 in lowland, midland, and highland, respectively. A previous study, in the Somali region, indicated that feed constraint was the major and equally important constraint in Gode, Kalafo, and Mustahil in Ogden cattle production with an index value of 0.30 [47]. Fogera cattle owners also reported that feed shortage especially during the dry season (October to January) and short rainy seasons (February to May) were the major

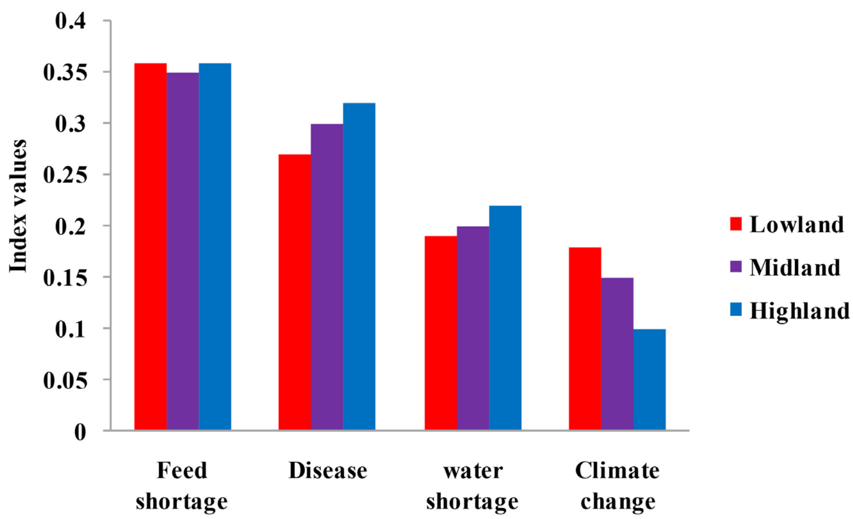

Figure 3. Perceived major constraints of Fogera cattle farmers at different agro-ecological zones.

constraints in the study areas. In addition to the constraints mentioned above, water shortage followed by climate change was the third and fourth-ranked constraints, respectively. Focus group discussion with model farmers and Fogera cattle owners reported that these constraints were affected cattle production through lengthening age at first service, age at first calving, and calving interval which would increase their cost of production and reduce income that could be expected from cattle production. The present finding corroborates the findings of [48] and [49]. Similarly, a study in West Hararghe Zone of Ethiopia shows that recurrent drought, feed shortage, water scarcity, and feed price increment were among the major constraints of betrothed small-scale cattle fattening business [50].

3.5. Perceptions of Fogera Cattle Farmers on Trait Preferences

Milk production was the first preferred trait in selecting females Fogera cattle followed by some adaptive characteristics such as disease-resistant, coat color, appearance, adaptability, and drought tolerance (**Figure 4(a)**). In the case of males, adaptive characters such as disease-resistant, adaptability, coat color, appearance, and drought tolerance were given priority over milk production (**Figure 4(b)**). Preferring for better disease resistance in both males and females might suggest the understanding of the farmers on the importance of selecting animals that can withstand disease in the disease-prone areas under the changing environmental condition. A previous study in Kenya shows that milk production, milk fat content, resistance to diseases, low feed requirement, hardship tolerance, and high growth rate of calves in order of importance [51]. Likewise, [47], reported that despite the importance of milk for pastoral and agro-pastoral society, the selection on the male side was less practiced which further confirms the importance of adaptive characters of livestock in pastoral societies which is corroborated with the present findings. Another survey study in the region indicated that there was preference for Fogera cattle over other breeds due to the presence of desired traits in the breed like better milk production, selling price, traction power, adaptability to the local environments, ability to disease resistance, and drought resistance [52], which is in line with the present findings.

3.6. Trends in Climate Change and Variability

3.6.1. Trends of Temperature

The overall mean annual minimum and maximum temperature in the area range from 11.08˚C to 26.39˚C, and a higher mean maximum temperature was observed in lowland (**Figure 5(a)**). Mean annual maximum temperatures ranged from 24.65˚C to 28.56˚C and generally higher magnitude was recorded in the short rainy season and lowland agro-ecology. The mean annual minimum temperature ranged from 9.12˚C to 13.37˚C (**Table 4**). The mean annual maximum temperature trend was significantly increasing except for midland. During the short rainy season, it was considerably increasing for all agro-ecological zones. The mean annual maximum temperature trend showed an increasing trend in

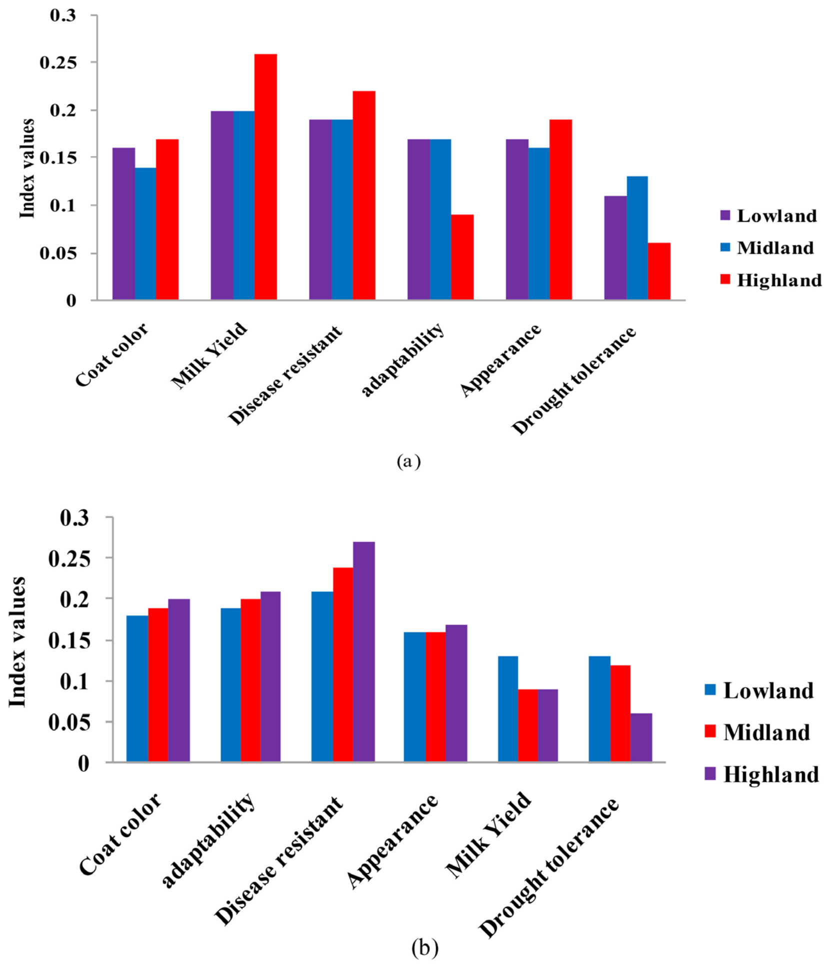

Figure 4. Perception of farmers on trait preferences for female (a) and male (b) Fogera cattle.

Table 4. Mann Kendal (MK) trend analysis of maximum and minim temperature at selected agro-ecological zones (1983-2019).

Maximum Temperature												
	Long rainy season			Short rainy season			Dry season			Annual		
Agro	μ	Z	β	μ	Z	β	μ	Z	β	μ	Z	β
Lowland	25.13	1.66*	0.02	32.07	3.22**	0.05	28.21	0.84	0.01	28.56	2.92**	0.02
Midland	23.17	0.55	0.01	28.83	2.40*	0.04	26.86	0.70	0.01	25.95	1.64	0.01
Highland	22.26	1.55	0.01	26.74	2.55**	0.04	24.96	1.56	0.02	24.65	4.41**	0.02
Minimum Temperature												
	Long rainy season			Short rainy season			Dry season			Annual		
Agro	μ	Z	β	μ	Z	β	μ	Z	β	μ	Z	β
Lowland	15.06	4.83***	0.04	13.89	4.02***	0.06	11.18	4.46***	0.06	13.37	5.14***	0.04
Midland	12.51	3.68***	0.04	11.08	3.29***	0.05	8.65	4.13***	0.06	10.75	4.64***	0.04
Highland	8.00	2.56**	0.01	10.8	2.16**	0.02	8.50	1.67*	0.01	9.12	2.58**	0.01

NB: Agro = Agro-ecological zones, μ = mean, β = Sen's Slope, Z = Mann Kendal test, ***, ** and * significant at 0.001, 0.01 and 0.05 p level respectively, while ns = non-significant at $p < 0.05$.

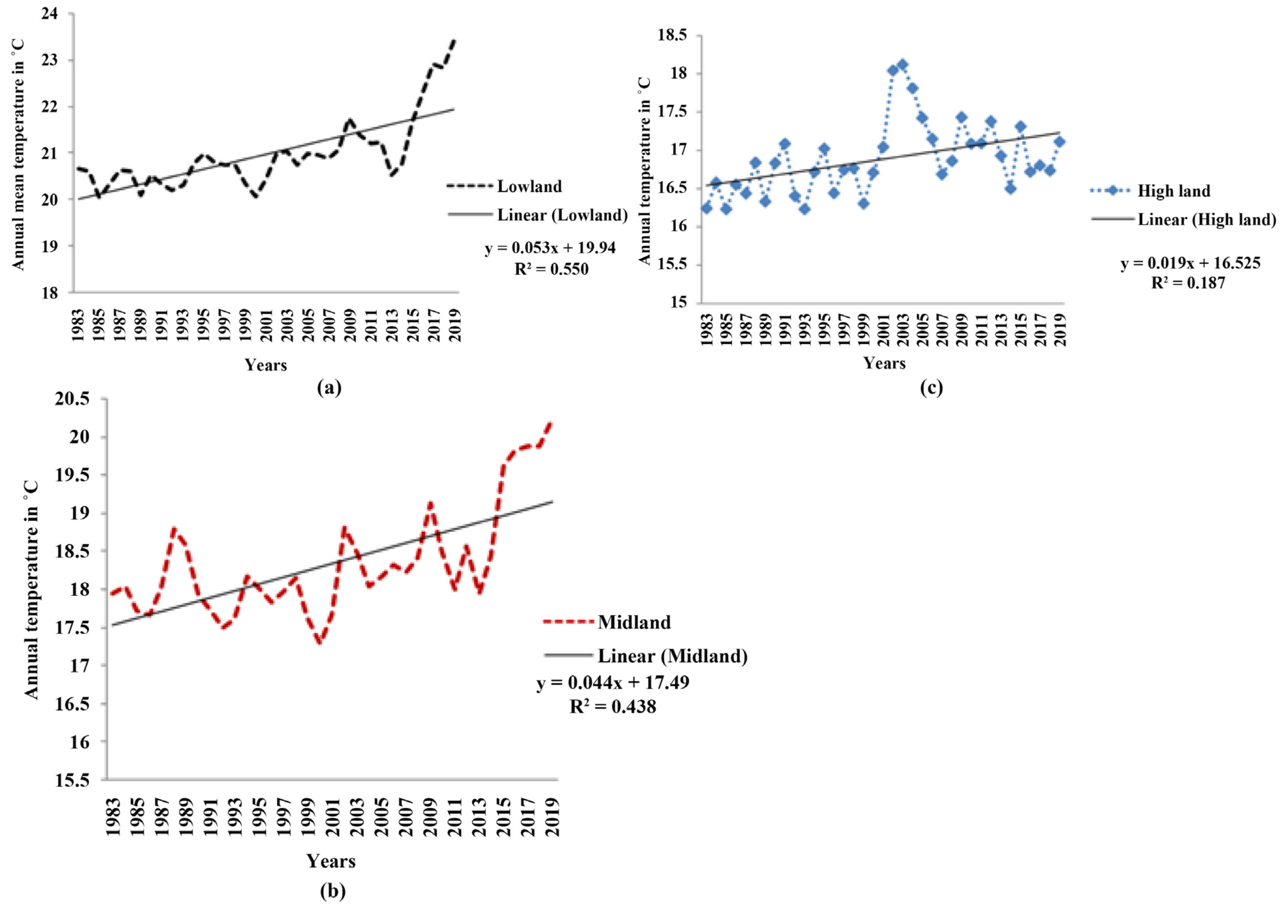

Figure 5. Annual mean temperature trend at lowland (a), midland (b), and highland (c) agro-ecological zones in the study areas.

the study areas which will help the planners to design appropriate strategies to minimize the impact of temperature on the livelihood of the farmers. Moreover, the mean annual minimum temperature trend was significantly increasing for all the agro-ecological zones. The mean minimum temperature trend was also significantly increasing during the long rainy season, short rainy season, and dry season along all agro-ecological zones considered. The mean annual temperature was significantly increasing for all agro-ecological zones as shown in Figures 5(a)-(c), which supports the statistical result. Farmers, key informants, and extension workers participated in the focus group discussion and interview also explained that temperature was increasing every year, which also confirms the statistical results. Another study conducted in the area also showed that most residents perceived that temperature had been increasing while rainfall was declining over the last decades [12] and [13] which were also consistent with the current findings. Most of the previous studies in this region [53] [54] [55] and in Ethiopia in general [14] also confirmed the presence of significant increasing trends in temperature.

3.6.2. Trends of Rainfall

The current result revealed that the mean annual rainfall ranges from 1130 to

1602 mm and a higher mean rainfall was observed in highland during long rainy season (Table 5). The mean annual rainfall trend was significantly decreasing in the lowland agro-ecological zone. Moreover, the mean annual rainfall trend was also decreasing in all agro-ecological zones although the level of decreasing trend was varied (Figures 6(a)-(c)). The MK test also shows that the mean annual rainfall was decreasing in midland and highland nevertheless the trend was not significant (Table 5). The long rainy season mean rainfall trend was decreasing significantly in lowland and highland agro-ecological zones. Even though the trend of long rainy season shows decreasing in midland agro-ecological zone but it was not significant (Table 5). Furthermore, the short rainy season mean rainfall trend was also indicated that decreasing in all agro-ecological zones but the

Table 5. Mann Kendal (MK) trend analysis of rainfall at selected agro-ecological zones (1983-2019).

	Long rain season			Short rain season			Dry season			Annual		
Agro	μ	Z	β	μ	Z	β	μ	Z	β	μ	Z	β
Lowland	889	−3.39***	−11.59	141	−0.77	−1.35	99	−1.03	−0.79	1130	−4.06***	−1.48
Midland	1157	−0.82	−1	162	−0.17	−0.25	115	0.9	0.91	1434	−0.3	−1
Highland	1315	−1.82*	−4.79	167	−0.41	−0.73	118	6.41	0.6	1602	−1.4	−5.4

NB: Agro = Agro-ecological zones, μ = Mean, β = Sen's Slope, Z = Mann Kendal test, μ = Mean, * and *** is significant at 0.05, and 0.001 while ns = non-significant at p < 0.05.

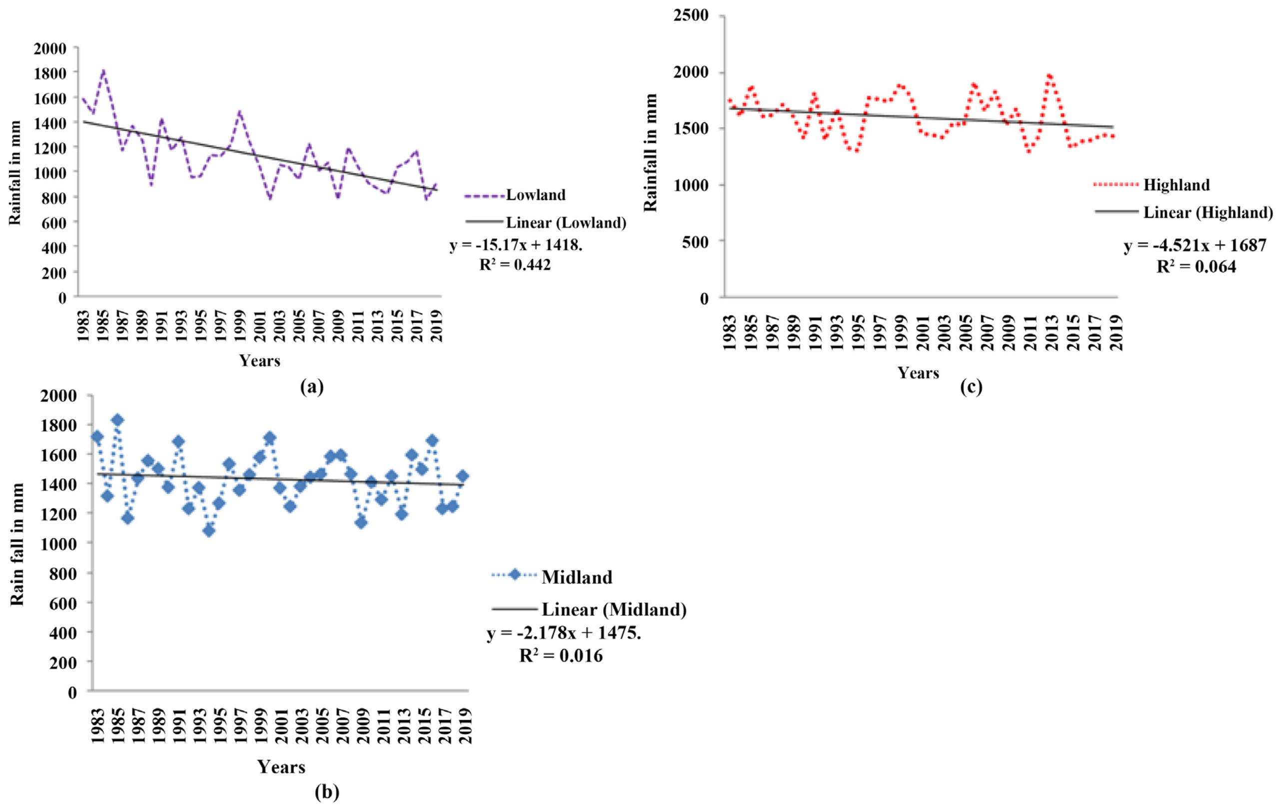

Figure 6. Annual mean rainfall trend in lowland (a), midland (b), and highland (c) agro-ecological zones in the study areas.

trend was not significant. The dry season mean rainfall showed that decreasing in lowland while increasing in midland and highland however the trend was not significant in all agro-ecological zones. The majority of the farmers, key informants, and extension workers participated in the focus group discussion and interview also indicated that rainfall had been decreasing every year. About 56.89%, 89.79%, and 83.72% of the respondents reported that rainfall was decreasing year after year in lowland, midland, and highland agro-ecological zones, respectively that are in line with the statistical results. The amount, duration, and intensity of rainfall were also decreasing in the study areas. Another survey research result in the area also reported that farmers perceived that the rise of temperature and a decline of rainfall [12], which is also in agreement with the current findings. Study in Pakistan also showed that summer season experienced significant negative trends [56].

3.6.3. Variability of Rainfall

The annual rainfall pattern in the area is dominated by the long rainy season. Due to this reason, annual rainfall and long rainy season rainfall showed similar coefficient of variation (CV) across all agro-ecological zones (Figure 7(a), and Figure 7(b)). As rainfall is comparatively abundant in the long rainy season that contributes (80.68%) in the study area, the CV is generally lowest along all

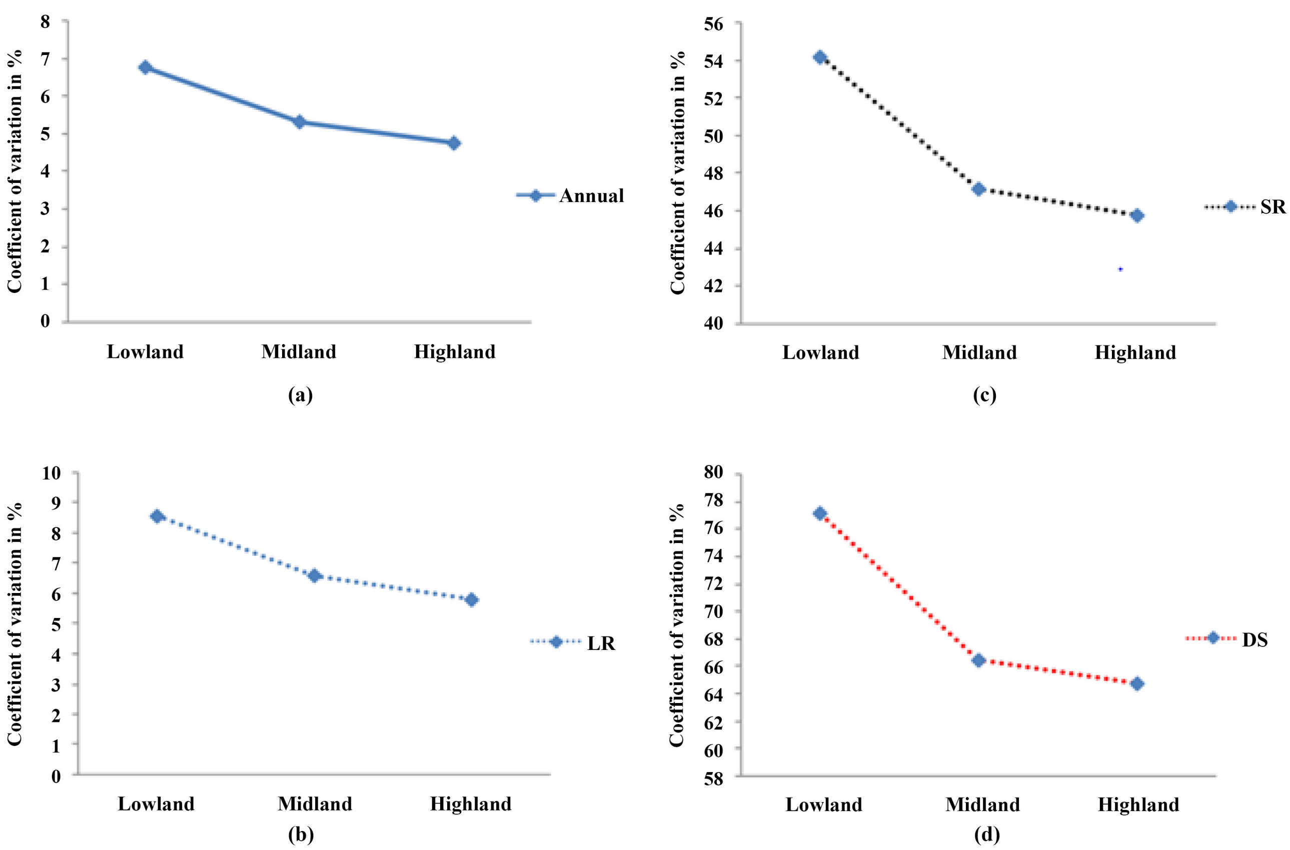

Figure 7. Coefficient of variation in percentage in agro-ecological zones (1983-2019). Where, LR = Long rainy season, SR = Short rainy season, and DS = Dry season.

agro-ecological zones. The CV falls below 20% in all cases for both annual and long rainy season. Moreover, CV was the smallest in the highland agro-ecological zone, where mean rainfall was the greatest. The short rainy season which contributes (11.28%) and dry season which contributes (7.97%) had considerably lower total rainfall than the long rainy season and showed high interannual variability at all along all agro-ecological zones (**Figure 7(c)**, and **Figure 7(d)**). Even though the highland agro-ecological zone tends to show a slightly smaller CV than the lowland agroecology, it had CV greater than 45% in the short rainy season and greater than 64% in the dry season. The current result is in line with the findings of [15]. Similar study conducted in the region also reported Ethiopian rainfall is highly variable [14].

4. Conclusion

The current result revealed that climate is variable in the study area. Meteorological result indicated that the annual mean temperature was increasing, while rainfall was decreasing. The short rainy season and dry season rainfall showed high interannual variability at all agro-ecological zones. Farmers' perceptions were in agreement with meteorological results. Farmers also indicated that forage and water availabilities were decreasing from time to time. However, drought frequency, Fogera cattle diseases, and mortality were increasing. To reduce the adverse effect of climate change farmers have developed their adaptation strategies. Relatively farmers preferred better disease resistance trait as adaptive characters in both male and female animals. Thus, future research efforts should be geared towards improving these traits. Fogera cattle owners also reported that the number of this breed was declining over time. Therefore, future research both on station and at farm level should be geared towards conservation strategies of the breed. A breeding strategy that should take into account disease resistance and adaptation traits should be considered in the future. Regular prediction of climate change and variability and designing pertinent response strategies is essential to reduce the adverse impacts of climate change for enhancing resilience capacity of Fogera cattle farmers in the study areas.

Limitation of the Study

This study was mainly targeted at Fogera cattle owners. Thus, further research is needed to understand how other livestock owners perceive climate change and variability and respond to perceived changes.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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