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Climate Change Impacts on Livestock Production and Adaptation Strategy used by Households in Loka Abaya District, Southern Ethiopia

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Abstract:
Climate change has affected the livelihoods of many households in many developing countries. The current study assessed the impacts of climate change on livestock production and the adaptation strategies used by households. A multistage sampling strategy was used to study select areas. In the first stage, four Kebele (lowest administration unit), two representing Moist-Weina Dega and other two representing Moist-Kolla were purposefully selected based on agroecological conditions and information indicating the involvement of different intervention works. A total of 160 households (73 from Moist-Weina Dega and 87% from Moist-Kolla) were selected using proportionally sampling strategy. About 6 – 8 focused group discussants were involved to complement household interviews. The finding revealed that households observed shifts in climatic indicators such as temperature, rainfall distribution/amount, and the occurrence of extreme events. Nearly 90% of households observed an increasing temperature trend, which was more commonly observed in moist Kolla (95%) than in moist Weina Dega (80%). About 61% and 76% of households perceived a decline in rainfall amount and a change in seasonal distribution, respectively, where it was more pronounced in the moist Kolla area than the moist Weina Dega area, which greatly affected crop and livestock production. Feed shortages and quality deterioration, reduced water availability, higher heat stress, and increased disease frequency were direct effects of climate change on livestock production, which ultimately reduced animals' weight gain, reduced milk yield and increased livestock mortality. Collecting and storing rainwater, income diversification, livestock destocking and shifting from large ruminants to small ruminants (goats), and livestock feed storage and temporary migration were livestock production-related adaptation strategies used by households. The use of improved livestock breeds (goats and poultry) and the supply of modern bee hives were reported as some of the introduced technologies in the livestock sector aimed at enhancing the adaptive capacity of households to climate change. The present study concluded that climate change greatly affected livestock production and the livelihood of producers and that there should be interventions supporting the adaptive capacity of households.

Keywords: Agro ecology, Adaptation strategy, Climate change, Livestock production

INTRODUCTION

Nowadays, the world is facing climate change, which is the most significant environmental challenge and has very considerable implications for various sectors, including agriculture in general and livestock production in particular (Sejian et al., 2015a). Globally, households experienced climate change mainly due to temperature and unpredictable rainfall distribution, ultimately affecting agricultural production (Karki et al., 2020). Livestock production has remained a major source of income and livelihood base for many households in most developing countries (Herrero et al., 2016). In Ethiopia, livestock production accounts for roughly 40% of the agricultural GDP. The rapidly increasing demand for animal-derived food suggests the importance of increasing livestock productivity. While Ethiopia has a large livestock population, the sector's productivity has remained very low due to many challenging conditions. Livestock production is highly vulnerable to the impacts of climate change due to the sector's dependence on natural resources and the susceptibility of animals to extreme weather events (Weindl et al., 2015). Seasonal fluctuations in herbage quality and quantity associated with climate change and variability have significant impacts on livestock production and lead to a decline in livestock productivity and production efficiency (Sejian, 2013). Further, many households in Ethiopia and other sub-Saharan Africa are still dependent on agriculture for their economies, where it provides food, income, and employment for the predominantly for many rural populations (Gemeda and Sima, 2015). Most interestingly, several million people in these areas are living and located in areas prone to extreme drought events leading to food insecurity and water shortages (Bekwet et al., 2015). The Loka Abaya district in southern Ethiopia is the place that has been deeply affected by climate change. In the area, households heavily rely on livestock production as a crucial source of income and livelihood for their residents. However, rising temperatures, irregular rainfall patterns, prolonged droughts, and other climate-related disturbances have resulted in significant disruptions to traditional livestock farming practices and the overall well-being of local communities. Considering these background pieces of information, the current research article was aimed at providing a comprehensive analysis of climate change impacts on livestock production and exploring the adaptive strategies employed by households as important intervention options to mitigate the impacts of climate change. This study also aimed to examine specific local contexts by exploring farmers’ practices to contribute valuable insights to inform future interventions and aid in the development of effective adaptation strategies.

MATERIAL AND METHODS

Description of Study Area

The research was conducted in Loka Abaya, located in Sidama regional. Loka Abaya is one of the districts in the Sidama Region of Ethiopia. The district is surrounded by the Oromia Region to the south, Lake Abaya to the southwest, the Wolaita Zone to the west, Boricha to the north, Dale to the northeast, Shebedino to the east, and Aleta Chuko to the southeast. It is located 50 km from Hawassa, a regional city, and 320 km from Addis Ababa, the capital city. The district is located at 6^{0}40' 05''-6^{0}54' 06''N and 38 0 00'13''-38 015'00''E with an altitudinal range of 560 to 1700 masl. The district's annual temperatures ranged between 17 and 20 °C, with an average annual rainfall of 900 to 1400 mm (Bekwet et al., 2015). Moist Kolla and Moist Weina Dega traditional agroecological conditions recognized in the district (Bekwet et al., 2015) fall under two seasons called Belg (February to April) and Kermit (July to October). High temperatures and the erratic nature of rainfall are common climatic problems in the study district. Natural resource degradation, frequent droughts resulting from climate change/variability, and increasing human population were major agriculture and food security-related problems (Bekwet et al., 2015). Mostly Kolla and Moist Weina Dega were traditionally recognized agro-ecological conditions in the districts. Mixed crop-livestock production with varied degrees across the district is practiced.

Sampling Strategy and Sample Size

A multistage sampling strategy was employed to select the study area. In the first stage, Kebeles in the Loka Abaya district were stratified based on traditional agroecological classification. Traditionally, there are agro-ecologies named Moist Weina Dega and Moist Kolla. A total of four Kebeles representing the aforementioned agro ecology were purposefully selected to carry out the study. Accordingly, Desse and Diremanchu represented Moist Weina Dega, whereas Argada Haro Dintu and Danshe Gambella were selected from the Moist Kolla area. The Kebeles were selected based on information that there have been interventions enhancing the community's capacity for better income. A total of 160 households, including 73 representing Moist Weina Dega and 87 representing Moist Kolla, were selected using a proportional and random sampling strategy. The proportional sampling strategy was employed to determine sample size per agro ecology, and the random sampling strategy was employed to include households for interviews.

Data Collection and Data Type

Household interviews and focused group discussions (FGDs) were used to obtain primary data. Semi-structured questionnaires that were pre-tested before the actual survey were used to interview households at their farm gates. Enumerators were trained to carry out household interviews with questionnaires that were translated into a local language that the community understands well. FGDs were employed to support the household interviews. Focused group discussants were selected based on their experience/knowledge of their environment, age, and active participation in community activities. They were elderly people, farmers with long farm experiences and the ability to use different options to mitigate climate change and related extreme events.

Data Analysis and Statistical Methods

Qualitative data obtained from survey, focused group discussion and physical observation was organized, summarized and interpreted through concept and opinions. To describe the explanatory variables collected on farmer's perception about climate change and others variables (temperature and rainfall data), descriptive statistics such as mean, frequency and percentage were computed independently for each parameter involved. Analytical tool of Statistical Package for Social Science (SPSS) version 20 was used for data analysis. Index method of ranking also used for ranking of parameter such as challenges affecting adaptive capacity of farmers and others similar parameters. Chi-square (X^2) test was employed to know the significant dependence of parameters between agro ecologies.

RESULT AND DISCUSSION

Demographic and Socio-Economic Characteristics of Respondents

The majority (85%) of the interviewed households, 87% in Moist Weina Dega and 83% in Moist Kolla, were male (Table 1). The result was consistent with previous studies (Gemiyu, 2009; Kashay et al., 2019; Addis and Abirdew, 2021). The overall mean age of interviewed households was 42.4 years. Households in Moist Kolla were significantly ($p<0.05$) older than those in Moist Weina Dega. Households in the present study were younger compared with a previous report (Tesfaye, 2008; Kashay et al., 2019), who reported a mean age of 52 years. The age of the household would be associated with their ability to better understand the changes that happened in the environment. This was consistent with previous studies (Kashay et al., 2019; Deressa et al., 2009), which reported age as a proxy measure of farming experience, indicating farmers with longer farming experience are more likely to perceive climate change and its impacts. Nearly 80% of households in the two studied agro ecologies were literate, with the majority (61.67%) attaining elementary school, followed by those reaching secondary school. Nearly 97% of sampled households were married, with 0.6% and 2.5%, respectively, being divorced and widowed. It was mentioned during the survey that being widowed would make households more vulnerable to disasters, including climate change impacts, as husbands play a higher role in income-generating activities. The mean family size of 4.98+1.18 was significantly ($p<0.05$) different between Moist

Weina Dega and Moist Kola. A higher mean number of households per family in Most Weina Dega (5.54+1.1) agro ecology would be associated with a relatively more conducive area for crop production than in Moist Kola. The result was in agreement with a previous study (Assefa, 2007), which reported a higher mean family size in Moist Weina Dega (7.9) than in Moist Kola (6.8). Households in moist Weina Dega are more reluctant to move outside looking for feed, water, and water for livestock and humans, which is more frequent in moist Kola.

Table 1: Demographic and socio-economic characteristics of households in study area

Variables	MWD		MK		Overall		X^2	*p*-value
	N	%	N	%	N	%		
Sex								
Male	64	87.67	72	82.76	136	85		
Female	9	12.33	15	17.24	24	15		
Educational status							**2.5600**	**0.1138**
Had not attained school	18	24.66	20	22.99	38	21.11		
Elementary school	54	73.97	57	65.52	111	61.67		
Secondary School	16	21.92	6	6.90	22	12.22		
Degree/diploma	5	6.85	4	4.60	9	5.00		
Marital status							**133.7626**	**<0.0001**
Single	0	0	0	0	0	0		
Married	71	97.26	84	96.6	155	96.88		
Divorced	0	0	1	1.15	1	0.625		
Widowed	2	2.74	2	2.3	4	2.5		

MWD = Moist-Weina Dega, MK = Moist-Kolla. N = number of households.

Land Holding of Respondents

The mean age, land, and livestock holdings in the study area are given in Table 2. Overall, the mean land holding observed in the present study was 1.13 ha/HH, which was narrower than the corresponding mean of 1.52 ha reported by Endeshaw (2007), 1.5 ha in the Alaba area (Gemiyu, 2009), and 2.3 ha of total mean land holding in the Kowet district of the North Shewa zone. The mean land size recorded in Moist-Kola (1.20 ha/HH) was significantly ($p<0.05$) lower than the corresponding mean value in Moist Weina-Dega (1.04 ha/HH), which was attributed to the difference in population density.

Livestock Holding of Respondents

The mean and standard deviation of different livestock species owned by sampled households are presented in Table 2. Cattle were the dominant livestock species, with a mean of 4.2 heads, which was significantly ($p<0.05$) different between the Moist Weina Dega (3.2 heads) and the Moist Kola area (5.2 heads). More cattle holdings in Moist Kola indicate a higher dependency of households on livestock production, which may result from more grazing land owned by households. Goats with an overall mean of 6.95+1.86 were significantly ($p<0.05$) higher in moist Kola (8.91+2.4) than in moist Weina Dega (5.0+1.3). The higher goat holdings in Moist Kola indicated the preference of goats among households and the ability of goats to adapt under challenging conditions—their ability to utilize browse species that are rarely utilized by other livestock. The mean goat holding observed in the present study was higher compared with a previous study (Endeshaw, 2007), which reported a mean of 5.98 goats per household in the Loka Abaya area. Sheep keeping was less common, with an overall mean of 0.61 heads, and the result was not significantly ($p>0.05$) different between the two agro-ecological conditions. Donkeys were the other valuable livestock species in the study area, with an overall mean of 0.84 heads. Donkeys play a great role in transporting goods from market to market and vice versa. Households further mentioned that they rent donkeys to obtain cash income, which notably contributed much to fulfilling income gaps for families during adverse times. Poultry was also another livestock species kept by many households in the study area. The observed mean (4.8) of poultry ownership was significantly ($p<0.05$) different between the two agro ecologies, where a higher mean was observed in moist Weina-Dega than in moist Kola. This difference is mainly attributed to the difference in poultry feed availability and its adaptability.

Table 2: Mean ± Standard deviation of family size, land holding and livestock holding of households in Moist Weina Dega and Moist Kolla agro-ecology

Variables	Moist Weina Dega	Moist Kolla	Overall mean	Significance
Age (year)	39.8±4.8	44.9±5.9	42.4±5.3	*
Family size	5.54±1.1	4.43±0.9	4.98±1.18	*
Land size (ha)	1.04±0.26	1.20±0.56	1.13±0.38	*
Livestock species				
Cattle	3.20±1.3	5.20±1.5	4.2±1.4	*
Goat	5.0±1.3	8.91±2.4	6.95±1.8	*
Sheep	0.71±0.8	0.51±0.8	0.61±0.8	Ns
Donkey	0.85±0.6	0.83±0.8	0.84±0.7	Ns
Chicken	5.48±2.1	4.21±1.5	4.8±1.8	*
TLU	3.31	5.05	4.0	

*p<0.05, TLU: Tropical Livestock Unit with conversion factor of 0.7, 0.5, 0.1, 0.1 for cattle, donkey goat and sheep respectively (Jalanke, 1982) and TLU for poultry = 0.013 (Strock et al., 1991).

Community Perception of Climate Change

Table 3 presents the change in climatic indicators in the study area based on farmers' perceptions. The perception of farmers to climate change observed in the present study was based on how they perceive the changes in climatic indicators. About 60% of the sampled households in the study area-71% in Moist Kolla and 48% in Moist Weina Dega observed that the amount of rain received had decreased. The decrease in rainfall in the present study was consistent with a previous study (Kashay et al., 2019), which reported more than 90% of interviewed households perceived a decrease in rainfall amount in the semiarid region of eastern Tigray region of Ethiopia. Chi-square (X^2) indicated that the decrease in rainfall amount was differently ($p<0.001$) perceived between moist Weina Dega and moist Kolla agro ecology – where perception was more common in moist Kolla. Nearly two-thirds of the sampled households in the study area observed changes in the seasonal distribution and patterns of rainfall over years. They further mentioned that rain has not only been coming lately but had also stopped early. The delayed rainfall onset and early cessation have limited crop growing periods and reduced feed and water availability to humans and livestock. Almost 96% of households in Moist Kolla and 81% in Moist Weina Dega reported increased environmental temperatures, which had a significant impact on their livelihood. None of the households in Moist Kolla agroecology observed a decreasing trend for environmental temperature. The result was in agreement with a previous study reporting more than 85% of households observed increasing temperature trends in the semiarid area of the eastern Tigray region (Kashay et al., 2019). Addis and Abirdew (2021) also reported an increase in environmental temperature in the central part of Ethiopia. The increase in temperature was significantly ($p<0.001$) dependent on agro ecology where households in the Kolla area more commonly perceived the increase in temperature as compared with proportion of households who perceived in the moist Weina Dega area.

Increased incidences of drought were more significantly ($p<0.0001$, $X^2 = 77.2894$) increased in Most Kolla (89%) than in Moist Weina Dega (27%), which could be associated with low rainfall amounts and changed seasonal distribution in Moist Kolla. Sometimes, households interviewed experienced unexpected flooding resulting from high rainfall at certain points in time, which causes crop damage, soil erosion, and property destruction.

Table 3: Perception of households to climate change

Indicators	Moist Weina Dega		Moist Kola		Overall		X2	p-value
	N	%	N	%	N	%		
Rain fall amount							**51.8422**	**<0.0001**
Decreased	35	47.95	62	71.26	97	60.63		
Increased	14	19.18	2	2.30	16	10.00		
No change	16	21.92	16	18.39	32	20.00		
I don't know	8	10.96	7	8.05	15	9.38		
Rainfall seasonal distribution							**102.762**	**<0.0001**
Changed	43	58.90	78	89.66	121	75.63		
No change	13	17.81	0	0.00	13	8.13		
I don't know	17	23.29	9	10.34	26	16.25		
Temperature							**100.254**	**<0.0001**
Increased	59	80.82	83	95.40	142	88.75		
Decreased	2	2.74	0	0.00	2	1.25		
No change	3	4.11	0	0.00	3	1.88		
I don't know	9	12.33	4	4.60	13	8.13		
Drought incidence							**77.2894**	**<0.0001**
Increased	20	27.40	78	89.66	98	61.25		
Decreased	3	4.11	0	0.00	3	1.88		
I don't know	50	68.49	9	10.34	59	36.88		
Flood incidence							**36.5111**	**<0.0001**
Increased	32	43.84	38	43.68	70	43.75		
Decreased	15	20.55	36	41.38	51	31.88		
No change	12	16.44	7	8.05	19	11.88		
I don't know	14	19.18	6	6.90	20	12.50		

Climate Change Impacts on Livestock Production

All households interviewed in the study area believed climate change had significant impacts on livestock production. The impact of climate change on livestock production was identified through household interviews and FGDs and ranked in order of importance (Table 4). The result indicated feed and water resource shortage, increased heat stress, and causing mortality were observed as major direct impacts of climate change on livestock production both in moist Dega and Kolla areas. The results of household interviews and FGDs showed that climate change has affected livestock production through its effects on feed resources. Reduction in the quantity of feed resources, decline in quality, seasonal fluctuation, and poor palatability of grass were observed livestock feed resources related impacts of climate change. Households further mentioned that climate change-related feed resource shortages and quality declines were the most serious, mainly during dry seasons, indicating there were highly seasonal variations in feed resources. In agreement with the results of the current study, reducing feed resource availability and declining quality were reported as potential impacts of climate change on livestock production (Kassahun, 2016; Mulata, 2016). Aklilu et al. (2013) further reported that the spatial distribution and temporal availability of pasture and water are highly dependent on rainfall. The author further mentioned that changing temperature ranges will result in changes in feed and pasture availability and quality, as well as an increased incidence of disease and pests. Households further explained that feed resource availability and quality decline were highly associated with rainfall amount and seasonal distribution, were insufficient and irregular rainfall highly affected feed production and quality. In agreement with this, a previous study reported that climate change affected pasture and rangeland production, causing a change in the nutrient balance of feed (Izaurralde et al., 2011).

On the other side, households mentioned that higher temperatures, which are exacerbated by climate change, caused a decline in the nutrient content of feed, quality deterioration, and made already scarce feed resources less palatable for livestock consumption. In line with the observations of households in the present study, previous studies reported that an increase in temperature resulted in poor-quality feed resources through deteriorating nutrient compositions (Thornton, 2009; Izaurralde et al., 2011). Households also believed that climate change-imposed impacts on livestock production by affecting water resources such as decreasing the volume of drinking water and drying up rivers, wells, and wetlands. Previous findings also reported climate change increased water stress on livestock (Izaurralde et al., 2011). Increased temperature further caused direct heat stress to animals, which reduced pasture grazing time and feed intake where livestock prefer shaded areas instead of grazing or feeding, which greatly affected the body gain and milk production performance of animals. In agreement with this, heat stress resulting from climate change significantly reduced livestock feed intake (Chang-Fung-Martel et al., 2021). Kassahun (2016) further found that a unit increment in the thermal humidity index resulted in a reduction of milk yield by 0.2 kg for high-yielding animals. Households also observed the death of livestock due to drought and disease which are highly associated with climate change. This was in line with previous studies, which found drought resulting from climate change caused livestock mortality and yield loss (Yilma et al., 2009; Kasaye, 2010; Goughan and Cawsell-Smith, 2015). Households also mentioned that the frequency of livestock disease occurrence has been increasing over the past 10 to 15 years which is associated with frequent change in relative humidity.

Table 4: Climate change impacts on livestock production

Variables	Moist Weina Dega			Moist Kola		
	N	Index	Rank	N	Index	Rank
Caused feed shortage and quality reduction	73	0.45	1	87	0.46	1
Reduction of water resources (rivers/wells)	73	0.22	2	87	0.25	2
Increased heat stress due to increased temperature	73	0.12	4	87	0.17	3
Livestock mortality due increased diseases	73	0.21	3	87	0.12	4

N: number of households involved ranking

Climate Change Impacts on Herd Dynamics and Yield

Trends of livestock species dynamics over decades between moist Weina Dega and moist Kola were assessed through household interviews (Table 5). Nearly 30% of households in Moist Weina Dega and 45% in Moist Kola mentioned increasing trends for cattle, whereas nearly 59% in Moist Weina Dega mentioned that the number of cattle owned showed decreasing trends. Chi-square (X^2) showed that trends of cattle population over the years were significantly ($p<0.05$) different between agroecology where more decreasing trends were observed in moist Weina Dega agroecology. The decreasing trends in cattle numbers in moist Weina Dega could be associated with decreasing trends in grazing land, which is exacerbated by the need for farming land and decreasing trends for available feed resources. Nardone et al. (2010) reported that climate change reduced the carrying capacity of rangeland which ultimately affected livestock species dynamics. Stark et al. (2011) also found a reduction of 80% in livestock holdings in drought-prone areas. According to FDGs, households were forced to reduce the number of cattle owned due to decreased feed resource availability shifting to other livestock species that can withstand the effects of climate change. In this regard, households in the presented study mentioned that keeping more numbers of goats is more advantageous, mentioning that goats have a better capacity for adapting to climate change as they can browse feed resources that cannot be utilized by other livestock species. A previous study found that goats possess a better capacity to adapt to hot environments as compared with large ruminants (Joy et al., 2020). Many interviewed households; 90% in Moist Kola and 68% in most Weina Dega perceived increasing trends for goats which indicate an increment in goat population significantly ($p<0.0001$; $X^2 = 77.28$) observed by higher households in moist Kolla than moist Weina Dega. A study by Joy et al. (2020) mentioned that the selection of thermo-tolerant animals such as goats helps to combat climate change impacts.

The majority of households in both agro-ecologies reported no change in the number of donkeys owned, whereas more than half of the interviewed households reported an increase in the number of poultry owned; less than 10% in MWD and 5% in MK reported decreasing trends in the number of poultry owned, indicating that poultry is relatively unaffected by climate change and the means for adapting to it.

Table 5: Trends of livestock species dynamics over previous decades between agro-ecologies

Trends (N=160)	Cattle		Goat		Donkey		Poultry	
	MWD	MK	MWD	MK	MWD	MK	MWD	MK
Increasing (%)	31.5	44.8	68.49	89.7	15.6	29.9	58.4	56.3
No change (%)	9.59	26.4	27.4	10.3	71.4	64.4	29.9	40.2
Decreasing (%)	58.9	28.8	4.11	0	13	5.75	11.7	3.45
Chi-square	5.528275		77.28945		0.333721		16.07485	
Prob>ChiSq	0.0187		<0.0001		0.5635		0.0002	

MWD = Moist Weina Dega (n= 73), Moist Kolla (n=87). n is number of households interviewed

Perceived Climate Adaptation Strategies by Households

Through FGD and key informant interviews, different climate change adaptation strategies were explored and ranked during individual interviews (Table 6). Harvesting of rainwater during rainy seasons was reported as one of the major (ranking index = 0.2) options to overcome a shortage of water. Individual interviews and FGD discussions revealed that farmers have been harvesting and storing rainwater using traditional structures that will be used for drinking for cattle, humans (in severe cases), and occasionally growing fruits. Collection and harvesting of rainwater were also used as important climate change adaptation strategies in many drought-vulnerable parts of Africa (Ferrand et al., 2014; Swe et al., 2015; Opare, 2018). Livestock species diversification and proper feed management (feed storage and utilizing browsing species) were observed as other important adaptation strategies used by the community. Farmers stated that when there is a severe drought, they are forced to sell cattle and buy cereal crops to store; this strategy allows them to restock with money from stored crop sales. Keeping a greater number of goats was observed as the best strategy, as goats can withstand drought by utilizing browsing species that would not be consumed by cattle, which was in close agreement with previous studies conducted in Ethiopia (Wassie, 2015), which reported goats as climate-smart agricultural practices. Livestock diversification in line with the result of current was practiced by households in Ethiopia (Megersa et al., 2015; Menghistu et al., 2021). A study by Hoffmann, (2013) found that locally adopted and diversified livestock species can potentially increase yield, improve food security and adopt climate change. Participation in climate-smart technologies, such as increased beekeeping practices using different beehives (traditional and modern), has been reported to have significant benefits for farmers, as honey and its by-products are used as sources of food and income, both of which contribute significantly to reducing potential harm from climate change. Beekeeping was not only seen as a means to adopt climate change but also a means of climate change mitigation as it reduces the extent of cutting trees because traditional bee hives are usually placed on the trees. In line with this, a previous study found that beekeeping was seen as a good option to mitigate and adapt to climate change (Degu et al., 2021). Temporal migration of households toward the Lake Abaya area was also perceived as an important adaptation strategy by communities in the study area. The higher migration percentage (65%) was reported in a previous study of Borana pastoralists (Abate, 2016). Moving animals to other sites where mixed crop-livestock production prevails reported as a means of adapting to climate change in Kenya (Silvestri et al., 2012). Establishing drought-resistant livestock feed and using crop residues were also other climate change adaptation strategies that were used to overcome feed shortages for livestock. Maize straw and hair coat bean straw were crop residues used by all households, which was in agreement with previous studies (Karanja et al., 2016).

Table 6: Perceived climate change impacts adaptation strategies in the study area

Climate change adaptation strategy	Number of households ranking							Index	Rank
	1	2	3	4	5	6	7		
Collection and storage of rain water	51	61	26	12	3	1	1	0.20	1
Improved crop variety selection	28	23	34	14	4	3	2	0.13	5
Livestock species diversification	41	29	45	18	6	4	4	0.18	2
Income diversification	8	9	19	17	10	8	5	0.07	7
Establishing drought tolerant livestock feed	10	7	8	8	33	29	21	0.08	6
Feed storage and utilizing browsing species	12	18	11	48	57	65	63	0.18	2
Temporary migration (for feed and water)	10	13	17	43	47	50	64	0.16	4
Total	**160**	**160**	**160**	**160**	**160**	**160**	**160**	**1**	

Factors Affecting Farmers' Adaptive Capacity

Factors affecting the adaptation capacity of farmers to climate change-related impacts were assessed through household interviews (Table 7). Then the households were asked to rank the perceived factors in order of their importance. Lack of appropriate and timely weather information was ranked as a major factor that greatly affected their preparedness to overcome the impacts of climate change. The results of individual interviews and FDGs indicated that a lack of weather information affected farmers' preparedness for forthcoming extreme events and land preparation for crop production and harvesting, which highly affected the agricultural production system and food security. Similarly, a previous study found households lacking access to weather information were reported as the main barriers in the process of climate change adaptation (Fosu-Mensah et al., 2012; Mubalama et al., 2020). Respondents also claimed that a lack of credit services was also seen as the main constraint affecting farmers' ability to adapt to climate change-related risks. According to respondents, much of the challenges occurred during drought periods, causing the loss of assets, whereas post-drought recovery was more challenging due to a lack of finance. Information gathered through the focused group discussion suggests that solving the problem of financial shortage and improving credit services during post-drought recovery greatly improves communities' capacity to adapt to the impacts of climate change. Silvestri et al. (2012) found that the capacity of households to adopt climate change is importantly constrained by a lack of credit services. Similarly, lack of improved technology and less development of infrastructure were among the important factors hindering the capacity of farmers to adapt to the impact of climate change. Improved technologies such as rainwater collection, long-term storage, and the utilization of feed-forage resources could improve the capacity for better adaptation and mitigation strategies. Field observation showed that most farmers collected and stored rainwater by digging a temporary hole. Under this condition, much of the stored water sinks to the ground, and other parts are lost through evaporation because of the lack of cover. Infrastructure, such as the lack of a suitable road to take farm products to market, was another problem preventing farmers from obtaining agricultural inputs on time and selling the products easily. The relative distance between a farmer's home and market, as well as the limited access farmers have to sell their products directly, increased the pressure on low-income people to respond to the effects of climate change. In agreement with this study, low market access for products was reported as an important factor reducing the capacity of producers to adapt the climate change (Silvestri et al., 2012). Farmers also indicated that the study area lacked strong institutional support and monitoring bodies and research that could carry out case studies, design policies, and implement them properly. Moreover, a previously degraded natural resource base and overexploitation of these resources currently worsen the issue of adaptation (Table 7)

Table 7: Factors affecting adaptation capacity of households to climate change impacts

Climate change adaptation strategy HH	**Number of households ranking (n =160)**							**Index**	**Rank**
	1	**2**	**3**	**4**	**5**	**6**	**7**		
Lack of weather information	66	58	41	9	5	0	0	0.24	1
Lack of credit services	40	32	50	14	7	1	0	0.18	2
Low-income source diversification	27	32	21	18	8	3	1	0.13	3
No modern technology to collect rainwater	10	15	19	28	10	12	5	0.10	6
Lack of strong institution/researches	8	12	11	29	28	24	23	0.10	6
Low infrastructural development	5	5	7	30	53	58	63	0.12	4
Degraded natural Resources	4	6	11	32	49	62	68	0.13	3

Institutional Support and Involvement

A previous study found that the presence of a complex mix of different institutional types can help address issues of climate change adaptation (Dietz et al., 2003). Amaru and Chhetri (2013) reported that sustainable adaptation to climate change requires widespread involvement and the integration of diverse institutions. A study by Mubaya et al. (2017) also reported that a mixture of public and private institutions plays a key role in facilitating local climate adaptation strategies in semi-arid areas of Zimbabwe. Despite a lack of coordination, some institutional support for households was observed during the survey and focused group discussions (Table 8). The main aims of these activities were to support and contribute to households' income generation, ultimately contributing to the adaptive capacity of households to disasters, including climate change. Capacity building on feed production and storage when feed is ample was one of the intervention areas mentioned for households (75%). Households interviewed mentioned that they have obtained capacity building and training on conserving feed when there is ample amount, planting drought-tolerant forage, and exploiting and using diversified locally available feed resources. During households' field observation, four main feed storage places were recognized, such as conserving feed on the ground, on the trees, in the home, and on the conserving bed. Conserving feed expected on the ground was mentioned as a good strategy as it reduced feed quality deterioration and unplanned forced consumption by livestock. It was observed that feed stored on the ground was subjected to unnecessary decomposition and forced consumption by livestock.

In addition to this, different livestock species, such as improved goat breed supply (31.9%), dissemination of improved poultry breed (25%), and supply of modern bee hives (35%), were supplied to households to contribute to their income and increase their adaptive capacity to climate change. A supply of improved crop seed varieties that can mature early and be able to grow in moisture stress (moist Kolla) was provided to 73% of the households interviewed.

Table 7: Institutional support and intervention area supporting households' capacity

Intervention area	MWD	MK	Overall
Capacity building on feed conservation (Yes %)	67.1	82.8	75.6
Supply of improved modern bee hives (Yes %)	34.2	35.6	35
Improved crop seed variety (Yes %)	89	59.8	73.1
Supply improved poultry breed (Yes %)	16.4	32.2	25
Plantation drought tolerant feed supply (Yes %)	46.6	54	50.6
Livestock breed improvement and supply (Yes %)	16.4	44.8	31.9

MWD = Moist Weina Dega (n=73), MK= Moist Kolla (n=87) agro ecology. n = number of households.

CONCLUSION

The findings of the present study showed that climate change was real and had far-reaching impacts on agricultural production in general and livestock production in particular. Interviewed households have seen rising environmental temperatures, unpredictable nature of rainfall, and increased frequency of extreme weather events as indicators of climate change. Climate change impacted livestock production by reducing the availability and quality of feed and water resources, impairing feed intake through heat stress, and causing livestock mortality. Households further believe the direct impacts of climate change on livestock production have significantly reduced livestock productivity and reproductive efficiency. Households used various livestock-related adaptation strategies, such as the collection and storage of rainwater, livestock species diversification, rearing animal species (goat) with more capacity for climate change impacts, better utilization and production of different feed resources, and temporary migration searching for feed and water. Lack of access to timely weather information and credit services, low levels of income diversity, a lack of modern technology assisting in the harvesting and storage of rainwater, low institutional support, and poor infrastructural development were major factors affecting the adaptive capacity of households. Provisions of timely weather information, research-based institutional support, and a more efficient rainwater collection strategy, along with the supply of input, would support farmers' adaptation to climate change impacts. Moreover, the support of households to adopt climate-smart agriculture would boost their capacity to adapt to climate change, food production, and environmental protection.

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