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Research article

Livestock farmers' perception of climate change and adaptation strategies in the Gera district, Jimma zone, Oromia Regional state, southwest Ethiopia

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ABSTRACT

The aim of this study is to assess livestock farmers' perception of climate change (CC)/variability and adaptation strategies in the Gera district. Rainfall and temperature were the variables taken in the CC perception study. A total of 190 smallholder livestock farmers were sampled for the survey. Primary data were collected through semi-structured questionnaire interviews, focus group discussions (FGDs) and meteorological data series of 2001–2020. The Statistical Package for Social Sciences (SPSS) version 20.0 was used to analyze the data. The results revealed that 79.17% of respondents perceived climate change over the past 20 years. About 84.9% and 82.9% of respondents perceived increasing temperature and decreasing rainfall over the past 20 years, respectively. Farmers' perception was consistent with meteorological data of the area, which also showed increasing trend in temperature and decreasing trend in rainfall. Farmers' perceived that anthropogenic action and natural processes, anthropogenic action, natural processes, and God's anger against human sins were the main causes of CC, in decreasing order. No statistical difference ($p > 0.05$) was found between AEZs regarding effects of CC except for incidence of trypanosomiasis. Decreased quality and quantity of feeds, water availability, milk production, and animal fertility, and increased calving interval, number of services per conception, incidence of animal disease, and parasite were perceived as the major impacts (indicators) of CC on livestock production and productivity in their order of importance. Diversification of mixed crop-livestock, diversification of livestock species, feed conservation, reducing herd sizes, water harvesting, provision of supplementary feeds, and forage production were the most practiced adaptation strategies. Lack of technical know-how about water harvesting, shortage of land for forage production, lack of improved forage seeds, lack of supplementary feed, poor livestock management skill, lack of feed conservation practices and poor access to market were the most important barriers to CC adaptation. It is concluded that there is a need for policy makers and livestock development stakeholders to formulate and implement intervention that promote farmers' perception and adaptation abilities to CC impacts and address the identified barriers for improving livestock productivity in the study area.

1. Introduction

Agriculture has been and still is the mainstay of the Ethiopia's national economy and contributes about 34.1% to the domestic gross product (GDP), 79% of rural employment, and 79% of foreign earnings (MoA, 2011). The livestock sector is an important sub-sector of agriculture and plays a key role in the economy of the country and it contributes 17–25.3% to the national GDP, 39–49% to the agricultural GDP, 12–15% of the export earnings, 60–70% employment opportunity and 50% of household incomes (Shapiro et al., 2017; Azage et al., 2013).

Ethiopia has the largest livestock population in Africa, with 65 million cattle, 40 million sheep, 51 million goats, 2 million head of horses, 9 million head of donkeys, 0.38 million head of mules, 8 million camels and 49 million chickens in 2020 (CSA, 2020a). The national herd supports, at least in part, the livelihoods of more than 11.3 million rural households, including 27–35% of the highland livestock keepers, and a large proportion of the lowland herders, who live below the Government of Ethiopia established poverty line (Shapiro et al., 2017).

If adequate measures are not taken to adapt to the adverse consequences of climate change in sub-Sahara Africa, the region will remain vulnerable to the widespread effects of climate change (FAO, 2009).

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Ethiopia is one of Africa's most vulnerable countries to CC and variability, with climate-related threats constantly affecting people's lives and livelihoods (Burnett, 2013). Climate-related shocks and pressures, the most severe of which are drought and flood, have harmed Ethiopia's agriculture industry (Deressa et al., 2011). Temperature and rainfall patterns have great influence on pasture availability cycle throughout the year among animal populations and the pattern of rain during the year strongly influences livestock production systems through pasture development and disease and parasites outbreaks, therefore influencing animal production and productivity (Tiruneh and Tegene, 2018).

Ethiopia is facing a warming trend in annual temperature as well as a worsening drought. In the last 55 years, the country's average temperature has risen by 0.37 degrees Celsius every ten years (McSweeney et al., 2010). Regional projections of climate models indicate a substantial rise in mean temperatures in Ethiopia over the 21st century and an increase in rainfall variability, with a rising frequency of both extreme flooding and droughts due to global warming (Robinson et al., 2013). A previous study showed that in line with the meteorological evidences, many farmers across Ethiopia perceived increasing temperature, decreasing and erratic rainfall in their villages in the past 20–30 years (Hadgu et al., 2014). Livestock diseases, crop diseases and pests limit agricultural productivity, food and feed shortages, exacerbated floods, and increased environmental refugees are all issues caused by CC (MoA, 2011).

Livestock and CC are intimately linked (Iqubal, 2013), and CC-related events have a major impact on livestock development (Kassaye, 2010). Rising temperatures cause heat stress in livestock, negatively affecting milk production, reproduction, and health (Hammami et al., 2013; Sanker et al., 2013). The change of climate and seasonal fluctuation in herbage quality and quantity will affect the well-being of livestock, and will lead to decline in production and reproduction efficiency of livestock (Sejian et al., 2013).

The trend and abundance of rainfall have a significant impact on the spatial distribution and availability of pasture and water (Aklilu et al., 2013). Changes in rainfall patterns and temperature levels have an effect on feed supply, grazing ranges, feed quality, and the prevalence of weeds, pests, and diseases (Coffey, 2008). Aside from the physiological effects of higher temperatures on individual animals, animal mortality as a result of droughts and floods, as well as disease epidemics linked to CC, could increase (McMichael and Lindgren, 2011). Heat stress causes animals to consume less food and drink more water, as well as improvements in their endocrine state, which increases their maintenance needs, resulting in decreased efficiency (Gaughan and Cawsell-Smith, 2015). Animal feed intake, mortality, development, reproduction, maintenance, and productivity are all expected to change as the climate warms (Robinson et al., 2013).

A decrease in rainfall, lengthening of the duration of the rainy season, and rise in temperatures had a significant impact on animal fodders (Never-smoker, 2014). Increase in temperature may increase lignin and cell wall components in plants (Sanz-Saez et al., 2012; Polley et al., 2013), which reduce digestibility and degradation rates (Polley et al., 2013), leading to a decrease in nutrient availability for livestock (Thornton et al., 2009). An increase in an ambient temperature from 25 to 32 °C has a negative impact on the dry matter intake and milk production of cows (West et al., 2003).

Farmers are major stakeholders in the fight against CC, as well as the control and management of land and land-based resources, especially in agricultural and livestock production (Lemma, 2016). Identifying potential adaptation practices to deal with the adverse effects of CC on livestock productivity can help identify the elements that influence adaptation strategy choice (Silvestri et al., 2012).

It is clear that the farmers' work enables them to experience-firsthand the dynamic nature of climate and ability to cope and adaptation strategies largely depend on the quality of perception (Ayal and Leal, 2017). Adaptation to CC is a global concern (Alam, 2015; Elum et al., 2017) and livestock farmers in Ethiopia are also practicing coping strategies to CC. Adaptation mechanisms such as the modification of production and management systems contains diversification of livestock animals and crops, integration of livestock systems with forestry and crop production, and changing the timing and locations of farm operations (IFAD, 2010). Guo et al. (2018) stated that the major CC adaptation strategies adopted by the livestock farmers in Tigray (Ethiopia) included improved health care, clean shed, provision of shade, selling animals during shock, provision of shade for day and dry season, use of feeding & watering trough and cross breeding.

Previous study reported that for any effective adaptation policy, the decisions and strategies in addressing the impact of CC on farmers must take into account farmers' knowledge and perception of CC, their potential adaptation measures, and possible barriers and constraints to such adaptation (Fosu-Mensah et al., 2012). Therefore, to better cope up and adopt CC strategies, it is very essential to understand farmers' perception of CC impacts on livestock production. Even though, few studies on smallholder farmers' perception to CC, its impacts on livestock production and adaptation strategies (Lomiso, 2020; Michael et al., 2020; Bewuketu, 2017; Mukuye and Mulu, 2021; Deressa et al., 2011) have been conducted in southern, northwestern, northeastern, central, and in the Nile basin of Ethiopia. Despite the importance of livestock in the livelihoods and food security in Gera district, to the best of our knowledge, current information about livestock farmers' perception and adaptation strategies to CC impacts on livestock production, has not been documented. The findings of this study are of crucial importance to provide baseline information for policy decisions as this is the first study to assess farmers' perception and adaptation measures to CC. Moreover, it adds to previous studies and contributes to CC adaptation and mitigation strategies for scaling up. The aim this study was to assess farmers' perceptions and adaptation strategies to CC, its impact on livestock production, adaptation barriers in Gera district.

2. Materials and methods

2.1. Description of study area

This study was conducted in Gera district (District of the Jimma zone, Oromia National Regional State, southwest Ethiopia (Figure 1)) between January to November 2021. The district is located between 7°13′ and 8° 56′ N latitudes and 35° 57′ and 37° 37′ E longitudes. Agro-ecologically the district is classified in to three agro-ecological zones (AEZs) (altitude based regions) viz. lowland (<1500 m above sea levels; m.a.s.l), midland (1500–2300 m.a.s.l) and high land (>2300 m.a.s.l) (MoA, 2000), which comprised of highland (46.11%), midland (50.19%), and lowland (3.7%). The rainfall pattern of the district is bimodal, usually, the long rainy season lasts from June to September, and the short rainy season occurs between March to May. The mean annual rainfall and temperatures ranges from 1880 to 2080 mm and 14.2 °C and 24.2, respectively. Agriculture is the main economic activity and characterized by a rain fed mixed crop-livestock farming systems. The livestock population of the district is estimated to be about 287, 840 cattle, 27,682 goats, 208, 890 sheep 69,550 equine. The major crops cultivated in the district include teff (*Eragrostis tef* (Zucc) Trotter.), wheat (*Triticum aestivum L.*), barley (*Hordeum vulgare* L.), maize maize (*Zea mays* L.), sorghum (*Sorghum bicolor* L.), field pea (*Pisum sativum* L.) and faba bean (*Vicia faba* L.). Moreover, vegetables and root crops produced in the area include onions, garlic, potato (*Solanum tuberosum* L.), cabbage and sweet potato (*Ipomoea batatas* L.). Coffee (*Coffee arabica* L.) is the main cash crop (Gera woreda Office of Agriculture and Natural Resource, 2021).

2.2. Study design, sampling procedure and sample size

The study used cross-sectional survey design to assess livestock farmers' perception of climate change and adaptation strategies in the study area. A multi-stage sampling technique was used employed to select the respondent for the study. In the first stage, Gera district is stratified into three AEZs based on altitude, viz, low (<1500 masl), mid

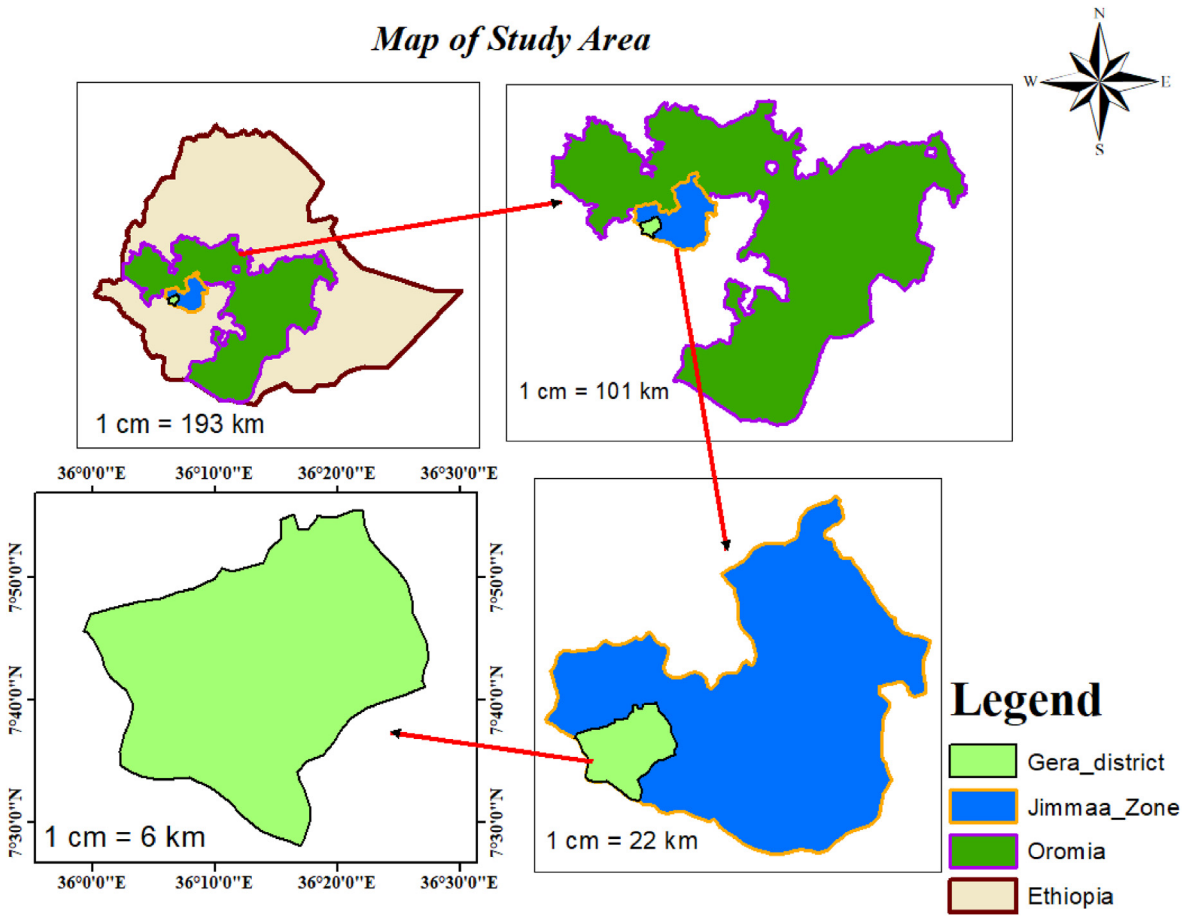


Figure 1. The study area, Gera district.

(1500–2300 masl) and high AEZs (>2300 masl) (MoA, 2000). In the second stage, from the total of 29 *Kebeles* (*Kebele* is the smallest administrative unit in Ethiopia) found in Gera district, 2 *kebeles* from high, 3 from mid and 1 from low AEZ were selected following a simple random sampling technique with the help of Agricultural Development Agents (ADAs) based on high livestock population. The sampling frame or a list of livestock keeping households in each AEZ was provided by the respective *Kebele* administration or ADAs Offices. The sampling frame for the study comprised 5708 households that were identified from the three AEZs of Gera district. Specifically, in high, mid, and low AEZs there were 2486, 2418, and 804 households on the list, respectively. In the third stage, based on the population of these three AEZs, a random sampling technique was used to select a total of 190 (83, 80 and 27 farmers in high, mid and low AEZs, respectively) livestock keeping households using probability proportionate to size sampling technique (Cochran, 1977). The sample size of each *kebele* and AEZ was determined by dividing the total number of livestock keeping households in the kebele/AEZ by the total number of households keeping livestock in the three AEZs and multiplying it by the sample size of the study area (Table 1).

2.3. Data collection methods

A single visit-multiple–subjects formal survey technique of face-to-face interview method of questionnaire administration was adopted to maximize the response rate. The data for this study were collected from primary and secondary data sources. The primary data were collected through a pre-tested, semi-structured questionnaires, focus group discussion (FGDs), key informant interviews (KII) and personal observation during the period of January–November 2021. Secondary data on actual recorded weather data of yearly average rainfall, minimum and maximum temperatures for a period of 2001–2020 were collected from the Ethiopian Meteorological Authority, Gera substation to verify farmers' perceptions regarding the rainfall and temperature trend. The questionnaire was designed in English, but to obtain reliable responses, the questionnaire administration was conducted using appropriate local terms in the common local language (Afan Oromo) spoken by the people in the study area. The interviews were administered by trained ADAs using the local language, *Afan Oromo* with close supervision of the first author. The questionnaire was pre-tested with 15 farmers (5 in each AEZ) before the survey was carried out to note the easy of answering the questionnaire, to adapt the survey instrument to the local conditions of the farmers identify errors associated with the questionnaire and interview content, clarity of questions and omit ambiguous statements, and provided an avenue to ensure the research enumerators understood the data collection process. Based on the pilot responses provided, necessary modifications were made in the questionnaire before administration. The questionnaire was designed to collect primary data on the socio-

Table 1. Summary of farmers selected from the high, mid and low AEZs of Gera district.

Agro-ecology	Kebele	Total household size	Sample size
Highland	Geba koro	1359	45
	Geda gute	1127	38
Midland	Kubo selaja	794	26
	Sedi loya	522	17
	Kola kimbibit	1102	37
Lowland	Oba toli	804	27
Total		5708	190

economic characteristics of the respondents (age, education level, household size, and landholding), farmers' perception of CC (trends of rainfall and temperature) over the past 20 years, perceived causes of CC, impacts of CC on livestock production, adaptation strategies in response to CC, and barriers to adaptation measures. To substantiate the responses acquired using the questionnaires, three FDGs, one per AEZ, was conducted. In addition, guided KIIs were administrated to Gera District Livestock and Natural Resources Development experts and ADAs. For FGD and KII, guide (check-list) was prepared to solicit diverse issues regarding perceptions of CC, causes of CC, impacts of CC on livestock production, adaptation strategies used barriers to adaptation and constraints of livestock production. Secondary data were obtained from annual reports of Gera District Agricultural, Natural Resource, and Livestock Development Offices and ADAs.

2.4. Data analysis

The data collected were processed and statistically analyzed using the Statistical Package for the Social Scientists (SPSS 20.0) software. Descriptive statistics such as frequencies, mean, standard deviation, and percentages were used to summarize and present livestock farmers' socio-demographic characteristics, sources of information about CC, perception on CC, causes of CC, adaptation strategies to CC, and the barriers to adaptation measures in response to CC. The comparisons of different AEZs using cross-tabulation and Pearson Chi-square (χ^2) tests were adopted for categorical variables. Whereas, the analysis of the data was performed using test statistics one-way ANOVA for quantitative data (age, household size and farm size) between AEZs The tests were two sided and were referenced for *P* value for their significance. Any *p*-value <0.05 was considered to be statistically significant.

Farmers' adaptation strategies and adaptation barriers to CC were ranked using weighted average Indices using the formula: Index = sum of (7 × number of responses for 1st rank +6 × number of responses for 2nd rank +5 × number of responses for 3rd rank+ 4 × number of responses for 4th rank +3 × number of responses for 5th rank +2 × number of responses for 6th rank +1 × number of responses for 7th rank) given for an individual adaptation strategies or barriers to adaptations divided by the sum of (7 × total responses for 1st rank +6 × total responses for 2nd rank +5 × total responses for 3rd rank +4 × total responses for 4th rank +3 × total responses for 5th rank +2 × total responses for 6th rank +1 × total responses for 7th rank) summed for overall adaptation strategies and barrier to adaptation (Kosgey, 2004). In determining farmers' perceived adaptation practices and barriers, respondents were requested to rank their perceived strategies and barriers based on a 1–7 rank, where 1 is the most important rank for adaptation practices and barriers and 7 is the least important rank for practices and barriers.

2.5. Ethical clearance

All the data collection instruments (household survey questionnaire and FGD checklists) were reviewed for ethical clearance and approved by the Jimma University, College of Agriculture and Veterinary Medicine. Moreover, informed consent was obtained from all surveyed households and FGD participants of this research.

3. Results and discussions

3.1. Socio-demographic characteristics of respondents

Table 2 summarizes descriptive statistics of socio-demographic characteristics of the sample respondents. Results of the study revealed that there were no significant differences ($P > 0.05$) in socio-demographic characteristics of the respondents between the AEZs of study area. The majority (91.4 %) of respondents were males, while females accounted for 8.6%. The reasons for high proportion of male respondents was probably be due to cultural issues that in male-headed households men are the main decision makers in the household, economic reasons and few number of female-headed (widows or divorced or separated) households in the study area. The result obtained in the current study is in agreement with that of Teshager et al. (2013) and Adugna et al. (2019) who also reported that 95.6% and 92.1% of the respondents were male in Illu Aba Bor Zone, and Mana and Sekoru districts, respectively.

The age of the respondents was not significantly different ($P > 0.05$) across the AEZs. The average age was 45.57 ± 0.75 years, indicating that majority of the respondents in the study area were middle and old aged and are more likely to notice CC and its impacts on livestock production due to their long experience. Higher age of the respondents could also increase their probability of adapting CC measures due to their long farming, social and physical environment experience than younger farmers. The study showed that few youths were involved in livestock production, which could be due to lack of access to land and high capital requirements for purchasing foundation stock, and they migrate to towns for paid jobs. The average age of recorded in the current study is in agreement with that of Adebabay (2009) who reported 45 year but higher than that of Tesfaye and Chairatanayuth (2007) who reported 41.2 years.

Regarding the educational level, majority of respondents (78.3%) had no formal education, followed by a few who were able to read and write. This was attributed to lack of access to educational institutions in the area. Hence, low level of education could influence adaptation to CC (decreasing rainfall and increasing temperature). This result is in line with the findings of Endeshaw (2007), who noted that 75% of the surveyed households in Dale district, Sidama zone were illiterate. However, it is lower than the findings of Mohammed et al. (2016), who reported that about 82.22% and 80% of the surveyed households in Kersa and Tiro Afeta districts of Jimma zone were illiterate. Education helps farmers to be more knowledgeable or access information sources regarding improved technologies and enable them to realize CC, its consequences on livestock production and adopt adaptation strategies. Thus, the low educational level of the respondents in the current study could have negative effect on adoption of adaptation strategies to CC to sustain livestock productivity. It could be said that households with higher education level are likely to be more aware and have better understanding of extension messages about CC and adaptation strategies. Tagel and Van

Table 2. Socio-demographic characteristics of respondents in the three AEZs of Gera district (Mean ± SE/%).

Characteristics	Agro-ecology zone			Overall	P-Value
	High	Mid	Low		
Mean ± standard error					
Age (years)	46.95 ± 1.13	44.32 ± 1.15	45.03 ± 2.13	45.57 ± 0.75	0.266
Household size (number)	7.31 ± 0.31	6.41 ± 0.31	6.5 ± 0.54	6.82 ± 0.20	0.113
Land size (ha)	2.87 ± 0.15	2.31 ± 0.15	2.5 ± 0.25	2.58 ± 0.10	0.123
Percentage (%)					
Sex					0.638
Male	92.8	88.8	92.6	91.4	
Female	7.2	11.3	7.4	8.6	
Level of education					0.898
No education	78.3	70	77.8	75.2	
Reading and writing	18.1	22.5	14.8	18.3	
Primary (1–6)	2.4	3.7	3.7	3.1	
Junior secondary (7–8)	1.2	2.5	3.7	2.2	
Secondary education (9–12)	-	1.2	-	1.2	

der Veen (2013) reported that education advances the farmers' CC perception as it helps to recall and forecast situations. Akinyemi (2017) reported that personal attributes such as age, education, gender, and agricultural experience affect how individuals perceive CC.

The family size was the same ($P > 0.05$) across the AEZs of the study area. The average family size was 6.82 ± 0.20 persons. This result is in line with the findings of Kassahun (2021) who noted average family size of 6.9 per household in Horro and Guduru districts. However, it is higher than the findings of Mekete et al. (2018) who reported 5.9 persons in central highlands of Ethiopia.

The average farm size was 2.58 ± 0.10 ha, which is much higher than the national landholding size of 0.95 ha (WFP/CSA, 2019). There was no significantly difference ($P > 0.05$) in land holding across the studied AEZs, with the highest average land size was recorded in lowland (2.5 ± 0.25 ha) and the lowest in midland (2.31 ± 0.15 ha) AEZ.

3.2. Farmers' sources of information to climate change

The results revealed shows that on average 18% respondents (20.5, 15 and 18% in high, mid and low AEZ, respectively) indicated that they receive information about climate change from radio, and 82% (79.5, 85 and 81.5% respondents in high, mid and low AEZs, respectively) of respondents reported that they obtain information from agricultural development agents. In this study, ADAs are the major source of information for farmers about climate change. This suggests that the role of ADAs is very instrumental in increasing farmers' awareness and access to information about climate change, and this promotes farmers' likelihood of practicing adaptation measures to CC effects. Okoro et al. (2016) reported that the major sources of information about climate change for rural farmers in the Enugu state were personal observation (98.1%), friends (83.8%), radio (57.1%), and television (26.6%).

3.3. Livestock farmers' perception and causes of climate change

Table 3 shows farmers' perception and causes of CC (rainfall and temperature). There was no significant difference ($p < 0.05$) in farmers' perception of climate change and causes, and rainfall and temperature trends between climatic zones. Overall, majority (79.2%) of respondents perceived CC over the last 20 years, while 20.8% of interviewees perceived climate variability (irregular) pattern. The majority (84.9%) of respondents perceived an increase in temperature over the last two decades, while about 4.9%, 7.3% and 2.9% perceived a decrease, no change and did not know, respectively. This result is in agreement with the finding of Adeoti et al. (2016), who reported that 84 % of respondents perceived an increase in temperature. With respect to rainfall, majority (82.9%) of respondents interviewed perceived a decreasing trend in rainfall over the past 20 years, while about 9.3%, 4.9% and 2.9% of respectively, perceived no change, increasing and did not know rainfall trends. This is in line with the finding of Bewuketu (2017), who reported that 83.22% of farmers in Wore Illu district perceived a decrease in rainfall over time. However, it is lower than the results of Tsige (2020), who reported that 92.2% of respondents in Hawassa Zuria perceived a decrease in rainfall over three decades. About 92.2, 78 and 83.3% respondents respectively in Farta, Gondar Zuria and Bahir Dar Zuria districts perceived a decreasing rainfall during the main rainy seasons due to climate change (Alemayehu and Getu, 2016). The results of the present study are in agreement with the findings of Acquah and Onumah (2011), who found that majority of the farmers' perceived increase in temperature and decrease in rainfall in western part of Ghana. Similar results were also reported from FGDs confirming farmers' perception of increase in temperature and decrease in rainfall over the past 20 years. They stated that there has been a variable and erratic rainfall with decline in amount and increase in temperature over the last two decades. They mentioned that temperature has become hotter and drier, and number of hot days increased and coldness during night times decreased. They also experienced variation in amount, distribution, timing and duration

Table 3. Livestock farmers' perceptions and causes of climate change in the study area (% of respondents).

Variable	AEZs			Total	p-value
	High	Low	Mid		
Farmers' perception of climate change					0.174
Climate has changed	71.08	85.18	81.25	79.17	
There was climate variability	28.91	14.81	18.75	20.83	
Causes of climate change					0.526
Anthropogenic action & natural processes	36.14	59.26	46.25	47.22	
Anthropogenic actions	33.73	22.22	28.75	28.23	
Natural processes	16.87	7.41	13.75	12.68	
God's anger due to human sins	13.25	11.11	11.25	11.87	
Changes in temperature					0.133
Increasing	74.7	92.6	87.5	84.9	
Decreasing	8.4	0	6.3	4.9	
No change	12.0	7.4	2.5	7.3	
I don't know	4.8	0	3.8	2.8	
Changes in Rainfall					0.123
Increasing	8.4	0	6.3	4.9	
Decreasing	71.1	92.6	85.0	82.9	
No change	15.7	7.4	5.0	9.3	
I don't know	4.8		3.8	2.9	

(months) of rainfall with less, irregular, early onset and early exit of rainy season, scattered and shorter rainy periods. They further mentioned crop planting periods have changed in their area with late start of crops cultivation becoming common due to CC, resulting in reduced crop yield and food insecurity. They also stated that the increasing temperature and decreasing rainfall affected the growth, maturity, quality and quantity of natural pasture, resulting in feed shortage, particularly during the long dry season. They further mentioned that anthropogenic activities such as deforestation and natural processes as possible causes of CC. Generally, the results indicate that interviewed and FGD farmers in the current study area had good knowledge of CC, which is a basic prerequisite for adaptation.

In this study, livestock farmers attributed CC to different causes such as anthropogenic activity and natural processes (47.2%), anthropogenic activity (28.2 %), natural processes (12.7 %), and God's anger due to human sins (11.9) for the perceived changes in rainfall and temperature trends. The anthropogenic action was related mainly to deforestation for the purpose of crop land expansion, construction and source of fuel wood, and was attributed to population growth. During FGDs, participants indicated similar causes of CC as results from the questionnaire interview. According to Kuruppu and Liverman (2011) 'God's anger 'caused CC perceptions limit self-efficacy beliefs in taking adaptation measures to climate variability related risks. Debela et al. (2015) also reported that farmers attributed supernatural forces (45%), natural processes (33%), and deforestation (16%) as the main CC causes.

3.4. Comparison between farmers' perception and meteorological data

Climate data from meteorological station in the study area is presented in Figures 2 and 3. Farmers' self-reported climate change perception is not sufficient to generalize about the actual trends of rainfall and temperature variability. Farmers' perception of CC is highly personal, site specific, and influenced by a number of factors (Meredith and Nathaniel, 2016). Therefore, it is helpful in comparing farmers' CC perception and the actual meteorological data which are essential preconditions for adaptation.

Farmers' perceptions of temperature change were compared to yearly rainfall and temperaturedata from 200 1 to 2020 acquired from the Gera district weather station of the Ethiopian Meteorological Agency,

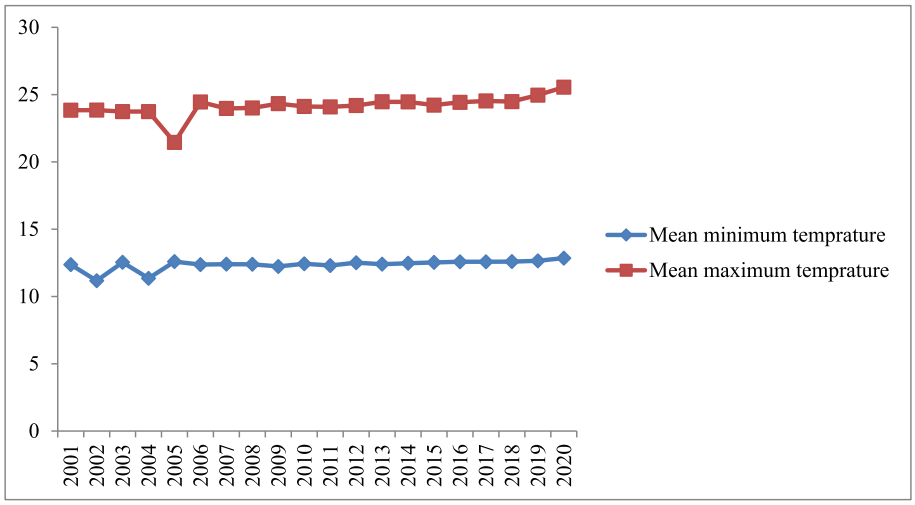


Figure 2. Minimum and maximum mean annual temperature trend for Gera district (2001–2020). (*Data source*: Ethiopian Meteorological Service Agency, sub-office 2021.

southwestern branch. The results indicated a decreasing and increasing trend in rainfall and temperature, respectively.

The results revealed that the mean annual temperature data for Gera district over the period 2001–2020 indicates that temperature has continuously increased (Figure 2). The mean annual temperature over this time period was 12.36 ± 0.4 °C. The minimum and the maximum of the mean values of annual temperatures within the period 2001–2020 were 11.17 and 12.85 °C and occurred in 2002 and 2020, respectively. The results revealed that the statistical analysis of the mean annual rainfall and temperature data for the study area within the period 2001–2020 confirmed the rising trend in temperature and decreasing trend in rainfall of the study area. The average annual temperatures between 2012 and 2020 of the meteorological data exceeded the overall mean for 20 years. The analysis of the weather data of temperature over the past 20 years showed a rising trend of 0.0545 °C per year in the temperature time series (Figure 2). This indicates farmers' perception of increasing temperature was in line with the recorded climate data.

The mean annual rainfall for the district over the period 2001–2020 indicates that rainfall has continuously decreased (Figure 3). The mean annual rainfall over this time period was 1791 ± 197.4 mm. The minimum and the maximum of the mean values annual rainfall within the period 2001–2020 were 1446.1 and 2198.2 mm and occurred in 2020 and 2001, respectively. The average annual rainfall between 2011 and 2020 of the meteorological data fell below the overall mean for 20 years. Regarding rainfall, most of the farmers interviewed perceived it has decreased. The analysis of the meteorological data for rainfall also indicated a decreasing tendency of -6.178 mm per year from 2001 – 2020. Therefore, farmers' perception of decreasing rainfall trend was in line with the recorded meteorological data (Figure 3). Generally, from this study we can conclude that livestock farmers appropriately speculated climate change/variability. These findings are in agreement with results of Hadgu et al. (2014), who reported that in line with the meteorological evidences many farmers across Ethiopia perceived that there was increasing temperature and decreasing and erratic rainfall in their villages in the past twenty to thirty years. The findings of the present study also corroborate with the report of Ayal et al. (2018).

3.5. Farmers' perceived climate change impacts on livestock production

Table 4 shows farmers' perception of CC (rainfall and temperature) impacts on livestock production and productivity over the past 20 years. In this study, there was no significant difference ($p > 0.05$) in impacts of climate change between agro-ecological zones except in the prevalence of trypanosomiasis. Decrease in feed quantity (68.1%), feed quality (64.8%), duration of feed availability (66.1%) and forage growth period (64.8%) were perceived by farmers as the most important impacts of CC

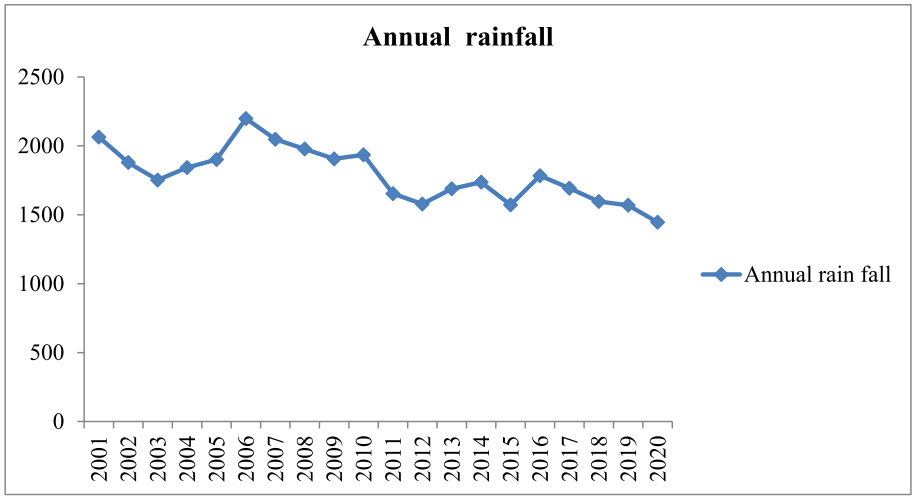


Figure 3. Mean annual rainfall trend for Gera district (2001–2020). (*Data source*: Ethiopian Meteorological Service Agency, sub-office 2021.

Table 4. Farmers' perception of impacts of climate change on livestock production in the study area.

Perceptions of climate change impacts on livestock production	Agro-ecology						Overall		P- value
	High		Mid		Low				
	N	%	N	%	N	%	N	%	
Climate change impacts on livestock feeds, water and health									
Feed availability									0.525
Increased	17	20.5	11	13.8	2	7.4	30	13.9	
Decreased	51	61.4	55	68.8	20	74.1	126	68.1	
No change	15	18.1	14	17.5	5	18.5	34	18	
Feed quality									0.467
Increased	17	20.5	12	15.0	3	11.1	32	15.6	
Decreased	46	55.4	52	65.0	20	74.1	118	64.8	
No change	20	24.1	16	20.0	4	14.8	40	19.6	
Length of forage growing period									0.651
Decreased	49	59.0	52	65.0	19	70.4	120	64.8	
Increased	16	19.3	13	16.3	2	7.4	31	14.3	
No change	18	21.7	15	18.8	6	22.2	39	20.9	
Duration of feed availability									0.372
Increased	17	20.5	11	13.8	2	7.4	30	13.9	
Decreased	47	56.6	54	67.5	20	74.1	121	66.1	
No change	19	22.9	15	18.8	5	18.5	39	20.0	
Livestock production									0.734
Increased	20	24.1	15	18.8	4	14.8	39	19.2	
Decreased	39	47.0	44	55.0	16	59.3	99	53.7	
No change	24	28.9	21	26.3	7	25.9	52	27.0	
Livestock disease susceptibility									0.345
Increased	46	55.4	49	61.3	19	70.4	114	62.4	
Decreased	17	20.5	14	17.5	1	3.7	32	13.9	
No change	20	24.1	17	21.3	7	25.9	44	23.7	
Morbidity of livestock									0.166
Increased	46	55.4	49	61.3	18	66.7	113	61.1	
Decreased	17	20.5	8	10	1	3.7	26	11.4	
No change	20	24.1	23	28.8	8	29.6	51	27.5	
Livestock species more susceptible to disease									0.991
Large ruminants	68	81.9	66	82.5	22	81.5	156	81.9	
Small ruminants	-	-	-	-	-	-	-	-	
Equines	15	18.1	14	17.5	5	18.5	34	18.1	
Livestock mortality									0.543
Increased	38	45.8	44	55.0	16	59.3	98	53.3	
Decreased	20	24.1	15	18.8	3	11.1	38	18.0	
No change	25	30.1	21	26.3	8	29.6	54	28.6	
Water availability									0.123
Increased	7	8.4	5	6.3	0.0	0.0	12	4.9	
Decreased	59	71.1	68	85.0	25	92.6	152	82.9	
No change	13	15.7	4	5.0	2	7.4	19	9.3	
I don't know	4	4.8	3	3.8	0.0	0.0	7	2.9	
Disease and parasite incidences									0.069
Increased	46	55.4	51	63.8	19	70.4	115	63.2	
Decreased	17	20.5	8	10.0	0.0	0.0	26	10.1	
No change	20	24.1	21	26.2	8	29.6	49	26.7	
Prevalence of trypanosomiasis									0.000
Increased	0.0	0.0	0.0	0.0	23	85.2	23	28.4	
Decreased	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
No change	83	100	80	100	4	14.8	167	71.6	
Occurrence of new diseases									0.534
Increased	37	44.6	40	50.0	16	59.3	93	51.3	
Decreased	25	30.1	17	21.3	6	22.2	48	24.5	
No change	21	25.3	23	28.7	5	18.5	49	24.1	
Outbreak of contagious disease									0.404
Increased	42	50.6	49	61.2	19	70.4	110	60.7	

(*continued on next page*)

Table 4 (*continued*)

Perceptions of climate change impacts on livestock production	Agro-ecology						Overall		P- value
	High		Mid		Low				
	N	%	N	%	N	%	N	%	
Decreased	18	21.7	14	17.5	3	11.1	35	16.8	
No change	23	27.7	17	21.3	5	18.5	45	22.5	
Impacts of climate change on livestock productive and reproductive performance									
Service per conception									0.744
Increased	45	54.2	49	61.3	18	66.7	112	60.7	
Decreased	17	20.5	13	16.3	3	11.1	33	16	
No change	21	25.3	18	22.5	6	22.2	45	23.3	
Age at first mating									0.362
Increased	44	53.0	49	61.3	19	70.4	112	61.5	
Decreased	15	18.1	8	10.0	2	7.4	25	11.8	
No change	24	28.9	23	28.8	6	22.2	53	26.7	
Age at first parturition									0.330
Increased	46	55.4	52	65.0	20	74.1	118	64.9	
Decreased	15	18.1	8	10.0	2	7.4	25	11.8	
No change	22	26.5	20	25.0	5	18.5	47	23.3	
Lactation length (cattle)									0.642
Increased	18	21.7	13	16.3	3	11.1	34	16.3	
Decreased	43	51.8	47	58.8	18	66.7	108	59.1	
No change	22	26.5	20	25.0	6	22.2	48	24.6	
Parturition interval									0.454
Increased	40	48.2	45	56.3	18	66.7	103	57.1	
Decreased	20	24.1	14	17.5	3	11.1	37	17.5	
No change	23	27.7	21	26.3	6	22.2	50	25.4	
Milk production (cattle)									0.577
Increased	18	21.7	13	16.3	3	11.1	34	16.36	
Decreased	46	55.4	52	65.0	19	70.4	117	63.6	
No change	19	22.9	15	18.8	5	18.5	39	20.06	
Lactation length (cattle)									0.642
Increased	18	21.7	13	16.3	3	11.1	34	16.3	
Decreased	43	51.8	47	58.8	18	66.7	108	59.1	
No change	22	26.5	20	25.0	6	22.2	48	24.6	
Meat yield/animal									0.558
Increased	17	20.5	12	15.0	3	11.1	32	15.53	
Decreased	48	57.8	53	66.3	20	74.1	121	66.06	
No change	18	21.7	15	18.8	4	14.8	37	18.43	
Animal growth rate									0.260
Increased	17	20.5	12	15.0	2	7.4	31	14.3	
Decreased	45	54.2	51	63.8	21	77.8	117	65.3	
No change	21	25.3	17	21.3	4	14.8	42	20.4	
Animal fattening period									0.862
Increased	46	55.4	49	61.3	18	66.7	113	61.1	
Decreased	15	18.1	13	16.3	4	14.8	32	16.4	
No change	22	26.5	18	22.4	5	18.5	45	22.4	

on livestock. According to Thornton et al. (2009) changes in herbage growth, changes in the floristic composition of vegetation, changes in herbage quality, and changes in the relevance of crop leftovers as animal feed are all possible effects of CC on forage availability and quality. This finding corroborates with the result of Craine et al. (2010), who examined CC impacts on forage quality and resulting nutritional status of cattle. They found that, increasing temperature and declining precipitation levels decrease forage crude protein, digestible organic matter and quality. According to Amole and Ayantunde (2016), options to better adapt feed resources to climate change effect may include cultivation of resilient forage species, fodder conservation including silage and hay making, improvement of forage quality such as processing of locally available feed resources, particularly crop residues, integration of forage legumes into arable crops and grazing management. These feed interventions can improve livestock productivity, enhance adaptation, and reduce greenhouse gas emissions.

In the present study area, natural pasture was reported to be the major source of feed for livestock. According to the respondents, the scarcity of feed was attributed to CC (increase in temperature and decrease in rainfall) happening in their area. FGD participants mentioned that they experienced earlier maturity of natural pasture grasses due to increasing temperature, thus shortening the duration of growth and decreasing biomass yield. According to FAO (2007) CC can affect livestock productivity, directly as well as indirectly through changes in the availability of fodder.

Regarding livestock productivity, about 53.7% and 53.7% of the respondents perceived decrease in livestock production and herd size as negative effects of CC, respectively. This finding concurs with that of

Michael et al. (2020), who reported that about 57.4 % of respondents in Awi zone mentioned a decrease in herd size of Fogera cattle across three AEZs due to CC impacts. However, the current result is lower than the findings of Astawsegn (2014) who reported that 92% of respondents in Soro wareda perceived the number and types of cattle were decreased from year to year due to CC.

With respect to animal health, the negative impacts of CC were reported to be an increase in livestock disease susceptibility, mortality of livestock, trypanosomiasis prevalence, occurrence of new diseases, and contagious disease outbreaks (Table 5). Both households interviewed and FGD participants reported occurrence of new livestock diseases due to CC, resulting in increased livestock morbidity, mortality and productivity. This result is in line with the findings of Adugna et al. (2019), who reported that 54.3% of respondents in Mana and Sokoru districts perceived increased livestock deaths due to CC risks. Previous study reported that as temperatures increase over the typical range, animal death rates rise and higher mortality rates under extreme weather situations (Vitali et al., 2015).

Overall, most (82.9 %) of respondents perceived decreasing availability of water resources due to CC, posing huge challenge to livestock production and productivity, especially during the dry season. FGD participants also reported scarcity of water over time due to reduction in rainfall and increasing temperature. This result is in line with findings of previous studies Mekuyie and Mulu (2021); Biadgilgn and Hailemariam (2018), who reported that about 90% and 62% of respondents respectively in Fentale district and Qola Temben district perceived a decrease and drying of water resources due to CC (decrease in rainfall). Results of FGD showed that water resources are intimately linked with CC, so the prospect of climate variability has serious implications for water resources in the study area. The result further indicated that CC caused a decreased amount of water available in rivers progressively from year to year.

With regard to animal productivity, majority of the respondents in the three AEZs reported increase in the number of services per conception and calving interval, and a decrease in animal growth, milk and meat production as negative effects of CC (rise in temperature and decrease in rainfall). These findings concur with those of Naqvi et al. (2012), who reported that thermal stress due to increase in temperature leads to reproductive inefficiency. An increase in uterine temperature of 0.5 °C above average is associated with a decline in conception rate of 12.8% (Funk et al., 2012). Kassahun and Veerasamy et al. (2016) reported that as heat stress compromises oocyte growth in cows by altering progesterone secretion, it causes infertility in most of farm animals resulting in prolonged parturition interval. It was reported that one of the most significant factors affecting milk production during heat stress is the unavailability of feed (Rust and Rust, 2013). Increasing air temperature, temperature humidity index and rising rectal temperature above the critical threshold levels are related to decrease dry matter intake and reduced milk yield (Padodara and Jacob, 2013). Parsons et al. (2001) and Bekele (2017) also reported that high temperatures may reduce feed intake, lower milk production, leading to energy deficits that may lower cow fertility, fitness and longevity. About 66.1% of the respondents perceived decreases in milk yield over time due to CC and its impact on feed availability. According to Wreford and Topp (2020), changes in the quantity and quality of feed supplies, access to water, the types and breeds of livestock that may be kept, livestock movement, and animal diseases are all possible effects of climate change. Our findings are consistent with findings of Yilma et al. (2009), who reported feed shortage, water scarcity, loss of livestock genetic resources, reduced productivity, and decreased mature weight and/or longer time to reach mature weight were the most important effects of CC on livestock production in their order of importance. Also, Tiruneh and Tegene (2018) reported that higher temperatures resulting from CC may increase the rate of development of certain pathogens or parasites that have one or

Table 5. Livestock farmers' ranking of adaptation strategies to impacts of climate change in the study area.

Adaptation strategies	High land										Midland									
	1st	2nd	3rd	4th	5th	6th	7th	8th	Index[a]	Rank	1st	2nd	3rd	4th	5th	6th	7th	8th	Index	Rank
Water harvesting	0	2	2	5	10	15	22	27	0.083	6th	4	5	6	8	12	10	17	18	0.112	6
Reducing livestock number	10	9	13	13	11	9	8	10	0.155	4th	11	8	8	10	6	11	14	12	0.139	5
Livestock species diversification	13	12	17	12	7	6	12	4	0.171	2nd	15	13	12	11	9	10	6	4	0.172	1
Change livestock species	10	11	10	15	10	9	10	8	0.156	3rd	11	7	12	12	14	12	4	8	0.153	3
Conservation of feed	6	5	5	9	22	18	8	10	0.132	5th	9	8	10	11	14	10	8	10	0.145	4
Supplementary feeding	2	3	8	6	8	11	8	6	0.081	7th	4	5	3	8	7	12	11	8	0.089	7
Forage production	0	0	0	3	2	4	1	3	0.016	8th	0	0	2	3	3	4	2	1	0.022	8
Mixed farming diversification	24	22	10	9	4	8	3	3	0.202	1st	10	16	13	11	7	6	10	7	0.163	2
Total	65	64	65	72	74	80	72	71			64	62	66	74	72	75	72	68		
	Lowland										Over all									
Water harvesting	3	2	4	2	4	5	3	4	0.137	5th	7	9	12	15	26	30	42	49	0.103	6
Reducing livestock number	3	2	2	5	3	4	4	4	0.134	6th	24	19	23	28	20	24	26	26	0.145	4
Livestock species diversification	3	7	3	4	2	3	2	3	0.163	2nd	31	32	32	27	18	19	20	11	0.171	2
Change livestock species	4	3	4	2	5	2	4	3	0.150	4th	25	21	26	29	29	23	18	19	0.155	3
Conservation of feed	5	4	3	4	2	3	2	4	0.158	3rd	20	17	18	24	38	31	18	24	0.141	5
Supplementary feeding	0	3	2	2	4	1	3	1	0.083	7th	6	11	12	16	19	24	20	18	0.084	7
Forage production	0	0	0	0	0	0	0	0	0	8th	0	0	2	6	5	8	3	4	0.016	8
Mixed farming diversification	5	4	4	3	6	2	2	0	0.174	1st	39	42	27	23	17	16	15	10	0.181	1
Total	23	25	22	22	26	20	20	19			152	151	152	168	172	175	162	161		

Index = sum of (7 × for rank 1 adaptation strategy +6 × for rank 2 + 5 × for rank 3 + 4 × for rank 4 + 3 × for rank 5 + 2 × for rank 6 + 1 × for rank 7) given for an individual strategies divided by the sum of (7 × for rank 1 + 6 × for rank 2 + 5 × for rank 3 + 4 × for rank 4 + 3 × for rank 5 + 2 × for rank 6 + 1 × for rank 7) summed over all strategies.

[a] The lower the rank for a given reason, the greater is its importance.

more life cycle stages outside their animal host. Furthermore, the spatial distribution and availability of pasture and water are highly dependent on the pattern and availability of rainfall (Tiruneh and Tegene, 2018). The shortage of feed and water contributes to reduced productivity and reproductive performance of livestock. This includes slow growth rate of animals, loss of body condition, reduced milk production and poor reproductive performance in mature animals (Yilma et al., 2009). Results from FGD also indicated similar negative effects of CC such as decrease in feed quality and quantity, and water availability, and increase in heat stress and diseases and parasite incidences, resulting in decreased animal production and productivity.

3.6. Livestock farmers' perceived ranking of adaptation strategies

Table 5 summarizes adaptation strategies to climate change as ranked by respondents based on their perceived importance. Adaptation to climate change is a two-step process which requires that farmers perceive climate change in the first step and respond to changes in the second step through adaptation (Asrat and Simane, 2018). In this study, the respondents were well perceived the effects of CC and practiced several adaptation measures such as water harvesting, reducing number of livestock, diversification of livestock species, changing livestock species, feed conservation, providing supplementary feed, forage production, and diversifying mixed crop-livestock (diversifying both crop and livestock types) farming. Among these adaptation strategies, mixed crop-livestock diversification and diversification of livestock species were ranked as the first and second most important measures with index values of (x = 0.202 and 0.174 and 0.171 and 0.163) in high and low AEZs, respectively. However, in the mid AEZ, diversification of livestock species and mixed crop-livestock production (crop and animal type diversification) were ranked as the first and second most important measures with mean index values of 0.172 and 0.163.

Across all the surveyed AEZs of the study area, mixed crop-livestock production and diversification of livestock species were ranked as the first and second most important CC adaptation strategies with mean index value 0.181 and 0.171. On the other hand, forage production was ranked the least important practice. This could be attributed to lack of information about forage production, lack of seeds and shortage of land. A similar finding is reported by Lomiso (2020), who found that reducing herd size, diversifying animals species, supplementary feeding, improving animal health, income diversification, and temporary migration as the main adaptation strategies practiced by livestock farmers in Hawasa zuria and Hula districts. In the present study, majority of the farmers adopted multiple cropping (cereals, root crops, vegetables and coffee) and raising cattle, sheep, goats, equines and chicken according to their suitability for the three AEZs against CC impacts.

Table 6. Livestock farmers' ranking of adaptation barriers to climate change in the study area.

AEZ	Barriers to adaptation strategies	1st	2nd	3rd	4th	5th	6th	7th	Index[a]	Rank
Highland	Lack of knowledge about water harvesting	20	16	15	12	11	6	3	0.176	1
	Shortage of land for forage production	18	12	13	11	16	6	7	0.161	2
	Shortage of supplementary feeds	13	14	13	12	7	10	14	0.139	4
	Absence of improved forage seeds	9	12	14	15	13	12	8	0.144	3
	Lack of information about feed conservation methods	6	8	11	10	13	21	14	0.120	6
	Lack of livestock market	6	8	8	11	12	14	24	0.112	7
	Poor livestock management skill	11	13	9	12	11	14	13	0.138	5
	Total	83	83	83	83	83	83	83	-	-
Midland	Lack of knowledge about water harvesting	16	17	14	12	8	8	5	0.168	1
	Shortage of land for forage production	14	12	11	15	12	11	5	0.155	2
	Shortage of supplementary feeds	13	11	8	10	13	11	14	0.139	4
	Absence of improved forage seed	10	13	16	10	14	5	12	0.148	3
	Lack of information about feed conservation methods	8	9	13	16	12	13	9	0.138	5
	Lack of livestock market	11	8	7	8	9	19	18	0.122	7
	Poor livestock management skill	8	10	11	9	12	13	17	0.127	6
	Total	80	80	80	80	80	80	80	-	-
Lowland	Lack of knowledge about water harvesting	3	3	4	3	5	5	4	0.132	3
	Shortage of land for forage production	3	3	4	3	4	5	5	0.129	4
	Shortage of supplementary feeds	5	6	4	5	3	2	2	0.166	1
	Absence of improved forage seed	3	4	6	6	4	3	1	0.156	2
	Lack of feed conservation skill	4	3	3	4	2	3	8	0.128	5
	Lack of livestock market	3	3	2	3	6	7	3	0.126	6
	Poor livestock management skill	6	5	4	3	3	2	4	0.116	7
	Total	27	27	27	27	27	27	27	-	-
Overall	Lack of knowledge on water harvesting	39	36	33	27	24	19	12	0.166	1
	Shortage of land for forage production	35	27	28	29	32	22	17	0.154	2
	Shortage of supplementary feeds	31	31	25	27	23	23	30	0.146	4
	Absence of improved forage seed	22	29	36	31	31	20	21	0.151	3
	Lack of feed conservation skill	18	20	27	30	27	37	31	0.129	6
	Lack of livestock market	20	19	17	22	27	40	45	0.118	7
	Poor livestock management skill	25	28	24	24	26	29	34	0.137	5
	Total	190	190	190	190	190	190	190	-	-

Index = sum of (7 × for rank barrier to adaptation +6 × for rank 2 + 5 × for rank 3 + 4 × for rank 4 + 3 × for rank 5 + 2 × for rank 6 + 1 × for rank 7) given for an individual barrier divided by the sum of (7 × for rank 1 + 6 × for rank 2 + 5 × for rank 3 + 4 × for rank 4 + 3 × for rank 5 + 2 × for rank 6 + 1 × for rank 7) summed over all barriers to adaptation.

[a] The lower the rank for a given reason, the greater is its importance.

3.7. Barriers to livestock farmers' adaptation to climate change

Table 6 shows barriers to adaptation to CC as ranked by respondents based on their perceived importance. In this study, livestock farmers faced some barriers to practice CC adaptation. In high and mid AEZs respectively, lack of information and knowledge about appropriate water harvesting practices with mean index values of (x = 0.166 and 0.168), shortage of land for forage production (x= 0.161 and 0.155) and lack of improved forage seeds or planting materials (x= 0.144 and 0.148) were perceived the important critical barriers to practice adaptation strategies to address effects of CC on livestock production. While in the lowland, shortage of supplementary feeds with index value of (x= 0.166), absence of improved forage seed (x= 0.156) and lack of knowledge on water harvesting (x= 0.132) were ranked as the most important constraints to adopt adaptation strategies for coping with impact of CC. The FGDs also confirmed the above reported priority barriers as the most important challenges to practice CC adaptation. findings of the current study contradict with the findings of Mihiretu et al. (2021), who identified lack of access to climate awareness raising training and extension services, unidentified reasons, shortage of climate information, limited access to credit and funding, and absence of eligible household labor as the main barriers to take any measure to CC adaptation measures, in descending order of importance.

3.8. Limitations of the study

The use of questionnaire to gather data limits the study as respondents relied on recall information which may be not accurate but not uncommon limitations of similar survey studies. Another limitation of this study is the use of cross-sectional data and focused only on livestock farmers in Gera district. A longitudinal approach would allow an exploration of the ways in which adaptation might change across time in the area. Despite its limitations, this study offers some interesting viewpoints into the farmers' perception and adaptation measures to climate change, impacts and adaptation barriers and provides baseline information for conducting related case studies in other settings.

4. Conclusions

This study assessed livestock farmers' perceptions of CC, its effects on livestock production, adaptations strategies and barriers to adaptation in Gera district. Understanding communities' perceptions and assessing their adaptive capacities are important strategies to establish successful risk-management programs (IPCC 2007). From the findings of the study, the following conclusions are drawn: majority of livestock farmers in the present study are aware of CC (increasing temperature and decreasing rainfall) and its impacts on livestock production, and practiced various adaptation strategies to address the negative effects of CC on livestock production and productivity. Majority of the farmers witnessed increase in temperature and decrease in rainfall over the last 20 years in their area. This was consistent with the recorded meteorological data within the past period 2001–2020, which showed rising trend in mean annual minimum and maximum temperatures and decreasing trend in rainfall. The respondents perceived that anthropogenic activities, natural processes and act of God as the main causes of CC. The study also found that farmers' in the present study were knowledgeable in identifying climate change related effects on livestock production and productivity. As far as impacts of CC on livestock are concerned, the respondents perceived decrease in feed availability and quality, water availability, milk production, fertility and animal growth rate as well as increase in number of services per conception, calving interval, spread of livestock diseases (trypanosomiasis), mortality, and livestock disease susceptibility. These impacts of CC could also affect the food security and livelihoods of the farmers. As far as adaptation strategies concerned, increasing mixed crop-livestock farming, livestock species diversification, feed conservation, reducing livestock numbers by selling animals, water harvesting, supplementary feeding, and forage production were perceived as the most important coping strategies. Among these measures, mixed crop-livestock production, which is the diversification of animals species and crop types have been widely practiced by majority of the farmers, which show that farmers in the current study perceive this measure was perceived as the most important coping strategy practiced in response to CC effects on livestock production and productivity; hence, these practice need to be considered when planning adaptation practices. With regards to the obstacles to adaptation, lack of knowledge or information about water harvesting, shortage of land for forage production, unavailability of improved forage seeds, lack of supplementary feeding, poor livestock management skill, lack of feed conservation skill, and poor access to market were perceived as the most critical barriers; thus, need to be considered during adaptation planning. Finally, it is recommended that there is a need for policy makers and livestock development stakeholders to formulate and implement interventions (access to timely weather information, introduction of improved forage production, appropriate and effective feed and water conservation technologies, weather-based livestock insurance schemes, diversifying livestock species that could withstand climate change, access to livestock market and adequate extension services) aiming at enhancing farmers' perception and adaptation abilities to CC impacts and to address the identified barriers to CC adaptation for improving livestock productivity in the study area. Moreover, the present study laid a basis for future in-depth research to assess the feasibility of farmers' adaptation practices to formulate and implement coping strategies that are more reliable, resilient and sustainable.

Declarations

Author contribution statement

Hassen Abazinab: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Belay Duguma; Eyerus Muleta: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

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Data availability statement

Data will be made available on request.

Declaration of interest's statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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