Scientific Research Publishing

American Journal of Climate Change, 2022, 11, 79-102
https://www.scirp.org/journal/ajcc
ISSN Online: 2167-9509
ISSN Print: 2167-9495

Pastoralists' Adaptation Strategies to Climate Change and Determinant Factors in Korahey Zone, Ethiopia

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How to cite this paper: Kemal, A. W., Mohammed, A. A., & Lelamo, L.L. (2022). Pastoralists' Adaptation Strategies to Climate Change and Determinant Factors in Korahey Zone, Ethiopia. *American Journal of Climate Change, 11,* 79-102.
https://doi.org/10.4236/ajcc.2022.112005

Received: February 13, 2022
Accepted: June 17, 2022
Published: June 20, 2022

Abstract

Climate change is a global phenomenon that involves the long-term fluctuation of the earth's climate system. Specifically, climate change is acknowledged as a vital challenge to pastoralist production systems. However, limited research attention was given to exploring the determinants of climate change adaptation strategies in the southeastern part of Ethiopia. Thus, the study tried to assess the predictors of pastoralists' climate change adaptation strategies in the Korahey zone of Ethiopia. The study was based on a survey of 215 representative pastoralist households were randomly selected from the three districts of the Korahey zone. To achieve the objective, household questionnaire surveys, key informant interviews, and focus group discussions were conducted to collect data at the household as well as the district level. Data were analyzed using descriptive statistics like percentage, frequency, mean, and inferential statistics (multinomial logit model). Multinomial logit was employed to analyze the determinant factors of pastoralists' adaptation strategies to climate change. The finding shows that household pastoralists adopt different climate change adaptation strategies in their locality; from this herd diversification (10.7%), storage of fodder (14.4%), mobility (23.7%), Livestock off-take (12%), saving scheme (8.8%) and household and herd splitting (15.3%) are the major pastoralists' adaptation strategies to climate change in the study area. The results of the multinomial logit model show that sex, age, family size, access to climate information, access to credit services, access to extension services and livestock ownership were identified as the major determinants factors of climate change adaptation strategies in Korahey zone. The study recommended that the local government, planners and decision-makers should give awareness regarding the role of information in the pastoralists'

adoption of climate change adaptation strategies and enhance extension services to support pastoralists in their adaptation efforts.

Keywords

Adaptation, Climate Change, Pastoralists, Multinomial Logit, Strategies

1. Introduction

Climate change is any significant change in the measures of climate lasting for an extended period and includes major changes in temperature, precipitation, or wind patterns, among other effects, that occur over several decades or longer (USEPA, 2016). Climate change refers to an enduring change in the state of the climate situation manifested by changes in the mean and/or the variability of its properties continuing for an extended period (Le Treut et al., 2007). The major common sign of climate change and variability are changes and variability in temperature and precipitation besides the occurrences of extreme climatic events especially drought, flooding sea level rise and storms (Seneviratne et al., 2012). It happened whether due to natural variability or as a result of human activity (IPCC, 2007).

Climate change is one of the major environmental threats facing the world today (Cicerone & Nurse, 2014). Global climate change has the potential to harm permanently the natural resource base on which agriculture depends, with a serious influence on food security. It also reduces the productivity of the majority of existing food systems and harms the livelihoods of those already vulnerable to food insecurity (HLPE, 2012). Empirical studies have confirmed that climate change poses direct negative impacts on agriculture, livelihood assets, water resources, and the nutrition and health status of people (Boko et al., 2007). Climate change and variability have been a major challenge to the development of Africa as a continent and Ethiopia as a nation in the last few decades among them, recurrently occurring droughts, which often result in a sharp reduction in agricultural output, is the major one (Conway & Schipper, 2011). Increasing in frequency and intensity of drought leads to a rise in the vulnerability of pastoral and agro-pastoral communities (Homann, 2008) as these communities are continuously losing an important amount of their livestock assets (Kassahun et al., 2008). Such complex socio-ecological problems facing the pastoral and agro-pastoral livelihoods call for informed policy interventions to achieve solutions to environmental- and livelihood-related challenges (Davies et al., 2012).

Pastoralists have an intimate relationship with their environment and rich the knowledge that enables them to both protect and exploit the changing rangeland conditions on which they depend (Notenbaert et al., 2012). Nevertheless, the pastoralists have never been passive victims of drought; Pastoral communities have developed various traditional adaptation mechanisms over the years to mi-

nimize their vulnerabilities to the impacts of climate variability (Omolo, 2010). Adaptive strategies are the main knowledge that enables them to reduce vulnerability to climate change stresses as well as to prepare for possible future extreme climate events (Hillbruner & Moloney, 2012; Field et al., 2012). Adaptation involves longer-term shifts in livelihood strategies as a response to change or to mitigate shocks and stresses on livelihoods due to climate change (Eriksen et al., 2005; Migosi et al., 2012). Therefore, households in pastoralist areas pursue several adaptation strategies such as diversification of livelihood, mobility, training in livestock health provision, diversification of herd composition and species, the slaughter of old and weak livestock, splitting households into subunits located in different areas, selling fuelwood and charcoal, searching for wage labor in towns, sending children to school and livestock off-take to mitigate the adverse impacts of climate change (Hurst et al., 2012; Martin et al., 2014; Opiyo et al., 2015). Pastoral community adaptation strategies for immediate demands in search of water and pasture (Dirriba, 2016), increasing their options for extracting resources from the rangeland (Hurst et al., 2012), a diverse portfolio of activities in their struggle for survival and improving their livelihood (Ellis, 1995).

The practicing adaptation strategies have already begun in Ethiopia, but efforts are still at a relatively early stage (Getahun et al., 2021). A complex web of interacting barriers to local-level adaptations exist that manifest from national to local scales, including political, institutional, cultural, social, behavioral, biophysical, cognitive and gender-related aspects (Barros et al., 2014). There is the consciousness that demographic, socio-economic and institutional factors determine the adaptive capacity of communities to climate variability and change (Mbow et al., 2019). Studies highlighted those different characteristics including demographic characteristics, income, family assets, family size, level of education, extension services, access to credit and savings, and facilities, climate change causal attributions, social capital, membership of the farmer-based organization, land ownership, agroecological settings and state of natural resources are determinant factors on communities' choice of climate change adaptation measures (Ndamani & Watanabe, 2016; Ayal & Filho, 2017; Mequannt et al., 2020). Household assets have a great influence on the adoption of farm technology (Mmbando & Baiyegunhi, 2016), due to a shortage of access to credit/cash flow; households are unable to invest in more costly and become vulnerable to climate change impacts (Atube et al., 2021). Access to late climate information also has negative impacts on planting, use of early maturing crops, and soil and water conservation measures (Belay et al., 2017). Community awareness of changes in climate attributes mainly temperature and precipitation is important for adaptation decision making (Maddison, 2007). Ownership of livestock is positively related to the use of adaptation methods (Deressa et al., 2009). The probability of choosing adaptation measures depends on locally available extension services in the community and lack of access to these services seem to have

a strong negative influence on the using adaptation strategies (Deressa et al., 2009; Aymone, 2009).

Several studies have been carried out focusing on determinant factors to climate change adaptation strategies in some areas of Ethiopia focusing determinants of farmers' choice of adaptation to climate change and determinants (Deressa et al., 2008; Belay et al., 2017), perception and adaptation to climate change (Deressa et al., 2011; Tessema et al., 2013), and strategies to climate change adaptation (Tazeze et al., 2012). However, none of them has focused explicitly on the eastern part of Ethiopia, mostly in the Somali region and some studies undertaken in the Somali region were only focused on Shinile, Fafan and Afder zones (Solomon, 2013; Michael, 2017; Mahad, 2020). As a result, adaptation strategies of pastoral communities to climate change and their determinant factors have not been sufficiently identified and documented in the Korahey zone, Somali Region Ethiopia. Therefore, this study was set out to examine the ongoing climate change adaptations strategies and analyze the major determinant factors of adaptation strategies to climate change practiced by the pastoral communities in the Korahey zone. Identifying and analyzing available adaptation practices and the major determinant factors will help in designing policies that can tackle major problems associated with adaptation activities to climate change in the study area.

2. Materials and Methods

2.1. Description of the Study Area

The study was conducted in the Somali regional state specifically the Korahey zone. Korahey is one of the administrative zones of the Somali region. It extends from 5˚20' - 7˚50'N Latitude to 43˚50' - 46˚30'E longitude, respectively. The altitude of the zone ranges from 456 to 1042 meters above sea level which is found within the southeastern lowlands of Ethiopia. The lowest elevation of the study area is found along the Fafen River which is estimated to be about 456 meters above sea level (Abdulahi et al., 2020) (**Figure 1**).

The climate of the zone is characterized as tropical semiarid. A vast area of the district experiences high temperature and low precipitation with mean annual temperature ranges between 20.75˚C - 31.25˚C. The annual rainfall of the Korahey varies between 295 mm and 595.6 mm (NMA, 2007). According to Abdulahi et al. (2020), the area has a bimodal rainfall pattern with two main rainy seasons in which the first being "Gu" which occurs from mid-April to the end of June. The second rainy season occurs from early October to late December and is locally known as "Deyr".

According to the 2007 census conducted by the central statistical agency of Ethiopia (CSA, 2007), the total population of the Korahey zone is 312,199 (of which 177,631 were males and 134,568 were females) with an annual average growth rate of 2.6 percent. There are significant variations in the distribution of the zonal population by districts. The largest proportion of the region's population

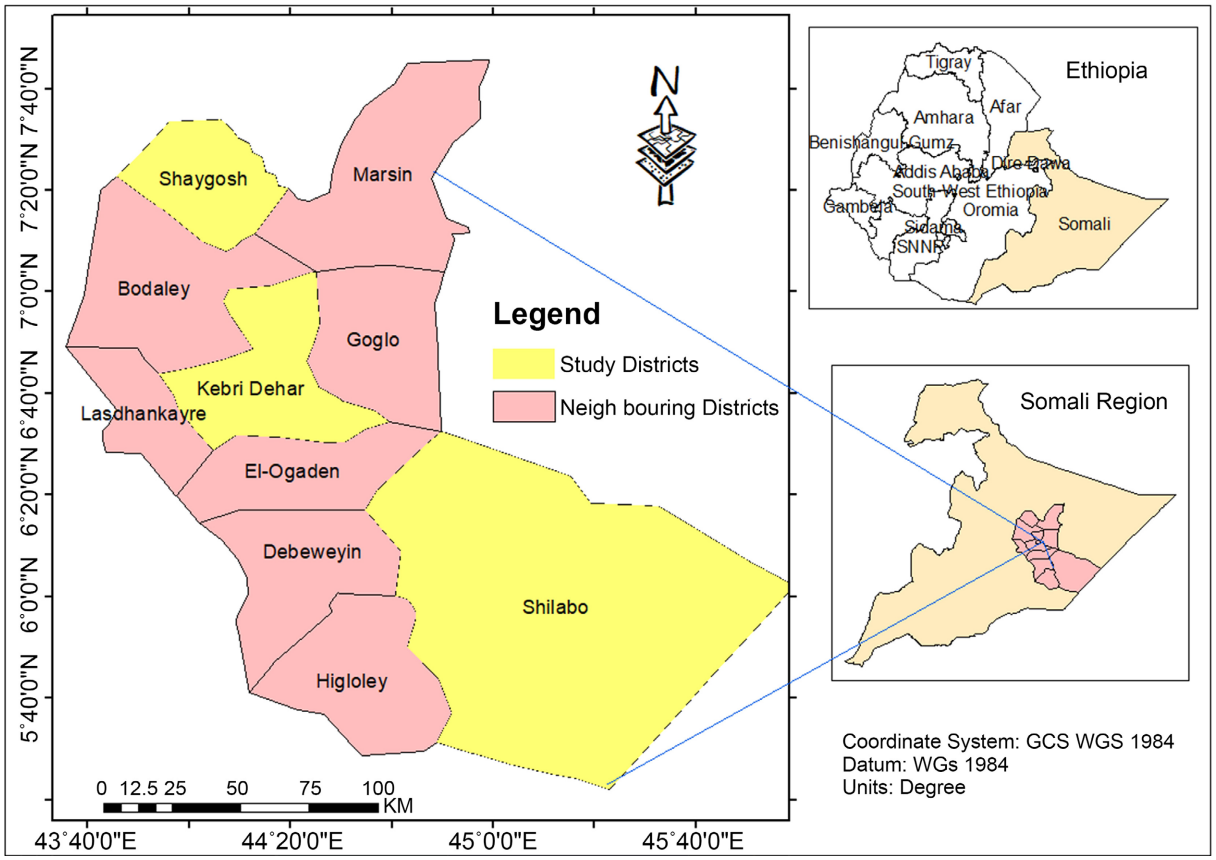

Figure 1. Map of the study area.

is found in Kabridahar districts with 43.6 percent followed by Dobo-Woin with a percentage share of 22.43 percent and Shilabo and Shekosh with corresponding proportions of 18.42 and 15.6 percent. As far as the economic activity of the zone is concerned, pastoralism is the dominant mode of livelihood systems. The major livestock species raised by the pastoralists of the study area are cattle, camel, sheep and goats. Since the livelihood of the area is based mainly on livestock rearing, crop production is not significant; the pastoralists are subjected to selling their livestock to buy food grains and other industrial products.

2.2. Study Design

The study employed a descriptive research design which is a good way of approaching research as it enables to counteract the weaknesses in both qualitative and quantitative research. The mixed research approach minimizes some of the limitations of using a single method because quantitative or qualitative research methods are not sufficient to address the complex social phenomena when they are treated independently (Creswell, 2003). Accordingly in this study, the mixed-method approaches that simultaneously combine the qualitative and quantitative techniques were applied at both data collection (focus group discussion, key informant interview and structured questionnaires') and analyses techniques to obtain information about the determinants of climate change adaptation strate-

gies of household pastoralists. Hence, data acquisition in the study was strengthened through triangulation or a combination of methodologies including qualitative and quantitative methods. The data was collected sequentially. Firstly, quantitative data was gathered by distributing questionnaires. Secondly, qualitative data was gathered through focus group discussions (FGDs) and key informant interviews on the same issues that need further explanation. The collected data was analyzed by employing both descriptive and econometric models.

2.3. Sampling Technique and Size

Multi-stage sampling procedures were employed to collect primary data. In the first stage, among other zones in the Somali region, the Korahey zone was targeted purposively as a study area because it is one of the most disadvantaged zones from the effects of climate change in the region. In the second stage, from the total districts of the Korahey zone, 3 districts namely, Kebridehar, Sheygosh and Shilabo were selected randomly because all districts are more or less affected by climate change in a similar way. From the selected districts, nine *Kebeles* (smaller administrative units in Ethiopia) were selected randomly; three *Kebeles* from each district. Finally, 215 sample pastoral households were selected systematically using probability proportional to size from nine *Kebeles* of the three districts to understand their socio-economic, demographic, livelihood profiles and characteristics as well as their perception regarding climate change adaptation strategies.

2.4. Data Collection Methods

The data was collected using household questionnaires, key informant interviews, and focus group discussions to get a broad view of pastoralists' climate change adaptation strategies and factors that influence pastoralists' climate change adaptation decisions. A questionnaire is a set of questions, either open-ended or closed-ended that the respondents are required to answer based on their knowledge and experience with the issue concerned (Bradley & Harrell, 2009). In line with this, the structured questionnaires were used to collect the data related to the perception of pastoral communities regarding the climate change adaptation strategies and determinant factors of climate change adaptation options of households. For this purpose, five train enumerators were employed for data collection in each district. Thus, to get quality data, enumerators were trained in data collection mechanisms by the researchers and the researchers supervised each enumerator to avoid bias of enumerators in collecting data. Key informant interviews were also held with knowledgeable people who have access to information on constraints to adapting to climate change. The individuals for key informant interviews were selected from government officials at the district level especially natural resource experts and development agents. In addition to this, focus group discussion was conducted on the same issues that need further explanation with separate groups of elders, youth and women in each district

comprising 6 - 10 individuals per group. It was moderated by the researcher using a checklist including climate change parameters in the area, the climate change adaptation strategies of pastoralists' response, and what factors influenced farmers' adaptation decisions.

2.5. Method of Data Analysis

The collected data were analyzed by using both quantitative and qualitative methods of data analysis. The analysis was done by applying descriptive statistics and an econometric model in line with answering the research question raised. Descriptive statistics like percentages and frequencies were used to analyze the household's adaptation strategies to climate change. The multinomial logit was conducted to analyze the determinants of pastoralists' climate change strategies as explained below.

Econometric Model (Multinomial Logit) Specification

The multinomial logit (MNL) model is the most commonly used model for the analysis of discrete choice data that are often used when the dependent variable has more than two nominal or unordered categories (Wulf, 2014; Greene, 2000; Cameron & Trivedi, 2005; Anas & Hiramatsu, 2012). As explained by Greene and Hensher (2003), either multinomial logit or multinomial probit regression model can be utilized when there is a dependent variable with more than two alternatives among which the decision-maker has to choose. However, owing to estimation difficulties imposed by the need to solve multiple integrations related to multivariate normal distributions, multinomial probit is rarely used in empirical studies (Chan, 2005; Wooldridge, 2010; Abera et al., 2021). In line with this, our study employed a multinomial logit model to analyze the determinant factors of pastoralists' adaptation strategies to climate change. The model was preferred not only because of its computational ease but also it exhibits a superior ability to envisage climate change adaptation and pick up the differences among the adaptation strategies of climate change. The assumption is that in a given period of the climate change occurrence, a pastoralist's household head chooses among different adaptation strategies that offer a way to reduce the adverse impact of climate change.

Hence, the multinomial logit model used in this study estimates the choices the pastoralists make regarding climate change adaptation strategies on what factors influence those choices. The model specification is given as follows.

Following the work of Tazeze et al. (2012), for a households' utility of two choices represented by U_j and U_k and β_j and β_k respectively; the linear random utility model could be specified as follows:

$$U_j = \beta_j X_i + \varepsilon_j \quad \text{and} \quad U_k = \beta_k X_j + \varepsilon_k \tag{1}$$

where:

U_j and U_k have perceived utilities of adaptation alternatives (strategies) *j* and *k*, respectively, is the vector of explanatory variables which influences the perceived the desirability of each option; *j* and *k* are the parameters to be esti-

mated, and ε_j and ε_k are error terms assumed to be independently and identically distributed (Greene, 2000).

In case of the climate change adaptation decision if the sample household pastoralist decides to use choice j in particular, then we assume that the perceived utility or benefit from option *j* is larger than the utility from other alternatives (say, *k*) depicted as:

$$U_{ij}\left(\beta_j X_i + \varepsilon_j\right) > U_{ik}\left(\beta_k X_j + \varepsilon_k\right),\ i \neq j,\ j \neq k \tag{2}$$

From the above relationship, the probability that household "*i*" with characteristics "*X*" choose adaptation option "*j*" was specified as Equation (3) below. This illustrates the probability that a household will use option *j* from among a set of climate change adaptation options as follows (Oo et al., 2017).

$$P\left(A_i = \frac{1}{X}\right) = \left(U_{ij} > U_{ik}\right) \tag{3}$$

Then we can express and simplify Equation (3) as the following;

$$P\left(\beta_j X_i + \varepsilon_j - \beta_k X_j - \varepsilon_k\right) > \frac{0}{X} \tag{4}$$

$$P\left(\beta_j X_i - \beta_k X_j + \varepsilon_j - \varepsilon_k\right) > \frac{0}{X} \tag{5}$$

$$P\left(\beta_j X_i + \varepsilon^* > \frac{0}{X}\right) = F\left(\beta_k^* X_i\right) \tag{6}$$

where

P is a probability function;

U_{ij}, U_{ik} and X_i are as defined above;

$\varepsilon^* = \varepsilon_j - \varepsilon_k$ is a random disturbance term;

$\beta^* = \beta_j - \beta_k$ is a vector of unknown parameters that can be interpreted as a net influence of the vector of independent variables influencing adaptation and $F\left(\beta_k^* X_i\right)$ is a cumulative distribution function of ε^* evaluated at $\beta_k^* X_i$. The exact distribution of *F* depends on the distribution of the random disturbance term ε^* (Tazeze et al., 2012). Several qualitative choice models can be estimated for the above function depending on the assumed distribution of the random disturbance term (Greene & Hensher, 2003).

As pointed out by Belay et al. (2017), the parameter estimates of the MNL model gives us only the direction of the effect of the explanatory variables on the dependent variables. Then the effects of explanatory variables on the probabilities interpreted by deriving the marginal effects as follows;

$$\frac{\partial P_j}{\partial X_i} = P_j\left(\beta_j - \sum_{k=0}^{j} P_k \beta_k\right) = P_j\left(\beta_j - \bar{\beta}\right) \tag{6}$$

Hence, the marginal effect of marginal probabilities measures the expected change in probabilities where a particular adaptation choice is being made by a unit change of the independent variable from the mean (Greene & Hensher, 2003; Oo et al., 2017).

The definition of Variables and Hypotheses

The dependent variables in this study are the climate change adaptation strategies adopted by pastoralists who include herd diversification, mobility, storage of fodder, livestock off-take, saving scheme and household splitting (Table 1) and no adaptation option was used as the base outcome. The explanatory/independent variables were selected based on the review of empirical as well as theoretical literature by relating with the study area context. Accordingly, the selected explanatory variables include household characteristics such as age, sex, family size, income, livestock ownership and climate-related characteristics of households such as access to climate information, access to extension services, access to credit, participation in government and NGO training and orientation, and access to safety net program (Table 1).

Table 1. Description, definition, and values of variables used in the multinomial logit.

Variable	Definition	Value and Unit of Measurement
Dependent variable		
Adaptation strategy	Adaptation option	Dummy, 0 = if the household not using the adaptation strategy 1 = using the adaptation strategy
	Adaptation strategies considered in this study includes: herd diversification, storage of fodder, mobility, livestock off-take, saving scheme and household splitting	
Explanatory Variable		
Age	Age of Household head	Continuous variable
Sex	sex of household head	Dummy, 1 = male, 0 = female
Family Size	Family size of household head	Continuous variable
Climate Information	Access to climate information	Dummy, takes the value of 1 if the household head has access to climate information's; 0 otherwise
Credit Service	Access to credit service	Dummy, takes the value of 1 if the household head has credit access; 0 otherwise
Extension service	Access to extension service	Dummy, takes the value of 1 if the household head has access to extension service, 0 otherwise
Participation in Training	Participation in government and non-government training and orientation program	Dummy, takes the value of 1 if household head has participation in government or NGO training & orientation programs; 0 otherwise
Safety net program	Access to safety net program	Dummy, takes the value of 1 if the household head access to safety net program; 0 otherwise
livestock Ownership	Household livestock ownership	Continuous variable
Pastoral Income	Annual income of Households	Continuous variable

Prior to running the model, the data were checked for the presence of any multicollinearity in the data set. The multicollinearity problem among continuous variables were tested using the variance inflection factor and the degree of association among dummy variables was checked by contingency coefficient. The result shows that no problem of multicollinearity was detected in both cases. The model fitness was assessed using Chi-square statistics. The likelihood ratio statistics indicated by the Chi-square test were found to be significant. The assumption of independent irrelevant alternatives was tested using the Hausman test specification procedure. This suggests that the multinomial logistic regression model specified in this research is appropriate for modeling pastoralists' preferences for climate change adaptation strategies (Negash, 2011; Belay et al., 2017).

3. Result and Discussions

3.1. Socio-Economic and Demographic Characteristics of Household Pastoralists

The demographic and socio-economic features of sample households were assessed and presented in (Table 2). The majority of the surveyed households (88.8%) of

Table 2. Sex, education, marital status, occupation and land ownership of households.

Socio-economic characteristics' of respondent		n = 215	
		Frequency	%
Sex	Male	191	88.8
	Female	24	11.2
Education	Illiterate	148	68.8
	Read and write	48	22.3
	Primary first cycle (grade 1 - 4)	10	4.7
	Primary second cycle (grade 5 - 8)	6	2.8
	High school and above	3	1.4
Marital status	Married	158	73.5
	Unmarried	19	8.8
	Divorced	14	6.5
	Widowed	14	6.5
	Widower	10	4.7
Occupation	Pastoralism and crop cultivation	18	8.4
	Pastoralism only	148	68.8
	Pastoralism and salary	18	8.4
	Pastoralism and petty trade	9	4.2
	Pastoralism and selling charcoal and fuel-wood	22	10.2

them were headed by the male while a few households, below 11.2% were headed by a female household head. Of the total respondents, more than 73.5% of households were married and the rest of 26.5% were households that were unmarried, divorced, and widowed and widower household heads. Concerning education level, 68.8% of respondents were illiterate, 22.3% can read and write while 4.7% and 2.8% attended the primary first cycle and primary second cycle of education respectively and the rest 1.4% were above high school. Pastoralism is the principal occupation and income source for the majority of households and more than 68% of households were pure pastoralists and the rest were involved in other income-generating activities (petty trades, employment, labour and charcoal, and fuel-wood selling) in addition to pastoralism.

The age of sample household pastoralists showed that the youngest household head was 31 years of age and the oldest was aged 75 years with a mean age of 53 years. The old-age households perceive the climate condition has a high probability of adapting to climate change (Destaw & Fenta, 2021) because the person is expected to acquire more experience in weather forecasting and that helps increase the likelihood of practicing different adaptation strategies to climate change as the age of the household head increases. Regarding the family size of household pastoralists, the largest family size of pastoralists was 9 and the smallest was 3 with a mean family size of 5.5. Large family size increases the probability of households using the adaptation strategies of climate change because households that have large active laborers have a high opportunity of pursuing various adaptation strategies in the face of adverse impacts of climate change (McCarthy et al., 2018; Destaw & Fenta, 2021). The study indicated that the livestock ownership of household pastoralists ranges from 5 to 28 livestock and 16.5 on average (**Table 3**). Livestock ownership is one of the predictors of climate change adaptation that helps pastoralists in making different adaptation options since it is used as the major source of income for pastoralists.

3.2. Pastoralists' Adaptation Strategies to Climate Change

Pastoral communities have developed various climate change adaptation strategies over the years which help them to minimize their vulnerabilities to the impacts of climate change. According to the response from respondents, climate change adaptation strategies have evolved through pastoralists' long experience in dealing with the known and sudden variability that they expect in seasons as a result of climate change such as drought, flood and heavy rainfall. These response mechanisms are the major adaptation and coping strategies employed by

Table 3. Age, family Size, Livestock ownership of respondents.

	N	Minimum	Maximum	Mean
Age of Respondents	215	31	75	53
Family Size of Respondents	215	1	9	6.11
Numbers of Livestock	215	5	28	16.5

pastoral households to adapt to the impacts of climate variability and reduce the adverse effects of climate change. From them, herd diversification (23), storage of fodder (31), mobility (51), Livestock off-take (26), saving scheme (19), and household and herd splitting (33) are the major pastoralists' adaptation strategies to climate change. The remaining 32 household pastoralists said they use no adaptation strategies for climate change (Figure 2).

From identified pastoralists' climate change adaptation options/strategies, herd diversification is one of the adaptation strategies pastoralists employed to cope with the impacts of climate change. Therefore, the study showed that herd diversification is a climate change adaptation strategy in the area that was dominantly employed in the past and still plays an important role in mitigation against climate change impacts. Respondents revealed that it is the mechanisms of having different livestock species such camel, shoats (goat and sheep), cattle and donkey to use scarce range resources, to reduce massive livestock loss during different climate change variability and hazards. Key informant interviews indicate that pastoralists in the Korahey zone presently prefer camels and goats as opposite to cattle since these species are perceived to be more resistant to climate change, mostly drought. These species adapt well to harsh arid environments and can withstand drought incidents more than cattle and pastoralists prefer them due to changes in vegetation composition and water scarcity as a result of climate change. According to the response from the focus group discussion, during rainfall shortages and drought time woody species with leafy fodder are more reliable than grasses; this encourages pastoralists to prefer browsers such as camel and goat from grazers. Respondents also revealed that when the livestock population (herd) is affected by climate change variability; rearing diverse livestock types (cattle, sheep, goat, and camel) by pastoral households enabled them to have an alternative. Pastoralists favor browsers (camel and goats) to adapt to climate-induced shifts in rangeland ecosystems and they are also more drought tolerant and disease resistant. Similarly, Hurst et al. (2012) and Megersa et al. (2014) found that having different species of livestock helps to feed on different

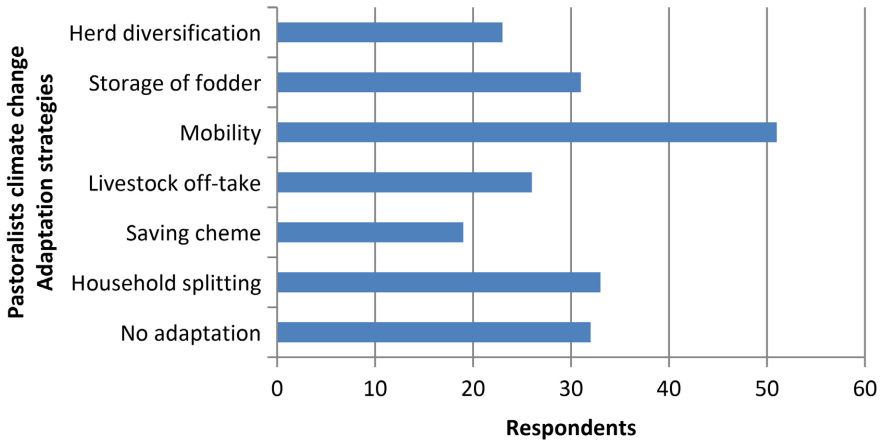

Figure 2. Pastoralist's adaptation strategies to climate change.

species of plants, increasing their options for extracting resources from the rangeland. Livestock like camels and goats are tolerant to the effects of drought and can survive on browsing trees and bushes during feed shortages (Mekuyie & Mulu, 2021).

Livestock off-take is also an important climate change adaptation strategy used by pastoralists. Livestock selling is normal in the study area to fulfill basic needs for buying household goods or other urgent needs; however, most households used to sell their livestock during climate change events mostly drought. Livestock selling is normal in the pastoral area to satisfy their requirements (Mekuyie & Mulu, 2021). According to respondents livestock off-take minimizes risk and allows them to reduce the possibility of the death of animals as a result of climate change impacts. This practice enabled pastoralists to sell their livestock during drought events because animals were unable to resist long dry periods due to a deficiency of feed and water. According to key informants, in times of climate variability (drought) livestock, off-take is the solution to reduce livestock losses as a result of feed shortages and diseases. They also realize that when drought temporarily reduces the rangeland pasture and water resources needed to sustain the life of the livestock it reduces livestock managing and feeding the load of pastoralists'. The study indicates that pastoralists sell livestock regularly even out of drought occurrence time to have a source of cash income and to cover other adaptation costs as well as to cope with the effects of climate change.

Mobility is also a major adaptation strategy practiced by pastoralists in the study area. They revealed that it is carried out in refuge grazing areas and to use water from permanent water points during climate change events. They commonly reported that they move back and forth between pastureland and settlement village and they increase their frequency and distance in search of pasture and water to reduce the adverse effects of drought. The report of FAO (2017) shows a similar finding that as some areas received relatively higher amounts of rainfall, migration of animals has been observed towards areas of comparatively better pasture and water availability. According to key informants, as a result of spatial and temporal availability of pasture and water mobility was not uniform across seasons. Therefore, pasture and water availabilities were among the major factors determining the duration and distance of mobility. Similarly, Mekuyie and Mulu (2021) found that mobility was the main strategy for pastoralists in light of the seasonal, annual and spatial variability of forages and water. Respondents show that during mobility the total household family members and all livestock owned may not be engaged in mobility.

In the study sites, a group of herds that includes the majority of livestock migrates seasonally while others like milking cows, weak livestock and calves remain to serve women and children at home but adult male herders move with the remaining herd. Okoti et al. (2014) also identified that usually, young men move with dry cows and bulls while old people, women and children stay behind with milking cows and calves. On the contrary, Dirriba (2016) found that if the

condition becomes worsen they migrated with all family and livestock. In the study area, there is task and responsibility for each social group. Women were responsible for caring for children, looking after calves and weak livestock, milking, preparing food, and fetching water. Children were assigned tasks of keeping newborn and weak calves while adult men were responsible to look after livestock such as camels and responsible for mobile herds, which were mostly away from the homestead. Respondents mentioned that mobility is still being practiced but it is not as much as in the past due to a decline in the livestock herd size because of recurrent drought. Similarly, the findings of (Lekapana, 2013) revealed that decline in herd size and reduction of grazing range constrained mobility of herds between available pasture plots and water points in pastoral areas.

Herd and household splitting were also adaptation strategies that the pastoralists employed for the century to cope with climate change variability. Pastoralists split their herd and household into different groups and locations mostly during worsen season, when the access and accessibility of pasture and water are scarce. As this study found these adaptation strategies were more interrelated and were used for securing from climate change impacts and also of maximizing the use of scarce range resources. Key informants revealed that during drought pastoralists split their herd and family members and then adjust the settlement of their family and herds into different places. Herd splitting also is a response mechanism where herds are split using kinship as a baseline mostly to far friends, kinsmen, clans and relatives. Lekapana (2013) showed that herd splitting was mentioned as a strategy of dividing and distributing to different family or clan members to be grazed separately. Respondent revealed that the split of the herd depends on productivity, labor availability, types and size of the herd, livestock health conditions and availability of feed in the area considered. When the labor becomes scarce wealthier households split their herds and lend to poor households and the father reproduction becomes common both for poor and wealthier households. Respondent revealed that this shields the poorer households from the adverse impacts of climate change and at the same time help the wealthier ones to escape risk. Pepela et al. (2019) confirm that borrowing herds from wealthier households ensure that poor pastoralists do not drop out of a pastoral livelihood.

3.3. Determinant Factors of Pastoralists' Climate Change Adaptation Strategies

The multinomial logistic regression model was employed to examine the influence of explanatory variables on household adaptation decisions to climate change. Ten explanatory variables were identified based on different literature (Tazeze et al., 2012; Addisu et al., 2016; Belay et al., 2017; Destaw & Fenta, 2021) and the researcher's decision by associating the issue with the study area context. The dependent variable was the climate change adaptation choice of pastoralists as discussed in the methodology part. From the considered adaptation option, "no

adaptation option" was used as the base category, and the estimated coefficients compared with the base category. The analysis was based on cross-sectional data collected from pastoralists of three districts of the Korahey zone namely: Kabridahar, Sheygosh and Shilabo. The results of the multinomial logit model (Table 4) showed that the explanatory variables influenced the choice of adaptation strategies of pastoralists to the effects of climate change. Thus, the variables that

Table 4. Parameter estimates of determinant of pastoralists' climate change adaptation option.

Explanatory Variable	Herd diversification	Storage of fodder	Mobility	Livestock off-take	Saving scheme	Household splitting
Sex	0.014 (0.984)	−1.163* (0.060)	−0.798 (0.159)	−1.595 * (0.014)	−1.639* (0.031)	−0.613 (0.327)
Age	−0.0008 (0.987)	1.163* (0.060)	0.048 (0.221)	−0.031 (0.487)	−0.0221 (0.675)	−0.0006 (0.988)
Family size	−0.337* (0.082)	0.294* (0.069)	0.090 (0.529)	0.562** (0.001)	0.644** (0.001)	0.181 (0.244)
Access to climate information	1.379* (0.031)	−0.312 (0.594)	−0.923* (0.077)	0.434 (0.518)	−0.511 (0.464)	−0.600 (0.289)
Access to credit service	3.237*** (0.000)	2.726** (0.001)	2.68** (0.001)	1.427 (0.137)	3.546*** (0.000)	2.413** (0.005)
Participation in different government and NGO Training	−0.638 (0.331)	−0.534 (0.366)	0.1763 (0.731)	−0.252 (0.686)	−0.385 (0.579)	0.382 (0.489)
Access to safety net program	−0.045 (0.942)	−0.005 (0.993)	0.370 (0.469)	0.846 (0.153)	1.053 (0.121)	0.0047 (0.993)
Access to extension visit	−0.610 (0.332)	−0.131 (0.809)	−0.931* (0.066)	−0.289 (0.616)	−0.545 (0.412)	−0.665 (0.221)
Livestock ownership	0.149* (0.029)	0.027 (0.638)	0.074 (0.169)	−0.013 (0.830)	0.0623 (0.394)	0.0798 (0.172)
Pastoral Income	−0.000018 (0.740)	3.94e−06 (0.932)	0.0000442 (0.286)	5.46e−06 (0.914)	0.0000813 (0.137)	0.0000963* (0.027)
Constant	−0.531 (0.876)	−2.673 (0.377)	−4.432 (0.108)	−1.698 (0.602)	−6.731* (0.071)	−4.801 (0.107)
Base Outcome	No Adaptation					
Number of Observation	215					
Prob > X^2	0.0000					
Pseudo R^2	0.1417					
Log likelihood	−350.76182					

***, **, * significant at 1%, 5% and 10% probability level respectively.

were statistically significant at less than or equal to 10% probability levels are interpreted and discussed in the following section.

Sex of Household Heads

The sex of the household head had negatively influenced the decision of pastoralists to practice some of the adaptation strategies for climate change. As **Table 4** shows that this variable has a negative and significant influence on three climate change adaptation strategies of household pastoralists namely: storage of fodder, livestock off-take and saving scheme at a 10% probability level respectively. This reveals that being a female-headed household decreased the likelihood of adaptation options to climate change such as storage of fodder, livestock off-take and the saving scheme of pastoralist households. This finding is similar to the result of the study conducted by (Addisu et al., 2016) which reported that the likelihood of taking adaptation practice decreases by 58.84% as the household is headed by females as compared to households headed by a male. It further clarifies that female-headed households are more vulnerable to the adverse impacts of climate change since most of the responsibilities in managing the house and the fieldwork were undertaken by the head of the household. Similarly in the study area, the socioeconomic inequality of female-headed households created more burdens on the female households than the male-headed households. Hence, the participation of women in the socio-economic activities of the study area has had a significant influence on the adaptation of climate change impacts on their livelihoods. In line with this, the results of marginal effects presented in **Table 5** shows show that being a female-headed household decreased the probability of livestock off-take by 7.6% as adaptation strategies to the effects of climate change. This could be because female household heads are less likely to meet the investment demands for such adaptation practices since they usually have limited access (Negash, 2011) due to heavy home responsibilities than their male counterparts.

Age of Household heads

Age of household is another explanatory variable hypothesized to have significant effects on climate change adaptation decisions of households. Thus it has a positive influence on pastoralist adaptation options, especially it is positively and significantly related to storage of fodder as a climate adaptation option at 10% level of significance. Furthermore, the result in **Table 5** indicates, that as the age of the household head increases by one year, the probability of the household mobility will increase by 1%. This finding is in agreement with the findings of (Tazeze et al., 2012) which suggests that, as the age of the household head increases, the person is expected to acquire more knowledge and experience in weather forecasting that helps to increase the probability of adopting and practicing different adaptation strategies to climate change.

Family Size

The family size of household pastoralists has a positive and significant impact on some pastoralists' adaptation decisions to change and negative in the case of

Table 5. Marginal effect due to independent variables.

Explanatory Variable	Herd diversification	Storage of fodder	Mobility	Livestock off-take	Saving scheme	Household splitting
Sex	0.066 (0.112)	−0.061 (0.335)	0.003 (0.968)	−0.076* (0.084)	−0.056 (0.134)	0.035 (0.61)
Age	−0.001 (0.733)	0.001 (0.809)	0.010* (0.080)	−0.004 (0.191)	−0.002 (0.394)	−0.002 (0.65)
Family size	−0.042*** (0.000)	0.019 (0.261)	−0.026 (0.196)	0.037** (0.002)	0.032** (0.002)	−0.00016 (0.993)
Access to climate information	0.071* (0.097)	0.038 (0.508)	−0.109 (0.128)	0.091* (0.040)	0.002 (0.945)	−0.009 (0.874)
Access to credit service	0.074* (0.044)	0.069 (0.237)	0.103 (0.151)	0.087* (0.087)	0.083* (0.012)	0.016 (0.790)
Participation in d/f government and NGO training	−0.043 (0.215)	−0.077 (0.182)	0.069 (0.337)	−0.018 (0.669)	−0.021 (0.521)	0.084 (0.186)
Access to safety net program	−0.024 (0.93)	−0.046 (0.425)	0.030 (0.667)	0.058 (0.186)	0.056 (0.140)	−0.046 (0.437)
Access to extension visit	−0.007 (0.837)	0.067 (0.263)	0.114* (0.096)	0.022 (0.604)	−0.002 (0.950)	−0.027 (0.651)
Number of livestock	0.007 (0.59)	−0.000005 (0.265)	0.005 (0.492)	−0.007 (0.139)	0.0005 (0.903)	0.004 (0.501)
Pastoral Income	−4.31e−06 (0.194)	−5.46e−06 (0.439)	2.50e−06 (0.663)	−0.000003 (0.422)	3.13e−06 (0257)	0.00001* (0.013)

***, **, * significant at 1%, 5% and 10% probability level, respectively.

others adaptation strategies. It has positive and significant influences on the storage of fodder, livestock off-take and saving scheme (p 0.069, 0.001 and 0.001) respectively (Table 4). The marginal effect result in Table 5 implies that a unit increase in family size increases the likelihood to practice livestock off-take by 3.7% and saving scheme by 3.2% as adaptation strategies to climate change effects. The probable reasons for the positive relationship are because adaptation strategies are labor-intensive (Tadesse & Dereje, 2021) and a larger number of productive household members increase pastoral production because it is associated with labor-intensive practices. The likelihood of adapting to climate change was higher with large household sizes than with small households probably due to the higher availability of labor (McCarthy et al., 2018).

Access to Climate Information

As it was hypothesized in the methodology section, access to climate information is one of the major explanatory variables that would have a paramount influence on pastoralists' climate change adaptation strategies. As hypothesized, it is found that access to climate information has a significant and positive influence on pastoralists' climate change adaptation decisions. According to the re-

sult of marginal effects indicated in Table 5, access to climate information of pastoralists increase the probability of practicing a herd diversification and livestock off-take by 7.1% and 9.1%. Because access to climate information helps pastoralists to make comparative decisions among alternative adaptation practices.

This finding is in line with the result of the study conducted by Tazeze et al. (2012) in the Babile district of East Hararghe zone which reported that getting information about seasonal forecasts and climate change increases the probability of using some of the climate adaptation strategies of the area.

Access to Credit Service

The result in Table 4 above shows that access to credit has a positive effect on pastoralists' adaptation strategies to climate change and hence, it significantly increases herd diversification and saving scheme by 1% whereas storage of fodder, mobility and household splitting at a 5% level of significance, respectively. The marginal effect in Table 5 shows access to credit increases the likelihood of practicing herd diversification by 7.4%, livestock off-take by 8.7% and saving scheme by 8.3%. In other terms, this implies that household heads that have access to credit was 0.074 times more likely ($p = 0.044$) to make herd diversification, 0.087 times more likely ($p = 0.087$) to employ livestock off-take, and 0.083 times more likely ($p = 0.012$) to save than those who did not have access to credit (Table 5). Similar to this finding, Nhemachena and Hassan (2007) also reported that access to affordable credit increases the financial resources of households and their ability to meet transaction costs associated with various adaptation options they might want to take. Credit availability helps farmers to strengthen their financial position and thus they can easily go for new adaptation (Okezie et al., 2011; Sunny & Bajinder, 2018).

Access to Extension service

Access to extension visit has a positive and significant effect on pastoralists' decision of mobility at a 10% significance level (Table 4). The marginal effect result indicates that pastoralists' access to extension packages increased the likelihood of mobility by 11.4% as one of the adaptation options of the impacts of climate change (Table 5). This finding is consistent with findings of previous studies in the central rift valley of Ethiopia (Belay et al., 2017) and lake tana sub-basin (Addisu et al., 2016), respectively, which indicated a strong positive relationship between access to extension visits and adoption of climate change adaptation practices. Because extension services are a key source of information for climate change and increase the probability of adopting different adaptation practices. Better access to crop and livestock extension services has a strong and positive impact on climate adaptation strategies (Nhemachena & Hassan, 2007).

Livestock ownership

The number of livestock is another explanatory variable that is found as having a positive relationship with the adoption of climate change adaptation strategies. The result in Table 4 indicates the number of livestock has a significant

impact on herd diversification at a 10% level of significance. This is because livestock plays a very important role to decide on the different alternatives of climate change adaptation options. It also serves as a source of income so that the pastoralists can easily decide their adaptation option to support their livelihood.

The study witnessed that the multinomial logit model was the best method to estimate factors that influence the climate change adaptation strategies of household pastoralists. The results of the multinomial logit model show that from the total explanatory variables assumed to influence the climate change adaptation strategies, seven of them were found to be significant. These were sex, age, family size, access to climate information, access to credit services, access to extension services and a number of livestock and pastoral income. The remaining variables found as be insignificant. That means those variables do have not as much influence on pastoralist adaptation option to the impacts of climate change in the study area.

4. Conclusion

The study was carried out to assess the determinants of climate change adaptation strategies of household pastoralists in the Korahey zone. The study employed a mixed research design to collect and analyze the data. The data collection methods such as household questionnaire surveys, key informant interviews, and focus group discussions were carried out to acquire first-hand data for analysis. Simple random sampling was used to select the districts as well as to select representative household pastoralists from the total population. Accordingly, 215 pastoralist households were selected from three districts of the Korahey zone namely: Kebri dehar, Sheygosh and Shilabo. The collected data was analyzed by employing three techniques, i.e. descriptive statistics like percentage, frequency, mean, and inferential statistics (multinomial logit model). The result of the study reveals that pastoralists adopt different climate change adaptation strategies in their locality which include herd diversification, mobility, storage of fodder, livestock off-take, saving scheme and household splitting. The results of the multinomial logit model show that from the total explanatory variables assumed to influence the climate change adaptation strategies, seven of them were found to be significantly influenced by climate change adaptation strategies of pastoralist households. These were sex, age, and family size, access to climate information, access to credit service, access to extension service and livestock ownership. Whereas in different government and non-government training and access to safety net programs are found to have an insignificant influence on climate change adaptation strategies of climate change. The study recommended that the local government, planners and decision-makers should give awareness regarding the role of information in the farmer's adoption of climate change adaptation strategies and enhance extension services to support pastoralists in their adaptation efforts.

Conflicts of Interest

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

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