The Impact of Livelihood Diversification As a Climate Change Adaptation Strategy on the Food Security Status of Pastoral Households in Southeastern and Southern Ethiopia

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Abstract

The objective of this study was to investigate the determinants of food security and quantify the impact of livelihood diversification as an adaptation strategy on the level of food security of pastoral households in Arero district in Borena zone and Rayitu district in Bale zone in Ethiopia. A multistage sampling technique was used, selecting 396 households from Arero and Rayitu districts. The study used a multidimensional food security index to measure the food security status of pastoralist households. The descriptive result showed that 60.6 percent, 20.2 percent, and 19.2 percent of the pastoralist households had medium, high and low food security, respectively. The result of ordered logistic regression showed that the age of household head, herd size (TLU) and frequency of extension contacts significantly increased the food security status of pastoralist households. However, male household head, age of household head, household size (adult equivalent) and distance to market significantly decrease the food security status of pastoral households in Arero district. On the other hand, the result of the multinomial endogenous switching regression model showed that the uptake of non-farm activities as well as crop production and non-farm activities together have a positive and significant impact on the level of food security of the pastoralist households. Therefore, the results of the study suggest that working on participatory strategies to promote livelihood diversification among pastoralist communities is very important to improve the food security of pastoralist households.

Keywords

Food security, determinants of food security, livelihood diversification, impact, Ethiopia.

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Introduction

For several decades, climate change has become one of the greatest challenges facing our planet. Climate change, which is one of the negative consequences of global warming, has become visible in the world since the Industrial Revolution. For example, by 2017, the global average temperature had increased by 1.1 degrees Celsius compared to the pre-industrial era (WMO, 2018). According to Guilyardi et al. (2018), the increase in global temperature is likely to reach 1.5 degrees Celsius between 2030 and 2052 if greenhouse gas emissions continue at the current rate.

Impacts from climate change are indiscriminately felt over the entire world. Nonetheless, dry and semi-arid rangelands, which make about 30% of the world's geographical area, have recently been badly impacted by climate change (Galvin et al., 2001; Herrero et al., 2016; Malagnoux, 2007). One effect of climate change in these regions is making the pastoral people there more susceptible to food insecurity and chronic poverty. According to FAO (2018), recurrent and overlapping climatic shocks increase the susceptibility of pastoralist communities to food insecurity, famine, and high rates of acute malnutrition in the drylands of Africa.

Short-term effects of climate change on pastoral households include more frequent and more intense extreme weather events, while long-term effects include changes in temperature and precipitation patterns. The pastoralist community's way of life is impacted by the pressure on pastoral resources, especially grazing pastures, brought on by the rising temperature, diminishing rainfall, longer and more frequent droughts, and issues with livestock feed (Hesse and Cotula, 2006). Also, it impacts the four aspects of food security in the communities of pastoralists, including food availability, food accessibility, food usage, and food stability (FAO, 2008).

Food insecurity, both chronic and seasonal, has long existed in Ethiopia. The incidence of recurring droughts and flooding is the primary cause of the latter form of food security. Areas of the nation that get frequent and insufficient rainfall are sometimes referred to be drought-prone areas. In the country's lowland pastoral and agro-pastoral zones and moist deficient highlands, the occurrence of food insecurity is especially severe (Siraje and Bekele, 2013). As a result, the country's food insecurity situation is getting worse due to climate change, which is manifesting itself in increasingly regular droughts and flooding.

A total of 268 million pastoralists and agro-pastoralists rely on the African rangelands, which stretch from the Sahelian West to the rangelands of Eastern Africa, the Horn, and the nomadic communities of Southern Africa, to feed 55 percent of the continent's livestock (FAO, 2018; World Bank Group, 2019). The effect of climate change on cattle in Africa is a generally unstudied topic, despite being the primary source of income for these underprivileged inhabitants. The interplay of the climate, which is becoming more variable, with other factors that are changing livestock systems and broader development patterns are poorly understood (Thornton et al., 2009).

Political instability (internal and external conflicts), socioeconomic conditions, corruption, military involvement in politics, religious tensions, ethnic tensions, and subpar bureaucracy are a few of the factors that worsen food security in developing nations, including Ethiopia (Abdulah et al., 2020). Moreover, several studies have shown that the food security problem in Ethiopia is due to natural and man-made factors. These include persistent droughts and irregular rainfall patterns, degraded ecosystems and land (resulting in low food production and productivity), rapidly increasing populations, inadequate rural infrastructure, and the effects of previous policy restraints (Asenso-Okyere et al., 2013; Melak and Kopainsky, 2014). Other factors that affect food security in Ethiopia include the dependence ratio, the amount of livestock owned, off-farm income, the level of education, remittances, food aid received, and credit (Hamud, 2018; Siraje and Bekele, 2013). These factors are influencing the level of food security in rural households by making it difficult to get hold of nutritiously adequate and safe food and limiting their ability to do so in socially acceptable ways.

Hence, in order to combat the negative consequences of climate change that threaten their food security and sustainable livelihoods, pastoral communities must use a variety of adaptation techniques. One of the techniques that vulnerable individuals can adopt to safeguard their current livelihood systems, diversify their sources of income, and alter their livelihood strategies is to build their resilience. Moreover, adoption of environmental and climate technologies such as renewable energies (wind energy, solar power and hydropower), conservation and storage technologies by pastoralist households plays an important role in reducing the occurrence of extreme climate events and their impacts. In accordance with Berhanu and Beyene (2014), pastoralist adaptation response strategies typically involve modifications to pastoral practices and a shift to non-pastoral livelihoods.

Several empirical studies have been carried out to examine the determinants of food security at the rural household level in Ethiopia. For example, Getaneh et al. (2022) analyzed the determinants of food security among agro-pastoral households in the northeastern Rift Valley of Ethiopia using a caloric intake approach and a logit regression model. Also, a study utilizing an identical mythology was carried out in the Abay Chomen District of Ethiopia's Oromia Regional State (Gebissa and Geremew, 2022). Additionally, solely the food availability dimension of food security was utilized to determine drivers of food security status in selected agro-pastoral communities of the Somali and Oromia Regions, Ethiopia, in a study conducted by Asenso-Okyere et al. (2013). Nevertheless, none of the research examined the level of food security in rural households using a multidimensional food security methodology.

On the other hand, some empirical studies have been done on the impact of livelihood diversification on the level of food security in Ethiopian rural households. For instance, Titay et al. (2017) used propensity score matching to examine the impact of livelihood diversification on food security in in Fedis district in Eastern Hararge Zone, Ethiopia. According to the study's findings, rural households that participated in livelihood diversification had an increase in their calorie intake. Similar findings were reached by a study on the effect of livelihood diversification on rural household food security in Goncha-Siso Enesie district of Amhara region in Ethiopia, which used the same method of measurements (Esubalew and Daniel, 2020). Nevertheless, none of the research employed a multidimensional food security approach and a multinomial switching regression model to evaluate the effect of livelihood diversification on the food security status of rural households. Instead, they all focused on utilizing a traditional method of measuring food security, the calorie intake approach. The study's objectives were to: (1) determine the multidimensional food security status; (2) identify the factors influencing the food security status of pastoral households; and (3) quantify the impact of pastoralist livelihood diversification on the food security status of pastoralist households using the multinomial switching regression model.

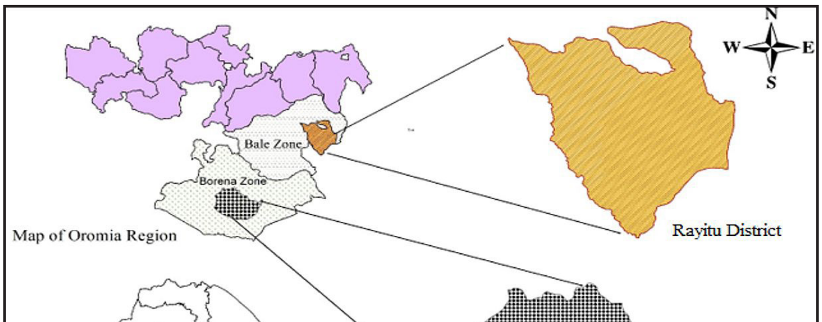
Materials and methods

Descriptions of the study areas

The study was conducted in Arero district of Borena zone in southern Ethiopia and Rayitu district of Bale zone in southeastern Ethiopia. Geographically, the Bale Zone is situated between 5.36ºN-8.12ºN and 39.21ºE-42.23ºE (Bekele et al., 2017). It is bordered by the Somali National Regional State of Ethiopia to the east, East Hararge Zone to the northeast, West Hararge and Arsi Zone to the north, West Arsi Zone to the west, and Guji Zone to the southwest (Figure 1). The eastern part of the zone is characterized by semi-desert climate and inhabited by pastoralist communities. Of the total 20 districts in the zone, seven districts, including Rayitu, Sewena, Gasara, Golgolcha, Ginnir, Goro, and Guradamole, are inhabited by pastoralist and agro-pastoralist communities.

Geographically, the Borena zone is situated in the southern region of the nation between latitudes 4º to 6º N and longitudes 36º to 42º E (Teshome et al., 2022). The Somali region borders it to the southeast, the West Guji zone to the north, the Southern Nation, Nationalities, and People (SNNP) to the west, and Kenya to the south (Figure 1). The zone is divided into 10 districts, among which Yabelo, Arero, Moyale, Dire, Telltale, Dugida Daw, and Miyu districts are all pastoral and agropastoral (Central Statistical Agency, 2013). The zone is mainly characterized by a semi-arid climate with bimodal, two rainy seasons, with average annual rainfall ranging from 350 mm to 1100 mm and an average annual temperature of 19°C (Debela et al., 2019; Desalegn et al., 2018; Worku et al., 2022).

One of the districts in the eastern part of the Bale zone is the Rayitu district. Ginnir, Somali Regional State, and Sewena all have borders with the district to the east, north, and south, respectively. Three perennial rivers, the Wabi Shebele, Weyib,



Source: Authors' drawing (2023)

Figure 1. Location of the study areas.

and Dinikte, also round the area. This district is one of the Bale zone's pastoralist community-dominated districts. With a bimodal rainfall pattern and erratic distribution, it is prone to drought. The long rainy season lasts from March to June, while the short-wet season lasts from September to October. The district is characterized by dry, hot weather, with an average annual temperature of 26 °C and lies within an altitude ranging between 500 and 1,785 meters above sea level (Getachew et al., 2014)

Arero district is one of the districts dominated by pastoralists and agricultural communities in the Borena zone. districts in the Borena zone that is dominated by pastoral and agro-pastoral communities is Arero. Arero district is situated physically at 4º45'0'N and 38º49'0'E (Giro and Jilo, 2020). It shares borders with the Somali region in the east, the Guji zone in the northeast, the Bule Hora district in the north, the Yabelo district in the west, the Dire district in the southwest, and the western districts of Moyale and Borbor (Figure 1). The only river in the area connecting Arero to Odo Shakiso and Liben, two Guji zone districts, is the Dawa River. The region is located between 750 and 1700 meters above sea level and experiences 91 millimeters of annual rainfall on average. The minimum and maximum average temperatures are 16.80 °C and 29.08 °C, respectively (Ejo et al., 2020). With Belg or Gana, the district experiences two distinct rainy seasons: a lengthy one from March to May and a brief one from September to November.

Data and methods of data analysis

A multistage sampling method was used for the study after selecting two zones, one from the southeastern and one from the southern part of Ethiopia, using a purposive sampling technique. The Bale zone was selected in the southeast and the Borena zone in the south. Each zone has seven pastoral and agropastoral districts. Rayitu, Sewena, Gasara, Golgolcha, Ginnir, Goro, and Guradamole districts are among those in the Bale zone that are predominantly pastoral and agro-pastoral. The districts of Yabelo, Arero, Moyale, Dire, Telltale, Dugida Daw, and Miyu are also pastoral agro-pastoral areas in the Borena zone. In the first phase, two districts where pastoralism dominates were deliberately selected: Rayitu in Bale Zone and Arero in Borena Zone. There are 18 and 19 kebeles in Arero and Rayitu districts, respectively. In the second phase, eight kebeles, four from each district, were selected randomly: Alona, Haro Dimitu, Fuldewa, Silala, Adela, Arda Kalo, Dedecha Farda, and Gurura. In the third phase, households were classified into different strata based on the classification of their local wealth status in the study areas. Finally, a simple random sampling method was used to select 396 pastoralist households using the Kothari (2004) formula to determine the sample size.

To achieve the objective, quantitative data were collected in addition to qualitative information. Quantitative data were collected on all livelihood capital indicators, including natural, physical, financial, human, and social capital (Table 1). Data from both primary and secondary sources were used for the study. Various data collection tools were used to collect primary data, including structured questionnaires, key informant interviews (KIIs), and observations. In addition, the Satellite Grided Meteorological Data were taken from AidData at William and Mary university website processed by (Goodman et al., 2019)

The impact of livelihood diversification on food security

Measurement of food security

Measuring food security is not a simple task, as there is no single method to measure it. Depending on the unique analysis setting, various methods have been employed to quantify food security at the household level. For example, anthropometric measurements of nutritional outcome markers of food insecurity such as underweight (low weight-for-age) and stunting (low height-for-age) reveal the effects of ongoing food poverty (WFP and CSA, 2019). This method of assessing food security has its limitations, as underweight and overweight are only proxy indicators of household food security and are not comprehensive (Haysom and Tawodzera, 2018). Additionally, a number of researchers have employed individual dietary intake and household income and spending questionnaires (Smith and Subandoro, 2007) to assess household food security

However, all of the above methods for measuring food security do not simultaneously consider the four dimensions of food security. Recently, a few (Sam et al., 2018; Wineman, 2014) have used a multidimensional food security index to assess food security status at the household level. The multidimensional food insecurity index, the other side of food security, was used by (Napoli et al., 2011) to measure and compare the severity of food insecurity in different countries around the world, particularly in developing countries. Therefore, a multidimensional food security index was used in this study to measure the level of food security of pastoralist households.

To construct a multidimensional index of food security, principal component analysis (PCA) was used to reduce the number of variables to be included in the model (Kim and Kim, 2012). In PCA, the weights for each indicator in the index are objectively derived from the data. Fourteen potential indicators are proposed to construct the index, and they are categorized under the four dimensions of food security (Table 1). Generally accepted criteria were used to select an appropriate number of these factors, based on a trade-off between having as few factors as possible (simplicity) and explaining most of the variation in the data or accounting for most of the information in the input variables (completeness). These include Kaiser's rule, which recommends that eigenvalues greater than one that cumulatively contribute to the total variance should be 70 percent (Dunn, 2008; Jolliffe and Cadima, 2016; Kaiser, 1960).

The first principal component captures the largest variation, and since data reduction is the main goal of this exercise, only the first component was used. This was converted into factor values that serve as weights for creating an index.

Following (Wineman, 2014) food security index is given by

$$FSI_j = W_i \sum \left(\frac{X_{ji} - X_i}{S_i}\right) \quad (1)$$

where FSI_j is the Food Security Index, W_i is the weight for the ith variable (the squared factor scores of i), X_{ji} is the jth household's value for the ith variable, X_i and S_i are the mean and standard deviations of the ith variable for overall households.

Then, the index will be standardized to a scale of 0-1 removing the mixture of positive and negative values (Sam et al., 2018) as follows:

$$FSIA_j = \frac{FSI_j - FSI_{min}}{FSI_{max} - FSI_{min}} \quad (2)$$

where $FSIA_j$ is adjusted FSI for jth household; FSI_j is unadjusted FSI for jth household; FSI_{min} minimum value of FSI in the sample and FSI_{max} is maximum value of FSI in the sample.

Finally, following (Sam et al., 2018) FSI was grouped into four categories, namely low food security ($0 \leq FSIA_j \leq 0.25$), medium food security ($0.25 < FSIA_j \leq 0.50$), high food security ($0.50 < FSIA_j \leq 100$).

Specification of ordered logit model

In this study, an ordered logit regression model was used to identify the determinants of food security status at the household level. Based on the FSI, the level of food security is classified into three categories, namely low food security, medium food security, and high food security. Thus, the measurement of food security based on this

Food security dimension	Indicator	Measurement
Food availability	Crop land	hectares per capita
	Food supply	All food crops in quintal per year produced and purchased
	Food aid	in quintal per year
Food access	Yearly household food expenditure	(ETB)
	Tropical Livestock Units (TLU)	Number of TLU
	Access to mkt	Distance in walking hrs. (inverse)
Food utilization	Distance to public health center	Distance in walking hrs. (inverse)
	Access to safe water	Liters of water per individual per day
	Dietary intake	(kcal/capita/day)
	Dietary diversity	HDDS (Household Dietary Diversity Score)
Food Stability	Livestock diversification	Livestock diversification index
	Livestock loss	Cost of livestock lost in the past one-year (inverse)
	Crop failure	Cost of crop failure in the past one year, (inverse)
	Stable food supplies	Number of months without any food shortage

Source: Authors' organization (2023)

Table 1: Dimensions of food security, indicators and measurement.

measurement index involves an ordered result.

Following (Greene, 2012), the model is specified as:

$$y_i^* = x'\beta + \varepsilon_i \quad (3)$$

Where y_i^* = the unobserved latent variable (FDI) measures food security status with four levels in increasing food security level, coded as 1 = low food security, 2 = medium food security and 3 = high food security and 4 = higher food security. x is the vector of independent variables and β is the vector of regression coefficients which are to be estimated.

The observed response categories are tied to the latent variable by the measurement model (Wooldridge, 2002).

$$y_i = \begin{cases} 1 \; if \; y_i^* \le \alpha_1 \\ 2 \; if \alpha_1 < y_i^* \le \alpha_2 \\ 3 \; if \; \alpha_2 < y_i^* \end{cases} \quad (4)$$

Where:μ_i's represents the thresholds or cut-points to be estimated/predicted along with the parameter vector β. For the estimated cut-off points, α follows the order $\alpha_1 < \alpha_2 < \alpha_3$

Following (Johnston and Dinardo, 1997; Wooldridge, 2002), the cumulative logistic model for ordinal response data is given by:

$$\left.\begin{aligned} Prob\{y = 1|x\} &= \Lambda(\alpha_1 \text{-} x\beta) \\ Prob\{y = 2|x\} &= \Lambda(\alpha_2 \text{-} x\beta) \text{-} \Lambda(\alpha_1 \text{-} x\beta) \\ Prob\{y = 3|x\} &= 1 - \Lambda(\alpha_2 \text{-} x\beta) \end{aligned}\right\} \quad (5)$$

Where Λ (.) is the cumulative logistic distribution function.

The parameters of the model specified in equation (4) are estimated using the maximum likelihood method. However, there is lack of clarity in interpreting the coefficients of the model. This necessitates for the partial change or marginal effect, which can reveal the effects of independent variables on the probability of four different levels of food security individually. For the four probabilities, the partial effects of changes in the regressors are:

$$\frac{\partial(y = 1|x)}{\partial x} = \Lambda(\alpha_1 \text{-} x'\beta)\beta$$

$$\frac{\partial(y = 2|x)}{\partial x} = [\Lambda(\alpha_2 \text{-} x'\beta) \text{-} (\alpha_1 \text{-} x'\beta)]\beta \quad (6)$$

$$\frac{\partial(y = 3|x)}{\partial x} = \text{-}\Lambda(\alpha_2 \text{-} x'\beta)\beta$$

Then, following (Wooldridge, 2002) the parameters α and β can be estimated by maximum likelihood as follows.

$$li(\alpha, \beta) = 1[y_i = 1]log[\Lambda(\alpha_1 \text{-} x_i\beta)] + \\ + 1[y_i = 2]log[\Lambda(\alpha_2 \text{-} x_i\beta) \text{-} \Lambda(\alpha_1 \text{-} x_i\beta)] + \\ + 1[y_i = 3]log[1 \text{-} \Lambda(\alpha_2 \text{-} x_i\beta)] \quad (7)$$

The brant test was used to identify whether any variable violates the parallel-lines/ the proportional odds assumption, as well as tests of the assumption for each variable separately.

Specification of multinomial endogenous switching model

The study used a multinomial switching regression model to assess the impact of livelihood diversification on food security status. The choice of livelihood diversification is assumed to be a choice by the individual pastoralist between adopting or not adopting livelihood diversification to maximize his expected utility. Livelihood diversification includes crop production and non-farm activities in addition to livestock production.

Following (Oparinde, 2021) and assuming that D_{ij}^* is the latent variable that measures the expected benefit from adoption of livelihood diversification. The latent variable model which describes the behavior of pastoral households in choosing one alternative among the different alternatives to maximize its expected benefit is given by;

$$D_{ij}^* = \beta_i C_i + E_{ij} \quad (8)$$

where D_{ij}^* is a latent variable that measures the expected benefit of the i[th] household by choosing among j[th] alternative, i =1,2,3…N, j = 0,1,2,… M, X_i is a vector of covariates, β_i is a vector of parameters to be estimated and U_{ij} is an error term. In multinomial endogenous switching model, a household has j choices and the latent outcome variable is given by;

$$F_{ij} = \begin{cases} 1 \; iff \; D_{i1}^* > \max_{k \neq 1}(D_{i1}^*), & \varepsilon_{i1} < 0 \\ . & . \\ . & . \\ . & . \\ M \; iff \; D_{iM}^* > \max_{k \neq M}(D_{i1}^*), & \varepsilon_{iM} < 0 \end{cases} \quad (9)$$

where F_{ij} is the observed value of the outcome variable for the i[th] households of choosing alternative j, U_{i1}, U_{i2} … U_{iM} are error terms of the outcome equations, i = 1,2,3…N, j = 0,1,2…M and F_{i1}^* is the latent variable.

The pastoral household without livelihood diversification adoption, $j = 0$ is the base category in this study. Hence, the food security status of the households is defined as m regime:

Regime 0: $F_{i0} = X_i \gamma_0 + V_{i0}$, if $A_j = 0$ (10)

Regime 1: $F_{i1} = X_i \gamma_1 + V_{i1}$, if $A_j = 1$ (11)

Regime 2: $F_{i2} = X_i \gamma_2 + V_{i2}$, if $A_j = 2$ (12)

where F_{ij} is the food security status, X_i is the vector other covariates, V_{ij} is the unobserved factor. Based on equations (10), (11), and (12), the following selection bias-corrected outcome equations are given.

Regime 0:

$$F_{i0} = X_i\beta_0 + \delta_0\left[\rho_0 m(P_{i0}) + \sum_j \rho_j\, m(P_{ij})\left(\frac{P_{ij}}{P_{ij}-1}\right)\right] + V_{i0,} \quad \text{if } A_j = 0 \qquad (13)$$

Regime 1:

$$F_{i1} = X_i\beta_1 + \delta_1\left[\rho_1 m(P_{i1}) + \sum_j \rho_j\, m(P_{ij})\left(\frac{P_{ij}}{P_{ij}-1}\right)\right] + V_{i1,} \quad \text{if } A_j = 1 \qquad (14)$$

Regime 2:

$$F_{i2} = X_i\beta_2 + \delta_2\left[\rho_2 m(P_{i2}) + \sum_j \rho_j\, m(P_{ij})\left(\frac{P_{ij}}{P_{ij}-1}\right)\right] + V_{i2,} \quad \text{if } A_j = 2 \qquad (15)$$

where P_{ij} is the probability that the i[th] rural household chooses the j[th] alternative, ρ_j is the degree of correlation between the error term of adoption equation, U_{ij} and the error term of the outcome equation, V_{ij} and $m(P_{ij})$ is the inverse transformation for the normal distribution function. The multinomial endogenous switching regression model is used to create selection corrected prediction of the counterfactual data of the food security status. Assuming household without livelihood diversification adoption, $j = 0$ as the base category, the food security status for households is given by:

$$E(F_{i1}/A_i = 1) = X_i\beta_1 + \delta_1\left[\rho_1 m(P_{i1}) + \sum_{k=1}^{M} \rho_k m(P_{ik})\left(\frac{P_{ik}}{P_{ik}-1}\right)\right] \qquad (16)$$

$$E(F_{i2}/A_i = 2) = X_i\beta_2 + \delta_2\left[\rho_2 m(P_{i2}) + \sum_{k=1}^{M} \rho_k m(P_{ik})\left(\frac{P_{ik}}{P_{ik}-1}\right)\right] \qquad (17)$$

In addition to this, once the actual mean values of the food security status for pastoral households are determined using the above two equations, the mean food security index for households from the counterfactual data is given by:

$$(F_{i0}/A_i = 1) = X_i\beta_0 + \delta_0\left[\rho_0 m(P_{i1}) + \rho_1 m(P_{i0})\left(\frac{P_{i1}}{P_{i1}-1}\right) + \rho_1 m(P_{i1})\left(\frac{P_{i3}}{P_{i3}-1}\right)\right] \qquad (18)$$

$$(F_{i0}/A_i = 2) = X_i\beta_0 + \delta_0\left[\rho_0 m(P_{i2}) + \rho_2 m(P_{i1})\left(\frac{P_{i1}}{P_{i1}-1}\right) + \rho_1 m(P_{i0})\left(\frac{P_{i3}}{P_{i3}-1}\right)\right] \qquad (19)$$

Lastly, the conditional average treatment effect on treated (ATT) could be computed by subtracting equations (16) and (17) from equations (18) and (19) respectively.

Definition of variables

Definition of dependent variables

Food insecurity: Food security was measured using a multidimensional food security index. Based on the multidimensional food security index, the food security status of pastoral households was classified as low, medium, and high. The same variable, the multidimensional food security index, was used to measure the impact of livelihood diversification options on the food security status of pastoralist households using a multinomial switching regression model.

Definitions of independent variables

Gender of household head (gender): The head of household is a person, male or female, who manages the household and usually supports the household economically. The gender of the household head is a dummy variable that takes the value of 1 if the household head is male and 0 otherwise. Studies have shown that male-headed households have higher food security than female-headed households (Kebede, 2019; Enete et al., 2014). Thus, in this study, male-headed households were expected to have a positive correlation with the food security status of pastoralist households.

Age of household head: Age is a continuous explanatory variable and is measured in years. Studies show that there is a positive relationship between household age and rural household food security (Jemal and Kim, 2014; Sani and Kemaw, 2019) so in this study, household age was expected to positively influence the food security status of pastoralist households.

Household size: Household size refers to the total number of household members and is expressed in adult equivalents. Studies have shown that household size is negatively correlated with household food security status (Mbolanyi et al., 2017). In this study, family size was expected to negatively affect the level of household food security

Educational level of household head: The educational level of the household head is a continuous variable indicating the number of years of schooling of the household head. Evidence shows that educated household heads are less poor (Abdela et al., 2021). For this reason, in this study, the educational level of the household head was expected to have a positive correlation with household poverty depth.

Livestock holding/ herd size (TLU): Herd size is a continuous variable indicating the number of livestock owned by the household, measured in tropical livestock units (TLU). Each livestock species in a household was converted to the corresponding livestock unit using the suggested conversion factors (FAO, 2004). Herd size has been shown to influence household food security status (Asenso-Okyere et al., 2013). Therefore, household herd size was assumed to have a positive correlation with food security.

Access to extension services: It is a continuous variable that takes into account the average number of visits of extension agents to a household per year. (Bogale and Shimelis, 2017) showed that access to extension services and their increased frequency helped to improve food security in rural households. To this end, it was hypothesized that the frequency of extension contacts positively influences the food security of pastoral households.

Access to credit: It is a dummy variable that takes the value of 1 if the household has taken a loan and 0 otherwise. This variable can allow households to obtain alternative and additional food, thus contributing to their food security. Food security status increases with access to credit (Bogale and Shimelis, 2009; Million et al., 2019). Therefore, it was reasonable to expect a positive relationship between access to credit and food security among pastoralist households.

Distance to nearest market: It is a continuous variable measured in waking hours and refers to the distance and accessibility of markets for livestock, livestock products, and petty trade in the nearest area. Mota et al. (2019) indicated that access to the nearest market and food security status of rural households are positively correlated. Therefore, it was hypothesized that distance to the nearest market negatively affects the food security of pastoralist households.

Distance access to veterinary service: Access to veterinary service is a dummy variable that takes 1 if the households have access to veterinary service, and 0 otherwise. Studies showed a positive correlation between the availability of veterinary services and the state of food security (Aragie and Genanu, 2017; Hussein and Janekarnkij, 2013). Thus, it was hypothesized that access to veterinary service to be positively related to food security of the pastoral households.

Access to food aid: Food aid is the giving of food or money in exchange for food to needy households to address their urgent food insufficiency issue. The dummy variable "Access to Food Aid" has a value of 1 if the household is receiving food assistance and a value of 0 otherwise. According to studies, food aid and the level of food security in rural farm households are positively correlated (Agidew and Singh, 2018; Abdulah et al., 2019). Therefore, the study proposed that there was a positive correlation between food aid and the level of food security in pastoral households

Non-farm income: A continuous variable, non-farm income, tracks the cash income that pastoral household members obtain. According to studies, receiving non-farm income in addition to farm revenue raises the level of food security in rural (Mbolanyi et al., 2017; Sani and Kemaw, 2019). Therefore, it was anticipated that non-farm income would have a positive impact on the pastoral households' level of food security in this study.

The value of productive assets: The value of productive assets is a continuous variable that measures the value of productive assets the household possessed. Studies showed that productive assets possessed by rural households and food security had a positive relationship (Mofya-Mukuka et al., 2017; Mutea et al., 2019; Nepal and Neupane, 2022). Therefore, the value of productive assets was expected to influence the food security status of pastoral households positively.

Climatic shocks (Livestock Shock): In this study, the term "climatic shock" refers to cattle shocks brought on by persistent droughts in the study locations. The dummy variable has two possible values: 1 if the household is at risk from the climatic shock and 0 otherwise. The study proposed that climatic shocks and the food security status of pastoral households have a negative relationship.

Result and discussions

Socio-demographic profile of households

Age of household head, educational level of household head, household size (adult equivalent), livestock size (TLU), frequency of extension contacts, and value of productive assets make up the sociodemographic profile of the sample homes (ETB). Table 2 presents the mean comparison of the profile for male and female household heads using a t-test. The average age of women who head households is much greater than that of men. On the other hand, at a 1% significance level, the mean education level attained by the male household head was higher than that of the female household head. However, male-headed households had mean adult equivalents and mean Tropical Livestock Units (TLU) that were higher than those of female-headed households at a 1 percent significance level. The mean frequency of contact with extension agents was significantly higher for the former than for the latter.

Satellite mereological data obtained from William and Mary University's AidData website and processed by Goodman et al. (2019) show that areal temperatures and precipitation have increased in the Arero district of the Borena zone and the Rayitu district of the Bale zone. The average minimum, maximum, and mean annual temperatures in Arero district were 18.79, 23.89, and 21.66°C, respectively (Table 3). And 59.06 mm of rainfall per year on average was recorded in the district. The average minimum, maximum and mean annual temperatures of Rayitu district were 19.89°C, 26.08°C and 24.15 °C, respectively.

The trends of these climate variables were tested using the Mann-Markell test, the Sen's slope test, and the innovative Sen trend analysis (Kendall, 1970; Sen, 1968; Şen, 2012), and similar results were found. The Sen's slope test showed that the minimum, maximum, and average temperatures of Arero district increased by 0.029°C, 0.027°C, and 028°C per year at 1%, 5%, and 1% significance levels, respectively (Table 3). The Sen slope test also showed that the average annual rainfall (mm) in the same district increased by 0.666 per year at a 1% significance level. Similarly, the Sen's slope test showed that the minimum, maximum, and average temperatures of Rayitu district increased by 0.024°C and 0.024°C and 023°C per year, respectively, at a 1% significance level. Sen's slope also showed that the same district's average annual rainfall (mm) was rising by 0.331 mm annually at a 5 percent significant level. Therefore, the temperatures and rainfall of the study areas have been increasing from year to year

As far as the climate variability is concerned, the standard deviation of monthly average precipitation (mm) (2011-2020) in Rayitu (3.53) was very close to that of Arero (3.61). The climatic change and variability have resulted in the occurrence of two drought events in the last

Variables	Mean		Mean diff.& its Std. Dev		t-value
	Male (340)	Female (56)	Mean diff.	Std. Dev.	
Age	40.15	46.23	-6.08	2.1	-2.89[a]
Education	3.58	1.23	2.34	0.65	3.59[a]
Adult equivalent	5.46	4.65	0.81	0.3	2.69[a]
TLU	10.82	7.23	3.59	1.75	2.05[b]
Extension contacts	15.84	12.61	3.24	1.04	3.12[a]
Productive asset	1583.23	1089.29	493.95	325.56	1.52

Note: [a] and [b] denote significant at 1% and 5 % significance levels, respectively
Source: Authors' computation (2023)

Table 2: Socio-demographic profile of households.

Districts	Min tem. (°C)	Sen's Slope (°C/year)	Max tem. (°C)	Sen's Slope (°C/year)	Av. tem. (°C)	Sen's Slope (°C/year)	Av. annual RF (mm)	Sen's Slope (°C/year)
Arero	18.79	0.029[a]	23.89	0.027[b]	21.66	0.028[a]	60.47	0.666[a]
Rayitu	19.89	0.024[a]	26.08	0.024[a]	24.15	.023[a]	59.06	0.331[b]

Note: [a] and [b] denote significant at 1% and 5 % significance levels, respectively
Source: Authors' computation (2023)

Table 3: the result of sen's slope for minimum, maximum and average temperature, and precipitation.

ten years alone, causing the deaths and diseases of livestock and crop failures in the study areas. These necessitated the pastoral households to diversify their livelihood as means of coping strategy to these climate change and variability shocks.

Household livelihood diversification

In order to combat the negative consequences of climate change, the pastoral household adopted a variety of livelihood diversification techniques, including crop production, and non-farm occupations, along with livestock herding. As shown in Table 4, roughly 49 percent of the sample's pastoral households have opted to adopt crop production to combat the negative effects of climate change. and variability. And, 22 percent of the sample's pastoral households engaged joint adoption of crop production and non-farm activities. Additionally, just 9.85% of the pastoral households adopted non-farm activities to cope with climate shocks.

Variable	Freq.	Percent	Com.
No diversification	76	19.19	19.19
Crop production	194	48.99	68.18
Non-farm activities	39	9.85	78.03
Crop production & non-farm activities	87	21.97	100
Total	396	100	

Source: Authors' computation (2023)

Table 4: Livelihood diversification of household.

Principal Component Analysis

The study used a multidimensional food security index to assess family food security. The four dimensions of food security, provided by the definition of food security, were used to create the composite food security index (World Bank, 1986). These include availability, access, utilization, and stability over time each having its indicators. The weighted indices of each dimension were combined into a single composite index to create the index. Finally, Principal Component Analysis (PCA) was used to create the food security index for pastoral households.

The major components were selected based on the widely used Kaiser's criteria, which suggests eigenvalues surpassing unity, and cumulative contribution to total variance to be 70% (Dunn, 2008; Jolliffe and Cadima, 2016; Kaiser, 1960). Accordingly, in order to create their respective indices, the first two primary components of the food availability and access dimensions were used (Table 5). In addition, the first three primary components were used to create the food stability and utilization indices. After adding up the four indicators' individual weights, a food security index for each pastoral household was produced. As a result, the households' food security status was divided into three categories: low food security, medium food security, and high food security (Table 7). Following (Sam et al., 2018), the food security status was categorized as low food security if $0 \leq FSi \leq 0.25$, medium food security if $0.251 \leq FSi \leq 0.5$, and high food security if $0.51 \leq FSi \leq 1.00$.

FS dimension	Component	Eigenvalue	Difference	Proportion	Cumulative
Food Availability	Comp1	1.474	0.619	0.491	0,.491
	Comp2	0.854	0.182	0.285	0.776
	Comp3	0.672	0	0.224	1
Food access	Comp1	1.468	0.601	0.489	0.489
	Comp2	0.867	0.202	0.289	0.778
	Comp3	0.665	0	0.222	1
Food utilization	Comp1	1.437	0.408	0.359	0.359
	Comp2	1.03	0.177	0.257	0.617
	Comp3	0.852	0.171	0.213	0.83
	Comp4	0.681	0	0.17	1
Food stability	Comp1	1.388	0.27	0.347	0.347
	Comp2	1.119	0.26	0.28	0.627
	Comp3	0.858	0.224	0.215	0.841
	Comp4	0.635	0	0.159	1

Source: Authors' computation (2023)

Table 5: Principal components' correlation.

Mean difference for food secure and food insecure sample households

The average age of household heads who experienced food insecurity was higher than that of household heads who did not, as shown in Table 6, and the difference was statistically significant at the 1% level. This suggests that households with older household heads were more likely to experience food insecurity than younger headed households. Additionally, the food insecure households had larger average households (adult equivalent) and longer average walking distances from the veterinarian service center than the food secure ones, and the difference was statistically significant at the 1% level. This suggests that as mean adult equivalent and mean distance from veterinarian care center increase, food insecurity also increases. In contrast, the mean Tropical Livestock Unit (TLU) and the mean non-farm income of the food secure households were higher than that of the food insecure ones, and the difference is statistically different at a 5 percent significant level.

Food security status

In this study, a basic or multidimensional method to measuring food security was used to assess the food security condition of pastoral households. To compare the outcomes of the two methods, food security status as determined by the indirect method/per capita daily calorie intake was also presented. The distinction between food-secure and food-insecure households was made using the minimum daily calorie requirement of 2,200 Kcal per person. As seen in Table 7, roughly 46% of the sample households had attained lower than the minimal calories per adult equivalent. The remaining sample families, or around 54% of them, were found to have achieved enough calories to be food secure.

In terms of the multidimensional technique to gauging food security, close to 80% of the sample homes fall into the low security and medium security categories. More specifically, the food security index result revealed that approximately 60.6% of pastoral households fell into the category of medium food security (Table 7). Additionally, it was shown that 19.2% and 20.2 percent, respectively, of the pastoral households fell into the categories of low and high food security. However, in a study conducted in the Indian state of Odisha using a similar approach, only about 32 percent of households fell into the medium food security category and only about 8 percent of households fell into the low food security category (Sam et al., 2018).In addition, the study showed that more than 60 percent of the sample households in the state were in the high and highest food security categories. Another study (Wineman, 2014) used panel data and a multidimensional index to analyze household food security in rural Zambia and found that 9 percent, 50 percent and 41 percent of the households were always food insecure, some times food insecure and never food insecure, respectively. The results show that food security statuses of households in Odisha state in India and rural areas of Zambia are better compared to food security status of households in Arero and Rayitu districts in Ethiopia as measured by multidimensional approach.

Variables	Mean		Mean diff.& its Std. Dev		t-value
	Food Secure (214)	Food insecure (182)	Mean diff.	Std. Dev.	
Age	38.46	44.01	-5.55	1.46	-3.80[a]
Education	3.79	2.60	1.20	0.46	2.60[a]
Adult equivalent	4.67	6.14	-1.47	0.20	-7.37[a]
TLU	11.46	8.97	2.48	1.23	2.03[b]
Extension contacts	15.49	15.26	-0.20	0.10	0.31
Productive asset	1656.36	1345.26	311.10	227.75	1.37
Distance to market	1.63	1.83	-0.20	0.13	-1.52
Distance to veterinary	1.65	2.14	-0.49	0.15	-3.19[a]
Non-farm income	2147.26	1060.14	1087.12	518.05	2.10[b]

Note: [a] and [b] denote significant at 1% and 5 % significance levels, respectively
Source: Authors' computation (2023)

Table 6: Results of mean difference test using t-test for food secure and food insecure sample households.

As determined by both the indirect/calorie technique and the multidimensional approach, the chi-square test demonstrated a strong correlation between food security status and the particular district (Table 7). According to the daily calorie intake method of measuring food security, the Rayitu district has significantly lower food security (46.85 percent) than the Arero district (58.10 percent). One way to look at it is that the Rayitu district had a higher percentage of high food secure households than the Arero area, according to the basic food security measuring approach. On the other hand, a greater proportion of households with inadequate food security was discovered in the Arero district than the Rayitu district (Table 7).

Determinants of food security

In order to identify the determinants influencing the food security status of pastoral households in the Arero district of the Borena zone and the Rayitu district of the Bale zone, the study used ordered logit. The parallel lines/proportional odds assumption was checked using the brant test (Williams, 2006), and there was no issue with the assumption being broken. The pastoral household's level of food security, which was divided into three categories—low, medium, and high—was the dependent variable. In the model, fourteen explanatory variables were fitted. These include the, gender (the male household head), the age of the household head, the interaction between the maleness and the age of the household head, family size (adult equivalent), the household head's educational status, the stock size (TLU), frequency of extension contacts, credit, distance to market, distance to a veterinary service center, food aid, value of productive assets. livestock shock, and being in Arero district.

According to the Wald test, the MNL model with the full set of explanatory variables represents a significantly better fit (LR chi2(12) = 150.99, p = 0.000) than a null model, indicating that at least one of the explanatory variables in the model has a significant impact on the food security status of pastoral households. Out of the fourteen explanatory variables that were utilized, the model's output showed that eight of them were statistically significant in affecting the food security status of pastoral households. These include household size (adult equivalent), livestock size (TLU), frequency of extension contacts, distance to market, and being in Arero district, as well as the gender, age, and interaction of the household head's gender and age (Table 8).

It was suggested that a male household head would have a positive impact on the level of food security in pastoral households in the research locations. However, it was discovered that the male household head had a negative and significant impact on the households' level of food security. Comparing male-headed families to their female counterparts, the marginal effect showed that the likelihood of slipping into a low-food security category increases by 25% and the likelihood of being in a high food security status reduces by 24%. Synonymously, according to Mbolanyi et al. (2017), the male-headedness of households has adversely impacted the food security status of households in a rangeland area of Uganda,

The level of food security in pastoral households was also anticipated to be influenced by the age of the family head positively. In contrast, the age of the household head was found to affect the food security status of pastoral households negatively at a 5 percent significance level. The marginal effect revealed that the probability of the household falling into the low food security category increased

	Food Security Status	district		
		Arero	Rayitu	Total
Multidimensional food security	Low food security	61 (24.11)	15 (10.49)	76 (19.20)
	Medium food security	147 (58.10)	93 (65.03)	240 (60.60)
	High food security	45 (17.79)	35 (24.48)	80 (20.20)
	Total	253 (100)	143 (100)	396 (100)
	Pearson chi^2 = 11.58		Prob = 0.003	
Food security as measured by kcal per day per adult equivalent	Food insecure	106 (41.90)	76 (53.15)	182 (45.96)
	Food secure	147 (58.10)	67 (46.85)	214 (54.04)
	Total	253 (100)	143 (100)	396 (100)
	Pearson chi^2 = 4.6552		Prob = 0.031	

Source: Authors' computation (2023)

Table 7: Food security situation by district.

Variables	Coefficients and Odds ratio		Marginal effects		
	Coef.	Odds ratio	Low FS	Medium FS	High FS
Gender (male)	-2.014[b]	0.925	0.25[b]	-0.011	-0.24[b]
Age	-0.045[b]	0.018	0.006[b]	-0.0003	-0.005[b]
Sex-age interaction	0.052[a]	0.02	-0.006[a]	0.0003	0.006a
Adult equivalent	-0.142[b]	0.062	0.018[b]	-0.001	-0.017[b]
Education	0.043	0.028	-0.005	0.0002	0.005
TLU	0.063[a]	0.013	-0.008[a]	0.0004	0.007[a]
Extension contacts	0.06[a]	0.016	-0.007[a]	0.0003	0.007[a]
Access to credit	-0.108	0.313	0.013	-0.001	-0.013
Distance to market	-0.631[a]	0.098	0.078[a]	-0.004	-0.075[a]
Distance to Veterinary	0.062	0.086	-0.008	0.0003	0.007
Food Aid	0.005	0.236	-0.001	0.00003	0.001
Productive asset	0.00008	0.00005	-0.00001	0.0000005	0.00001
Livestock shock	-0.059	0.339	0.007	-0.0003	-0.007
Arero (district)	-0.797[b]	0.346	0.099[b]	-0.004	-0.094[b]
cut1	-4.216	0.985			
cut2	-0.375	0.954			
Number of obs. = 396 LR $chi^2(14)$ 150.99 Prob > chi^2 = 0.000 Pseudo R^2 = 0.2021					
Log likelihood = -298.09478					

Note: [a] [b] and [c] denote the significance level at 1 percent, 5 percent and 10 percent
Source: Authors' computation (2023)

Table 8: Results of ordered logit model.

by 0.6 percent and the probability of falling into the high food security level decreased by 0.5 percent as the age of the household head increased by one year. However, it was discovered that the pastoral households' food security status was positively and considerably impacted by the male household head's aging. The marginal effect of the interacting variables revealed that when the male household head's age rises by one year, the likelihood that the household falls into the low food security category lowers and the likelihood that it falls into the high category rises by 0.6 percent. Similarly, a study by Sani and Kemaw (2019) found a negative correlation between Assosa rural households' food security status and household head's age.

The household size (adult equivalent) was proposed to affect the food security status of the pastoral households negatively. In line with the proposal, the household size was found to influence the food security status of the households negatively at a 10 percent significant level. According to the marginal effect of household size, as household size grows by one unit, the likelihood of having low food security levels increases by 1.8 percent and the likelihood of having high food security levels falls by 1.7 percent. Similar to this, a study conducted in Afar area of Ethiopian found a negative correlation between household size and food security for pastoral and agro-pastoral communities (Kahsay et al., 2019)

It was proposed that the livestock size (TLU) of the pastoral household would have a favorable impact on their level of food security. As predicted, the model's output showed that, at a 1% level of significance, livestock size (TLU) was found to favorably influence the food security status of pastoral households. According to the marginal effects linked to livestock size (TLU), a one-unit increase in TLU reduces the likelihood of being in a low food security level by 0.8 percent and raises the likelihood of being in a high food security level by 0.7 percent, respectively. The conclusion suggests that having more livestock helps a pastoral home maintain a high degree of food security and prevents it from slipping into a low level. The results of earlier investigations support the discovery (Abdela et al., 2021; Kahsay et al., 2019).

The frequency of extension contacts was proposed to affect the food security status of pastoral households. The model's output revealed that, at a 1% level of significance, the frequency of extension contacts was found to positively influence the households' food security status.

The marginal effects showed that by 0.7 percent, the likelihood that a household is in a high-security level of food security improves and the likelihood that it is in a low-security level of food security reduces. This suggests that the extension agent's ongoing assistance to the pastoral households helped to improve their level of food security. Participation in extension services had also been proven to favorably and significantly influence smallholder farmers' level of food security, according to a study carried out in Kenya's coastal Kilifi South Sub-County (Chege et al., 2018).

The proximity of markets to the residential areas of the pastoral household is one of the factors that influences access to food. Due to this, it was assumed that the pastoral households' level of food security would be negatively impacted by their distance from the market. At a 1% level of significance, it was discovered that the households' food security status was negatively impacted by the distance to the market center, as predicted. The model's results showed that the probability of having low food security levels increases by 7.8% and the probability of having high food security levels decreases by 7.5% the farther one walks from the nearest market center. The outcome may imply that a household's ability to access food decreases with increasing distance from the nearest market center, negatively affecting food security status. The results are consistent with those of the earlier studies (Abdela et al., 2021; Sani and Kemaw, 2019).

Being in Arero district was found to have a negative and significant impact on the food security status of pastoral households. Consistent with the descriptive statistics, the marginal effects of being the Arero district have demonstrated that, when compared to their counterparts in the Rayitu district, pastoral households in the Arero district are more likely to be in low food security levels and less likely to be in high food security levels, respectively, by 9.9 percent and 9.4 percent. The results imply that, in comparison to the Rayitu district of the Bale zone, the food security position of pastoral households has gotten worse in the Arero district of Borena. According to a study carried out in the Gamo Gofa zone of Ethiopia, rural households in the Kamba district (semi-arid) were more sensitive to food security than those in the arid Kamba district (Fassil and Adem, 2021).

The impact of livelihood diversification as climate change adaptation strategy on pastoralists' food security status.

The multinomial endogenous switching regression model was used to examine the impact of livelihood diversification on the degree of food security in the pastoral families in the study areas. The multidimensional food security index was not significantly impacted by the instrumental factors (access to climate information and distance to a road), indicating that the model was well-fitted. The model generates the mean outcomes for adopter household livelihood diversification and what would have happened if the adopters had not diversified. The mean outcome for the non-adopters (the control group) is also included, as is the mean outcome that would have occurred if the non-adopters had chosen livelihood diversification or the alternative scenario. The disparities between the first two outcomes provide average treatment on those who have been treated and adopted (ATT), while the differences between the last two outcomes offer average treatment on those who have not been treated and have not adopted (ATU). Table 9 summarizes the average impact of livelihood diversification as a method for coping with climate change on the multidimensional food security of pastoral households.

The findings showed that households that engaged in non-farm activities, joint crop production and non-farm activities, together with livestock keeping, had higher levels of food security than households that did not engage in these activities. At a 5% level of significance, the difference between the mean food security index value of crop-producing households and the counterfactual (had the producers not produced) (ATT) was 0.091. The adoption of non-farm activities by households greatly raises the food security index value by 28.38. The food security index value would have grown by 12.30 percent if non-adopters of non-farm activities had chosen to engage in non-farm activities. On the other hand, if the households that haven't adopted non-farm activities had done so, the indexed value of food security would have gone up by 16.53 percent. Similarly, a study done in Nigeria found that households who adopted strategies for coping with climate change had higher levels of food security than those who didn't (Ogunpaimo et al., 2021).

The joint adopters of crop production and non-farm activities had a mean indexed value of food

Outcome variable	Diversification	Mean outcome		Treatment Effects	
		Adopted	Not Adopted	ATT/ATU	Impact (%)
		Actual (X)	Counterfactual (Y)	$Z = (X\text{-}Z)$	$\left(\frac{Z}{Y}\right) * 100$
Multidimensional food security	Crop production	0.364	0.349	0.015 (0.011)	4.27
		0.29	0.268	0.022^{b} (0.011)	8.01
	Non-farm activities	0.411	0.32	0.091^{a} (0.023)	28.38
		0.301	0.268	0.033^{b} 0.016)	12.3
	Crop & Non-farm	0.506	0.426	0.080^{a} (0.029)	18.83
		0.384	0.268	0.115^{a} (0.016)	42.97
HT Effects		BH_1	BH_0	TH	
Multidimensional food security	Crop production	0.0744^{a} (0.01)	0.0811^{a} (0.015)	-0.0065 (.012)	
	Non-farm activities	0.1094^{a} (0.023)	0.0516^{a} (0.015)	0.0578^{b} (0.023)	
	Crop & Non-farm	0.1224^{a} (0.021)	0.1576^{a} (0.028)	-0.0352 (0.027)	

Note: ^{a,} and ^{b} denote the significance level at 1 percent and 5 percent; values in the parenthesis are standard errors
Source: Authors' computation (2023)

Table 9: ATT and ATU of Livelihood diversification: MESR Estimates.

security of 0.506. At a 1% level of significance, the difference between the joint adopter's mean food security index value and the counterfactual value (ATT) was 0.08, making it significant. In comparison to the counterfactual, pastoral households' joint adoption of crop production and non-farm activities significantly raises the food security index by 18.83 percent. The conclusion suggests that combining crop production and non-farm activities leads to a greater improvement in the degree of food security for the adopting pastoral families. A similar increase (42.97 percent) in the food security index would have occurred if non-adopters of the joint activities had chosen to do so. Similarly, a study carried out in southwest Nigeria revealed that adopting measures for adapting to climate change had raised the food security index of adopter fish farmers (Oparinde, 2021).

The base heterogeneity values for adopters (BH_1), non-adopters (BH_0), and transitional heterogeneity (TH) was presented in Table 9. There were positive and significant values of base heterogeneity (BH_1) in the adopters of crop production, indicating that there are no sources of heterogeneity among adopters and non-adopters of crop production and that adopters had more food security than non-adopters. Similar to adopters, non-adopters' positive base heterogeneity values (BH0) show that if they had adopted the same activities, crop production, non-farm activities, and joint of both activities, they would have been more food secure. The positive and significant values of transitional heterogeneity (TH) for the adopter of non-farm option imply that the impact of adopting the non-far activities on food security level would be significantly higher for pastoral households who adopted compared with those who did not adopt (if they would decide to adopt).

Conclusion

The study's objectives were to investigate the factors that affect the food security of pastoral households and the impact of adopting livelihood diversification on the level of food security for households in the districts of Arero in the Borena zone and Rayitu in the Bale zone. The study measured the level of food security in pastoral households using multidimensional approach and classified it as low, medium, and high. According to the approach's descriptive results, the percentages of pastoral households with medium, high and low levels of food security were 60.6 percent, 20.2 percent, and 19.2 percent, respectively. More particular, the majority of pastoral households - nearly 80% - were in low and medium food security categories. Additionally, Rayitu district had 24.48 percent households with high food security than Arero district did (17.79 percent). In contrast to Rayitu district (10.49 percent)., Arero district had a considerably greater percentage of households with low food security, about 24%.

Ordered logit regression and multinomial endogenous switching regression models were the two econometric models used in the study. To determine the variables influencing the households' level of food security, the ordered logit was utilized. The impact of implementing livelihood diversification on the degree of food security in pastoral households was evaluated using the multinomial endogenous switching regression model. According to the results of ordered logistic regression, the interaction between the household head's age and gender, the size of the livestock (TLU), and the frequency of extension contacts considerably improves the food security situation of pastoral families. The food security status of the pastoral households is, however, significantly reduced by the maleness of the household head, age of the household head,

The results of the multinomial endogenous switching regression model, on the other hand, demonstrated that the adoption of non-farm activities and the combination of both activities had a favorable and significant impact on the degree of food security of pastoral households. The model's output showed that the pastoral household's degree of food security increased as a result of engaging in livelihood diversification as an adaptation strategy. More specifically, adopter households' adoption of non-farm activities and joint adoption of crop production and non-farm activities boosted the food security index by 28.38% and 18.83%, respectively. In addition, the positive and significant value of base heterogeneity (BH1) revealed that the adopters are more food secure than non-adopters.

The study offers some guidance for governmental bodies working at various levels and non-governmental organizations to work on the situation of food security of the pastoral community in semi-arid areas. The local government should concentrate on enlarging local markets to ensure food accessibility and make it easier for people to sell their livestock to buy food items because the households' level of food security was influenced by the distance to the market center. Working on community-participatory policies that encourage the diversification of livelihoods in pastoral communities is extremely important, as the study's findings showed that the adoption of non-farm activities and crop production and non-farm activities jointly improved the food security level of the pastoral household. More realistically speaking, it appears crucial to promote livelihood diversification by developing the appropriate infrastructure, addressing the financial issues facing pastoral households, and launching the formation and growth of micro and small businesses in semi-arid regions.

The study contributes to the food security literature by flashing lights on pastoral households' food security status using cross-sectional data and a multidimensional food security index method of measuring food security in semi-arid areas. Additionally, it adds to the body of literature a more accurate way to assess the impact of livelihood diversification as an adaptation strategy on the degree of food security in pastoral households through the use of multinomial endogenous switching model. However, as the study focused only on the selected districts, a wider scope, further study on food security and vulnerability to food insecurity of pastoral households in semi-arid appears to be crucial,

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Appendix

Used abbreviations

ATT	Average treatment effect on the treated
ATU	Average treatment effect on the untreated
CSA	Central Statistical Agency
FAO	Food and Agriculture Organization of the United Nations
FSI	Food Security Index
PC	Principal component analysis
SNNP	Southern Nation, Nationalities, and People
TLU	Tropical Livestock Units
WFP	World Food Program
WMO	World Meteorological Organization