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Pastoralists' Choices and Determinants of Climate Change Adaptation Strategies: Evidence from Teltele District, Oromia Regional State, Ethiopia

Girma Amare Ragasa
OROMIA Agricultural Research Institute, ,Ethiopia
Corresponding: Girma Amare girmare2017@gmail.com

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A B S T R A C T

Pastoralism is the main source of income for millions of people globally, primarily in Africa, and it has a significant negative influence on them due to climate change. Therefore, this study aimed to determine the most common climate change adaptation strategies utilized by pastoralists and their determinants in the Teltele district, Southern Ethiopia. Through a systematic random selection process, 349 sampled pastoralists were selected from three kebeles within the district. Primary data was gathered through semi-structured, focus groups, and key informant interviews. Descriptive statistics were employed to analyze climate change adaptation strategies, as well as socio-demographic, economic, and institutional characteristics. A multivariate probit (MVP) model was used to identify the determinants of pastoralists' choice of climate change adaptation strategies. The results revealed that pastoralists use herd mobility, livestock diversification, and destocking as major adaptation strategies. Furthermore, this study showed that the selection of adaptation strategies by pastoralists is highly influenced by several factors, including sex, age, ownership of livestock, access to credit, availability of climate information, market distance, pastoral income, and membership in a social group. Therefore, future policy and research should concentrate on enhancing pastoralists' access to climate information, market and credit access, pastoral income, strengthening their association, and rangeland management, and assessing the financial impact of each adaptation option on their means of subsistence to increase their capacity to adapt in the future.

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INTRODUCTION

In developing nations, climate change harms smallholder farming households and agriculture (FAO, 2019). Drought, floods, altered wind patterns, excessive precipitation, heat waves, and tropical cyclones are manifestations of climate variability and extremes (Tamene et al., 2023; Ayal et al., 2020; Sani et al., 2016). Their negative effects are lowering ecological service performance and degrading the ecosystem (Leal Filho et al., 2021). Climate variability and extremes have a particularly negative impact on the livestock system in developing countries, making it more difficult for pastoralists to make a living and provide food security (Gebeyehu et al., 2021; Ayal et al., 2021; Sani et al., 2016; Herrero et al., 2016). Developing nations are particularly vulnerable to climate change because of their economies' excessive reliance on industries that are sensitive to climate change (AGRA, 2018; IPCC, 2018). Sub-Saharan Africa (SSA) is one of the areas that is most susceptible to climate change and unpredictability (IPCC, 2018).

Many problems can arise from climate change and variability, including water and pasture shortages, an increase in livestock diseases, a decrease in the size of the herd due to high cattle mortality, weakened ox traction power, longer reproductive periods, lower livestock productivity, higher management costs, and a decline in the market value of livestock. These are all brought on by recurrent droughts, floods, extremely high temperatures, a high rate of illnesses, insufficient health care, population pressure, weak socioeconomic systems, an absence of appropriate policies, inadequate institutional frameworks, insufficient investment support systems, and resource-based conflicts (Ayal et al., 2020, 2018a, 2018b; Leal Filho et al., 2020; Gebremeskel et al., 2019). Because the climate-sensitive sector is the only source of income and food for pastoralists in developing countries, the consequences of climatic unpredictability and extremes could lead to food insecurity (Herrero et al., 2016).

The government of Ethiopia prioritizes agricultural development to promote economic growth, combat poverty, and ensure food security. Ethiopia's livestock and fisheries sector holds immense potential for economic growth and development. With the largest livestock population in Africa and ranking fifth in the world, the sector accounts for nearly 20 percent of the country's GDP and employs a significant portion of the labor force with an estimated 80 million livestock (USAID, 2020). Livestock in East Africa is vital to the region's culture, food security, and livelihoods despite the region's vulnerability to climate change. It also makes a substantial annual GDP contribution, accounting for roughly 20% of Ethiopia's GDP. Africa's highest cattle population is found in Ethiopia (Bekele, 2017). However, due to interconnected demographic, hydro-meteorological, biological, and policy issues, pastoralism's contribution to family food security and the national economy is under threat, and it is even at a crossroads (Ayal et al., 2020; Gebremeskel et al, 2019; Herrero et al., 2016).

The majority of the population's limited economic options, their inability to tolerate or absorb disasters, and the frequent biophysical shocks they experience hinder Ethiopia's ability to adapt to climate change (NAP-ETH, 2019). The IDDRSI (2022) report states that the pastoralists and agro-pastoralists- who herd

their cattle in the arid and semi-arid lowlands (ASALs) make up the most vulnerable group to climate change, accounting for over 12% of the nation's total population, or over 12–15 million people, or 2-3 million households. Frequent droughts, rising temperatures, and decreased rainfall are the main threats caused by climate change that influence pastoral and agro-pastoral livelihoods through food, animal feed or pasture, livestock loss, and a drop in species dynamics (Tofu et al., 2023). The Borana pastoralists' livestock system is extremely vulnerable to climate extremes and change, to which they have little ability to adjust (Ayal and Leal, 2017). The effectiveness of their adaptation choice to climate extremes is doubtful (Hurst et al., 2012). In the Borana Zone, disease outbreaks, irregular rainfall, and recurring droughts severely affect livestock output. Therefore, to increase pastoralists' and agro-pastoralists capacity for adaptation both now and in the future, it is critical to comprehend the factors that influence their choice of adaptation.

The majority of research on how people's livelihoods are affected by climate change and how they are adapting to it is done in Ethiopia's highlands, where communities can adjust to the effects of climate change more effectively due to comparatively favorable environments (Deressa et al., 2011; Alemu and Mengistu, 2017). Nonetheless, little information is available, especially at the local level, in the country's pastoral communities (Debela et al., 2015). Earlier studies focus on the impact of climate variability, vulnerability, adaptation practices of pastoralists, and identifying factors that determine the choice of adaptation techniques among Borana pastoralists. However, they neglected to take into account how various adaptation techniques that pastoralists can employ are interrelated. They employed a multinomial probit model, which failed to account for the likelihood of numerous adaptation alternatives being interdependent. This implies that pastoralists have limited options when it comes to selecting an adaptation strategy from a range of mutually exclusive (independent) options. Stated otherwise, there is no correlation between complementarity or substitution between any of the adaptation options and the others, either favorably or negatively (Young et al., 2009). Nevertheless, pastoralists may select many adaptation strategies simultaneously, and the possibilities for recognized adaptation may have interdependencies (e.g. Doyo et al., 2018; Tolera and Fayera, 2020; Duba et al., 2021; Gebeyehu et al., 2021; Kemal et al., 2022). Thus, the current study acknowledges that pastoralists may choose more than one adaptation strategy at the same time and states that diverse adaptation techniques are not always mutually exclusive. Unlike previous studies, this one also uses the multivariate probit (MVP) model, which takes into account the interdependence of adaptation strategies and simultaneously computes all adaptation strategies with a set of explanatory variables, to acknowledge the possibility of some potential correlations between the chosen measures. Moreover, perception was added to the list of explanatory variables in the current study that were not present in earlier research.

LITERATURE REVIEW

Adaptation Strategies to Climate Change and Their Determinants

Tolera and Fayera (2020) conducted a study on the pastoral system in the face of climate variability: household adaptation strategies in the Borana Rangelands, Southern Ethiopia. The study found that herd size, number of the active labor force, access to extension services, literacy of household heads, family size, and access to early warning have significant effects on the choice of strategies used by pastoral households. However, the literacy level of pastoral household heads was negatively related to the decision of households to adopt camel rearing as an adaptive strategy in response to climate variability-induced stressors. The negative relationship is probably explained by a generally low level of literacy rate in the study area and Borana pastoralists' complete reliance on their indigenous knowledge to manage their livestock. It is also likely that relatively literate pastoral households choose to be engaged in other adaptation strategies which need less initial investment cost, as the market price of a camel is high. Contrary to this finding, Maddison (2007) argued that education diminishes the probability that no adaptation is taken. Likewise, Lelamo et al. (2022) conducted a study in the Korahey zone of the Somali regional state in eastern Ethiopia on the characteristics of drought and pastoralists' adaptation strategies. Based on the respondents' choices the studies identified most commonly used adaptations strategies were mobility, herd diversification, livestock off-take, increasing puck animals (drought livestock), sending children to school, selling livestock products, and livelihood diversification.

Dirriba and Jema (2015) investigated factors influencing coping strategy choices for climate extremes in the Yabello District, Borana Zone, Oromia Regional State, Ethiopia, using a multinomial logit (MNL) model. According to their findings, pastoral and agro-pastoral income, livestock holding, access to credit, education status of the household, sex of the household head, market distance from the homestead, early warning information, and access to training are all factors that influence the choice of coping strategies for climate extremes. Other variables, such as household size, distance to water from the homestead, and amounts of non-farm non-pastoral income, had no negative impact on the decision to use coping strategies. They also identify four major pastoralists' climate change coping strategies: 1 (livestock diversification-based coping strategies), 2 (integrated crop-livestock diversification), 3 (livestock diversification, water, and rangeland management-based coping strategies), and 4 (integrated crop-livestock diversification-based coping strategies) (livestock diversification, income-earning opportunities, and strategic feeding system adjustment based).

METHODOLOGY

Description of Study Areas

The study was conducted in the Teltele district, in the Borana zone of Oromia Regional State Southern Ethiopia. The town of the district is Milami. It is located 668 km from the capital city of the country, Addis Ababa to the South. It is also located 100 km from the city of the Zone, Yabelo. It is bordered on the south by the Republic of Kenya, on the west by South Omo, on the north by

Southern Nations, Nationalities, and People's Region (SNNP), Konso Zone, on the northeast by Dillo district, and the southeast by El-weye district. The district is one of the driest parts of the Borana zone and, therefore, the pastoral communities of this area are the most vulnerable to climate change specifically drought as a result of both human and climatic factors (TDAO, 2022).

The district lies approximately between 04° 56′ 23″ N latitude and 37° 41′ 51″ E longitude and the altitude range from 496– 1500 meters above sea level. The annual rainfall of the area ranged from 400 to 650 mm. That is characterized as bi-modal. This is to say that 60% of rainfall occurs from March to May and 27% of rainfall occurs from September to November. The mean annual temperature ranged from 28 to 32 0C. The total area of land in the district is 10,627.82 square kilometres out of which 25% is arable, 2.5% was under cultivation, 48% pasture, 5% forest, 20% shrub and brush, and the remaining 2% is considered swampy, degraded or otherwise unusable (Fenetahun et al., 2020; TDAO, 2022). In the district, there were 23 rural Kebeles and 2 small towns, of which 13 are inhabited by pure pastoralists and the remaining 12 are dominated by agro-pastoralists (TDAO, 2022).

Description of Study Areas

The purposeful selection of the Teltele district was based on the district's dependence on precarious livelihoods and the intensity of the drought. A multistage sampling technique was used to choose the respondents and kebeles that made up the representative sample.

The sample size was determined using the formula developed by Yemane (1973) at a 95% confidence interval and a 5% level of precision.

$$\mathrm{n} = \frac{\mathrm{N}}{1 + \mathrm{N}(e)^2} \quad (1)$$

Where: N= total number of the target population, n= sample size, e = margin of error.

Data Type, Sources, and Methods of Data Collection

Both quantitative and qualitative data were collected for this investigation. Semi-structured questionnaires were used to gather quantitative data from the sample houses, while key informant interviews (KIIs) and focus group discussions (FGDs) were used to gather qualitative data. Primary and secondary sources of data were both used in the study.

Data Type, Sources, and Methods of Data Collection

Methods of Data Analysis

The primary analytical methods employed to examine the data were multivariate probit (MVP) regression analysis and descriptive statistics. The results of the key findings were presented as narratives to support the quantitative data, and the qualitative data from key informant interviews and concentrated group discussions were analyzed using thematic analysis techniques to process and identify patterns or themes in the qualitative data.

Descriptive statistical analysis

To summarize, present, and interpret survey results on demographic, socioeconomic, pastoralists' adaptation options, and institutional factors, quantitative data from the questionnaire were analyzed using descriptive statistics like mean, standard deviation, minimum, maximum, percentage, and frequency distribution. STATA software version 17 was utilized for the analyses.

Econometric data analysis

Determinants of choice of adaptation strategies for climate change

In response to climate change, pastoralists typically employ a range of adaptation strategies rather than depending just on one, so the adoption option is multivariate. Because the MVP econometric model (R=100) illustrates the simultaneous influence of several independent factors on each adaptation method, the study adopted it (Belderbos et al., 2004). Additionally, the error terms can be freely connected with this method. According to Ndiritu et al. (2014), the association arises from the complementarity or substitutability of various adaptation techniques. While the negative correlation shows the substitutability of various adaptation strategies, the positive correlation between the error terms implies complimentary. The theory underpinning the analysis, known as expected utility maximization, states that pastoralists acting individually i will respond to climate change by adopting a particular adaptation measure if the expected utility from that adoption (U* ij) is higher than the expected utility from any other alternative measures, including continuing business as usual (i.e., not adopting any measure). The multivariate probit model contains many latent variables and multiple binary dependent variables. However, in this study, the multivariate model consists of three binary choice equations. (such as destocking, livestock diversification, and herd mobility). Based on information gathered from respondents and earlier research, these methods were chosen (Doyo et al., 2018; Tolera and Fayera, 2020; Duba et al., 2021; Kemal et al., 2022). As a result, the model presupposes that the continuous latent variable must be greater than zero for any binary observable variable to take on a value of 1. Using a set of n binary dependent variables $yhpj$, the multivariate probit econometric technique employed for this study is characterized by the following:

$$\mathrm{y} * \mathrm{hpj} = \mathrm{x'hpj\beta j} + \mathrm{Uhpj, j} = 1, 2 \ldots \mathrm{m} \quad (2)$$

$$yhpj = \begin{bmatrix} 1, if\ y * hpj > 0 \\ 0, otherwise \end{bmatrix} \quad (3)$$

Where j = 1,2, … m denotes the climate change adaptation strategies available; $\boldsymbol{x}'hpj$ is a vector of explanatory variables, $\boldsymbol{\beta}j$ denotes a vector of a parameter to be estimated, and $\boldsymbol{u}hpj$ are random error terms distributed as a multivariate normal distribution with zero means and unitary variance. It is assumed that a rational hth pastoralist has a latent variable, $y * hpj$ which captures the unobserved preferences or demand associated with the j^{th} choice of adaptation strategy.

Operational Definition and Measurements of Variables

Dependent Variables

The adaptation strategies that the sampled households used in response to climate change were the dependent variables for the MVP model of this study. Adaptation techniques were chosen based on the steps sample households take to lessen the effects of climate change. Previous research has found a variety of climate change adaptation strategies. After asking the sampled respondents about a variety of possible adaptation techniques, the researcher finally picked three key adaptation strategies that are the most commonly used in the area as the dependent variables for the multivariate probit model. These consist of destocking (selling livestock), livestock diversification, and herd mobility. For each dependent variable, it is a dummy variable that takes the value of 0 if pastoralists do not use it and 1 if they do.

Explanatory variables

The selection of climate change techniques for adaptation by pastoralists is anticipated to be influenced by a variety of factors. Below is an explanation of the variables that are thought to affect pastoralists' decision-making on adaptation techniques. Every variable is defined along with its theory and past empirical study findings. Consequently, it is hypothesized that the following explanatory factors may have an impact on pastoralists' selection of adaptation techniques.

Table 1. Synopsis Of The Explanatory Factors And The Proposed Hypothesis

Variables	Description	Types and Measurements	Expected Sign
SEX	Sex of household head	Dummy; 1= male 0= female	+/-
AGE	Age of household head	Continuous (Years)	+/-
EDULEVL	Education level	Continuous (years)	+
HHSIZE	Household size	Continuous (number)	+/-
TLU	Size of the livestock	Continuous (TLU)	+
CREDIT	Credit use	Dummy (1 if yes, 0 if not)	+
FEXCONT	Extension contacts	Desecrate (Number)	+
CLIMTINFO	Climate information	Dummy (1 if yes, 0 if no)	+
TRAINING	Climate training	Dummy (1 if yes, 0 if no)	+
MKTDST	Distance to market	Continuous (km)	+/-
PASTINC	Pastoral income	Continuous (ETB)	+
NONPASINC	Non-pastoral income	Continuous (ETB)	+
MEMBSG	Membership in social groups	Dummy (1 if yes, 0 if no)	+
PERCEPT	Climate change perception index	Continuous between 1 and 5	+

RESULTS AND DISCUSSION

Socio-Demographic and Institutional Characteristics of Sampled Households

The sample of respondents included both male and female heads of households. The majority of the sampled respondents were men, based on the descriptive data. Table 2 reveals that 82% of the sampled households had a male head, whereas 18% of the respondents had a female head. Using credit lessens financial constraints and empowers pastoralists to implement adaptation measures that lessen the adverse effects of climate change. Table 2 shows that, of the sampled households that were polled in total, 59% reported receiving credit,

while 41% reported not using credit at all during the survey period. All FGDs indicate that the significant drought that struck the study area in 2022 and the attention it received from the government and other relevant organizations is the reason why the majority of sampled households used credit services for a longer time than in previous years. Important explanations for why some sampled respondents did not receive credit are revealed by qualitative analysis gleaned from individual interviews and KII. These reasons include high interest rates, concerns about not being able to pay, and a dearth of trustworthy group members whose credit and saving intuitions lend money through group responsibility.

In all, 80.23% of the sampled households had access to climate information, compared to 19.77% who did not. Table 2. As it broadens their understanding of the detrimental effects of climate change, receiving climate information is essential. Even though 80.23% of the sampled households have access to climate data, the source is antiquated; instead, Table 4 shows that 45.65% and 17.19%, respectively, of the households in the sample received climate information from Qaalluu (the Indigenous climate forecasters) and pastoralists' associations. This implies that the source of climate information, which is still traditional and is not constantly reliable, is not supported by the source of climate information from methodological agencies. Nkuba et al. (2019) asserted, however, that utilizing both traditional climate forecasts and contemporary (science) forecasting techniques will lessen geographical variation and improve the accuracy of meteorological forecast predictions.

It is important to select appropriate techniques for climate change adaptation and to increase awareness through climate-related training. Nevertheless, 98.85% of the tested families do not have access to training on climate-related issues, while just 1.5% of them did (Table 2). The only government structures that could receive training were the local ones. For pastoralists, belonging to a social group offers advantages such as coordinated product marketing, loans, labor availability, and access to high-quality inputs, and information. Table 2 shows that 89% of the respondent households are affiliated with a rural community-based institution, whereas 11% are not. This demonstrated the cultural values held by the Borana pastoralists, which include migratory cattle herding, close family relationships, and a complex political and cultural system of customs known as the Gada system. If available, this system can even aid in the transformation of climate information. The average age of the sampled household heads was 51.34 years, with a range of 35 to 85 years (Table 2). The size of the sampled households varied from 3 to 16 people. Table 2 shows that the average household size of all the sampled households was eight people. This is more than the 4.6 persons per household average for rural Ethiopia (ESS, 2021). Nonetheless, this is comparatively equivalent to a previous study (Debela et al., 2019) that discovered an average family size of 7.6. This raises the prospect of a labor force engaged in cattle rearing; yet, because raising cattle is not economical, the density and reproductive efficiency of livestock have declined, and the dangers associated with climate change have increased animal mortality. The sampled respondent has 1.5 years of formal schooling on average. (Table 2).

This demonstrated that even though schooling raises the degree of comprehension regarding climate change adaptation, a greater proportion of the selected households are nonetheless illiterate. According to FAO (2020), expanding adult education programs is crucial since knowledge is a weapon against food insecurity and climate change.

Pastoralists may have made better decisions in exploring and employing a variety of livelihood options and creating effective adaptation strategies as a result of the knowledge and expertise acquired from veterinary extension service providers (Dinku, 2018). This implies that there is a greater chance that pastoralists would broaden their adaptation techniques to address the consequences of climate change. On the other hand, Table 2 reveals that the sampled households' average frequency of contact was 0.61 days per month or 7.32 days annually. The pastoralists' dispersed population, strong inclination for mobility, and unequal extension pastoral ratio could all be contributing factors to this. Lastly, the market serves as the primary hub for pastoralists to exchange what they produce, buy supplies like salt and vaccines for their herds, and share any knowledge they may have. Market distance takes into account not just the physical distance between a consumer's home and the market, but also the infrastructure and input they can access. The average distance was 13.94 km to the closest market center. (Table 2).

Table 2. Descriptive Summary Of Dummy And Continuous Variables (n = 349)

Variables	**Dummy**	**Frequency**	**Percent (%)**
Sex of HH	Female	62	17.77
	Male	287	82.23
Credit use	Yes	206	59.03
	No	143	40.97
Receive climate information	Yes	280	80.23
	No	69	19.77
Training on climate-related issues	Yes	4	1.15
	No	345	98.85
Membership in social groups	Yes	310	88.83
	No	39	11.17
Summary of continuous variables			
Variables	**Mean**	**Std. Dev**	
Age of household	51.34	10.34	
Household size	8.06	2.41	
Education	1.5	3.87	
Frequency of extension contacts (days)	0.61	0.40	
Nearest market distance (Km)	13.94	7.73	

Source: Own survey data, 2022

Basic infrastructures household head can access

Electricity and livestock health posts were unavailable to the pastoralists in the sample. Furthermore, clean drinking water for cattle, people, and rural roads

is inaccessible to 90%, 72%, and 67% of them, respectively. On the other hand, Table 4 shows that 93% and 100% of the sampled respondents, respectively, had access to human health posts and elementary schools. Even though the majority of sampled households had access to human health and school facilities, they nevertheless had to travel a considerable distance to get there because those facilities are located far from their home. Participants in interviews and FGDs at Gandhile revealed that one major issue was the restricted access to essential infrastructures. Another major obstacle to maintaining the health and productivity of their livestock is the lack of or inadequate access to animal health care services. One of them stated, and they agreed with him:

"Our cows miscarry frequently, which could be brought on by insufficient vaccinations. They eventually develop foot and mouth disease and become weak, thin, and emaciated as a result of not receiving proper medical care and medication. Water is another major issue. Even with so many cattle, there isn't enough water to satisfy their needs. It can be tough to locate any drinking water at times. Furthermore, our kids should have to travel great distances to receive an education" (Gandhile FGDs).

Table 3. Basic Infrastructures Household Head Can Access (n = 349)

Infrastructures	**Yes (%)**	**No (%)**
Access to Human Health Post	93.1	6.9
Access to Livestock Health Post	0	100
Access to Rural Road	33.24	66.76
Access to Clean drinking water for Human	28.37	71.63
Access to Clean drinking water for Livestock	10	90
Access to School (Primary)	100	0
Access to Electricity	0	100

Source: Own survey data, 2022

Source Of Climate Information For Sampled Households

Table 4 indicates that Qaalluu, or Indigenous climate forecasters, is the primary source of climatic information for most sampled households (45.85%). On the other hand, 2.87% of sampled households got climate information from the radio, while 18.91% of them got it from no source at all. The outcome showed that the usual approach which is inaccurate is the only source of climate information in the research area.

Table 4. Source of climate information for sampled households (n = 349)

Sources	**Frequency**	**Percentage (%)**
Indigenous climate forecasters'	160	45.85
Not received	66	18.91
Pastoralists association	60	17.19
Development Agent	30	8.60
Non-governmental Organization	23	6.59
Radio	10	2.87

Source: Own survey data, 2022

Economic Characteristics of the Sampled Households

The tropical livestock unit recorded 2.17 TLU per capita, according to Table 5. Livestock, especially cattle, not only contributes to cultural heritages and

economic prosperity but also establishes the social standing of pastoral households in society (Dirriba, 2016). Nonetheless, scholarly data indicates that the number of animals owned by pastoralists is dropping, from 4.1 to 2.3 TLU, with the most current estimate being 2.48 TLU (Kadiro and Beyene, 2020). This also applies to the research area, where there is occasionally a decline in the number of cattle per person. This implied that the pastoralists of Borana were becoming less self-sufficient in their cattle output. Respondents' herd consisted of goats, cattle, chickens, sheep, donkeys, camels, and mules.

The profit from cattle and livestock products is known as pastoral income. According to Table 5's statistics, the typical household sampled makes 12,122 ETB annually from livestock and animal products. Higher-income households are better able to invest in various adaptation techniques because water and animal feed are the hardest resources to obtain during climatic extremes. In response to the different dangers to pastoral livelihoods, pastoralists are encouraged to diversify their activities and sources of income in addition to their income from livestock. The findings showed that non-pastoral activities such as handicrafts, firewood cells, petty trades, wood, charcoal sales, and remittances provide an average of 1,771 ETB annually for the sampled household (Table 5).

Table 5. Summary of Economic Characteristics of the Sampled Households (n = 349)

Variables	Mean	Std. Dev
Current Year Livestock size (TLU)	2.17	0.84
Pastoral income (ETB)	12,122.05	3,238.27
Non-pastoral income (ETB)	1,771.63	2,337.24

Source: Own survey data, 2022

Climate Change Adaptation Strategies

Studies have been conducted on some adaptation strategies used by pastoralists. Consequently, the pastoralists' most popular adaptation techniques in the district have been determined to be as follows. These are established by comparing the frequency of adoption of these adaptation methods by pastoralists to all other options surveyed. Pastoralists accounted for responses of 78.80%, 73.93%, 66.48%, 4.30%, and 4.01%, respectively, to the following adaptation strategies: herd mobility, livestock diversification, destocking, drought-tolerant livestock species, and herd split and exchange (Table 6). Out of the three adaptive techniques, the most prevalent reaction was herd mobility. Communities of herders typically embrace mobility to make efficient use of the limited and fragmented rangeland resources for sustainable livelihoods in the face of climate changes in dryland habitats. FGD and KII results showed that there was a great deal of variation in the availability of fodder in terms of both time and space. Nonetheless, pastoralists knew when and where the forages were available because of their prior experience. Conversely, out of the trio of adaptation tactics, destocking, or selling cattle, was the least utilized. A person without a head of cattle is considered a qolle (destitute) in the Borana culture because of the various social roles that cattle have. They don't sell their cattle as a result. The researcher discovered using KII and FGDs that respondents frequently take two or more

actions at once to prepare for climate change, particularly drought. This shows that there is a simultaneous and interdependent usage of adaptation techniques in the studied area. Pastoralists finally replied that praying to God is the best way to combat all of these climate change-related dangers.

Table 6. Summary of major adaptation strategies used by pastoralists (n = 349)

Adaptation Choice	Number	Percent (%)
Herd mobility	275	78.80
Livestock diversification	258	73.93
Destocking (livestock selling)	232	66.48
Drought-tolerant livestock species	15	4.30
Herd split and exchange	14	4.01

Source: Own survey data, 2022

Determinants of Pastoralist's Choice of Climate Change Adaptation Strategies

The sex of the head of the household had a negative and significant impact on two of the pastoralists' strategies for adapting to climate change: livestock diversification and destocking (selling livestock), at significant levels of less than 10% and 5%, respectively (Table 7). This suggests that households led by men are more likely than households headed by women to pursue livestock diversification. Because females bear the majority of the responsibility for running the household due to their many tasks, female-headed households may be more burdened by socioeconomic disparity than male-headed households when it comes to diversifying their livestock. Livestock diversification is less common in households headed by women since it involves a wide variety of labor-intensive livestock species, including but not limited to cattle, camels, donkeys, sheep, and goats.

According to Megersa et al. (2014), labor and economic factors most notably, the ability to pay for camel purchases have a substantial impact on the adoption of livestock diversification. In the same way, the findings showed that households headed by men are more likely than households headed by women to embrace destocking or selling livestock. This might be the case because, in comparison to male household heads, female household heads usually kept less livestock. The outcome is consistent with research by Addisu et al. (2016) and Kemal et al. (2022) which discovered that households headed by women had a lower probability of adopting adaptation strategies to climate change, including selling livestock to pastoralist households.

The MVP model's result indicates that, at less than a 1% probability level, the age of the household head positively and considerably affected the option to adapt to livestock diversification, and at less than a 10% probability level, it significantly affected destocking and herd mobility (Table 7). It contradicts the results of research that Berhanu and Beyene (2015) conducted. According to their findings, there is a considerable drop in the likelihood of pastoral practices changing as people age. Nonetheless, the study's findings supported the idea that the likelihood of selecting every adaptation strategy rises with the age of the household leader. As people age, they are more likely to acquire greater

knowledge and experience in weather forecasting, which raises the possibility that a household head may adopt and implement different strategies for adapting to climate change. This result is consistent with those of Kemal et al. (2022) and Tazeze et al. (2012).

The adoption of herd mobility adaptation choices is positively and significantly impacted by livestock size (TLU) at less than a 5% probability level, according to the MVP model results (Table 7). This result is consistent with the reality among the pastoralists of Borana, where households with greater cattle holdings employ more herd mobility strategies. Furthermore, the mobility practice increased with the number of livestock holdings. This implies that the likelihood of continuing to use herd mobility practice as an adaptive response grows with the size of livestock holdings. Large livestock-holding households frequently relocate with their herds to avoid potential droughts. This result aligns with the findings of (Mengistu and Haji, 2015; Berhanu and Beyene, 2015; Tolera and Fayera, 2020) who found that the adoption of herd mobility rises with the size of livestock.

At less than 1% and 5% significant levels, respectively, the probability of adopting herd mobility and destocking (livestock selling) is positively correlated with credit availability (Table 7). Access to credit enables pastoralists to implement a range of adaptation strategies, including shifting the species composition of their herds to acquire drought-tolerant livestock species, such as camels, through destocking (selling livestock) during periods of severe drought to pay for food, animal feed, and other social expenses. It takes financing in addition to destocking to buy species like drought-tolerant camels. The outcome is comparable to the conclusions reported by Kemal et al. (2022) and Mengistu and Haji (2015). According to their analysis, pastoralists' financial resources and capacity to cover the transaction costs of numerous adaptations measures they might wish to implement during a severe climate are enhanced by their access to affordable credit. Similarly, access to financing raises the possibility that pastoralists may employ a range of strategies for adaptation to deal with climate change, according to Duba et al. (2021).

At less than a 1% likelihood level, the adoption of herd mobility is positively and significantly impacted by access to climate information (Table 7). This implies that access to climate-related information increases the possibility of maintaining long-standing pastoral migration patterns as adaptive responses. This may be the case because pastoral mobility is implemented using extensive information. (Information regarding the safest travel methods, the presence of water and pasture, the legislation, security issues, etc.). Tolera and Fayera (2020), Marie et al. (2020), and Kemal et al. (2022) all came to the same conclusion. They discovered that pastoralists can make more informed decisions about various adaptation strategies when they have access to climate information.

The market is the main source of financial resources and other necessities. Thus, distance from the closest market has a significant and negative impact on the adoption of livestock diversification at a less than 1% probability level, while it has a significant and positive impact on the adoption of destocking (livestock selling) at a less than 5% probability level (Table 7). Households further away

from the market are less likely to employ livestock diversification as an adaptation strategy to deal with climate change, according to the negative association between livestock diversification and distance to the nearest market. One explanation might be that the households nearer the market centres just trade their herds at the market they use to diversify their sources of revenue for a living. Therefore, pastoralists are less likely to diversify their livestock if they reside a long way from the closest market. Doyo et al. (2018) discovered the same outcome. Pastoralists may be exposed to climate shock (risks) directly or indirectly as a result of the challenges faced by households in distant places in accessing market services.

An alternative interpretation of the positive correlation is that pastoralists who reside far from the closest market most likely sell a sizable portion of their livestock to a broker once. Their decision to sell a large number of cattle at once, even if they are inexpensive, may be justified by the fact that they will not have access to the market in time to buy salt and feed for their herds during a severe drought, which will aggravate destocking. However, brokers profit from this, not pastoralists. Thus, expanding market access may have a major positive impact on pastoralists' capacity to support themselves in the face of climate change as well as their traditional livelihood methods.

The MVP model's results show that, at less than 10% and 5% probability levels, pastoral income has a significant and favorable impact on adopting herd mobility and destocking (selling cattle). (Table 7). Increasing pastoral income by a unit makes implementing herd mobility and destocking more likely. This is accomplished by routinely selling livestock, even in the absence of drought, to create cash flow, pay for further adaptation expenses, and manage the consequences of climate change. When selecting an adaptation strategy under climate risk, herd mobility is contingent upon the availability of labor, the types and size of the herd, the health of the animals, the accessibility of feed in the area, and the household income. They sell their animals first to raise the necessary funds for taking the necessary adaptation steps in the event of a severe drought. As a result, the chance of implementing herd mobility and destocking is positively correlated with pastoral income. The possibility that pastoralists will use a range of adaptation techniques to deal with climate change increases as pastoral income rises (Duba et al., 2021; Kemal et al., 2022).

There are several benefits to being a member of a social community that supports pastoralists: they get information, credit, coordinated product marketing, labor, and high-quality inputs. At less than a 5% probability level, the outcome shows that membership in a social organization has a significant and positive effect on destocking, or the selling of animals (Table 7). The result is consistent with Bate et al. (2019), who argue that membership in cooperatives or groups provides access to structured product promotion, credit, high-quality inputs, and market information needed to complete a transaction. Furthermore, collectives can facilitate people's access to more market information, social support, government assistance, and consultation when purchasing and selling livestock and livestock products (Zhang et al., 2019).

Table 7. Results of multivariate probit model for climate change adaptation strategies

Variables	Herd mobility		Livestock diversification		Destocking (livestock selling)	
	Coef.	Std.er.	Coef.	Std.er.	Coef.	Std.er.
SEX	-0.0334813	0.2288507	-0.4021152*	0.2141478	-0.4591756**	0.2135809
AGE	0.018502*	0.0097846	0.0330135***	0.009416	0.0163864*	0.0084505
EDULEVL	0.0041653	0.0301407	0.0242451	0.0386964	-0.0088028	0.0197986
HHSIZE	-0.0386446	0.0354183	-0.0312025	0.0340077	-0.039388	0.0322676
TLU	0.2400156**	0.102956	0.0968086	0.0903311	-0.110002	0.0872082
CREDIT	0.5077095***	0.1696242	0.1534133	0.1571861	0.3022315**	0.151595
FEXCONT	-0.0474789	0.2096335	-0.0491162	0.1965235	-0.1469153	0.1881088
CLIMTINFO	0.6394897***	0.1924729	-0.0026937	0.1845374	0.1056792	0.1837353
TRAINING	4.296403	84.94746	0.1142525	0.7744665	0.1677482	0.7510271
MKTDST	-0.0060941	0.0111934	-0.03099***	0.0104906	0.0271253**	0.0096265
PASTINC	0.0000471*	0.0000265	-0.0000395	0.0000247	0.0000589**	0.000024
NON_PASINC	0.000039	0.0000355	-0.000016	0.0000323	0.0000247	0.0000315
MEMBSG	0.1460247	0.2501886	0.0375784	0.2290636	0.4710988**	0.2303334
PERCEPT	0.3741828	0.2615323	0.1307521	0.2589633	-0.1240381	0.2448088
_cons	-3.140057***	1.200622	-0.3023126	1.150298	-0.7015259	1.108485
/atrho21	0 .5671296***	0.11876	Joint probability (success) 0.5095828			
/atrho31	0.9931964***	0.1329407	Joint probability (failure) 0.0805269			
/atrho32	0.4510856***	0.1097449	Multivariate probit (SML, # draws = 100)			
rho21	0.5132481***	0.0874758	Log pseudo-likelihood = -499.61069			
rho31	0.758722***	0.0564122	Number of observations = 349			
rho32	0.422791***	0.0901278	Wald chi2(42) = 105.55			
			Prob > chi2 = 0.0000			

Source: Model result from own survey data, 2022

***, **, and * imply significance at 1, 5, and 10 percent probability levels, respectively.

Likelihood ratio test of rho21 = rho31 = rho32 = 0: chi2(3) = 103.963 Prob > chi2 = 0.0000.

CONCLUSIONS AND RECOMMENDATIONS

Pastoralists are extremely vulnerable to climate change due to their location, which is remote, underdeveloped, and highly affected by climate change and variability. Similarly, because of frequent and severe drought, Borana pastoralists are the most vulnerable to the effects of climate change in Ethiopia. The findings of this study offer relevant information for policymakers, researchers, and other stakeholders on the state of pastoralists' awareness of the changing climate and where to start interventions. Additionally, it identified the major adaptation strategy used by pastoralists. Most importantly, it identified the key factors to take into account during the intervention to take advantage of the available adaptation strategies to support pastoralists' capacity for adaptation.

The researcher recommended that future policy and research should focus on improving pastoralists' socioeconomic, institutional services, and rangeland management, and evaluating the economic impact of each adaptation option on the livelihood of pastoralists to build their capacity for future adaptation.

conclusions and implementation of the research results.

ADVANCED RESEARCH

This study was identifying only three major adaptation strategies and their determination using the MVP model and aggregating some of the others in each

category to avoid convergence problems in running the model and the impact of each adaptation strategy was not considered in this study.

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