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DETERMINANTS AND PERCEIVED CLIMATE VARIABILITY ADAPTATION SUCCESSFULNESS OF PASTORAL, AND AGROPASTORAL HOUSEHOLDS IN BORENA ZONE, SOUTHERN ETHIOPIA

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ABSTRACT

The article identifies climate change adaptation response determinants and examines perceived adaptation successfulness among pastoral households in Borana zone of Southern Ethiopia. In this study a mixed research design was used. Data was collected from 417 sample households selected using multistage sampling methods, key informants and focus group discussion participants. Descriptive statistics and econometrics analysis were used to analyze quantitative data while content analysis was used for qualitative data. The study reveals that a combination of demographic, socio-economic, and environmental factors influence the adoption of these strategies. The analysis identifies variables such as education level, credit association membership, access to extension services, and climate change training as consistently significant factors associated with multiple adaptation strategies. This understanding enables policymakers, practitioners, and stakeholders to develop targeted sustainable interventions, programs, and policies that enhance resilience and reduce food insecurity in vulnerable populations and thereby contribute to the achievement of sustainable development goals (SDG 13).

Keywords: adaptation strategies, Borena, pastoralists, agropastoral, climate variability, perceptions

INTRODUCTION

Anthropogenic climate change is the dominant driver of observable global climate change over the past century (IPCC, 2021). Global average surface temperature has risen by about 1.1°C (2°F) since the late 19th century, with the past four decades being the warmest on record (NOAA, 2022). Temperature increase is causing a wide range of impacts across the globe inter alia, altering precipitation patterns worldwide, with some regions experiencing increases in heavy rainfall events and flooding, while others face more frequent and severe droughts (IPCC, 2021). In addition, shifts in the water cycle disrupt agricultural productivity, water supplies, and natural ecosystems. Hence, frequency and intensity of droughts has increased in the Mediterranean, Africa and northeastern Brazil in recent decades (Spinoni et al., 2019).

Sub Saharan Africa is one of the most vulnerable continents to the impacts of climate change due to its high exposure, low adaptive capacity, and dependence on climate-sensitive sectors like agriculture (IPCC, 2022). Average temperatures across Africa have increased by around 0.7°C over the past century, with more frequent and intense heat waves (Niang et al., 2014). Further warming of 2-6°C is projected by the end of the 21st century, depending on emissions pathways (IPCC, 2022). Trends show decreasing rainfall in parts of North and Southern Africa, while the Sahel region has experienced increased rainfall variability (Niang et al., 2014). Climate models indicate more intense wet and dry extremes, including droughts and flooding, with complex regional variations (IPCC, 2022). Crop yields, especially for staple foods like maize, millet, and sorghum, are projected to decline significantly due to the combined effects of higher temperatures, shifting rainfall, and increased pests/diseases (Schlenker & Lobell, 2010).

Ethiopia is considered one of the most vulnerable countries to the impacts of climate change in Africa due to its high dependence on climate-sensitive sectors like agriculture, limited adaptive capacity, and exposure to extreme weather events (IPCC, 2022). Average temperatures in Ethiopia have increased by about 1°C over the past century, with more frequent and intense heat waves (Conway & Schipper, 2011). Climate models project further warming of 1-5°C by the end of the 21st century, depending on emissions pathways (IPCC, 2022Crop yields, especially for key staples like teff, maize, and sorghum, have declined due to the combined effects of rising temperatures, shifting rainfall, and increased pests/diseases (Deressa et al., 2011). Livestock productivity is also threatened by heat stress, water scarcity, and pasture degradation (Legesse et al., 2014). Food insecurity and malnutrition are major concerns, as 80% of the population relies on rain-fed subsistence farming (FDRE, 2019).

Sustainable Development Goal 13 (SDG 13) aims to take urgent action to combat climate change and its impacts. One of the significant challenges posed by climate change is its impact on food security, particularly among vulnerable populations like pastoralists. Pastoralist communities, whose livelihoods heavily rely on livestock and natural resources, face unique challenges in ensuring food security in the face of changing climate patterns. SDG 13 aligns with the promotion of sustainable agriculture practices that enhance resilience to climate change and contribute to food security. Vermeulen et al. (2018) emphasize the importance of climate-smart agriculture, which integrates sustainable intensification, adaptation, and mitigation strategies to enhance agricultural productivity while reducing greenhouse gas emissions and improving resilience.

As climate change impacts continue to manifest around the world, the success of adaptation efforts has become an important area of research and evaluation. Numerous studies have examined the outcomes and effectiveness of various climate change

adaptation strategies implemented at the local, national, and global levels (Degla et al., 2016; Gezie, 2019; Hilemelekot et al., 2021; Temesgen et al., 2014; Tofu et al., 2020). Factors contributing to successful adaptation include stakeholder engagement and collaboration, institutional and governance capacity, robust knowledge, and information, flexible and iterative approaches, and adequate and sustainable financing.

Research has identified several key factors that contribute to the successfulness of climate change adaptation efforts. Adaptation measures are more likely to succeed when they involve the active participation and buy-in of relevant stakeholders, including local communities, policymakers, the private sector, and civil society organizations (Shackleton et al., 2015; Ensor & Berger, 2009). Strong institutions, clear policy frameworks, and effective governance structures are critical for the successful planning, coordination, and implementation of adaptation interventions (Biesbroek et al., 2013; Oberlack, 2017). Adaptation efforts benefit from a solid understanding of local climate risks and vulnerabilities, as well as access to reliable data, tools, and scientific knowledge to inform decision-making (Lemos et al., 2012; Moser & Ekstrom, 2010). Adaptation strategies that are adaptable, flexible, and able to evolve based on changing conditions and new information tend to be more successful in the long run (Wise et al., 2014; Fazey et al., 2016). Sufficient and reliable financial resources are necessary to support the implementation, monitoring, and long-term maintenance of adaptation interventions (Paavola & Adger, 2006; Buchner et al., 2019).

Assessing the successfulness of climate change adaptation requires a conceptual framework that considers the multifaceted and context-dependent nature of these efforts. Several theoretical perspectives have been applied to analyze the factors influencing adaptation outcomes. These are vulnerability reduction framework, resilience-based frameworks, transformative change frameworks, process-oriented approaches and outcome-based frameworks.

Vulnerability reduction framework evaluates adaptation success based on the extent to which interventions reduce the vulnerability of communities, ecosystems, or systems to climate change impacts. Key indicators include reduced exposure, sensitivity, and enhanced adaptive capacity (Eriksen & Kelly, 2007; Adger, 2006). Resilience theory emphasizes the ability of social-ecological systems to absorb change, self-organize, and adapt in the face of disturbances. Successful adaptation is assessed by improvements in system resilience, including diversity, modularity, and the capacity for learning and renewal (Folke, 2006; Berkes et al., 2003). Transformative change frameworks evaluate adaptation in terms of its potential to catalyze deeper, systemic changes in social, economic, and environmental systems. Successful adaptation is seen as facilitating fundamental shifts in values, behaviors, and institutional structures (Pelling, 2011; O'Brien, 2012). Process-oriented approaches focuses on the quality of the adaptation process itself, including stakeholder engagement, institutional capacity, governance arrangements, and social learning. Success is determined by the robustness of these process-related factors (Moser & Ekstrom, 2010; Biesbroek et al., 2013). Outcome-based frameworks assess the tangible impacts and benefits of adaptation, such as improved food security, water access, disaster resilience, or ecosystem health. Success is measured directly against these concrete objectives (Adger et al., 2005; UNFCCC, 2010).

These different theoretical lenses offer complementary insights and can be used in combination to provide a more holistic understanding of adaptation successfulness. Successful adaptation is often a function of the interplay between these various factors, including vulnerability reduction, system resilience, transformative change, process quality, and tangible outcomes.

Based on the current literature on climate change adaptation, there appears to be a research gap in understanding the successfulness of adaptation efforts in lowland areas of Ethiopia. As much of the existing research on climate change adaptation in Ethiopia has focused on the highland and midland areas of the country, there is research gap on in lowland areas. However, there are a dearth of empirical studies that systematically evaluate the outcomes and success of adaptation interventions specifically in the lowland regions (Asfaw & Admassie, 2004; Deressa et al., 2009). Second, because of the unique socio-ecological context of lowlands there are lack of literature on factors like pastoralist livelihoods, water scarcity, and ecosystem fragility that create a unique context for adaptation and may require different approaches and indicators of success (Bekele, 2017; Aklilu & Alebachew, 2009). Third, there is lack of inadequate consideration of local knowledge and participation. Adaptation initiatives in the Ethiopian lowlands have often been top-down, with insufficient incorporation of local communities' traditional coping strategies and meaningful participation in the design and implementation of programs (Ayal et al., 2015; Debela et al., 2015). Fourth, there is lack of long-term monitoring and evaluation. There is a general paucity of longitudinal studies that track the long-term outcomes and sustainability of adaptation projects in the lowland regions. Most assessments have been snapshot evaluations without comprehensive monitoring frameworks (Gebrehiwot & van der Veen, 2013; Tesfahunegn et al., 2016). Finally, disconnect between adaptation and development priorities. Adaptation efforts in the Ethiopian lowlands are often not well integrated with the broader development agenda and priorities of these marginalized regions. This disconnection can undermine the effectiveness and scalability of adaptation interventions (Asfaw & Admassie, 2004; Deressa et al., 2009). Addressing these research gaps through in-depth, context-specific studies in the Ethiopian lowlands could provide valuable insights to identify the determinants of successfulness of climate change adaptation in Borena area and there by improve them. Therefore, this paper will examine the determinants of perceived climate change adaptation successfulness in Borena, Southern Ethiopia.

MATERIALS AND METHODS

Description of the study area

The study was carried out in the southern section of Ethiopia's Oromia regional state, in the Borena Zone. The zone borders Kenya in the south, the Southern Nations in the west, the Guji zone in the east, and the Somali regional state in the southeast. The zone is located between latitudes 4 and 6 N and longitudes 36 and 42 N (Figure, 1).

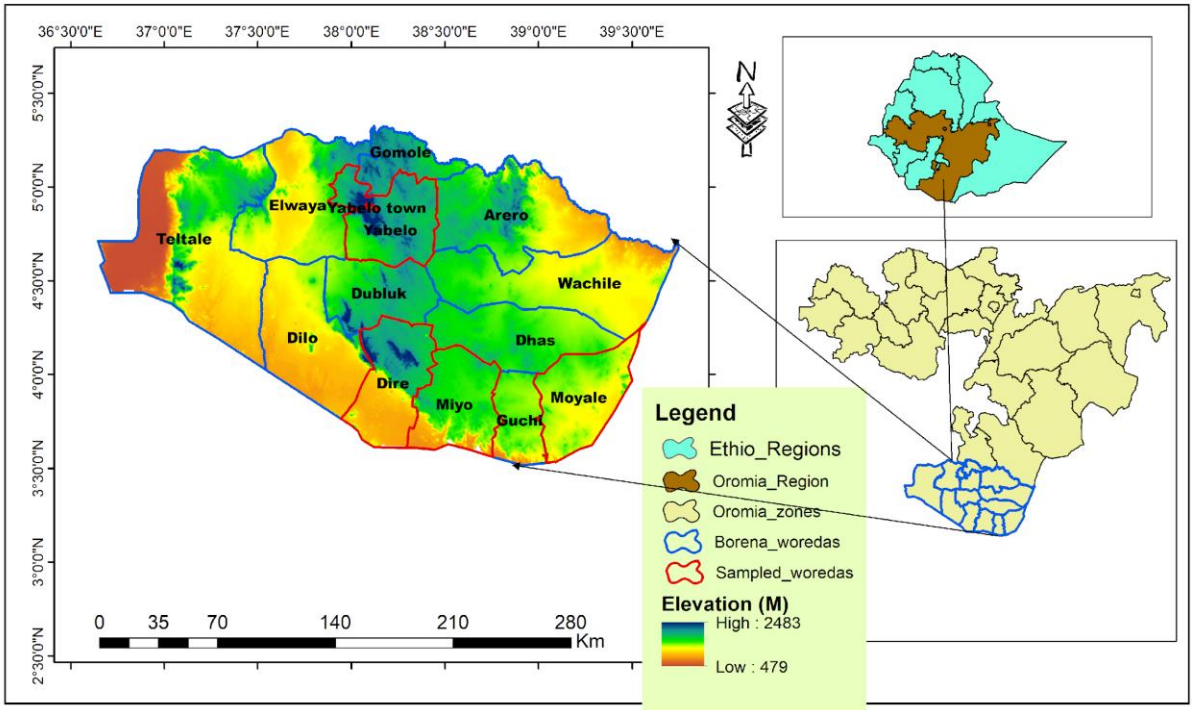

Figure 1: Map of the study area (Borena Zone)

Source: Own GIS construction (2023)

The zone's terrain is made up of gently sloping peaks that, in certain places, rise to heights of 2,000 meters above sea level. The Borena Zone has a mean elevation of 1,500 meters above sea level and a total size of 48,743 km2, divided into 13 districts.

The region has sub-humid zones in addition to a mostly arid and semi-arid climate. The lowland portions of Borena have been severely affected by droughts, and the region's rainfall patterns are erratic. In lowland areas, the long rainy season, which runs from March to May, accounts for about half of the yearly rainfall, while the short rainy season, which runs from September to November, accounts for around 30%. Because of the area's erratic rainfall patterns, pasture availability is scarce and very variable (NAPA, 2007). Pastoralism is the main source of income in the research area (Alemu, 2017; Alemu & Adugna, 2015). The food security of households is significantly challenged by climate variability and change (Nigussie et al., 2018).

Data Sources and Research Design

The research design for the study on determinants and perceived climate variability adaptation successfulness of pastoral and agro-pastoralist households in Borena Zone, Ethiopia involved a mixed-method approach. Firstly, a cross-sectional survey was conducted to collect quantitative data from a representative sample of pastoral and agro-pastoralist households in the study area. The survey included questions related to household demographics, socio-economic characteristics, climate variability adaptation strategies, and perceived success of these adaptation efforts. Additionally, qualitative data were gathered through in-depth interviews and focus group discussions with key informants and community members to gain a deeper understanding

of the determinants influencing climate adaptation success. The combination of quantitative and qualitative data has provided a comprehensive understanding of the factors impacting climate variability adaptation success among pastoral and agro-pastoralist households in Borena Zone, Ethiopia.

2.1 **Sampling technique and sample size determination**

The study used a multi-stage sampling technique to select the sample. The target population for this study was the pastoral and agro-pastoral households in the Borena zone, Ethiopia. The sample frame was the list of all households in the selected districts (woredas) of Borena zone. The Borena zone was selected due to vulnerability of climate variability, and low implementation of adaptation strategies, and coping response, and high food insecurity level. In the first stage, four districts were selected with purposive sampling technique. At the second stage, sample kebeles were selected using simple random sampling. In the third stage, representative sample households were selected using stratifies sampling technique. The sample size determination and non-response bias were critical considerations for the quantitative survey. The sample size was determined using Cochran's (1977) formula, which is widely used when there is a large population and when the study requires accurate variability and heterogeneity of the population.

$$n = \frac{z^2 pq}{e^2}$$

n = required sample size

Z = standard normal value which is 1.96 for 95% confidence interval (5% significance level)

p = estimated proportion of population (maximum variability) (0.5)

q = (1-p) or estimated proportion of failure

e = the desired level of precision (0.05)

Therefore, the estimated sample size yield 384 household heads. The final sample size was 417 by considering the 10% non-response rate.

2.4 Data collection: tools and procedure

Primary data were collected from pastoral and agro-pastoral households using structured questionnaires. The survey gathered information on household demographics, socio-economic characteristics, climate variability adaptation strategies, and perceived success of these adaptation efforts. In addition to the surveys, qualitative data was collected through in-depth interviews and focus group discussions (FGDs) with key informants (KIIs) and community members. For FGD, a total of 12 heterogeneous FGD participants were selected, representing a broad cross-section of the pastoral and agro-pastoral communities. In addition, 12 key informants, and 2 case studies were conducted. Thus, quantitative, and qualitative data provided a comprehensive understanding of the determinants and perceived successfulness of climate variability adaptation among pastoral and agro-pastoralist households. In addition, secondary data were collected from reports of the Borena Zone office, farmers' cooperative, central statistical agency (CSA), and published and unpublished documents. Finally, experienced enumerators were recruited and trained to collect data from the sample households.

Method of data analysis

The data were analyzed using STATA version 17 statistical software. Descriptive statistics, and econometrics analysis were used to analyze quantitative data while content analysis was used to analyze qualitative data. The frequency and percentage of perceived adaptation successfulness were portrayed. Thematic content analysis was used to identify recurring patterns and themes in the qualitative data, complementing the quantitative findings to offer a comprehensive understanding of the research focus.

After collecting the qualitative data, it was transcribed and organized, followed by the identification of key emerging themes and patterns. Subsequently, the data was coded to categorize and label it according to the identified themes and patterns. A coding framework or codebook outlining the categories, subcategories, and definitions used for coding the data was then created, followed by an analysis examining the frequency and distribution of different themes and patterns.

Econometrics analysis

In this study econometric analysis was applied to examine the determinants and perceived climate variability adaptation successfulness. The dependent variable of this study is a binary variable indicating perceived climate change adaptation successfulness i.e. successful=1; not successful=0. To identify the determinants and perceived climate variability adaptation successfulness a multivariate probit model was applied.

The multivariate probit model is a statistical model that is used to estimate several correlated binary outcomes jointly (Greene, 2012). The multivariate probit model was justified for researching the perceived climate variability adaptation successfulness due to its ability to analyze multiple correlated dependent variables simultaneously. This model allows for the examination of the complex relationships between various aspects of perceived climate variability adaptation successfulness and providing a more comprehensive understanding of the interplay between these factors. Compared to other possible models, the multivariate probit model offers the advantage of capturing the joint distribution of the dependent variables, which is essential for studying the interconnected nature of perceived climate variability adaptation successfulness.

The MVP econometric model is characterized by a set of binary dependent variables (Y_{ij}), such that:

$$Y_{ij}^{*} = \beta_i' X_{ij} + \varepsilon_{ij}, \text{ ----------(2)}$$

And

$$Y_{ij} = \{1,\ if Y_{ij}^{*} > 0\ 0,\ otherwise \text{ ----------(3)}$$

Where i=1,2 denotes perceived climate variability adaptation successfulness for food insecurity such as 1= risk sharing and 2= on weather information. Whereas for perceived climate variability adaptation successfulness, Where i=1, 2,...8, denotes 1=veterinary service, 2=water harvesting;3=feed conservation;4=seasonal migration;5=modern forecast info precision;6=extended search for feed; 7=destocking, and 8=receiving government aid

The Eq. (2) assumption is that a rational j^{th} household has a latent variable, Y*ij, which captures the unobserved preferences derived from the i-th perceived climate variability adaptation successfulness. This latent variable is assumed to be a linear combination of copying responses of climate variability (Xij), as well as unobserved characteristics captured by the stochastic error term εij. The vector of parameters to be estimated is denoted by βi. Given the latent nature of Y*ij, the estimations are

based on observable binary discrete variables Yij, which indicate whether pastoral and agro pastoral households have the i-th perceived climate variability adaptation successfulness. If the specific perceived climate variability adaptation successfulness is independent of another perceived climate variability adaptation successfulness, then Eqs. (2) and (3) specify univariate probit models where information on pastoral and agro pastoral household perceived climate variability adaptation successfulness does not alter the prediction of the probability that they have another perceived climate variability adaptation successfulness. Since we assumed that a pastoral and agro pastoral household have multiple perceived climate variability adaptation successfulness, the error terms in Eq. (2) jointly follow a multivariate normal (MVN) distribution, with 0 conditional mean and variance normalized to 1. Where ($\rho 1$,$\rho 2$,$\rho 3$) distributed MVN (0, Ω″) and the symmetric variance-covariance matrix ″ is given by:

$$\Omega = [1\ \rho_{12}\ \ \rho_{13}\ \rho_{21}\ 1\ \rho_{23}\ \rho_{31}\ \rho_{32}\ 1\ ] \text{----------(4)}$$

where (ρ_{im}) denotes the pairwise correlation coefficient of the error terms corresponding to any two perceived effects climate variability equations to be estimated in the model.

The off-diagonal elements in the covariance matrix, ρ_{im} which represent the unobserved correlation between the stochastic component of the i^{th} and m^{th} perceived climate variability adaptation successfulness, are important. This assumption means that Eq. (3) tests whether an MVP model was appropriate for the analysis or the univariate probit model suffices for the analysis.

To determine the effect of independent variables on perceived climate variability adaptation successfulness against socio-economic and institutional variables, the final analysis contains marginal effect analysis results based on Eq (5) (Greene, 2012). Therefore, the marginal effect of socio-economic and institutional variables (X_{ij}) was calculated because marginal effects measure the effects that a specific socio-economic and institutional variable has on the perceived climate variability adaptation successfulness of pastoral and agro pastoral households while all other variables are held constant.

Marginal Effect of X_{ij} = Pr (Y_i = 1|X, X_{ij} = 1) – Pr (Y_i=1|X, X_{ij} = 0) ----------(5)

RESULTS

The survey result showed that most of pastoralist and agro pastoralist rate their adaptation successful except destocking. The success rate for veterinary services was 55.0%, indicating that more than half of the households reported that veterinary services has assisted in successfully adapting to climate change. As access to veterinary services is vital for the health and well-being of livestock, which are the primary assets for pastoralists and agro-pastoralists, the high success rate suggests that effective veterinary services have played a significant role in supporting livestock health and adaptation when facing climate variability. Water scarcity is a major challenge in arid and semi-arid regions, making water harvesting technology critical. It has a success rate of 45.0%, suggesting that there is room for improvement in the effectiveness of water harvesting technologies in these contexts. Enhancing water availability and management through improved technologies can contribute to successful adaptation in the face of water scarcity.

The success rate for feed conservation and storing practices is particularly relevant in the context of pastoralism and agro-pastoralism, where access to adequate and nutritious animal feed can be limited. Hence, a higher success rate of 71.0% implies

effective feed conservation and storage practices have positively contributed to the adaptation of livestock rearing, ensuring availability of feed during lean periods and improving overall resilience.

Seasonal migration is a common adaptive strategy employed by pastoralists and agro-pastoralists to cope with the variability of resources across different regions and seasons. A success rate of 69.0% showed that seasonal migration has been an effective adaptation strategy in these contexts. By moving livestock to areas with better forage and water availability, pastoralists and agro-pastoralists can optimize their livestock production and reduce their vulnerability to resource scarcity due to the impact of climate change.

Accurate and timely weather forecasts are crucial for pastoralists and agro-pastoralists to make informed decisions regarding resource management and livestock mobility. A notable success rate of 73.0% for modern forecast information precision indicates that access to reliable forecast information has played a significant role in successful adaptation, enabling pastoralists and agro-pastoralists to anticipate and respond to climatic variations effectively.

Extended search for feed is particularly relevant in the pastoralist and agro-pastoralist context, where forage availability can be limited. An impressive success rate of 81.0% for this variable, suggesting that the efforts invested in finding alternative sources of feed have yielded positive results. The practice of actively seeking out additional feed resources has contributed to successful adaptation, ensuring adequate nutrition for livestock and maintaining their productivity even during resource-scarce periods.
Destocking, which involves reducing livestock numbers during periods of resource scarcity, is an important adaptive strategy for pastoralists and agro-pastoralists. Surprisingly, the data shows a lower success rate of 27.0% for destocking indicates that the effectiveness of destocking as an adaptation strategy may be limited in these contexts. Alternative approaches, such as targeted off-take programs or market-based interventions, may need to be explored to improve the outcomes of destocking practices.

In the pastoralist and agro-pastoralist context, government support and assistance programs play a crucial role in enhancing adaptation and resilience. The data reveals a success rate of 62.0% for receiving aid from the government, indicating that such support has been effective in facilitating successful adaptation. Government interventions, including financial assistance, provision of veterinary services, and infrastructure development, have contributed to improved livelihoods and adaptive capacity in these systems.

The findings highlight the importance of veterinary services, feed conservation and storage, seasonal migration, access to accurate forecast information, and the active search for alternative feed sources. However, there is room for improvement in water harvesting technologies, destocking practices, and further enhancing government support. These insights can guide policymakers, practitioners, and communities in formulating targeted interventions to strengthen adaptive capacity and resilience in pastoralist and agro-pastoralist contexts.

Table 1: Perceived climate variability adaptation successfulness, Borena Zone

Variables	Adaptation successfulness	
	Not Successful (%)	**Successful (%)**
Veterinary service	45.0	55.0
Water harvesting technology	55.0	45.0
Feed conservation and storing	29.0	71.0
Seasonal migration	31.0	69.0
Modern forecast info precise	27.0	73.0
Extended search for feed	19.0	81.0
Destocking	73.0	27.0
Receiving aid government	38.0	62.0

In the pastoralist and agro-pastoralist context, several variables play a crucial role in shaping the livelihoods and adaptation strategies of the communities involved such as the socioeconomic characteristics and access to resources among the population. The mean age of the heads of households or key decision-makers is 44.40 years. This indicates that the responsibility for managing the livelihoods and making important decisions falls on individuals who have accumulated significant life experience. The age factor is important as it influences the knowledge, skills, and decision-making capacity within the community.

The mean income of 1431.26 Birr reflects the economic situation of the population. It provides an understanding of the financial resources available to the households and their capacity to invest in productive activities, purchase necessary inputs, and withstand economic shocks. The income level is closely linked to the success and resilience of pastoralist and agro-pastoralist livelihoods.

Market distance, with a mean of 10.19 kilometers, is a critical factor in accessing and participating in economic activities. The proximity to markets affects the availability and affordability of goods and services, as well as the opportunities for selling agricultural products or acquiring necessary inputs. The longer the market distance, the greater the challenges faced by the community in engaging in trade and accessing a variety of resources.

Household size, with a mean of 6.51 adult equivalents, provides insights into the size and composition of households. It helps determine the labor force available for agricultural activities and the division of responsibilities within the family. The larger the household size, the greater the need for resources, including land, water, and food, to sustain the livelihoods of all household members.

Land size, with a mean of 1.82 hectares, is a critical resource for pastoralists and agro-pastoralists. It represents the average amount of land available for cultivation or livestock rearing per household. The land size directly impacts the productivity and sustainability of agricultural activities, as well as the resilience of the community to external shocks and resource scarcity.

The gender distribution among the heads of households reveals that 51.80% are male, while 48.20% are female. This highlights the importance of considering gender dynamics and ensuring equitable participation and decision-making in the context of pastoralism and agro-pastoralism. Gender-sensitive approaches can facilitate the empowerment of women and promote inclusive and sustainable development.

Education levels within the population indicate that a significant proportion, 77.22%, has no formal education. This highlights the need for targeted interventions to improve access to education and promote literacy and numeracy skills among the population. Education plays a crucial role in enhancing livelihood opportunities, improving resilience, and enabling communities to adapt to changing circumstances.

Access to climate change training, with 45.32% of the population having access, signifies the importance of building knowledge and capacity to understand and respond to the challenges posed by climate change. Training programs can equip individuals with the skills and information necessary to adopt climate-smart practices, mitigate risks, and adapt their livelihood strategies to changing environmental conditions.

Access to weather information, with 75.30% of the population having access, is a valuable resource for agricultural planning and decision-making. Timely and accurate weather forecasts enable individuals to adjust their farming practices, anticipate climatic variations, and make informed choices regarding crop cultivation, water management, and livestock rearing.
Credit access, with only 32.61% of the population having access to credit, points to the need for expanding financial services in pastoralist and agro-pastoralist contexts. Access to credit can facilitate investment in productive assets, diversification of income sources, and the adoption of innovative practices. Improving financial inclusion is crucial for enhancing economic resilience and reducing vulnerability.

The engagement in off-farm and non-farm activities by 63.07% of the population highlights the diversification of livelihood strategies beyond traditional agriculture. This broader economic participation can provide additional income streams, reduce dependence on environmental resources, and enhance the overall adaptive capacity of the community.

Access to extension services by 42.21% of the population signifies the importance of technical support and knowledge dissemination in improving agricultural practices. Extension services play a vital role in disseminating information, introducing new technologies, and providing guidance to enhance productivity, natural resource management, and adaptation to changing conditions.

In conclusion, the analysis of socioeconomic characteristics and access to resources among pastoralist and agro-pastoralist communities provides valuable insights into the factors that shape their livelihoods and adaptation strategies. These findings can inform policymakers, development practitioners, and researchers in designing targeted interventions, policies, and investments to address the specific needs and challenges faced by these communities. By recognizing the importance of factors such as age, income, market proximity, land size, education, gender, access to climate information, credit, off-farm

opportunities, and extension services, stakeholders can work towards promoting sustainable and resilient livelihoods in pastoralist and agro-pastoralist contexts.

Table 2: Description of demographic, socioeconomic and institutional variables

Variables	Category	Mean/Percent
Age of head (year)		44.40
Income (Birr)		1431.26
Market distance (Km)		10.19
Household size (adult equivalent)		6.51
Land size (hectare)		1.82
Life experience (year)		34.34
Sex of head	Male	51.80
	Female	48.20
Education level	No formal education	77.22
	Primary education	18.94
	High school & preparatory	2.88
	Above diploma	0.96
Access to climate change training	Yes	45.32
	No	54.68
Access to weather information	Yes	75.30
	No	24.70
Credit access	Yes	32.61
	No	67.39
Off- farm/non-farm	Yes	63.07
	No	36.93
Extension services	Yes	42.21
	No	57.79

Table 3 shows that in the risk sharing model; age, household size, monthly income, and climate change training significantly affect risk sharing adaptation response on food security. Household size shows a negative relationship, implying that larger household sizes are associated with lower adaptation successfulness in addressing food insecurity ($p<.05$). Monthly income has positive coefficients, suggesting that higher income levels and access to climate change training are associated with greater adaptation successfulness ($p<.05$).

Whereas in the weather information model; education level, credit association membership, climate change training, and weather information have positive coefficients, indicating that higher education levels, membership to credit association, access to climate change training, and weather information are associated with higher adaptation successfulness while market

distance, shows a negative relationship, suggesting that increased distance to markets is associated with lower adaptation successfulness.

Table 3: Results of Multivariate Probit model (MVP) of adaptation successfulness for food insecurity, Borena Zone

Variables	Risk sharing	Weather information
Age	0.01*(0.01)	0.01(0.01)
Sex of household head	0.29(0.18)	-0.20(0.15)
Household size	-0.09**(0.05)	0.05(0.04)
Education level	0.01(0.08)	0.36***(0.08)
Monthly income	0.001***(0.00)	0.001*(0.00)
Credit access	0.06(0.18)	0.09(0.16)
Credit ass. membership	0.30(0.18)	0.64***(0.16)
Access to extension services	-0.13(0.18)	-0.08(0.15)
Market distance	0.02(0.02)	-0.03**(0.01)
Life experience in the area	-0.01(0.01)	-0.00(0.01)
Climate change training	0.23(0.18)	0.32**(0.15)
Access to weather information	0.15(0.19)	0.32*(0.18)
Constant	-0.18(0.64)	-1.57***(0.57)

The multivariate Probit model results provide insights into the factors associated with different strategies related to food insecurity adaptation. These strategies include variables such as veterinary service, water harvesting, feed conservation, seasonal migration, modern forecast information precision, and extended search for feed, destocking, and receiving aid from the government.

For the veterinary service adaption strategy, the analysis shows that household size has positive significant association while membership to credit association and climate change training have negative significant association. This suggests that household size significantly influence successfulness rating of veterinary services while credit association and climate change training negatively affect successfulness rating. This shows the trainings given did not emphasize about the veterinary service to their livestock. On the other hand, the money they get from the credit union is used for other purposes or they have lost most of their livestock due to drought.

On the other hand, the water harvesting adaptation strategy is influenced by several variables. The age, monthly income, credit association membership, access to extension services, and climate change training have varying degrees of significance. Specifically, variables such as credit association membership and access to extension services more likely to rate water harvesting as a successful adaptation strategy.

Similarly, for the feed conservation strategy, age, education level, monthly income, access to extension services, market distance, life experience in the area, and climate change training have influence on adoption of feed conservation. Notably, variables such as age, education level, monthly income, market distance, and climate change training have significant positive associations with feed conservation. Life experience in the area, on the other hand, has negative associations with this strategy. The seasonal migration adaptation strategy is significantly associated with the sex of the household head, education level, monthly income, credit association membership, market distance, and life experience in the area. Variables such as the sex of the household head, monthly income, market distance, and life experience in the area positive associations with seasonal migration while education level and credit association membership have negative association with seasonal migration. This suggests that pastoralist households with certain characteristics (male, high monthly income, far from market, and longer stay in the area) are more likely to rate seasonal migration as a successful adaptation strategy.

Regarding modern forecast information as an adaptation strategy, variables such as age, education level, monthly income, credit association membership, life experience in the area, and climate change training, have varying degrees of significance. Education level, monthly income, credit association membership, life experience and climate change training show positive associations with modern forecast information precision, indicating that better education and training increase the likelihood of rating of modern forecast information as a successful adaptation strategy.

Regarding extended search for feed, variables such as sex, household size, monthly income, market distance, and life experience in the area have varying degrees of significance. Sex, household size, monthly income, and market distance has positive associations with extended search for feed, indicating that household heads with characteristics such as male, large household size, better monthly income, and far from market increase the likelihood of rating of extended search for feed as a successful adaptation strategy while staying in the area longer associated with extended search for feed as unsuccessful adaptation strategy. Regarding destocking, variables such as monthly income, credit association membership, and life experience in the area have varying degrees of significance. Monthly income, credit association membership, and life experience in the area have positive associations with destocking indicating that household heads with better monthly income, members of credit association and staying longer in the area are likely to rate destocking as a successful adaptation strategy.

Regarding receiving government aid as adaptation strategy is significantly associated with the age, sex of the household head, education level, monthly income, credit association membership, life experience in the area, and access to weather information. Variables such as age, education level, monthly income, and access to weather information have positive associations with receiving government aid indicating that household heads with old age, relatively educated, better monthly income, better access to weather information are likely to rate receiving government aid as a successful adaptation strategy. On the other hand, sex, credit association membership, and life experience in the area have negative association with receiving government aid indicating that male household heads, not member credit association, and staying longer in the area are likely to rate receiving government aid as a unsuccessful adaptation strategy.

Table 2: Multivariate Probit model result of adaptation successfulness for climate variability, Borena Zone

Variables	Veterinary service	Water harvesting	Feed conservation	Seasonal migration	Modern weather forecast for precise info	Extended search for feed	Destocking	Receiving government aid
Age	0.00(0.01)	0.01*(0.01)	0.02***(0.01)	-0.01(0.01)	-0.02***(0.01)	0.01(0.01)	-0.01(0.01)	0.01**(0.01)
Sex of household head	-0.03(0.14)	0.20(0.14)	-0.20(0.15)	0.49***(0.15)	0.04(0.14)	0.32**(0.16)	-0.03(0.15)	-0.40***(0.14)
Household size	0.06*(0.04)	0.01(0.04)	0.05(0.04)	0.02(0.04)	0.01(0.04)	0.07*(0.04)	0.01(0.04)	0.05(0.04)
Education level	0.02(0.06)	0.08(0.06)	0.15**(0.06)	-0.13**(0.06)	0.10*(0.06)	-0.08(0.06)	0.08(0.06)	0.16***(0.06)
Monthly income	0.001 (0.01)	0.001*(0.001)	0.001***(0.00)	0.001** (0.001)	0.001(0.001)	0.001**(0.001)	0.001***(0.001)	0.001*(0.001)
Credit access	-0.08(0.14)	-0.08(0.15)	-0.16(0.15)	0.09(0.15)	0.09(0.14)	0.07(0.16)	0.09(0.15)	0.07(0.14)
Credit ass. membership	-0.79***(0.14)	0.81***(0.14)	0.16(0.16)	-0.51***(0.15)	0.58***(0.14)	-0.15(0.17)	0.40***(0.15)	-0.65***(0.15)
Access to extn. services	-0.02(0.14)	0.45***(0.14)	0.42***(0.16)	-0.03(0.14)	0.07(0.14)	0.00(0.16)	0.19(0.14)	0.11(0.14)
Market distance	0.02(0.01)	0.02(0.01)	0.03**(0.01)	0.04***(0.01)	-0.00(0.01)	0.05***(0.01)	-0.02(0.01)	0.00(0.01)
Life experience in the area	-0.00(0.00)	-0.00(0.00)	-0.01***(0.01)	0.01***(0.00)	0.03***(0.01)	-0.01**(0.01)	0.02***(0.00)	-0.02***(0.00)
Climate change training	-0.24*(0.13)	0.35**(0.14)	0.41***(0.15)	-0.19(0.14)	0.23*(0.14)	-0.00(0.15)	-0.03(0.14)	0.08(0.13)
Access to weather info	0.19(0.15)	0.23(0.16)	-0.00(0.17)	0.21(0.16)	-0.11(0.15)	0.08(0.17)	0.01(0.17)	0.28*(0.14)
Constant	1.06**(0.51)	-3.63***(0.56)	-2.48***(0.58)	0.25(0.53)	-2.37***(0.52)	-0.30(0.55)	-2.45***(0.55)	0.01(0.49)

***, **, * are significant at 1 %, 5 %, and 10 %, respectively

DISCUSSIONS

The findings from the multivariate probit model emphasize the importance of considering multiple factors that influence perceived climate variability adaptation successfulness of different adaptation strategies.

Regarding veterinary service as an adaptation strategy, previous research has highlighted the importance of access to veterinary care and its impact on livestock health and productivity while this study focuses on the perceived successfulness of veterinary service in pastoralist areas. The current study's findings suggest that the perceived success of veterinary services is influenced by household size, credit association membership, and climate change training. A study conducted by Gizaw et al., (2021) concluded that use of and satisfaction with animal health services significantly varied across livestock production systems, geographic locations, socioeconomic strata, and service providers. Specifically, satisfaction with veterinary services is determined by availability and accessibility of the services.

Water harvesting has been recognized as an important adaptation strategy to cope with water scarcity in arid and semi-arid regions. The current study's results align with previous research that highlights the significance of factors such as income, access to extension services, and credit association membership in promoting the successful implementation of water harvesting practices. For instance, a study by Muriu-Ng'ang'a et al., (2017) conducted in Kenya found that age, household size, farm size, farming history, training, and formal education were important factors which influenced successfulness of rainwater harvesting. Water harvesting systems offer technical and institutional options for climate change adaptation in agriculture. Water harvesting technologies have also been explored as a means of enhancing water availability for agricultural purposes (Balderama, 2015).

Feed conservation is another critical strategy for addressing food insecurity among the pastoralist communities. Previous study by Tegegne et al. (2016) have shown that factors such as education, income, and access to extension services play a vital role in the adoption of feed conservation practices. The current study's findings are consistent with this literature, indicating that age, education level, income, market distance, and climate change training positively influence the adoption and perceived success of feed conservation strategies. These results suggest that targeted educational programs, improved income opportunities, and better access to extension services can enhance the effectiveness of feed conservation practices.

Seasonal migration is a common adaptation strategy employed by pastoralist communities to cope with resource fluctuations. Previous studies have examined the factors associated with seasonal migration decisions and success. Pastoralists rely on the movement of their livestock to access grazing lands and water sources that vary in availability throughout the year. This strategy allows them to optimize resource utilization and ensure the survival and well-being of their herds. Seasonal migration is crucial for pastoralists as it enables them to access fresh grazing lands and water sources during different seasons. This strategy helps them cope with resource fluctuations, such as changes in rainfall patterns and the availability of forage (Tugjamba et al., 2023).

Moreover, the key informant interview suggests that gender-sensitive policies, educational opportunities, peaceful environment, and improved market infrastructure can support successful seasonal migration strategies.

Precision of modern weather forecast has gained attention as a valuable tool for climate change adaptation. There is strong need for improved forecast accuracy, capacity building, and effective communication to enhance adaptation efforts in Ethiopia (Belay et al., 2021). Focus group discussion revealed, most of the community members rely on traditional weather forecasting methods which needs to further integrate with the modern forecasting methods to further increase the precision of the system. These findings highlight the need for targeted capacity-building on integration of the modern and traditional weather forecasting, use of media, and improved access to accurate and timely weather information.

The extended search for feed is a strategy employed by pastoralist communities to mitigate the impacts of resource scarcity. Pastoralist communities often employ extended search for feed as a strategy to mitigate the impacts of resource scarcity. This strategy involves actively seeking out alternative sources of forage for their livestock when their usual grazing areas become depleted or inaccessible. By expanding their search for feed, pastoralists aim to ensure the survival and well-being of their livestock during periods of resource scarcity.
Changes in climate patterns, including prolonged droughts and erratic rainfall, have a significant impact on forage availability. Pastoralists are forced to search for extended forage options to cope with the changing climate conditions. Limited access to markets and low prices for livestock products can discourage pastoralists from selling their animals. This can lead to extended forage search as they try to maintain their livestock's condition and productivity (Mohamed et al., 2020).

Destocking is an adaptation strategy employed during periods of resource scarcity to reduce the burden on livestock and manage available resources more efficiently. Previous studies have examined the factors influencing destocking decisions and outcomes. The current study's findings align with existing literature, which indicated that various socioeconomic factors influence destocking decisions. These include the influence of different factors such as drought severity, socioeconomic characteristics, household size, cattle loss, and market price on destocking decisions (Nketiah & Ntuli, 2024).

According to a study by Catley et al., (2013), government support through social protection programs, safety nets, and livestock-related interventions can enhance the resilience of pastoralists and help them cope with shocks such as droughts or conflicts. These programs provide essential resources, such as food assistance, cash transfers, veterinary services, and livestock insurance, which help protect pastoralists' assets and support their livelihoods during challenging times. According to the discussion with the key informants, it is important to emphasize that perceived success may not always align with actual success in receiving government aid. Factors such as the eligibility criteria, documentation requirements, availability of resources, and the overall efficiency and transparency of the aid system can significantly influence an individual's ability to receive assistance.

CONCLUSION AND IMPLICATION

The analysis reveals that the adoption of specific strategies is influenced by a combination of demographic, socio-economic, and environmental factors.

The findings indicate that variables such as education level, credit association membership, access to extension services, and climate change training consistently show significant associations with multiple adaptation strategies. This suggests that knowledge, access to resources, and skills development play a crucial role in enabling households to implement effective adaptation measures.

Additionally, the results highlight the importance of gender in shaping adaptation strategies. The sex of the household head emerges as a significant factor for certain strategies, indicating that gender dynamics and social norms can influence decision-making processes related to food insecurity adaptation.

Market distance and life experience in the area also demonstrate notable associations with some strategies. These findings suggest that proximity to markets and knowledge of local conditions can impact the feasibility and effectiveness of certain adaptation measures.

It is worth noting that the significance and direction of associations vary across different strategies, indicating the contextual nature of food insecurity and adaptation. Therefore, tailored sustainable interventions and policies that consider the specific circumstances and needs of different regions and communities are crucial for promoting effective and sustainable adaptation.

Overall, the multivariate probit model provides valuable insights into the complex factors that shape food insecurity adaptation strategies. By understanding these associations, policymakers, practitioners, and stakeholders can develop targeted interventions, programs, and policies to enhance resilience and reduce food insecurity in vulnerable populations. Further research and monitoring are essential to continually refine and improve our understanding of the dynamics of food insecurity and adaptation in a changing world.

The relationship between SDG 13, sustainability, and meteorological hazards in the context of Borena pastoralists highlights the need for comprehensive disaster risk management strategies that integrate climate resilience, sustainable practices, and community engagement. By addressing the causes and impacts of meteorological hazards on food security, and by promoting sustainable development principles, Borena pastoralist communities can enhance their resilience and improve their livelihoods in the face of climate change. It is crucial for policymakers, researchers, and practitioners to collaborate and implement context-specific strategies that empower pastoralist communities and ensure their long-term sustainability.

REFERENCES

Adger, W. N., Arnell, N. W., & Tompkins, E. L. (2005). Successful adaptation to climate change across scales. *Global environmental change*, 15(2), 77-86.

Aklilu, Y., & Alebachew, A. (2009). Assessment of climate change-induced hazards, impacts and responses in the southern lowlands of Ethiopia. *African Climate Change Fellowship Program*, Addis Ababa, Ethiopia.

Ayal, D. Y., Filho, W. L., Ayanlade, A., Radeny, M., Rosenstock, T. S., & Wekesa, A. (2015). Institutional perspectives of climate-smart agriculture: a systematic literature review. *Sustainability*, 7(8), 10031-10057.

Balderama, O.F. (2015). Technical and Institutional Options of Water Harvesting Systems for Climate Change Adaptation in Agriculture. In: Leal Filho, W. (eds) *Handbook of Climate Change Adaptation*. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-38670-1_66

Bekele, S. H. (2017). Efforts to address climate change in Ethiopia. *African Journal of Environmental Science and Technology*, 11(4), 194-205.

Belay, A., Demissie, T., Recha, J. W., Oludhe, C., Osano, P. M., Olaka, L. A., Solomon, D., & Berhane, Z. (2021). Analysis of climate variability and trends in Southern Ethiopia. *Climate*, 9(6). https://doi.org/10.3390/cli9060096

Berkes, F., Colding, J., & Folke, C. (Eds.). (2003). *Navigating social-ecological systems: building resilience for complexity and change*. Cambridge University Press.

Biesbroek, G. R., Klostermann, J. E., Termeer, C. J., & Kabat, P. (2013). On the nature of barriers to climate change adaptation. *Regional environmental change*, 13(5), 1119-1129.

Buchner, B., Clark, A., Falconer, A., Macquarie, R., Meattle, C., Tolentino, R., & Wetherbee, C. (2019). *Global Landscape of Climate Finance 2019*. Climate Policy Initiative.

Catley, A., Lind, J., & Scoones, I. (2013). *Pastoralism and Development in Africa*. doi:10.4324/9780203105979

Debela, N., Mohammed, C., Bridle, K., Corkrey, R., & McNeil, D. (2015). Perception of climate change and its impact by smallholders in pastoral/agropastoral systems of Borana, South Ethiopia. *SpringerPlus*, 4(1), 1-12.

Degla, P. K., Adekambi, S. A., & Adanhoussode, P. (2016). Drivers of Multiple Cropping-Systems as Adaptive Strategy to Climate Change in Central-Benin (West Africa). *Journal of Agricultural Science*, 8(8). https://doi.org/10.5539/jas.v8n8p48

Ensor, J., & Berger, R. (2009). *Understanding climate change adaptation: Lessons from community-based approaches*. Practical Action Publishing, United Kingdom.

Eriksen, S. H., & Kelly, P. M. (2007). Developing credible vulnerability indicators for climate adaptation policy assessment. *Mitigation and Adaptation Strategies for Global Change*, 12(4), 495-524.

Fazey, I., Moug, P., Allen, S., Beckmann, K., Blackwood, D., Bonaventura, M., ... & Harkness, R. (2018). Transformation in a changing climate: a research agenda. *Climate and Development*, 10(3), 197-217.

Fikru, T. (2023). *Location map of Borena Zone*. (Note: Own creation)

Folke, C. (2006). Resilience: The emergence of a perspective for social–ecological systems analyses. *Global Environmental Change*, 16(3), 253-267.

Gezie, M. (2019). Farmer's response to climate change and variability in Ethiopia: A review. *Cogent Food and*

Agriculture, 5(1). https://doi.org/10.1080/23311932.2019.1613770

Gizaw, S., Woldehanna, M., Anteneh, H., Ayledo, G., Awol, F., Gebreyohannes, G., Gebremedhin, B., & Wieland, B. (2021). Animal Health Service Delivery in Crop-Livestock and Pastoral Systems in Ethiopia. *Frontiers in Veterinary Science*, 8. https://doi.org/10.3389/fvets.2021.601878

Healthy People 2030. (n.d.). *Food Insecurity - Healthy People 2030*. Retrieved from https://health.gov/healthypeople/priority-areas/social-determinants-health/literature-summaries/food-insecurity

Hilemelekot, F., Ayal, D. Y., Ture, K., & Terefe Zeleke, T. (2021). Climate change and variability adaptation strategies and their implications for household food Security: The case of Basona Worena District, North Shewa zone, Ethiopia. Climate Services, 24(November), 100269. https://doi.org/10.1016/j.cliser.2021.100269

IPCC. (2021). *Climate Change 2021*: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, United Kingdom.

IPCC. (2022). *Climate Change 2022*: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, United Kingdom.

Legesse, B., Ayele, Y., & Bewket, W. (2013). Smallholder farmers' perceptions and adaptation to climate variability and climate change in Doba district, west Hararghe, Ethiopia. Asian *Journal of Empirical Research*, 3(3), 251-265.

Lemos, M. C., Kirchhoff, C. J., & Ramprasad, V. (2012). Narrowing the climate information usability gap. *Nature Climate Change*, 2(11), 789-794.

Mekonnen, M. M., & Hoekstra, A. Y. (2016). Four billion people facing severe water scarcity. *Science Advances*, 2(2), e1500323.

Mohamed Sala, S., Otieno, D. J., Nzuma, J., & Mureithi, S. M. (2020). Determinants of pastoralists' participation in commercial fodder markets for livelihood resilience in drylands of northern Kenya: Case of Isiolo. *Pastoralism*, 10, 1-16.

Moser, S. C., & Ekstrom, J. A. (2010). *A framework to diagnose barriers to climate change adaptation. Proceedings of the national academy of sciences*, 107(51), 22026-22031.

Muriu-Ng'ang'a, F. W., Mucheru-Muna, M., Waswa, F., & Mairura, F. S. (2017). Socio-economic factors influencing utilisation of rain water harvesting and saving technologies in Tharaka South, Eastern Kenya. *Agricultural Water Management*, 194, 150–159. https://doi.org/https://doi.org/10.1016/j.agwat.2017.09.005

Niang, I., Ruppel, O. C., Abdrabo, M. A., Essel, A., Lennard, C., Padgham, J., & Urquhart, P. (2014). Africa. In*: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects*. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

Nketiah, P., & Ntuli, H. (2024). Empirical analysis of drought-induced cattle destocking in South Africa. Jàmbá: *Journal of Disaster Risk Studies*, 16(1), 1-7.

NOAA. (2022). *Climate Change: Global Temperature. National Oceanic and Atmospheric Administration*. https://www.climate.gov/news-features/understanding-climate/climate-change-global-temperature

Oberlack, C. (2017). Diagnosing institutional barriers and opportunities for adaptation to climate change. *Mitigation and Adaptation Strategies for Global Change*, 22(5), 805-838.

O'Brien, K. (2012). Global environmental change II: from adaptation to deliberate transformation. *Progress in Human Geography*, 36(5), 667-676.

Paavola, J., & Adger, W. N. (2006). Fair adaptation to climate change. *Ecological economics*, 56(4), 594-609.

Pelling, M. (2011). *Adaptation to climate change*: from resilience to transformation. Routledge.

Shackleton, S., Ziervogel, G., Sallu, S., Gill, T., & Tschakert, P. (2015). Why is socially-just climate change adaptation in sub-Saharan Africa so challenging? A review of barriers identified from empirical cases. Wiley Interdisciplinary Reviews: *Climate Change*, 6(3), 321-344.

Spinoni, J., Barbosa, P., De Jager, A., McCormick, N., Naumann, G., Vogt, J. V., ... & Pulwarty, R. (2019). A new global database of meteorological drought events from 1951 to 2016. *Journal of Hydrology*: Regional Studies, 22, 100593.

Teklu, A., Simane, B., & Bezabih, M. (2023). Effect of Climate Smart Agriculture Innovations on Climate Resilience among Smallholder Farmers: Empirical Evidence from the Choke Mountain Watershed of the Blue Nile Highlands of Ethiopia. *Sustainability (Switzerland)*, 15(5), 1–26. https://doi.org/10.3390/su15054331

Temesgen, D., Yehualashet, H., & Rajan, D. S. (2014). Climate change adaptations of smallholder farmers in South Eastern Ethiopia. *Journal of Agricultural Extension and Rural Development*, 6(11), 354-366.https://doi.org/10.5897/JAERD14.0577

Tesfahunegn, G. B., Mekonen, K., & Tekle, A. (2016). Farmers' perception on causes, indicators and determinants of climate change in northern Ethiopia: Implication for developing adaptation strategies. *Applied Geography*, 73, 1-12.

Tofu, D., Fana, C., Dilbato, T., Dirbaba, N., Pastoralism, G. T.-, & 2023, U. (2020). Major Climate Change Adaptation and Coping Strategies in Borana, Southern Ethiopia: A Review. *Journal of Resources Development and Management*, 69, 2020. https://doi.org/10.7176/jrdm/69-01

Tugjamba, N., Walkerden, G., & Miller, F. (2023). Adapting nomadic pastoralism to climate change. *Climatic Change*, *176*(4), 1-20. [28]. https://doi.org/10.1007/s10584-023-03509-0

UNFCCC. (2010). *Synthesis report on efforts undertaken to monitor and evaluate the implementation of adaptation projects, policies and programmes and the costs and effectiveness of completed adaptation projects, policies and programmes, and views on lessons learned, good practices, gaps and needs*. UNFCCC.

Vermeulen, S. J., Campbell, B. M., & Ingram, J. S. (2018). Climate change and food systems. *Annual Review of Environment and Resources*, 43, 369-396. doi:10.1146/annurev-environ-102017-025826

Wise, R. M., Fazey, I., Stafford Smith, M., Park, S. E., Eakin, H. C., Archer Van Garderen, E. R., & Campbell, B. (2014). Reconceptualising adaptation to climate change as part of pathways of change and response. *Global Environmental Change*, 28, 325-336.

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