Journal of Sustainability (2026) 2:1, 1-28
https://doi.org/10.55845/jos-2026-21121

RESEARCH ARTICLE

Climate Resilience of Pastoral Livelihoods among Borana Oromo in Southern Ethiopia

Boru Daniel[1*], Boku Tache[2], Abaynhe Amare[1], Alemayehu Regassa[1]

Received: 24. January 2026 / Accepted: 26. April 2026 / Published: 25. May 2026
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Abstract

This study examines household resilience to climate change among Borana Oromo pastoralists in southern Ethiopia, focusing on two production subsystems: Dirree and Golboo. Data were collected through a household survey (n = 360), focus group discussions, and key informant interviews. The Household Climate Resilience Index (CRI) was developed using FAO's key resilience components, including assets, income and food access, adaptive capacity, social safety nets, access to public services, and system stability. Principal Component Analysis (PCA) was applied to determine the relative contribution of indicators, while Structural Equation Modelling (SEM) measured overall household resilience. Differences in resilience components were further analysed using Multivariate Analysis of Variance (MANOVA). The findings reveal significant variation in adaptive capacity among social groups, adult men, women, and youth across the two subsystems. Dirree exhibits higher resilience in most components compared to Golboo, except in access to social safety nets. These differences are largely attributed to variations in local conditions and disparities in access to public services. The results underscore the importance of context-specific interventions tailored to the unique characteristics of each subsystem. The study emphasises that strengthening system-level resilience is essential for improving pastoral livelihoods in the Borana lowlands. It recommends targeted actions to address key constraints within resilience components. Furthermore, long-term resilience requires integrating indigenous environmental knowledge into development planning, enhancing institutional capacity, improving access to services and cross-border resources, and promoting peace building, innovation, and supportive policy frameworks.

Keywords Borana · Livelihoods · Pastoralism · Production System · Social Groups · Resilience

1. Introduction

Pastoralism as a livestock-centred livelihood pursuit is practised in Africa mostly in an ecosystem where access to the vital resources (pasture, water and mineral licks) is constrained by variability. Variability emanates mainly from spatio-temporal fluctuation in the rainfall regime that causes sporadic distribution of the major resources over different units of the rangeland (Tache, 2008a). This mosaic nature in the life-supporting resources invokes mobility as a crucial pastoralists' strategy that permits access to patchy resources (Tache, 2008b). Mobility takes place within common property resource borders but is regulated through a collective agency of customary resource governance institutions that are mandated to apply societal rules and regulations in resource management (see Helland, 1982; Tache, 2000a; Bassi, 2005). In Borana, for instance, elders designated to manage resources in each locality (*jaarsa ardaa*), or in a larger grazing subunit (*abbootii dheedaa*), discourage spontaneity and free rider's behaviour in land use practices. This means that regulatory

[*] Corresponding author: borudani2005@gmail.com
[1] Jimma University, Department of Natural Resources Management, Jimma, Ethiopia
[2] Borana University, Yabelo, Ethiopia

arrangements lay out institutional mechanisms that prevent resource degradation or address scarcity when it occurs.

Whereas, conventionally, resource systems in the dryland pastoral context feature inherent fluctuations, for decades now, global climate change has been disrupting the ecosystem and pastoralists' land use strategies tailored to the ecological characteristics. As a result, pastoralists are compelled to live under additional livelihood dilemmas (Yilma et al., 2009; Mekuyie et al., 2019; Ayele et al., 2020; FAO, 2021; Muluneh, 2021; Bogale and Erana, 2022; Mulugeta et al., 2025; Boru et al., 2026). On top of that, resource misappropriation and large-scale land grabbing have been widely unfolding (Fekadu et.al., 2016), only to worsen the current dilemma in the prospects of pastoralism. Among the adverse consequences of climate change and anthropogenic influences, a degeneration of poverty from a transient to a chronic condition due to the accumulated impacts of recurrent droughts that undermined herd recovery (Tache, 2008a).

In Ethiopia, pastoralists inhabit the lowlands, which are typically arid or semi-arid (Kurt, 2003; FAO, 2018), accounting for 61% of the country's total land area. The lowlands directly support nearly 20 million pastoralists and agro-pastoralists (CSA, 2013; FAO, 2018). Pastoralists easily constitute 15% of the 130 million population of the country and are distributed in the national regional states of Oromia, Somali, Afar, Gambella, Benishangul Gumuz, Southern Ethiopia and parts of Tigray (USAID, 2016).

Borana pastoralists rely heavily on livestock for their livelihoods, the conduct of social transactions and performance of cultural and political duties. Similarly, like other herder communities, they commonly bear the brunt of global climate change. For instance, according to a post-drought assessment report, the most recent 2020-23 deadly drought alone is estimated to have wiped out about 80% of the cattle population in Borana Zone (BZBGO, 2024). The reach of the impacts of climate change transcends the economic realm and stretches to physical, nutritional, health, socio-cultural, institutional and psychological dimensions. Due to the multidimensionality of impacts, the system's resilience easily gets weaker and poses viability concerns. Enhancing climate resilience, therefore, implies addressing the root causes in those interrelated elements. It further suggests promotion of indigenous knowledge systems that hitherto enabled food production in the arid and semi-arid environments (see Bekele et al., 2020; Bekele et al., 2021; Girma et al., 2025).

Numerous studies have dealt with pastoral resilience from different perspectives. We enumerate below only a few for our immediate purpose. A study carried out in East Africa, West Africa and the Sahel explored pastoralist strategies to enhance households' resilience on a larger scale (FAO, 2021). Ambelu et al. (2017) and Daniel et al. (2023) analysed the Borana experience. The former suggests intervention pathways for pastoralist resilience building, whereas the latter investigated it, focusing on both pastoralists and agro-pastoralists. In the southern Afar region, Mekuyie et al. (2018) assessed pastoralist resilience to climate variability and change. Bekele et al. (2021) examined the resilience of agro-pastoral households impacted by large-scale investments in Ethiopia.

These studies, despite their significant contributions to the subject matter, did not assess the impacts of climate change on social groups in various microclimatic parts of the drylands (i.e. production sub-systems). Accordingly, proper attention would have aided better conceptualisation of differential impacts of climate change on inhabitants of microclimatic sub-regions, and on social groups, pointing to corresponding recommendations for disaggregated resilience building.

This research attempts to contribute to bridging this gap by using the socio-ecological model as a comprehensive framework to provide an in-depth insight into various ways of improving climate resilience among the Borana pastoralists. It involves a comparative analysis of traditional production sub-systems in central Dirree and Golboo and suggests how to build pastoral resilience among social groups besides the system-level focus. The general objective of the study is to identify context-specific strategies for enhancing climate resilience among Borana pastoralists across production sub-systems and social groups. More specifically, the research 1) examines the livelihood strategies employed by Borana pastoralists in response to climate variability and change. 2) identifies key socio-ecological factors that enable or constrain resilience across different production sub-systems and social groups, and 3) suggests contextually grounded strategies for strengthening climate resilience in Borana pastoral systems under current viability challenges. In order to implement these objectives, we raise the following questions: 1) How do Borana pastoralists adapt their livelihood strategies to ongoing climate variability across different production sub-systems? 2) What socio-ecological factors enable or constrain climate resilience among different social groups within these systems? 3) What context-specific strategies can enhance climate resilience among Borana pastoralists under current environmental and socio-economic conditions?

Findings from this research are hoped to provide inputs for future researchers, policy makers, and for planning pastoral development and disaster risk reduction programs in Borana and other pastoral areas of Ethiopia and beyond.

This study conceptualises pastoralist climate resilience (Fig 1) as the capacity of a production system to sustain food production under environmental stress, including droughts and other climate-related shocks. This aligns with Berkes and Ross (2013), who emphasise resilience as encompassing recovery, adaptation, and transformation. Adaptive strategies such as mobility, livelihood diversification, and community-based resource management are central to resilience (Aldunce et al., 2014). Key determinants include asset ownership, social safety nets, access to public services, income and food security, and natural resource availability. Social capital and indigenous institutions play a critical role in facilitating collective action and risk-sharing (Aldunce et al., 2014).

Moreover, access to education, healthcare, and infrastructure enhances human capital and adaptive capacity, while diversified income sources reduce vulnerability (Alefu et al., 2017). Sustainable resource management and supportive policy frameworks are equally vital (Reid et al., 2013). The interaction between household capacities and social group dynamics reinforces system-level resilience, supported by adaptive governance structures (Folke, 2006).

In conclusion, a comprehensive understanding of pastoral resilience is essential for designing effective interventions. Strengthening adaptive capacities at both household and community levels is critical to sustaining pastoral livelihoods in the face of increasing climate uncertainty.

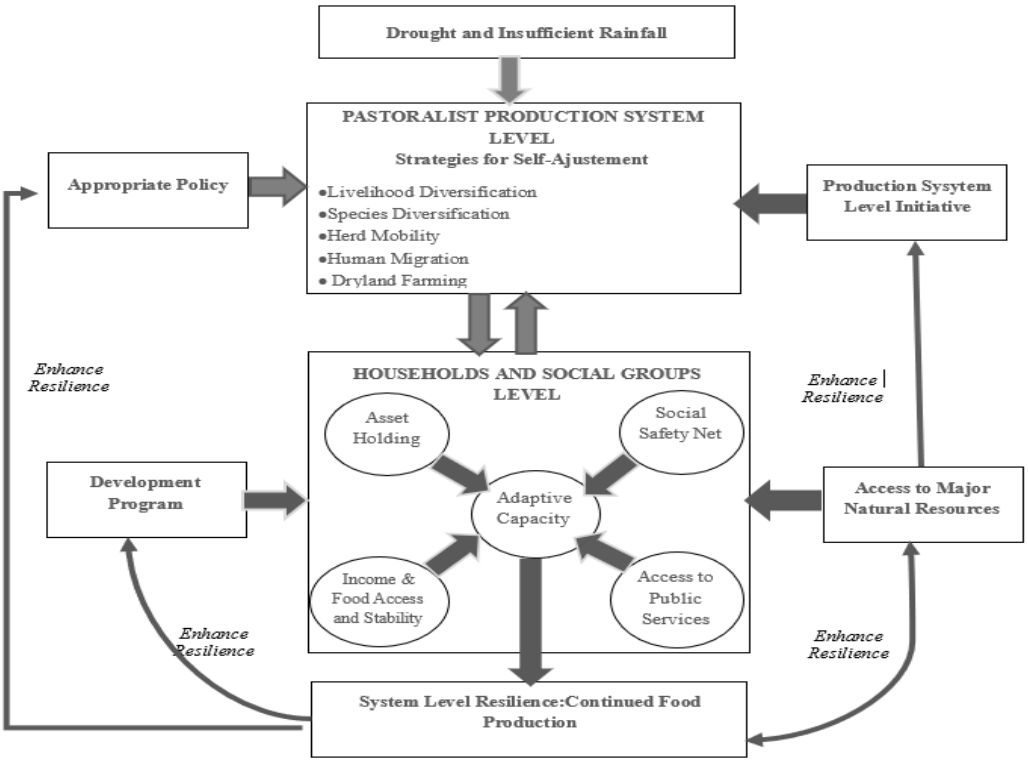


Figure 1. Conceptual Framework for Enhancing Climate Resilience in Borana *(Source: Author's own design)*

2. Materials and methods

2.1. Description of the study area

The study was conducted in two indigenous production sub-systems of Borana pastoralists, Dirree and Golboo. Before delving into a description of the selected subsystems, let us touch upon how the Borana Oromo classify their territory based on their indigenous ecological knowledge. The Borana Oromo inhabit the southern part

of Ethiopia and northern Kenya. River Daawwaa divides the Ethiopian part of the Borana land into two macro regions of Liiban (east of the river) and Dirree (west of the River) (Helland, 1982). The macro regions break down into two and five grazing zones (dheeda) respectively. Diida Liiban and Golba Liiban constitute the Liban macro region, whereas Dirree comprises five grazing zones: central Dirree, Wayaama, Goomolee, Malbee and Golboo (Tache, 2000a). Each micro region displays peculiar ecological characteristics arising from its physical and microclimatic background. The micro regions thus display variant endowment with natural resources, which, however, are functionally interconnected in supporting pastoral livelihoods (Tache, 2008b).

The central Dirree sub-system is home to most of the deep *Tulaa* wells that provide perennial water service in dry seasons. Semi-sedentary pastoralist settlements are hence concentrated within a 10-15-kilometre radius that permits access to the wells. Lactating herds graze around the homesteads of these semi-permanent villages. Golboo, on the other hand, covers the drier southwestern lowlands suited for rearing camels and small ruminants in satellite camps (*foora*) (Fig. 1). Physical aridity confines access to the lush grass in the Golboo plains to rainy seasons alone, and once the rain-availed waters dry up, herders move their stock to the adjacent perennial wells. The distribution of the major natural resources varies across grazing zones over seasons. Therefore, mobility and flexible institutional arrangements enable access to the common property resources according to societal rules that regulate access (Tache, 2000a; Oba and Kotile, 2001).

2.2. Sampling procedure

Both purposive and random sampling procedures were followed in this study. First, the two production subsystems were selected purposively, considering their relative agroecological variations and frequency and severity of drought events in the areas. Four Pastoralist Associations (PA), Dubuluk and Meelbanaa from central Dirree, and Arbale and Hoboqi from Golboo, were selected randomly. Next, twenty villages (*ollaa*), which had been involved in the preceding qualitative assessment, were included in the study. Then, five villages per PA were randomly selected for an in-depth investigation.

Sample size was determined by allocating to the selected twenty villages, proportional to the total number of households in each. Within each selected village, the desired households were randomly picked from the sampling frame, using the villages' registry in the PAs. Accordingly, a total of 360 households were selected in accordance with the single population proportion formula. Selection is based on the following assumptions: a proportion of 50%, which is conservative and gives the largest sample size, 3% margin of error, and 95% confidence interval, and a 10% non-response rate. The population proportion formula is as follows.

$$N = Z(1-\alpha/2)^2 * p\,(1-p)/d^2 \qquad \text{(Eq. 1)}$$

Where:

n = Required sample size

Z (1 - α/2) = Z-score corresponding to the desired confidence level

p = Estimated proportion of the population

d = Margin of error (the maximum acceptable difference between the sample proportion and the true population proportion)

Data were collected from the sample villages from October 10 to December 10, 2024. The study was approved by the Institutional Review Board of Jimma University. Following this, permission was obtained from all pertinent offices at various levels, and verbal consent was acquired from each participant before the questionnaire was administered.

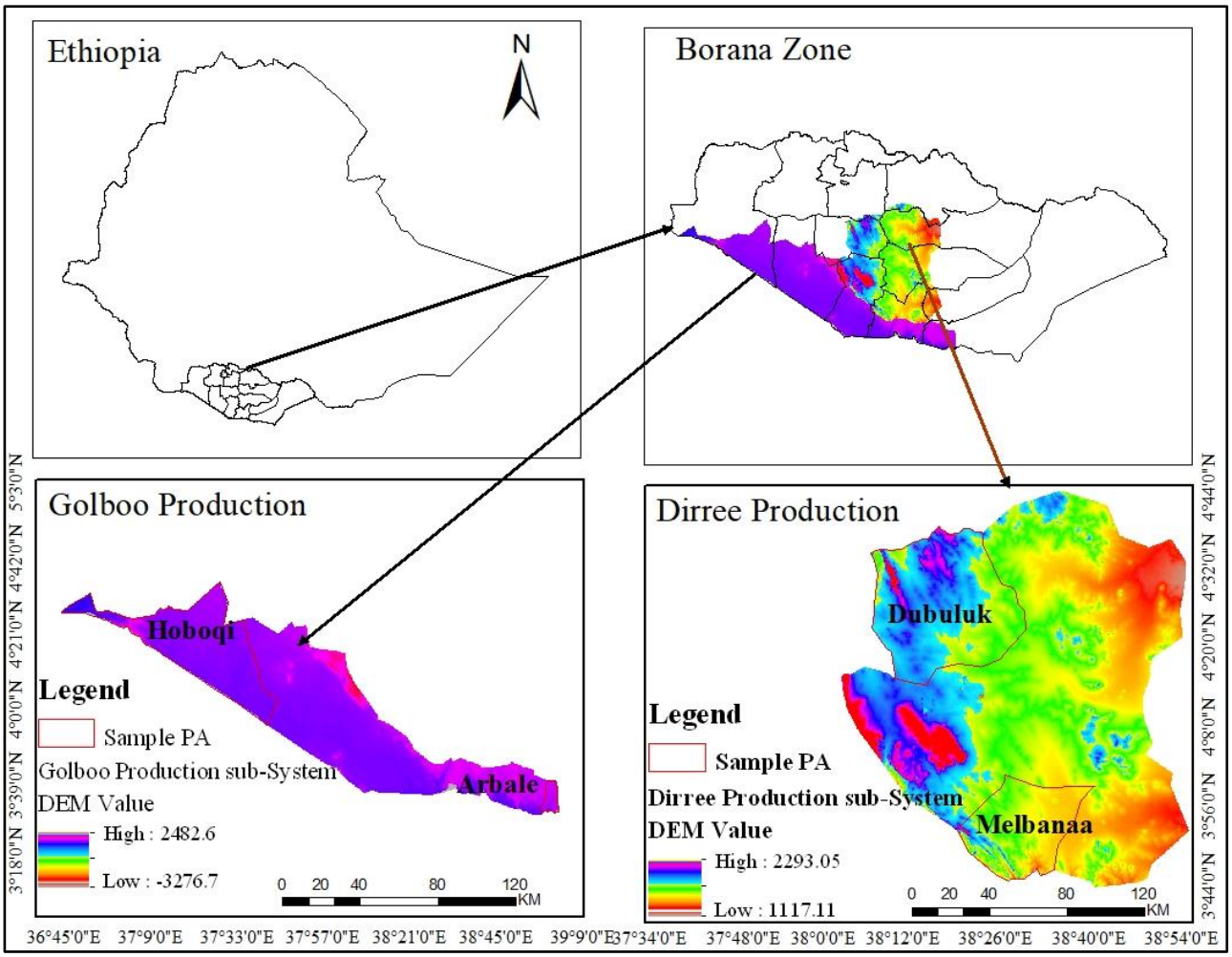


Figure 2. Map of the study area (Source: Ethiopian Geospatial Information Agency, 2018)

2.3. Data collection tools and methods

A semi-structured household survey questionnaire was administered to capture all of the FAO's six resilience dimensions, comprising households' assets (A), income and food access (IFA), adaptive capacity (AC), social safety net (SSN), access to public services (APS) and stability (S) (FAO, 2016). Besides, the survey covered households' climate change information, adaptation strategies, farm labour, networks, and remittances. In designing the questionnaire, we used inputs from the qualitative assessment and pretested the tool on 5% of the sample size.

Ten development agents (DAs) were selected from the target PAs and trained on data collection techniques and ethical requirements in research. They conducted the enumeration in the local language (Afaan Oromo) under close supervision.

Key informant interviews (KIIS) were conducted with 30 participants drawn from the sample villages and various organisations, supplementing the household survey data. On top of that, six focus group discussions (FGDs) consisting of mixed-gender FGDs, female-only FGDs, and youth-only FGDs enriched the survey data. In addition, leaders of the customary institutions (Gadaa) and elders, community experts on indigenous weather forecasting (*ayyaantuu*), officers from the districts' Disasters Risk Management (DRM) participated in the FDGs. The discussions captured existing livelihood strategies and mechanisms for enhancing climate-resilient pastoralism.

2.4. Data analysis

Quantitative data were analysed using Statistical Package for the Social Sciences (SPSS) version 24, an Excel sheet, and STATA version 14 software. Additionally, a multivariate method, principal component analysis (PCA), was used to analyse household data with the objective to reduce dimensionality of large data sets, increase interpretability, and minimise loss of information from the data sets (Jolliffe and Cadima, 2016). It also analyses a data table in which observations are described by several interrelated dependent variables (Abdi et al., 2010). In our case here, we used PCA to generate adaptive capacity.

2.5. Quantitative assessment of pastoralists' resilience to climate-induced shock

The concept of resilience is applied across disciplines, but its definition is mainly associated with disaster resilience and the ability of a household or a system to cope with longer-term climate change, including transformative changes (DFID, 2013). In recent years, the quest to quantify individuals', households', and society's resilience to disasters or extreme events beyond their control has remained challenging due to the quantifiability of resilience. Given that the data analyst does not observe resilience of those units, its quantification demands a detailed modelling approach. Various authors have thus employed different modelling approaches to this end. For instance, Alinovi et al. (2008), Alinovi et al. (2010), and Demeke and Tefera (2010) employed a latent variable approach to quantify resilience among households in Kenya, Palestine, and Ethiopia, respectively. Other researchers assessed resilience in Ethiopia by focusing on conditions in eight indicators (e.g. Birhanu et al., 2016; Ambelu et al., 2017). The dimensions include livestock, infrastructure, social services, environment, social network, governance/peace and security, human capital and psychosocial conditions. Mekuyie et al. (2018), on the other hand, analysed resilience from six dimensions: assets, adaptive capacity, social safety nets, public service accessibility, income and food access, and stability. Daniel et al. (2023) identify five dimensions: social safety nets, public service accessibility, assets, income, and food access. They expressed these dimensions as latent variables. Following this, resilience was estimated in a two-stage procedure. The first procedure uses factor analysis to identify the set of latent variables that explain resilience. Then, the identified latent variables from the first stage are used to calculate the resilience index of the sampled households.

One limitation with the above approach, however, is the difficulty inherent in identifying the variables that will act as proxies for resilience. This is because resilience is a multifaceted concept. Additionally, there is a difficulty in defining the levels or categorising resilience and in finding its determinants if the proxy variable approach is employed. In this paper, we adopt the multi-stage modelling approach developed by Alinovi et al. (2010), given its flexibility in adapting to very different real cases. The use of this approach assumes that the alternatives accessible to a household for making a living would determine a household's resilience at a given point in time.

Empirically, the resilience index (RI) for a household (i) is described as:

$$RI = f(IFAi, APSi, Ai, SSNi, ACi, Si) \quad \text{(Eq. 2)}$$

Where, AS = Asset, AC = Adaptive capacity, SSN = Social safety net, APS = Access to public service, IFA = Income and food access, S = Stability (Alinovi et al., 2008; Mekuyie et al., 2018; Daniel et al., 2023).

Firstly, the indicators of resilience were chosen from the related literature (Adane, 2018; Mekuyi et al., 2018; Mengistu et al., 2019; Daniel et al., 2023), and adapted to this study by consulting the KIs about the relevance of the indicators to HHs' resilience to climate change in the study area.

Secondly, the observed indicators' values were normalised or standardised using the mean and standard deviation (Eq. 3). Indicators' normalisation was necessary to make their value comparable within a similar range (Mekuyie et al., 2018).

$$INi = \frac{xi - \bar{y}}{s} \quad \text{(Eq. 3)}$$

Where In = Indicator normalization/standardization, x = observed indicator value, $\bar{y}$ = mean of indicator, s = standard deviation of indicator, and i = the number of indicators under dimensions of resilience, such as access to AS, AC, SSN, APS, IFA, and S.

Thirdly, the indicator weight assignment was made by multiplying the data normalised or standardised value by PC that has an eigenvalue greater than or equal to 1 (Demisse et al., 2024). The indicator's weight assignment (Iwi) is denoted mathematically as Eq. 4.

$$Iwi = Ci * INi \quad \text{(Eq. 4)}$$

Where Ini = Indicators' normalised values for i variables, Ci = Component loading/value has an Eigenvalue greater than or equal to 1.

Fourthly, the values of resilience components (AS, AC, SSN, APS, IFA, and S), or called latent variables, are estimated from the indicator weight value of each respective component (Eq. 5).

$$RCv(1\text{-}6) = Iw1 + Iw2 + Iw3 + Iw4 + ... + Iwi \quad \text{(Eq. 5)}$$

Where RCv (1-6) = Resilience Components 1(AS), 2(AC), 3(SSN), 4(APS), 5(IFA) and 6(S), Iw1…. Iwi = Weight of indicators included under each resilience component.

Fifthly, the individual HH resilience index (HRI) was calculated by multiplying the indicator's normalised values by the component loading generated by the PCA (Asmamaw et al., 2019) in STATA.14 software. A PCA was used to examine the components of resilience and the percentage variance explained by each of the components, as well as their commonalities. According to the approach proposed by Alinovi et al. (2010), the factor variance obtained for each factor from the PCA was multiplied by the generated factor to develop the RI of each household (see Eq. 6).

$$HRI = Iwi * CLi \quad \text{(Eq. 6)}$$

Where HRI = HH resilience index, Iwi = ith indicators weight assignment, CLi = Component loading generated for i variables.

The Kaiser-Meyer-Olkin (KMO) measure is a statistic used to assess the suitability of data for factor analysis(Kaiser, 1970). It ranges from 0 to 1, with values closer to 1 indicating that factor analysis may be appropriate.

Here's how you can calculate the KMO value

$$KMO = \sum_{i=1}^{n} \sum_{j=1, j \neq i}^{n} r_{ij}^2 / \sum_{i=}^{n} \sum_{-(j=1, j \neq i)}^{n} r_{ij}^2 + \sum_{i=1}^{n} \sum_{-(j=1, j \neq i)}^{n} p_{ij}^2 \} \quad \text{(Eq. 7)}$$

Where r_{ij} are the elements of the correlation matrix, and p_{ij} are the elements of the partial correlation matrix.

Multivariate analysis of variance **(MANOVA)** was used to test the resilience components (AS, AC, SSN, APS, IFA, and S) variations among pastoral group HHs in both Dirree and Golboo production sub-systems.

The Structural Equation Modelling (**SEM)** approach proposed by Alinovi et al. (2010) was used to determine the relative contributions of resilience components to HH resilience status. SEM is a comprehensive statistical technique used for analysing complex relationships among observed and latent variables. Confirmatory Factor Analysis (CFA), Chi-square(χ^2), and the Root Mean Square Error of Approximation (RMSEA) were used to test validity, closeness to match and fitness of the data

Confirmatory Factor Analysis (CFA) is a statistical measurement model used to assess whether observed (indicator) variables adequately represent one or more underlying latent constructs (Sasongko et al., 2016). It enables researchers to test the validity and reliability of predefined measurement structures by examining how well the observed indicators load onto their respective latent variables (Ghozali, 2017). CFA is therefore particularly useful for theory-driven research, where relationships between variables are specified a priori.

The general CFA measurement model is expressed as:

$$\boldsymbol{X} = \boldsymbol{\Lambda_x \xi} + \boldsymbol{\delta} \quad \text{(Eq. 8)}$$

Where:

X: vector of observed (indicator) variables of size $q \times 1 \Lambda_x$: matrix of factor loadings (λ), representing the strength of the relationship between observed variables and latent constructs, with size $q \times n$

ξ: vector of latent variables of size $n \times 1$

δ: vector of measurement errors associated with the indicators, of size $q \times 1$

A commonly accepted threshold for factor loadings is greater than 0.40, indicating that an indicator sufficiently explains the latent construct (Hair et al., 2010). Higher loading values reflect stronger relationships and greater construct validity.

The statistical test in Goodness of Fit (GOF) is Chi-square(χ^2); it is used to test how close the match is between the covariance matrix of the sample S and the covariance matrix of the model $\sum \theta$. The statistical test χ^2 is

$$\chi 2 = (n-1)F(S, \sum(\theta)) \quad \text{(Eq. 9)}$$

The higher χ^2 value indicates a bad fit, while a small χ^2 value indicates a good fit. The Root Mean Square Error of Approximation (RMSEA) is a widely used fit index to assess how well a model, with estimated parameters, fits the population covariance matrix (Ghozali, 2017).

The RMSEA calculation formula is as follows:

$$RMSEA = \sqrt{F0 / df} \quad \text{(Eq. 10)}$$

Where F_0 is the estimated population discrepancy (the minimum fit function), df is the model's degree of freedom.

RMSEA values range from 0 to 1, with lower values indicating better fit. A value of 0.05 or less is often considered a good fit, while values up to 0.08 indicate a reasonable fit, and values above 0.10 suggest a poor fit.

3. Results

3.1. Socio-demographic characteristics

Table 1 presents background characteristics of the 360 respondents to the household survey. The majority of the respondents (59.5% in Dirree and 66% in Golboo) were male, their mean and median ages being 39.4 ± 18.2 and 49 years, respectively. In terms of educational status, a large majority of the respondents (83% and 77% in Golboo and Dirree, respectively) were preliterate, showing a very low level of literacy status among the sample communities.

Table 1. Socio-demographic characteristics of survey respondents, Borana, 2024 *(Source: Author's own work)*

Variable	Category	Dirree		Golboo	
		N	%	N	%
Sex	Male	107	59.5	120	66
	Female	73	40.5	60	34
Education	Formal education	17	9	13	7
	Read and write	25	14	18	10
	Can't read and write	138	77	149	83
Marital Status	Married	130	72	115	64
	Widow	22	12	50	28
	Divorced	18	16	15	8
Age	15-24	28	16	22	12
	25-34	31	17	33	18
	35-44	35	20	40	22
	45-54	48	27	42	24
	55-64	33	18	35	19
	≥65	5	2	8	5

3.2. Household economic activities

As Table 2 shows, the primary economic activity among household members is livestock rearing. Both men and women are heavily engaged in livestock production, with males in Dirree (91.5%) participating at a higher rate than those in Golboo (93.3%). Females also demonstrate strong involvement, with participation rates of 83.5% in Dirree and 86.6% in Golboo. In contrast, participation in crop farming is much lower for both sexes. Males show 32% involvement in Dirree and none in Golboo, while females have 23% participation in Dirree and no participation in crop farming activities in Golboo.

In Golboo, aridity and the volcanic nature of the soil render rain-fed crop cultivation a minimal option. Therefore, animal husbandry remains the dominant economic activity in which women play a vital role. In Dirree, by contrast, crop cultivation is widely practised. Both the impoverished pastoralists, out of desperate need for survival after heavy herd loss to the recent drought, and private 'investors', for profiteering out of the communities' land, are involved in land fencing for farming.

Males exhibit moderate engagement in small business activities, with participation rates of 60% in Dirree and 18% in Golboo. In comparison, females demonstrate higher rates of participation, at 74% in Dirree and 87% in Golboo. Casual work participation is low for both genders; males report 30% in Dirree and 23.3% in Golboo, while females' rate is 14% in Dirree and 12% in Golboo.

In charcoal burning, practised out of dire necessity, males show lower participation (17% in Dirree and 7.5% in Golboo) than females, who are more actively involved (34% in Dirree and 18.5% in Golboo). Females collect firewood for marketing, with 7% in Dirree and 5% in Golboo, while males do not participate at all. Participation in blacksmithing is very low, with marginal male involvement (2.8% in Dirree and 1.6% in Golboo), and no reports on females' involvement.

Poultry production shows significant female participation (71% in Dirree and 68% in Golboo), whereas males have no recorded involvement. Males are actively engaged in mining, with participation rates of 23.4% in Dirree and a substantial 70.8% in Golboo, while no females' participation is reported.

In livestock brokering, males participate at rates of 38.3% in Dirree and 26.7% in Golboo, with no female involvement reported. Additionally, males display some level of participation in motor bicycle transport services (11.2% in Dirree and 16.7% in Golboo), while there is no female participation in this emerging activity.

Overall, our livelihoods data indicate that males generally dominate livestock production and mining, while females show stronger participation in small businesses, poultry farms, firewood collection and charcoal burning across the two production sub-systems.

Table 2. Households' participation in main economic activities October, 2024 *(Source: Author's own work)*

Variable	Category	Dirree		Golboo	
		N	%	N	%
Livestock production	Male	98	91.5	112	93.3
	Female	61	83.5	52	86.6
Crop farming	Male	34	32	-	-
	Female	17	23	-	-
Small business	Male	64	60	22	18
	Female	54	74	52	87
Causal work	Male	32	30	28	23.3
	Female	10	14	7	12
Charcoal production	Male	18	17	9	7.5
	Female	25	34	11	18.5
Firewood	Male	-	-	-	-
	Female	5	7	3	5
Black smith	Male	3	2.8	2	1.6
	Female	-	-	-	-

Table 2 (Cont.). Households' participation in main economic activities October, 2024 *(Source: Author's own work)*

Variable	Category	Dirree		Golboo	
		N	%	N	%
Poultry production	Male	-	-	-	-
	Female	52	71	41	68
Mining	Male	25	23.4	85	70.8
	Female	-	-	-	-
Livestock brokering	Male	28	38.3	32	26.7
	Female	-	-	-	-
Motorcycle transport service	Male	12	11.2	20	16.7
	Female	-	-	-	-

3.3. Measures of pastoralist resilience between production sub-systems and among social groups

The climate resilience index used to assess resilience was calculated from six main components and 33 indicators. During the initial estimation phase, the adequacy of data was evaluated using the Kaiser-Meyer-Olkin (KMO) measure to validate the application of PCA (Table 3). The KMO values obtained were 0.5674 for Dirree and 0.5298 for Golboo, indicating a moderate correlation among variables, and confirming that the sample size was sufficient to proceed with PCA, as both values surpassed the minimum acceptable threshold of 0.05 for the respective production sub-systems (Table 3). The PCA results reveal that only one component, with an eigenvalue greater than one (>1), was relevant for estimating household resilience, as illustrated in the screen plot (Figures 3 and 4). This component accounts for a cumulative variance of 58.15% for Dirree data and 54.66% for Golboo data.

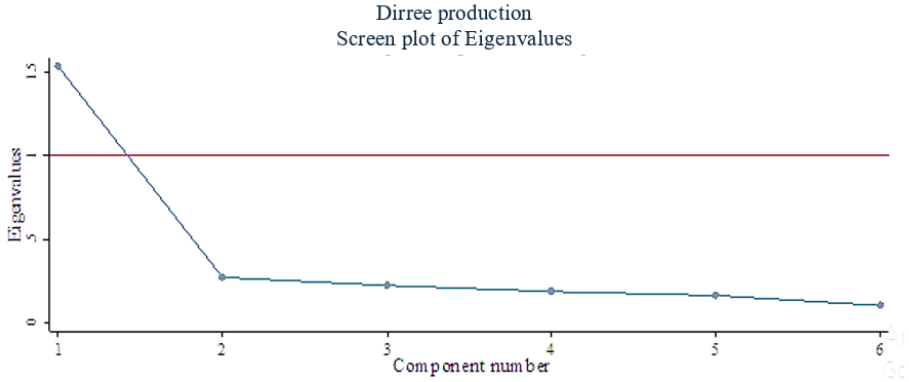


Figure 3. Screen plot of Eigenvalues after PCA

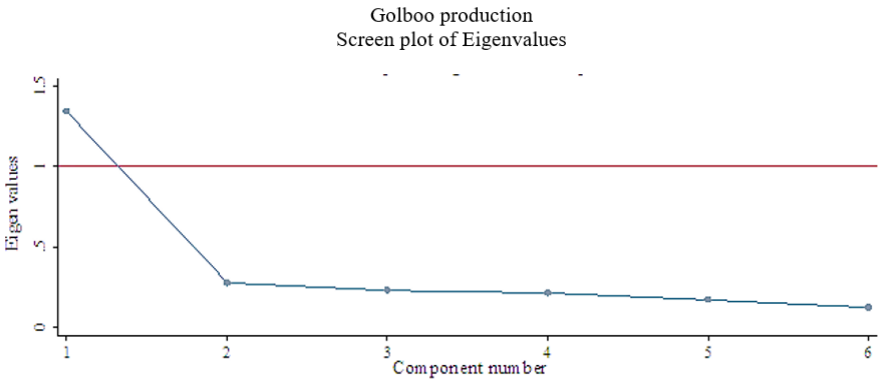


Figure 4. Screen plot of eigenvalues after PCA

Table 3. Eigenvalues and variance explained by PCs *(Source: Author's own work)*

Principal components/ covariance	Dirree production				Golboo production			
	Number of obs = 180				Number of obs = 180			
	Number of comp. = 6				Number of comp. = 6			
	Trace = 2.395221				Trace = 2.1094222			
Rotation: (unrotated = principal)	Rho = 0.9211				Rho = 0.8640			
Component	Eigenvalue	Difference	Proportion	Cumulative	Eigenvalue	Difference	Proportion	Cumulative
Comp1	**1.44263**	1.06734	0.5415	**0.5999**	**1.23822**	1.27021	0.6351	**0.5188**
Comp2	0.275584	0.036314	0.1158	0.6722	0.267332	0.012098	0.1123	0.7456
Comp3	0.261233	0.018941	0.0844	0.7744	0.243210	0.053410	0.1022	0.8320
Comp4	0.231171	0.040022	0.0901	0.8151	0.202515	0.046541	0.0771	0.9002
Comp5	0.172415	0.058098	0.0699	0.9321	0.159320	0.055466	0.0702	0.9555
Comp6	0.122720	.	0.0610	1	0.098444	.	0.0451	1
	Principal components (eigenvectors)				Principal components (eigenvectors)			
Variable	**Comp1**	Unexplained			**Comp1**	Unexplained		
AS	**0.9541**	0.2655			**0.9905**	0.1891		
AC	**0.2012**	0.3710			**0.0925**	0.3644		
SSN	**0.1545**	0.3891			**0.0189**	0.2788		
APS	**0.0144**	0.1900			**0.0435**	0.2851		
IFA	**0.0408**	0.3619			**0.0544**	0.3417		
S	**-0.0575**	0.2526			**-0.0236**	0.3308		
KMO	**0.5815**				**0.5466**			

Note: AS= Asset, AC = Adaptive capacity, SSN = Social Safety net, APS = Access to public service, IFA = Income and food access, S = Stability

Resilience indicators and index values for the study area are presented in Tables 4 to 8. The categories of assets, adaptive capacity, access to public services, income and food access, social safety nets, and stability were organised by production sub-systems and social groups, which are discussed in the following sections.

3.3.1. Asset (AS) The results indicated that household assets are primarily driven by livestock ownership, access to credit, and labour availability across both sub-systems. However, a key distinction emerges between Dirree and Golboo (Table 4).

In Dirree, asset accumulation is more diversified, with cropland ownership, irrigation access, and input use playing a significant role. This reflects the integration of crop production into the livelihood system. In contrast, Golboo remains more strictly pastoral, with minimal engagement in cultivation and therefore weaker contributions from land- and irrigation-related variables.

Social differentiation is also evident. Credit access plays a particularly important role for women and youth, suggesting its function as a compensatory mechanism for groups with otherwise limited asset bases. Labour availability is especially for youth, while access to information (via mobile phones and radio) disproportionately benefits adult men and youth.

A location-specific dynamic is observed in Golboo, where motorcycle ownership contributes more strongly to livelihoods, likely due to cross-border market access with Kenya. Across both systems, access to pastureland remains a foundational asset underpinning pastoral resilience.

Table 4. Contribution of observed variables to estimate asset (AS) *(Source: Author's own work)*

Variables	Production system		Pastoral group		
	Dirree	Golboo	Adult men	Women	Youth
Livestock owned (TLU)	0.880	0.952	0.941	0.831	0.810
Cropland owned,	0.694	0.228	0.481	0.398	0.514
Access to irrigation water	0.421	0.212	0.388	0.201	0.222
Access to irrigation inputs	0.414	0.201	0.225	0.211	0.259
Access to credit	0.721	0.700	0.711	0.921	0.762
Information tools	0.664	0.562	0.622	0.521	0.567
Labour	0.621	0.552	0.581	0.420	0.613
Motorcycle ownership	0.381	0.458	0.311	0.125	0.555
Pastureland owned	0.621	0.604	0.621	0.421	0.556

3.3.2. Adaptive capacity (AC) Table 5 presents results from the analysis of households' adaptive capacity, which is shaped by a mix of traditional practices and emerging strategies. The most influential factors include herd composition adjustments, income diversification, access to credit, and education.

A notable pattern is the partial transition toward agro-pastoralism in Dirree, where combining livestock and crop production enhances food security. Women, in particular, engage in this transition, often around micro-dam schemes. In contrast, such integration is far less pronounced in Golboo.

Innovative mechanisms such as livestock insurance are beginning to play a role in buffering climate shocks, with insured households reporting compensation during drought events. This signals a shift toward market-based risk management.

However, some traditionally central pastoral strategies, especially mobility and herd splitting, show reduced contributions to adaptive capacity. This likely reflects increasing structural constraints, including land-use change (expansion of cultivation) and conflict, which limit movement. Similarly, extension services appear to have an uneven impact, being less effective in Golboo.

Table 5. Contribution of observed variables to estimate adaptive capacity (AC) *(Source: Author's own work)*

Variables	Production system		Pastoral group		
	Dirree	Golboo	Adult Men	Women	Youth
Herds composition change	0.772	0.961	0.882	0.831	0.800
Herd splitting	0.441	0.456	0.444	0.441	0.440
Combining livestock production with crop farming	0.601	0.321	0.503	0.442	0.452
Access to extension	0.332	0.311	0.305	0.301	0.308
Level of education	0.525	0.500	0.512	0.508	0.522
Income diversification	0.722	0.699	0.701	0.722	0.723
Access to credit	0.602	0.661	0.644	0.652	0.63
Livestock insurance	0.651	0.561	0.611	0.521	0.568
Mobility	0.322	0.014	0.181	0.036	0.145

3.3.3. Social safety nets (SSN) Table 6 presents factor loadings for the observed variables used to assess social safety nets. The impact of these variables on pastoralist households varied across the production subsystems and among social groups. Pastoralist women relied more on food and cash handouts from the government and NGOs, compared to the youth and adult men. Conversely, cash-for-work programs had a significant effect on the youth and adult men, perhaps due to their level of participation in the social safety net activities. Furthermore, remittances had a greater influence on households in Golboo than on those in Dirree,

relating, again, to Kenya, where better transboundary job opportunities attract seasonal youth migration to remit money back home.

Table 6. Contribution of observed variables to estimate social safety nets (SSN) *(Source: Author's own work)*

Variables	Production system		Pastoral group		
	Dirree	Golboo	Adult Men	Women	Youth
Food aid from the government and NGOs	0.741	0.823	0.751	0.850	0.740
Cash for work	0.720	0.668	0.662	0.332	0.8950
Cash aid	0.602	0.618	0.448	0.665	0.442
Remittances	0.372	0.442	0.331	0.438	0.374

3.3.4. Access to public services (APS)

The result depicted in Table 7 indicates that access to essential public services, including health care, education, veterinary services, and markets, is a major differentiating factor between the two sub-systems.

Households in Golboo face significantly poorer access across all service categories, indicating a structural disadvantage relative to Dirree. This spatial inequality directly constrains adaptive capacity and livelihood diversification.

Within social groups, women are particularly disadvantaged in accessing markets, which limits their economic participation and adaptive potential. Access to early warning information is relatively similar across systems, though its benefits are mediated by other structural constraints.

Table 7. Contribution of observed variables to estimate access to public services (APS) *(Source: Author's own work)*

Variables	Production system		Pastoral groups		
	Dirree	Golboo	Adult Men	Women	Youth
Time taken to the nearest health centre	0.521	0.445	0.501	0.408	0.472
Time taken to the nearest market centre	0.428	-0.241	0.302	-0.120	0.398
Time taken to the nearest school	0.527	0.401	0.462	0.461	0.488
Time taken to the nearest veterinary clinic	0.500	0.411	0.488	0.403	0.442
Access to early warning system (EWI)	0.555	0.541	0.541	0.403	0.521

3.3.5. Income and food access (IFA) Income and food access show relatively modest variation between the two sub-systems, though per capita income contributes less to resilience in Golboo (Table 8). This suggests a heavier reliance on non-monetary or subsistence-based strategies in that system.

Across social groups, youth consistently demonstrate relatively better income and food access. This may be linked to higher mobility, engagement in diversified activities, and participation in labour markets, including migration.

Table 8. Contribution of observed variables to estimate income and food access (IFA) *(Source: Author's own work)*

Variables	Production system		Pastoral group		
	Dirree	Golboo	Adult Men	Women	Youth
Total income	0.430	0.421	0.411	0.401	0.452
Per- capital expenditure	0.521	0.566	0.541	0.512	0.521

3.3.6. Stability (S). Stability measured through inverse indicators of shocks reveals that livestock loss, market volatility, and conflict are major destabilising forces across the study area(Table 9).

Golboo experiences higher levels of instability, particularly due to livestock losses and conflict. Conflict is especially pronounced along border areas involving the Gabra, where competition over pasture and water resources frequently escalates. These conflicts disproportionately affect women, further compounding their vulnerability.

Crop loss is more relevant in Dirree, reflecting its agro-pastoral nature, while it remains negligible in Golboo. Market instability, however, affects all groups similarly, underscoring the systemic nature of economic shocks.

Table 9. Contribution of observed variables to estimate stability (S) *(Source: Author's own work)*

Variables	Production system		Pastoral group		
	Dirree	Golboo	Adult Men	Women	Youth
Livestock loss	-0.144	-0.282	-0.262	-0.254	-0.234
Crop loss	-0.128	-0.028	-0.133	-0.092	-0.125
Market volatility	-0.138	-0.281	-0.244	-0.232	-0.236
Conflict	-0.116	-0.329	-0.228	-0.233	-0.201

3.4. Distribution of resilience components among social groups

Figures 5(a) and (b) provide an overview of how adult men, women, and youth household heads (HHs) access resilience components. Results from MANOVA show variations among these components, as detailed in Table 10. The analysis reveals several differences among the three social groups. Variations in asset holdings among adult men, women, and the youth-led HHs are significant in both subsystems, suggesting uneven access to resources and services. For instance, adaptive capacity significantly varies among the groups in both subsystems, indicative of disparities in HHs' ability to adjust to climate change. The status of the social safety net did not significantly vary among the groups in either of the sub-systems, hinting at equivalent access to social support systems. Basic public services show significant differences between the groups in both, implying uneven public provision that might fulfil the needs of different social groups. Income and food access status show significant differences in Dirree. It shows variations in the diversification of income sources among the youth and women there. The stability component reveals a significant difference in both production subsystems, designating a difference in the effect of the stability component on social groups' resilience. Generally, adult men and the youth HHs exhibit notably higher stability in Dirree compared to Golboo. In both production subsystems, women-headed HHs are highly unstable.

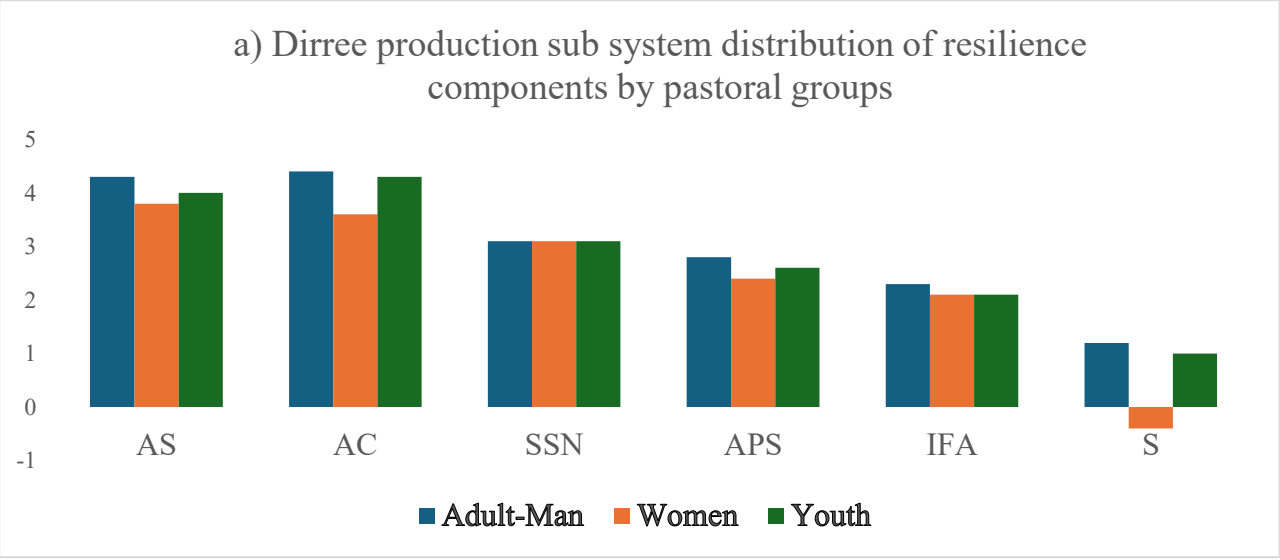


Figure 5. Pastoral group households' access to resilience components

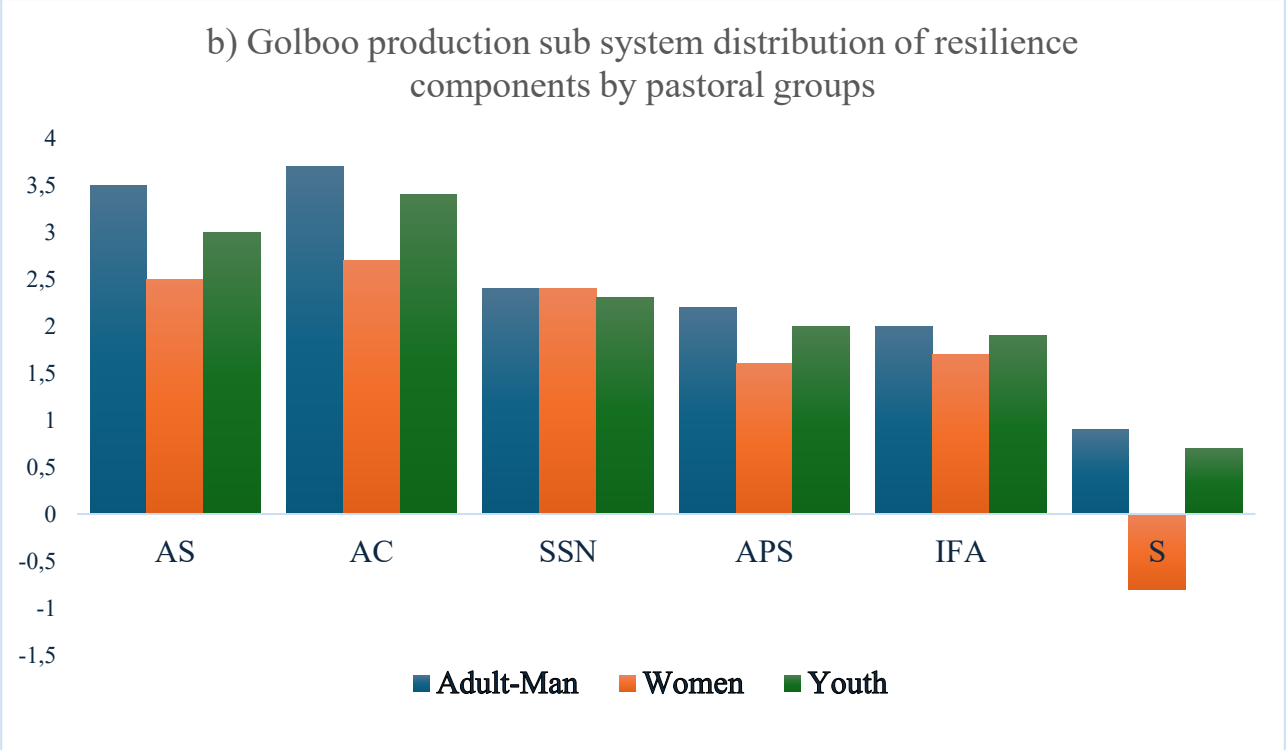


Figure 5 (Cont.). Pastoral group households' access to resilience components

Table 10. Resilience components variation among pastoral groups in the production subsystems *(Source: Author's own work)*

Dirree production system (MANOVA Tests)						
Effect		**Value**	**F**		**Sig.**	
Adult-man	Pillai's Trace	0.247	11.406b		.000	
	Wilks' Lambda	0.701	11.406b		.000	
	Hotelling's Trace	0.444	11.406b		.000	
	Roy's Largest Root	0.444	11.406b		.000	
Source		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Adult-man	AS	17.210	1	17.210	14.956	.000
	AC	8.721	1	8.721	44.211	.000
	SSN	7.001	1	7.001	30.134	.000
	BPS	3.501	1	3.501	15.018	.000
	IFA	1.621	1	1.621	7.215	.406
	S	1.002	1	1.002	1.624	.002
Effect		**Value**	**F**		**Sig.**	
Women	Pillai's Trace	.211	11.297b		.000	
	Wilks' Lambda	.666	11.297b		.000	
	Hotelling's Trace	.318	11.297b		.000	
	Roy's Largest Root	.318	11.297b		.000	

Table 10 (Cont.). Resilience components variation among pastoral groups in the production subsystems *(Source: Author's own work)*

Dirree production system (MANOVA Tests)						
Source		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Women	AS	16.721	1	16.721	13.021	.000
	AC	8.223	1	8.223	43.033	.000
	SSN	7.332	1	7.332	29.001	.433
	BPS	3.445	1	3.445	12.231	.000
	IFA	1.321	1	1.321	6.608	.108
	S	.331	1	.331	1.126	.001
Effect		**Value**	**F**		**Sig.**	
Youth	Pillai's Trace	0.127	12.406b		.000	
	Wilks' Lambda	0.701	12.406b		.000	
	Hotelling's Trace	0.383	12.406b		.000	
	Roy's Largest Root	0.383	12.406b		.000	
Source		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Youth	AS	16.999	1	16.999	12.916	.000
	AC	8.633	1	8.633	41.161	.000
	SSN	7.411	1	7.411	29.632	.000
	BPS	6.621	1	6.621	14.991	.000
	IFA	1.351	1	1.351	6.297	.421
	S	2.902	1	2.902	1.001	.002
Golboo production system (MANOVA Tests)						
Effect		**Value**	**F**		**Sig.**	
Adult-man	Pillai's Trace	.402	13.221b		.000	
	Wilks' Lambda	.625	13.221b		.000	
	Hotelling's Trace	.689	13.221b		.000	
	Roy's Largest Root	.689	13.221b		.000	
Source		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Adult-man	AS	45.541	1	45.541	38.265	.000
	AC	4.007	1	4.007	20.275	.000
	SSN	3.521	1	3.521	29.42	.453
	BPS	3.525	1	3.525	12.098	.000
	IFA	1.661	1	1.661	5.11	.112
	S	.331	1	.331	0.221	.002
Effect		**Value**	**F**		**Sig.**	
Women	Pillai's Trace	.400	12.151b		.000	
	Wilks' Lambda	.604	12.151b		.000	
	Hotelling's Trace	.663	12.151b		.000	
	Roy's Largest Root	.663	12.151b		.000	
Source		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Women	AS	42.441	1	42.441	35.255	.000
	AC	3.707	1	3.707	17.285	.000
	SSN	3.672	1	3.672	30.15	.453
	BPS	3.315	1	3.315	11.165	.000
	IFA	1.512	1	1.512	4.21	.112
	S	.109	1	.109	0.125	.002

Table 10 (Cont.). Resilience components variation among pastoral groups in the production subsystems *(Source: Author's own work)*

Golboo production system (MANOVA Tests)						
Effect		**Value**	**F**		**Sig.**	
Youth	Pillai's Trace	.400	12.151b		.000	
	Wilks' Lambda	.602	12.151b		.000	
	Hotelling's Trace	.663	12.151b		.000	
	Roy's Largest Root	.663	12.151b		.000	
Source		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Youth	AS	42.441	1	42.441	35.255	.000
	AC	3.707	1	3.707	17.285	.000
	SSN	3.672	1	3.672	30.15	.453
	BPS	3.315	1	3.315	11.165	.000
	IFA	1.512	1	1.512	4.21	.112
	S	.109	1	.205	0.209	.002

3.5. The cumulative resilience capacity of pastoralist HHs and groups in two production sub-systems

The resilience scores for Dirree and Golboo were 0.484 and 0.394, respectively, indicating lower resilience in Golboo. Among the social groups, women score 0.401, lower than adult males (0.442) and the youth (0.444) (Table 11). The main reason for the weak resilience capacity observed in both production sub-systems (Dirree = 0.494 and Golboo = 0.378), and among the groups (adult males = 0.426, women = 0.416, the youth = 0.412), has to do with asset holding. But households in Dirree demonstrate better asset-holding capacity; relative drought severity and a degree of livelihood diversification could be underlying differential competence.

The second significant factor affecting resilience in both areas and among social groups is income and food access, which is notably lower in Golboo (0.490) and for the women's group (0.457). Besides, poor adaptive capacity significantly contributes to the low resilience observed in Golboo (0.311) and among women pastoralists (0.311). Adult males and the youth group in Dirree exhibit better resilience. Access to public services also plays a role in resilience, with scores of 0.486 for Dirree and 0.422 for Golboo. Similarly, social safety nets are crucial for resilience building, scoring the highest (0.532) in the Dirree production sub-system.

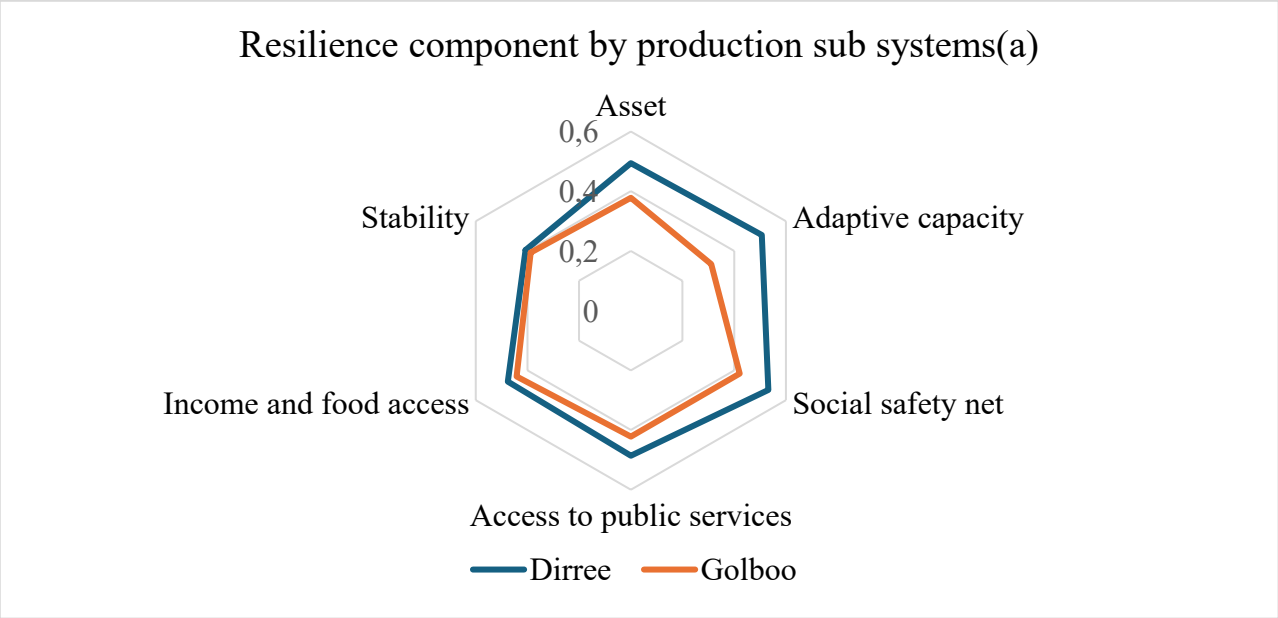
Stability across the two subsystems is significantly affected by livestock losses, whereas crop losses are more severe in Dirree. As stated, conflicts are more prevalent in Golboo, while market instability affects both. This highlights that climate-related livestock and crop losses, along with conflicts and market failures, are the most prevalent problems in the study area.

Table 11. PCA results of the resilience score *(Source: Author's own work)*

Variables	Production system		Pastoral groups			Overall CRI
	Dirree	Golboo	Adult Men	Women	Youth	
Asset	0.494	0.378	0.426	0.416	0.412	0.425
Adaptive capacity	0.506	0.311	0.458	0.311	0.464	0.434
Social safety net	0.532	0.421	0.408	0.415	0.410	0.437
Access to public services	0.486	0.422	0.451	0.422	0.425	0.441
Income and food access	0.476	0.442	0.466	0.457	0.487	0.466
Stability	0.407	0.388	0.441	0.387	0.466	0.423
Overall Borana CRI-Average	0.484	0.394	0.442	0.401	0.444	0.433

Findings regarding the major components are visualised in spider diagrams (Figures 3 and 4). The diagram's scale ranges from 0 (indicating low resilience) at the centre to 0.6 (indicating high resilience). Figure 3 indicates that the Dirree sub-system shows relatively higher resilience concerning adaptive capacity, access to public services, and stability, whereas Golboo ranks lowest across all resilience dimensions except for social safety nets. Overall, despite the generally low resilience capacity of the Borana Zone, Golboo is the least resilient compared to Dirree.

The study characterises variations among adult men, women, and the youth pastoral HHs' resilience status in Dirree and Golboo as observed from Figure 4. The resilience status of adult men, women, and the youth in Dirree is better than that of those inhabiting the Golboo lowlands. Adult men exhibit better resilience across all components in both production subsystems, except the social safety net. In contrast, women exhibit better resilience in the social safety net than adult men and the youth. The youth exhibit better access to public services, assets, income, and food security and stability than women. Overall, women have lower resilience compared to the other two social groups in both subsystems.



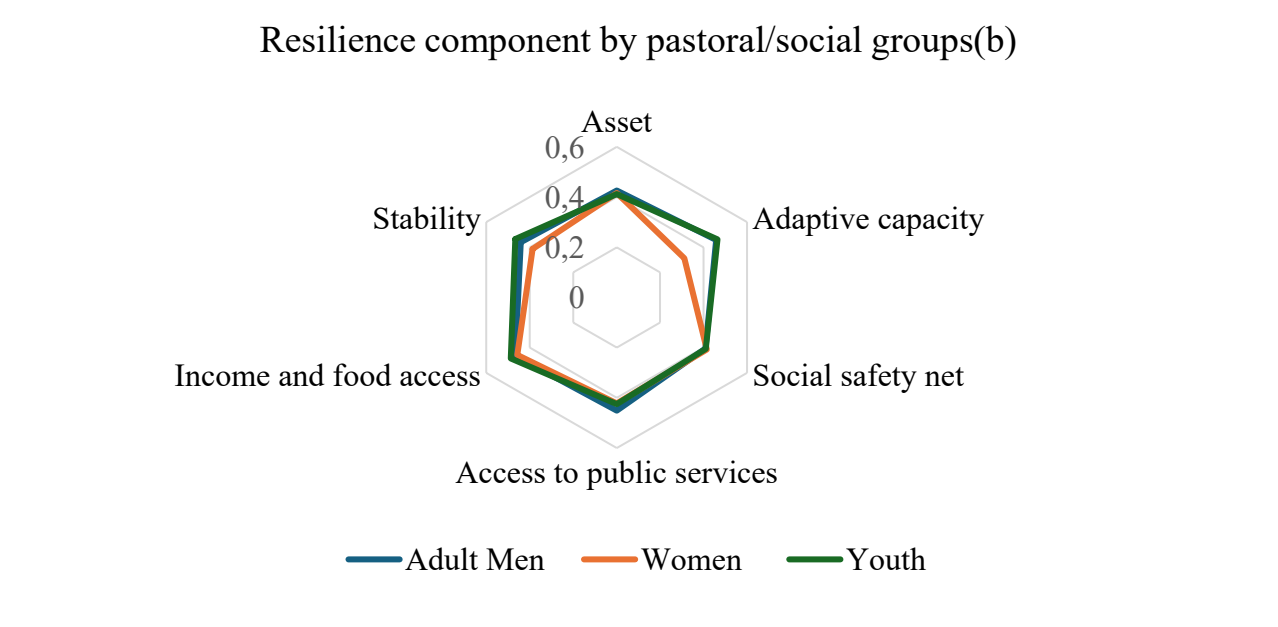


Figure 6a and b. Pastoralist households' resilience status

Figure 7 illustrates the statistical results from the SEM analysis regarding the contributions of different components to household resilience in the two production sub-systems. In Dirree, the model's appropriateness for assessing household resilience was evaluated through standardised SEM estimates. Findings demonstrate its suitability as indicated by a Confirmatory Factor Index (CFI) of 0.94 and a Chi-squared (χ^2) value of 0.175. Furthermore, the low error value (RMSEA = 0.003), which is below the threshold of 0.05, confirms the model's adequacy for further analysis.

The investigation found a weak positive correlation between household resilience status and several key components, including AS, AC, SSN, APS, and IFA, as well as a lower positive correlation with S in the Dirree production sub-subsystem. In Golboo, the SEM results show a CFI value of 0.94, a Chi-squared (χ^2) value of 0.533, and a low RMSEA error value of 0.002. These findings indicate that the model was adequate for data analysis, as illustrated in the figure on the right. A weak positive correlation was noted among households' ownership of AS, AC, SSN, IFA, and APS, while their S situation was negatively correlated with their resilience status.

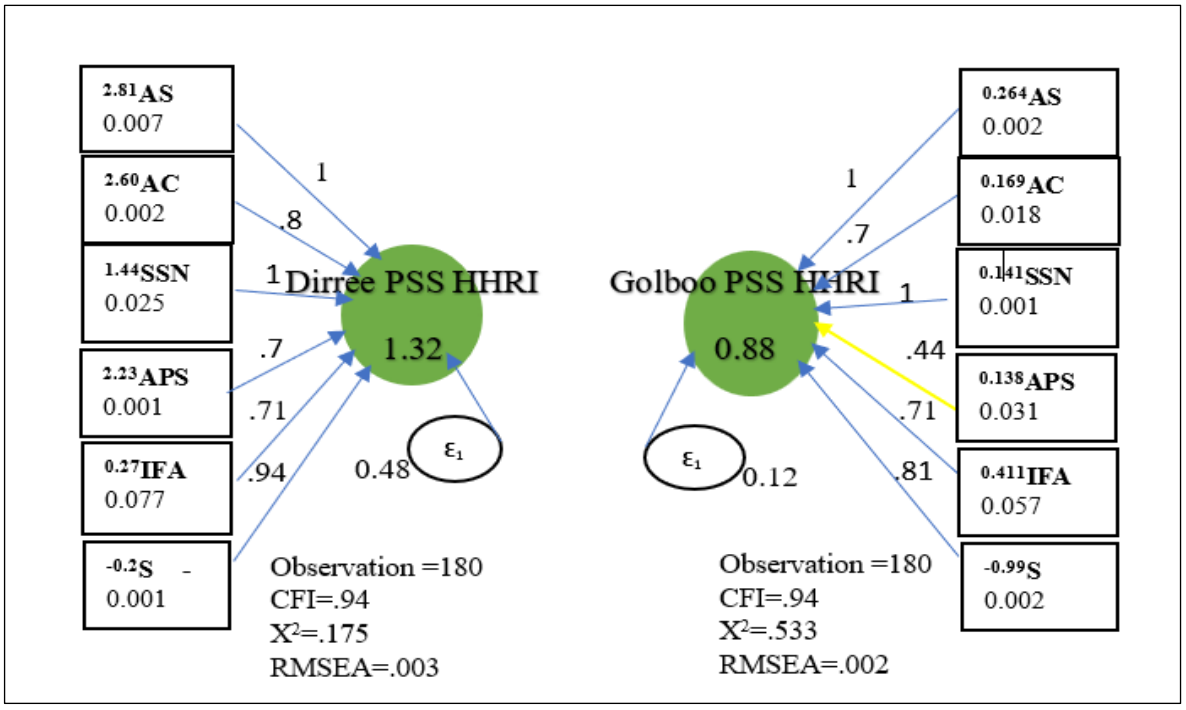


Figure 7. Contributions of resilience components to HH resilience in both production subsystems

Note: HHRI = HH resilience index, CFI = Confirmatory fit index, X^2 = Chi square test; RMSEA = Root mean squared error approximation, PSS = Production subsystem, green colour designates HH resilience status. The arrow with the yellow colour was found to have a less significant contribution to the HH resilience status.

3.6. Mechanisms for building resilient pastoralism

The Borana community, like many pastoral communities, is actively engaged in implementing a range of measures to cope with and mitigate the impacts of climate change. These strategies are paramount in sustaining their livelihoods and way of life amid increasing climate variability and extreme weather events. Methods vary across social groups within the community, each employing unique approaches to build resilience against climate change. Additionally, external actors, including the government and other development actors, play a significant role in supporting these communities through various initiatives.

3.6.1. Enhancing resilience-building strategies by adult men According to the majority of our respondents (85%), adult men design various adaptive strategies that consider both short-term household

benefits and long-term community development needs. Their adaptive strategies are diverse, and encompass livelihood diversification, environmental conservation and investment in child education.

Based on the KIIs, FGDs, and quantitative analysis of resilience components, livelihood diversification emerged as the principal household strategy. Men tend to expand their income sources to manage the risks associated with climate variability. They implement it by participating in livestock trade, livestock breed improvement, and seeking other income opportunities. By broadening their economic activities, they not only improve household financial stability but also contribute to gradual economic resilience building at the level of the community, demonstrating a proactive approach consciously adopted in response to disasters.

Another important strategy is participation in livestock brokering, which has become an important economic activity for men. Through brokering, men significantly influence the local livestock market by facilitating the movement of livestock and resources, highlighting their adaptability and entrepreneurial spirit in response to economic and climatic challenges.

Natural resource conservation is also a critical response to climate change challenges, with men actively involved in managing water and pasture resources. These practices are essential for sustaining pastoral livelihoods and are adapted to the changing environmental conditions. Initiatives such as area enclosures and water management projects for public use demonstrate their commitment to sustainable land governance, which is crucial for ecosystem restoration and ensuring the availability of resources for future generations.

Furthermore, Borana men recognise the importance of education and prioritise their children's schooling as a foundation for future economic stability and resilience. They view education as a strategic investment that will enable educated family members to provide financial support to their families, particularly through remittances during challenging periods like drought years. This assistance is vital to purchase feed for the herds and for post-drought restocking.

In summary, the adaptive strategies employed by adult men in Borana represent a comprehensive response to complex challenges posed by climate change. Through livelihood diversification, livestock brokering, natural resource conservation, and child education, they are designing a framework for sustainable development and resilience.

3.6.2. Enhancing resilience-building strategies by women Women in the study area tend to lead the way in adapting to climate change, using both innovative and traditional methods to attain household economic stability. According to 90% respondent households, the one significant activity for women is charcoal burning, which is less preferred but a vital income source for the economically disadvantaged households. This labour-intensive process transforms a living tree into charcoal, a valuable energy source. While the meagre income generated from charcoal sales provides relative financial independence and strengthens women's roles in the local economy to some extent, it also raises environmental concerns like deforestation.

Women also engage in petty trade, selling items such as homemade liquor and essential goods. This flexible form of trade allows them to operate in various locations, from local markets to roadside stalls. The proceeds contribute to household income diversification and reduce vulnerability to climate-related food scarcity.

The formation of savings and credit groups (although prone to sustainability challenges) and community support networks are other key strategies among women across the two sub-systems. These groups operate on the principles of synergy and mutual aid, pooling resources to support members during significant life events and emergencies. They provide financial assistance while fostering community solidarity, enabling women to share information and strategies for adaptation, which strengthens overall resilience to climate change.

According to KII and FGD reports in pastoral communities like Dirree, women's involvement in crop production has grown significantly. This shift towards crop cultivation is a strategic response to changing environmental conditions and economic needs, with an aim to contribute to food security and additional household income. Crop production provides a supplement to animal husbandry by availing a food source and additional income during favourable seasons, reflecting broader trends in rural adaptation to climate change.

Overall, the adaptive strategies of women in Borana demonstrate their essential role in addressing climate change challenges. Through charcoal production, petty trade, savings groups, and crop cultivation, they not only opt to enhance their households' resilience but also play a critical part in the economic and social dynamics of their communities. Any support tailored to empowering the women's group is vital for fostering positive changes amidst environmental and economic challenges.

3.6.3. Enhancing resilience-building strategies by the youth A household survey report indicates that 74% of respondents view involvement in the motor bicycle business as a remarkable adaptive strategy across the production sub-systems. Insights from the key informant interviews also suggest that many young people have entered this sector either as transporters or as motorbike traders, sourcing bikes from Kenya. Our informants perceive the motor bicycle boom ambivalently. On the one hand, they acknowledge the role bikes play in improving operational efficiency. Notably, it significantly shortens the time taken in resource scouting, water transportation, and carrying infirm animals during major mobility seasons. It also generates additional household income. Elders state these as positive developments. On the other hand, they see this growing sector as diversionary, referring to the young labourers shifting from the pastoralist routines.

Regarding mining, youth outmigration to various traditional gold mining sites in the Borana Zone or across the Kenya border is widely practised. 80% of the household survey respondents note the activity as an alternative venture for the lucky youth and adult men in both subsystems. This broader movement is creating a new trend whereby the youth are crossing the conventional pastoral livelihood boundary in significant numbers. Emergence of alternative income sources is shifting labour from rural to urban-linked livelihoods as part of their adaptation strategies.

However, in the light of the advent of motor bicycle business discussed above, one would infer that besides its positive outcomes in terms of income generation, youth migration to urban centres (as unqualified daily labourers) or opportunistic gold miners puts the prospects of pastoralism at a crossroads.

Saving and credit groups facilitated an additional support platform for the youth, providing financial services during vital events such as weddings, childbirth, and traditional child naming rituals. The conduct of these rituals that once relied on parental, relatives' and neighbourhood support now requires more collective efforts driven by the scale of the impacts of climate change on livestock assets. Furthermore, the option of the youth joining defence forces or a rebel group was mentioned during an FGD session held with the youth as a controversial yet tangible survival response in severe food shortage at home.

The strategies outlined above highlight efforts to restore pastoralist resilience and adaptability in confronting climate change, displaying a shift towards innovative and sometimes unconventional approaches to ensuring survival and economic stability.

4. Discussion

Borana pastoralism is undergoing profound change in systems' resilience and livelihood strategies. While the drivers of change may vary (innovation, sheer survival, state policy, etc.), climate change remains the single most important ecological phenomenon that critically influences the direction of the change. We analysed resilience, focusing on FAO's six components mentioned above, and found that adaptive capacity is the most determining factor. Households responded to the collapse in the main livelihood through a host of strategies, including herd composition, integrating livestock production with crop farming, and diversifying income sources, particularly in the Dirree production sub-system. For example, expansion of crop cultivation in Borana rangeland triggered competition with mobile land use systems for decades (Tache and Oba, 2010), while other response mechanisms assumed occasional and more opportunistic forms (e.g. mining).

Access to education, extension services, and credit also plays a significant role across both production subsystems. However, mobility and herd splitting have had a lesser impact on pastoralist households in both. This apparent decline in the role of mobility and herd splitting in resilience building stands out as a strange phenomenon seen from conventional pastoralism and pastoralists' risk aversion behaviour. This needs further investigation.

Our results align with previous works conducted in various pastoralist areas in analysing those multiple strategies pastoralists devise to adapt to and manage the impacts of climate change (Ambelu et al., 2017; Mekuyie et al., 2018; Bekele et al., 2021; Daniel et al., 2023; Girma et al., 2025; Oba, 2024).

Our data show low resilience capacity observed in both production subsystems (Dirree = 0.494 and Golboo = 0.378) and among pastoral groups (adult males = 0.426, women = 0.416, youth = 0.412). Besides those indicators considered in this study, other factors might have played into the present resilience status in Borana. However, households in Dirree demonstrate better asset-holding capacity, perhaps due to comparative advantages in accessing services or relative possession of property (livestock, pastureland, access to credit and labour). In addition, supply of irrigation inputs and availability of irrigable land and water to irrigate the field

have a positive impact on asset holding (see Ambelu et al., 2017; Mekuyie et al., 2018; Bekele et al., 2021; Daniel et al., 2023; Girma et al., 2025). Households in Golboo exhibit little or no participation in crop cultivation. Pastoralists' limited experience in crop cultivation and unsuited microclimatic conditions and geological features (widespread volcanic rocks, for instance) are prominent hindering factors here.

Credit services had important influences on asset holdings by women and the youth in both production subsystems, as labour does. In contrast, the availability of labour and livestock holding significantly contributed to asset building. Overall, farmland ownership, access to irrigation, and associated inputs like improved seed supply played a significant role.

Limited access to public services had a low CRI score in both production subsystems and among the social groups. Particularly, the Golboo case (CRI = 0.422) presents an important resilience predictor compared to Dirree (CRI = 0.486). Mekuyie et al.'s study (2018) in the Afar region of Ethiopia confirms that access to public services enhances economic connectivity through market access. Access to public services also improves households' capacity to build assets and develop human capital through improved access to health and education.

Regarding the social safety net, pastoralist women depend more on food and cash assistance from the government and NGOs than the youth and adult men. In contrast, cash-for-work programs significantly benefited the youth and adult men. Notably, remittances were more impactful for households in Golboo because of the area's proximity to an international border, compared to those in Dirree. Inhabitants of the former enjoy better access to job opportunities in Kenya, from where they remit money back home.

A similar study also confirms the role of social safety nets in enhancing household resilience, especially for the impoverished ones, as they help mitigate the impact of crises (Daniel et al., 2023). Driven by a rise in poverty levels, households in the pastoralist areas increasingly rely on aid handouts from charities, NGOs, and other international organisations, although support from relatives and friends remains important (Ambelu et al., 2017; Amare and Sime, 2018; Mekuyie et al., 2018; Daniel et al., 2023)

Livestock losses severely affect stability in both Dirree and Golboo, whereas specifically, households in Dirree experienced crop failure frequently. Concerning conflict, its occurrence is more prevalent in Golboo, while market instability has had a serious influence on both subsystems. This highlights that climate-related livestock and crop losses, along with conflicts and market failures, are prevalent in the study area, and the findings concur with those of Mekuyie et al. (2018).

To conclude, among its salient features, dynamism defines pastoralism in the unstable environment. The Borana experience is similar to what the findings from this study reveal. As Oba argues, "…pastoralism has been adjusting to all the shocks and trying to operate in the risky and volatile environment. … the pastoral system and its customary institutions enabled the society to survive, but also show the considerable pressure under which the system has been operating" (2024: 2).

Household adaptive capacity has been weakened increasingly by severe environmental collapse (Oba, 2024), the most recent being the 2020-23 episode that eroded households' asset base in East Africa at a massive scale. As a result, optimal herd recovery is severely suppressed, resulting in both aggregate and per capita livestock holding (Tache and Sjastaad, 2008). Nevertheless, household capacity to adapt to drought impacts displays internal variation between the two production subsystems. Accordingly, households in Dirree demonstrate better asset-holding capacity than those in Golboo. This indicates that, beyond the resources required in traditional pastoralism, access to other emerging livelihood opportunities significantly influences the system's resilience.

Households design response strategies within the constraints of resource conditions, access to services, labour, policy, extension support and security. And every response strategy may play its role, whether as an immediate gap filler or as a contributor to long-term sustainability, but each needs a thorough scrutiny. In the aftermath of the most recent deadly drought episode, for instance, migration of the youth to urban areas, or to various traditional gold mining sites within the Zone or across the Kenya border, is diverting labour. This carries profound implications for the prospects of pastoralism. On top of this, the advent of the motor bicycle business, despite its positive impact in terms of income generation, tends to pull the youth out of the pastoral routines. Interpretation of this trend depends on what to emphasise: extensive pastoralism, 'transitioning out', or an innovative blend? Concerning irrigation, while it offers a huge potential for improved household income and food security in the lowlands, only rigorous empirical data can enable sound conclusions about its impacts in the study area, as the scheme was introduced in Borana only recently.

5. Conclusion

This study examines climate resilience among Borana Oromo pastoralists by comparing the Dirree and Golboo production systems using FAO resilience dimensions. It finds that resilience varies significantly across systems due to differences in ecological conditions, institutional support, and socio-economic factors. Dirree demonstrates relatively higher resilience, supported by better access to veterinary services, infrastructure, and reliable water sources, which enhance households' ability to cope with climate shocks. In contrast, Golboo faces greater vulnerability due to recurrent drought, aridity, and cross-border conflicts that restrict mobility and weaken traditional coping mechanisms.

Adaptive capacity emerges as the most critical component of resilience. Pastoralists actively respond to climate stress through strategies such as herd diversification toward drought-tolerant animals, income diversification, and engagement in risk management tools like livestock insurance. However, disparities persist, as women and youth often face limited access to resources and decision-making power. The study also emphasises the importance of indigenous knowledge and social institutions, though these are increasingly challenged by external pressures.

6. Recommendations

In light of the major findings from this study, we forward the following recommendations that are hoped to contribute to pastoralist resilience building by mitigating the impacts of climate change on pastoral livelihoods and improving the overall well-being of the communities in the study area.

1. A shift from short-term humanitarian assistance toward structured, long-term resilience building is essential for strengthening pastoral systems in the Borana Zone. Government agencies, NGOs, and development partners should prioritise system-based capacity building by designing locally tailored training programs on climate adaptation, including herd management, drought preparedness, and sustainable resource use. Such efforts must build on and institutionalise indigenous knowledge systems by integrating them into formal rangeland management and extension services, while also strengthening community-based mutual support institutions rooted in traditional reciprocity. Given the transboundary nature of pastoral systems, cross-border coordination with Kenya is critical to facilitate seasonal mobility agreements, shared resource governance, and sustained peacebuilding initiatives, particularly in conflict-prone areas such as Golboo.
2. At the same time, climate-smart agro-pastoral practices should be promoted in suitable areas, especially in agro-pastoral zones like Dirree. Regional governments and extension systems need to expand dryland agriculture programs that emphasise drought-tolerant crops and water-efficient irrigation technologies, while ensuring the provision of appropriate input packages such as seeds and small-scale irrigation tools. Strengthening farmer training services around integrated crop–livestock systems is equally important, as is enhancing women's participation in irrigated and small-scale farming, particularly in areas supported by micro-dam schemes.
3. Enhancing adaptive capacity also requires expanding inclusive access to education, financial services, and enterprise development opportunities. Investments in mobile and context-appropriate education systems are necessary to reach pastoral populations, while financial inclusion initiatives, including microcredit, savings groups, and livestock insurance, should be scaled up to reduce vulnerability to shocks. In parallel, entrepreneurship and vocational training programs targeting youth and women can promote income diversification, supported by asset-building initiatives that combine livestock-based and non-livestock livelihood options.
4. Legal and institutional frameworks must also be strengthened to protect pastoral mobility and rangeland systems. This includes formal recognition of grazing rights and mobility corridors, as well as measures to prevent the unregulated expansion of cultivation into critical grazing areas. Policymakers should reinforce customary institutions that govern access to land, water, and pasture, while promoting integrated land-use planning that reflects the functional interdependence of production sub-systems such as Dirree and Golboo.

5. Improving access to basic services and climate-sensitive infrastructure is another priority, particularly in underserved areas like Golboo. Public investment should focus on expanding health, veterinary, and education services through mobile or decentralised delivery systems, while improving market access infrastructure to support livestock trade. Early warning systems must be strengthened to ensure the timely dissemination of climate and market information. Water development interventions should be carefully designed to maintain ecological balance between water availability and pasture conditions, and rangeland restoration programs should actively incorporate pastoralists' indigenous ecological knowledge.
6. Given the significant role of conflict in undermining stability, there is a need to strengthen conflict management and resource governance mechanisms. Establishing permanent cross-border peace committees involving Borana communities and neighbouring groups such as the Gabra can help manage disputes over shared resources. All development interventions should adopt conflict-sensitive approaches, while joint agreements on pasture and water use should be promoted in border areas.
7. Finally, further research and evidence-based policy design are needed to deepen understanding of pastoral resilience. Research institutions and development partners should expand studies to include additional production sub-systems across the Borana rangelands, generate disaggregated data on climate impacts across gender and social groups, and pilot context-specific resilience interventions with clear pathways for scaling up successful practices.

Acknowledgements Not Applicable

Author Contributions The first author was responsible for conceptualization, field data collection, data analysis, interpretation of the results, and preparation of the first draft of the manuscript. The second author contributed to editing, interpretation of the findings, and provided substantial input to the final version of the manuscript. The third and fourth authors contributed to reviewing and editing the draft of the document.

Funding Not Applicable

Data Availability Upon request from the corresponding author

Declarations

Competing Interests The authors declare no competing interests.

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Reference

Abdi, H., Williams, L., Jackknife, I. and Salkind, N. 2010. Encyclopaedia of research design. thousand oaks: Sage publications; 2010, (In press).

Adane, A. 2018. Rural households' resilience to food insecurity in Southern Ethiopia: The case of Boricha woreda in Sidama zone. Addis Ababa university college of development studies centre for rural livelihood and development. 197p

Aldunce, P., Indvik, K., Borquez, R., Adler, C. and Galaz, V. 2014. Resilience in the context of climate change: a systematic review of the literature to aid a navigation of diversity. Center for Climate and Resilience Research, Blanco Encalada 2002, Santiago, Chile

Alefu, C., Dalga, Y. and Samuel, T. 2017. The adaptation and mitigation strategies for climate change in Pastoral communities of Ethiopia. *American Journal of Environmental Protection*, 6(3): 69-74.

Alinovi, L., D'Errico, M., Mane, E. and Omano, D. 2010. Livelihoods strategies and household resilience to food insecurity: An empirical analysis to Kenya, European report on development. Italy.

Alinovi, L., Mane, E. and Romano, D. 2008. Towards the measurement of household resilience to food insecurity: Applying a model to Palestinian household data. Deriving food security information from national household budget surveys. Experiences, Achievement, Challenges. FAO. Rome, pp. 137–152

Amare, A. and Sime, B. 2018. Does adaptation to climate change and variability provide household food security? Evidence from Muger sub-basin of the upper Blue-Nile, Ethiopia. *Ecological Processes*,7(13)

Ambelu, A., Birhanu, Z., Tesfaye, A., Berhanu, N., Muhumuza, C., Kassahun, W., Daba, T. and Woldemichael, K. 2017. Intervention pathways towards improving the resilience of pastoralists: A study from Borana communities, southern Ethiopia. *Weather and Climate Extremes* 17: 7–16

Asmamaw, M., Mereta, T. and Ambelu, A. 2019. Exploring households' resilience to climate change-induced shocks using Climate Resilience Index in Dinki watershed, central highlands of Ethiopia. *PLoS One* 14(7): e0219393.

Ayele, T., Dedecha, D. and Duba, D. 2020. The impact of climate change on pastoralist livelihoods in Ethiopia: A review. *Journal of Resources Development and Management* 63: 2020

Bassi, M. 2005. Decisions in the Shade. Political and Juridical Processes among the Oromo-Borana. Trenton: Red Sea Press.

Bekele, E., Drabik, D., Dries, L. and Heijman, W. 2021. Resilience of agropastoral households affected by large scale land investments: The case of Ethiopia. *Research in Agriculture and Applied Economics*.

Bekele, H., Jima, G. and Regesu, H. 2020. Undernutrition and associated factors among lactating women: Community-based cross-sectional study in Moyale District, Borena zone, southern Ethiopia. *Hindawi*, 2020(2):1-10

Berkes, F. and Ross, H. 2013. Community resilience: Toward an integrated approach. *Society and Natural Resources*, 26(1):5–20.

Birhanu, Z., Ambelu, A., Birhanu, N., Tesfaye, A., Woldemichael, K. 2016. Understanding resilience dimensions and adaptive strategies to the impact of recurrent droughts in Borana zone, Oromia region, Ethiopia: a grounded theory approach. *International Journal of Environment and Public Health*,14(2):118

Bogale, G. and Erena, Z. 2022. Drought vulnerability and impacts of climate change on livestock production and productivity in different agro-ecological zones of Ethiopia. Journal of Applied Animal Research, 50(1): 471–489.

Boru, D., Boku, T., Amare, A. and Alemayehu, R. 2026. Climate change, climate variability and drought: impacts on pastoral livelihoods in Borana zone, Southern Ethiopia *International Journal of Climate Change Strategies and Management*, 18(3):46-47 https://doi.org/10.1108/IJCCSM-07-2025-0217

BZBGO (Borana Zone Buusaa Gonofaa Office). 2024. Post drought assessment report., 2024. Yaballo.

Coates, J., Swindale, A. and Bilinsky, S. 2007. Household Food Insecurity Access Scale (HFIAS) for measurement of food access: Indicator Guide.

CSA (Central Statistical Agency). 2013. Population projection of Ethiopia for all regions at Woreda level from 2014–2017. Addis Ababa.

Daniel, T., Fana, C., Dilbato, T., Bekele, N. and Tesso, G. 2023. Pastoralists' and agro-pastoralists' livelihood resilience to climate change-induced risks in the Borana zone, south Ethiopia: Using resilience index measurement approach. *Pastoralism*, 13:(4).

Daniel, T., Woldeamanuel, T. and Haile, F. 2022. Smallholder farmers' vulnerability and adaptation to climate change induced shocks: The case of northern Ethiopia highlands. *Journal of Agriculture and Food Research,* 8: 100312.

Demeke, M. and Tefera, N. 2013. Sustainable resilience for food and nutrition security: The case of farming rural households in Ethiopia. Rome: Agricultural Development and Economics Division (ESA), Food and Agricultural Organization (FAO)

Demisse, U.,Bazezew, A. and Bantigegen, S. 2024. Rural households' resilience to the adverse impacts of climate variability and food insecurity in the North-eastern highlands of Ethiopia, *Heliyon* 10 (2024) e32960

DFID (Department for International Development). 2013. Embedding disaster lessons review, Conflict, Humanitarian and Security Department (CHASE). International Document.

Dong, S. 2016. Overview: Pastoralism in the world. Building resilience of human-natural systems of pastoralism in the developing world: Interdisciplinary perspectives, 1–37.

EGIA (Ethiopian Geospatial Information Agency). 2018. Map of study area, Scale 1:250,000, EGIA, Addis Ababa.

FAO (Food and Agriculture Organization). 2016. A dynamic analysis of resilience in Uganda. ESA Working Paper No. 16-01 Agricultural Development Economics Division

FAO (Food and Agriculture Organization). 2018. Livestock production systems spotlight cattle sectors in Ethiopia. Africa Sustainable Livestock, 2050. ©FAO, 2018 I8271EN/1/01.18.

FAO (Food and Agriculture Organization). 2021. Boosting smallholder resilience for recovery: Safeguard vulnerable pastoralist and agro-pastoralist households in East and West Africa and the Sahel. Accra: FAO COVID-19 Response and Recovery Programme.

Fekadu, B., Boku, T., Gadissa, T., Jabessa, T. and Medihanit, A. 2016. Assessment of the customary land administration and natural resource management in the pastoral areas of the *Oromia Regional State*. Addis Ababa, Ethiopia. 91p.

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

Gebremeskel, N., Desta, S. and Kassa, G. 2019. Pastoral development in Ethiopia. Trends and the way forward. Development knowledge and learning. World Bank and the International Fund for Agricultural Development (IFAD)

Ghozali, I. 2017. Model Persamaan Struktural konsep dan Aplikasi with Program Amos 24. Semarang: Universitas Diponegoro.

Girma, A. 2025. Assessing barriers to effective climate change adaptation strategies in the Teltele Districts, Oromia Region, Southern Ethiopia, *Asian Journal of Natural Sciences,* 4(1):13-30

Girma, A., Chanyalew, S. and Million, S. 2025. Pastoralists' perception towards climate change and meteorological evidence, A case of Teltele District, Oromia Region, Ethiopia, *Sustainable Environment,* 11(1): 2489189

Hair, J., Black, W., Babin, B. and Anderson, R. 2010. Multivariate data analysis seventh edition. New York: Prentice Hall International.

Helland, J. 1982. Social organization and water control among the Borana. *Development and Change*, 13:239-258. SAGE, London

Jolliffe, I. and Cadima, J. 2016. Principal component analysis: A review and recent developments. PubMed. government. 13(375):265

Kaiser, H. 1970. A second-generation little jiffy. *Educational and Psychological Measurement*, 30(3): 907-910.

Kurt, L. 2003. Environmental assessment management framework for the pastoral community development project. Washington, DC: Environmental resources management.

Lameso, L., Taye, B. and Husein, A. 2022. Drought characteristics and pastoralists' response strategies in Korahey zone, Somali regional state, Eastern Ethiopia. *Scientific African*, 16(6): e01254.

Magda, N., Simon, A. and Ced, H. 2009. Pastoralism and climate change. Humanitarian Policy Group Overseas Development Institute 111 Westminster Bridge Road London SE1 7JD United Kingdom

Mekuyie, M. and Desta, M. 2021. Perception of impacts of climate variability on pastoralists and their adaptation/coping strategies in Fentale District of Oromia Region, Ethiopia. *Environmental Systems Research*, *10*(1).

Mekuyie, M., Jordaan, A. and Melka, Y. 2018. Understanding resilience of pastoralists to climate change and variability in the southern Afar Region, Ethiopia. *Climate Risk Management*, *20*, 64–77.

Mekuyie, M., Jordaan, A. and Yoseph, M. 2019. Vulnerability of Southern Afar pastoralists to climate variability and change, Ethiopia. Jàmbá: *Journal of Disaster Risk Studies*, *11*(1).

Mengistu, A., Seid, T. and Argaw, A. 2019. Exploring households' resilience to climate change-induced shocks using Climate Resilience Index in Dinki watershed, central highlands of Ethiopia. *PLOS ONE*, *14*(7), e0219393.

Mulugeta, T., Siobhan, M., Matthew, B. and Mirgissa, K. 2025. Perceived impacts of climate change in pastoralist regions of Ethiopia: A qualitative study applying the concept of One Health. *International Journal of Environmental Research and Public Health*, *22*(2):257

Muluneh, M. 2021. Impact of climate change on biodiversity and food security: A global perspective. A review article. Agriculture Food Security. 10(36)

Muse, A., Mohamed, D. and Faisal, M. 2023. Pastoralists adaptation strategies and resilience capacity to climate change in Somalia: A Scoping Review

Oba, G. and Kotile, D. 2001. Assessments of landscape level degradation in southern Ethiopia: pastoralists versus ecologists. *Land Degradation and Development*, *12*(5): 461–475.

Oba, G. 2024. Pastoralist resilience to environmental collapse in East Africa since 1500. Palgrave Macmillan

Reid, H., Faulkner, L. and Weiser, A. 2013. The role of community- based natural resource management in climate change adaptation in Ethiopia. London, No. IIED Climate Change Working Paper No. 6. 68p.

Saroj, P., Dipak, T. and Yagya, M. 2021. The role of livelihood diversification and social capital in the movement of households: A case Study from central Nepal. *South Asian Journal of Social Sciences and Humanities*, 2(4):27-50

Sasongko, E., Mustafid, N. and Rusgiyono, A. 2016. Penerapan Metode Structural Equation Modelling untuk Analysis Kepuasan Pengguna Sistem Informasi Akademik Terhadap Kualitas Website (Studi Kasus Pada Website Sia.undip.ac.id). GAUSSIAN, 5(3), 395-404.

Tache, B. and Oba, G. 2010. Is poverty driving Borana herders in Southern Ethiopia to crop cultivation? *Human Ecology*, 38(5): 639-649.

Tache, B. and Sjaastad, E. 2008. Mutual assistance and poverty reduction among Borana Oromo: The institution of Buusaa Gonofaa, Norwegian University of Life Sciences

Tache, B. 2000a. Changing patterns of resource control among the Borana pastoralists of Southern Ethiopia: A lesson for development agencies. In Pastoralists and Environment: Experience from the Greater Horn of Africa. Edited by Leif Manger and Abdel Ghaffar M. Ahmed, Addis Ababa, 51-73.

Tache, B. 2008a. Pastoralism under stress: Resources, institutions and poverty among the Borana Oromo in Southern Ethiopia. PhD Dissertation. Norwegian University of Life Sciences, Ås, Norway.

Tache, B. 2008b. Borana managed landscape in southern Oromia, Ethiopia, paper presented at "The landscape dynamic mosaic— embracing diversity, equity and change", IUCN Congress in Barcelona.

Tache, B. 2010. Participatory impacts assessment of drought reserves areas in Guji and Borana Zones, Oromia Region. Report prepared for Save the Children USA, Addis Ababa.

Tesso, G., Emana, B. and Ketema, M. 2012. Analysis of vulnerability and resilience to climate change induced shocks in North Shewa, Ethiopia, *Agricultural Sciences* 3(6), 871.

USAID (United States Agency for International Development). 2016. Resilience at USAID progress report. Washington, DC: USAID. Center for Resilience

Yilma, Z., Haile, A. and Guernebleich, E. 2009. Effects of climate change on livestock production and livelihood of pastoralists in selected pastoral areas of Borana, Ethiopia; Food and Agriculture Organization of the United Nations, Sub Regional Office for Eastern Africa (FAO/SFE): Addis Ababa, Ethiopia, 32.

Youngmann, R., Zilber, N., Workneh, F. and Giel, R. 2008. Adapting the SRQ for Ethiopian populations: a culturally sensitive psychiatric screening instrument. Transcult. Psychiatry 45, 566–589.