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Climate Change Impacts and Adaptation Strategies among Pastoral Communities in Yabello District, Borana Zone, Ethiopia

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ABSTRACT

Climate change presents a critical challenge to the sustainability of pastoral livelihoods in the arid and semi-arid regions of Africa, particularly in Ethiopia's Borana Zone. This study investigates the profound impacts of climate change on pastoral communities in the Yabello District and comprehensively evaluates the adaptation and coping strategies they employ. Employing a robust mixed-methods research approach, data were collected through a structured household survey (n=150), complemented by key informant interviews (n=15) and focus group discussions (n=3) to capture both quantitative and qualitative dimensions. The findings reveal that a vast majority of pastoralists perceive significant climatic shifts, with 82% reporting increased drought frequency, 76% citing severe declines in water availability, and 68% noting a substantial reduction in pasture biomass. Key climate change indicators identified include highly erratic rainfall patterns (reported by 89% of respondents) and steadily rising temperatures (72%). While traditional adaptation mechanisms such as seasonal mobility (practiced by 65%) and herd diversification (54%) remain prevalent, they are increasingly inadequate in the face of intensifying and compounding climatic stressors. The study further highlights

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foundational systemic vulnerabilities, including limited institutional support and inadequate infrastructure, which severely hinder effective adaptive responses. This research concludes by emphasizing the urgent need for targeted policy interventions that enhance climate information systems, promote climate-smart pastoral practices, and integrate these marginalized communities into broader climate resilience frameworks.

Keywords: Climate Change Adaptation; Pastoralism; Vulnerability; Ethiopia; Resilience Strategies

1. Introduction

Climate change is a global phenomenon characterized by shifts in temperature, precipitation patterns, wind speed, and humidity, with profound implications for ecosystems and human livelihoods [1]. The Intergovernmental Panel on Climate Change (IPCC) projects a rise in global average temperatures by 1.4 to 5.8°C by 2100, accompanied by altered precipitation patterns and increased climate variability [2]. These changes exacerbate existing vulnerabilities, particularly in regions like Africa, where poverty, fragile ecosystems, and weak governance systems limit adaptive capacities. Ethiopia, with 80% of its population reliant on rain-fed agriculture, is highly susceptible to climate-induced disruptions, including land degradation, recurrent droughts, and food insecurity [1].

In the Yabello District of Ethiopia's Borana Zone, pastoral communities confront escalating climate change challenges, including erratic rainfall, rising temperatures, and prolonged droughts. These shifts have reduced water availability, diminished pasture biomass, and intensified socio-economic vulnerabilities, jeopardizing the livelihoods of pastoralists reliant on livestock. Despite the severity of these impacts, comprehensive studies assessing climate change's specific effects on pastoralism in this region remain scarce. This research addresses this gap by examining the extent and nature of climate change's consequences on pastoral livelihoods, with a focus on both the challenges faced and the coping strategies employed by these communities.

Through a mixed-methods approach, this study identifies key climate-related challenges, analyzes their socio-economic repercussions, and evaluates existing adaptation strategies. The findings aim to inform targeted interventions, such as climate-smart pastoral practices and improved water infrastructure, while advocating for stronger institutional support. By bridging localized research gaps, this work contributes to policy frameworks designed to enhance pastoral resilience. Furthermore, it integrates community-specific vulnerabilities into broader climate action agendas, providing actionable insights for policymakers and stakeholders to foster sustainable adaptation.

2. Materials and Methods

2.1. Description of the Study Area

The study was carried out in Yabello District, one of the districts in the Borana zone of Oromia region which lies 570 km south of Finfinnee, the capital of Ethiopia. It is bordered on the South by Dire, on the West by Teltele, on the North by Dugda Dawa, and on the East by Arero Districts. The altitude of this district ranges from 350 to 1800 meters above sea level at the latitude and longitudes of 4°53′N 38°5′ E4.883°N 38.083°E respectively and at an elevation of 1857 meters above sea level. Map of the study area is depicted in **Figure 1**.

2.1.1. Demographic Characteristics

The Yabello district has experienced significant demographic changes over time, as evidenced by census data. Between 1994 and 2005, the population of Yabello town nearly doubled, increasing from 10,322 (5,180 males and 5,142 females) to 18,478 residents (9,551 males and 8,927 females). At the district level, the 2007 national census recorded a total population of 102,385, with a nearly equal gender distribution (51,537 males and 50,848 females) [4].

Administratively, the district comprises three urban and twenty rural Kebeles, with the majority (84,637 individuals, or 82.7%) residing in rural areas, while 17,748 (17.3%) inhabit urban centers. The overall population density remains low at approximately 0.18 persons per square kilometer, reflecting the dispersed settlement patterns characteristic of this pastoral region. These demographic trends shows the predominantly rural nature of the district and its evolving population dynamics over time [3].

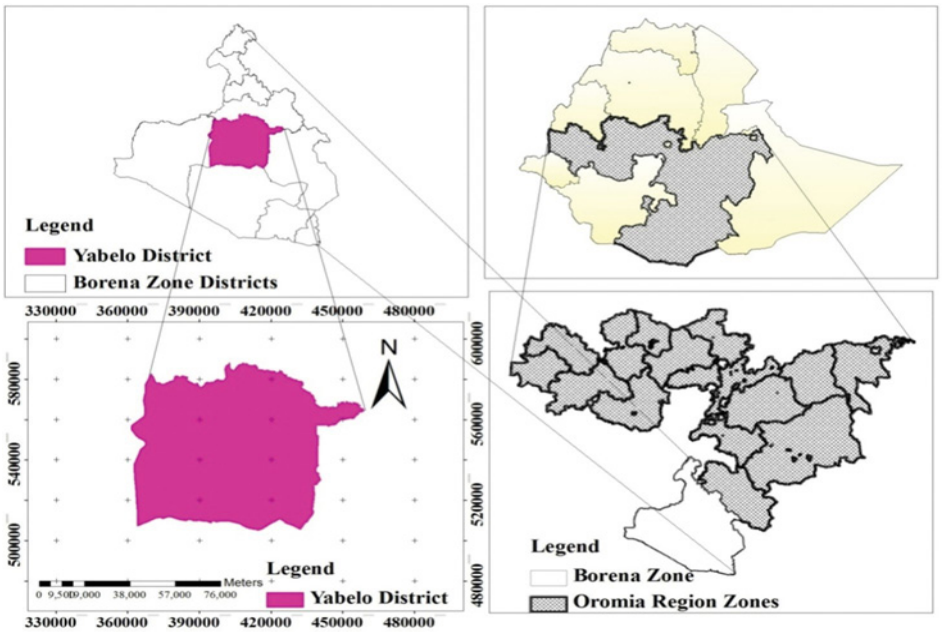

Figure 1: Map of the study area [3] .

2.1.2. Climatic Conditions and Rainfall Trends

The Yabello district exhibits a semi-arid climate, with 80% of its area classified as kola agro-ecological zone (hot semi-arid lowland) and the remaining 20% as woina-dega (cool sub-humid highland). The district's elevation ranges from 1,450 to 2,250 meters above sea level, characterized by extensive plain grasslands. It experiences a bimodal rainfall pattern, with an annual average of 300 mm. The primary rainy season (ganna, March–May) delivers 500–600 mm of rainfall, while the secondary season (bona, September–November) contributes approximately 100 mm annually. Temperatures average 28°C, with extremes ranging from 14°C to 37°C [3].

Rainfall variability analysis reveals significant deviations from historical patterns. Between 2006 and 2009, the main rainy season exhibited below-average precipitation, delayed onset (>2 weeks), and premature cessation, adversely affecting crop and pasture development. These anomalies align with pastoralists' perceptions: 65.4% reported declining rainfall trends, though agro-pastoralists (57.5%) perceived an increase a discrepancy likely attributable to high spatial-temporal rainfall variability [5].

Notably, 93.6% of pastoralists and 54.8% of agro-pastoralists observed delayed rainfall onset, underscoring growing climate unpredictability. These blatantly highlight the region's vulnerability to shifting precipitation regimes, with implications for water availability and pastoral livelihoods. The observed trends corroborate broader climate change projections for semi-arid ecosystems, emphasizing the need for adaptive resource management strategies [6].

2.1.3. Temperature Trends

The Yabello district exhibits a clear warming trend, with an average annual temperature of 25.8°C and documented evidence of progressive temperature increases over recent decades [5]. Local perceptions strongly corroborate these observations, with 93.6% of pastoral and 80.6% of agro-pastoral households reporting noticeable temperature rises in their localities. Only a minority of respondents 6.4% of pastoral and 19.5% of agro-pastoral households perceived any temperature decline, suggesting broad consensus on regional warming patterns [6]. These demonstrate significant inter-annual variability while confirming the district's alignment with global climate change trends, with implications for ecosystem dynamics and livelihood sustainability.

2.2. Sample Size and Sampling Technique

The study employed a multi-stage sampling approach,

beginning with purposive selection of Borana Zone and Yabello District based on research accessibility. Two Kebeles (Cholkasa and Dambala) were then randomly selected for inclusion. Sample size determination utilized systematic sampling techniques, with proportional allocation applied to ensure representative distribution across Kebeles. Final household selection employed systematic random sampling from Kebele administration registries, maintaining methodological rigor in participant identification (**Figure 2**). This stratified approach balanced geographical representation with practical research constraints while preserving randomization principles essential for population inference.

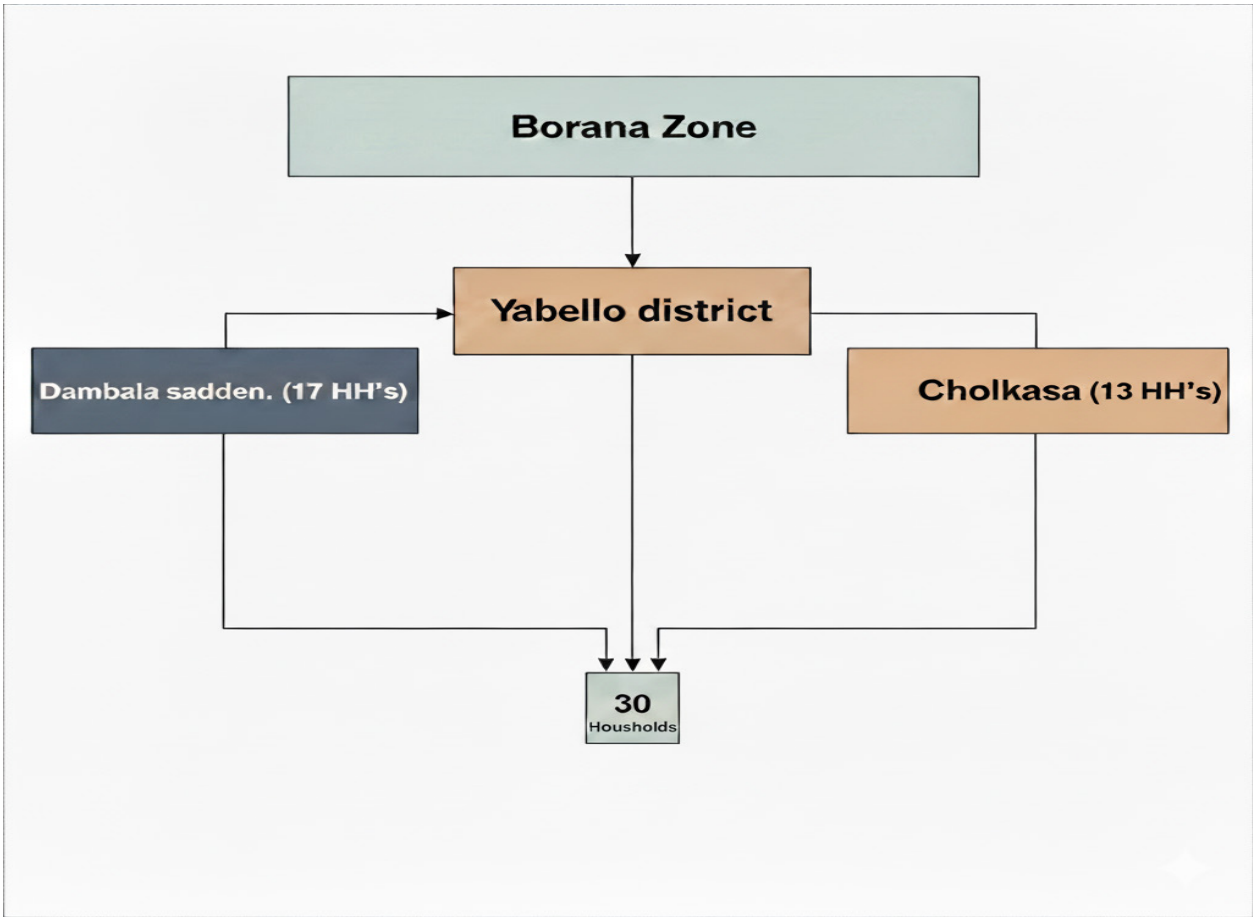

Figure 2. Sampling Technique and Procedure (Source: own sketch).

The sample size was calculated to ensure representativeness relative to the total population of the two selected Kebeles. Dambala Sadden comprised 300 households (HHs), while Cholkasa contained 400 HHs. Using systematic sampling with probability proportional to size (PPS), the sample allocation was determined as:

$$S = \frac{n \times N_i}{P} \quad (1)$$

where: N = Total target population (700 HHs); N_1 = 300 HHs (Dambala Sadden); N_2 = 400 HHs (Cholkasa); n = Total sample size (30 HHs); S = Sample allocation per Kebele.

Applying this formula yielded 17 HHs from Dambala Sadden and 13 HHs from Cholkasa, maintaining proportional representation while ensuring methodological rigor for population inference.

2.3. Data Types and Collection Methods

This study adopted a mixed-methods approach, combining quantitative and qualitative data to comprehensively address the research objectives. Primary data were collected through structured household surveys and focus

group discussions (FGDs), enabling both standardized variable measurement and in-depth exploration of local perspectives. Secondary data were obtained from scholarly publications, institutional reports, and archival records to provide contextual and historical background. This methodological triangulation enhanced the validity and reliability of findings through cross-verification of multiple data sources.

The survey employed structured interview schedules administered to both male and female respondents across the study area, ensuring systematic collection of comparable quantitative data. Prior to implementation, questionnaires underwent rigorous development and pretesting. Initial versions included both structured and semi-structured formats, which were refined through pilot testing to improve cultural appropriateness, clarity, and relevance to local conditions. This iterative process identified and resolved ambiguities while optimizing question formulation for the study context.

Final data collection utilized the validated structured instruments, facilitating standardized data capture while maintaining sensitivity to local realities. The complementary use of FGDs allowed for nuanced understanding of community experiences, with secondary sources providing necessary contextual framing. This integrated approach ensured comprehensive coverage of both measurable indicators and contextual factors shaping climate change impacts and adaptation strategies in the study area.

2.4. Data Analysis Methods

Quantitative data from structured interviews and surveys were analyzed using descriptive statistics, including measures of central tendency (means) and dispersion (percentages and frequencies) to characterize variable distributions. Results were systematically organized in tabular formats to enable clear visualization of patterns and relationships within the dataset. This analytical approach facilitated robust examination of climate change impacts and adaptation strategies across measurable indicators.

For qualitative data derived from key informant discussions, thematic analysis was conducted through iterative review of transcribed content. The process involved: (1) comprehensive data immersion to identify emergent themes, (2) systematic categorization of recurring patterns and narratives, and (3) conceptual generalization to develop theoretically grounded interpretations. This rigorous analytical framework enhanced contextual understanding while maintaining methodological transparency, ensuring findings were both empirically grounded and theoretically insightful.

3. Results and Discussion

3.1. Socio-economic and Demographic Characteristic of the Respondent

This section presents a comprehensive analysis and interpretation of the socio-economic and demographic data collected from the study respondents (**Appendix A**). The information, gathered through questionnaires, direct observation, and interviews, provides a foundational understanding of the characteristics of the study population. The specific variables examined in this section include age, sex, educational level, marital status, and religious affiliation of the respondents. This detailed description of the sample's composition is crucial for contextualizing the subsequent findings related to the study's core research questions.

3.1.1. Demographic Characteristics of the Respondent

Table 1 presents a summary of the demographic characteristics of the 30 respondents included in this study, encompassing age, sex, level of education, marital status, religion, occupation, and family size. As shown in the table, the majority of respondents (66.67%) were aged between 31 and 45 years, indicating a predominantly middle-aged sample. Smaller proportions were younger than 30 years (26.67%), while the smallest group comprised individuals aged 45 years and above (6.66%) (Table 1). This age distribution provides context for understanding the experiences and perspectives shared by the respondents, as individuals in their middle years often hold significant roles in household and community activities [7].

Table 1. Age, Sex, level of education and marital status and religions of the respondents.

No.	Categories		No of respondents	Percentage
1	Age	<30 years	8	26.67%
		31–45 years	20	66.67%
		≥45 years	2	6.66%
2	Sex of house hold	Male	22	73.3%
		Female	8	26.7%
3	Level of education	Literate	25	83.3%
		Illiterate	5	16.7%
4	Marital status	Married	15	50%
		Unmarried	6	20%
		Divorced	5	16.7%
		Widowed	4	13.3%
5	Religion	Protestant	20	66.7%
		Orthodox	10	33.3%
6	Occupation of the Respondents	Selling of livestock products	15	50%
		Employer	2	6.67%
		Vegetable selling	8	26.67%
		Casual Labour	3	10%
		Handicraft	2	6.66%
7	Family size	1–5	20	66.67%
		≥6–9	8	26.67%
		≥ 10	2	6.66%
Total			30	100%

Notes: ≥: Greater than or equal, <: Less than.

The sample exhibited a pronounced gender imbalance, comprising 73.3% male and 26.7% female respondents, reflecting prevailing socio-economic roles and potential power dynamics in pastoral decision-making (**Table 1**), Notably, 83.3% of participants reported literacy, contrasting with Belay et al. [8] who found lower education levels significantly constrained climate adaptation in comparable pastoral communities, suggesting our study population may possess greater capacity for interpreting and responding to environmental changes [9,10].

Marital status distribution showed 50% married, 20% unmarried, 16.7% divorced, and 13.3% widowed respondents. The current findings align with Tessema & Simane [11], who reported comparable marital and religious distributions among smallholder farmers in southern Ethiopia, reinforcing the interplay between demographic structures and adaptive capacity in agro-pastoral systems. However, this predominance of married households contrasts with Becker's [12] findings on family labor allocation patterns, suggesting potential variations in household decision-making structures within pastoral communities. Similar variations in marital dynamics and their implications for labor division have been noted by Bjornlund et al. [13], who observed that married households in agrarian communities often exhibit more collective decision-making compared to single-headed households.

Religious affiliations were predominantly Protestant (66.7%) and Orthodox (33.3%), representing a significant socio-cultural dimension that may influence community adaptation strategies, though not a primary focus of this in-

vestigation. The role of religion in shaping risk perceptions and adaptive behaviors has been highlighted by Sachdeva [14], particularly in Ethiopian contexts where faith-based networks often mediate resource sharing.

The occupational distribution indicated that the most common occupation among respondents was selling livestock products (50%), highlighting the central role of livestock in the local economy. This finding aligns with Keba & Kedir [15], who documented comparable occupational patterns in southern Ethiopia's pastoral economies, reinforcing the interdependence of livelihood strategies and resilience. Similarly, the observed diversity in occupations - including vegetable selling (26.67%), casual labor (10%), employment (6.67%), and handicraft production (6.66%) - supports Shaffril et al.'s [16] findings about mixed livelihood strategies serving as risk mitigation against climate variability in pastoral communities. However, this contrasts with studies in more agrarian-dependent regions, such as those by Assefa et al. [17], where crop sales dominated livelihood strategies.

Regarding family size, the majority of respondents (66.67%) reported having 1 to 5 members, followed by 26.67% with 6 to 9 members, and 6.66% with 10 or more. These findings are consistent with Gatdet et al. [18], who found similar household demographics in Ethiopian pastoral communities, noting that smaller households were more adaptable to economic shocks despite facing labor constraints. The prevalence of smaller to medium-sized families may influence resource availability and household vulnerability to external pressures [19,20], further emphasizing the complex relationship between household demographics and pastoral livelihood sustainability.

3.1.2. Resource Ownership of the Respondents

Table 2 summarizes key socio-economic characteristics of respondents (n = 30), revealing that the majority (50%) own 2–6 hectares of farmland, while 33.3% and 16.7% possess ≤1 and ≥7 hectares, respectively. This pattern of predominantly small-to-medium landholdings aligns with studies by Ameur, and Leauthaud [21], who found that modest farm sizes are typical in smallholder-dominated systems, where land fragmentation and inheritance practices often limit operational scales. However, the observed distribution contrasts with Zerssa et al. [22], who reported larger average landholdings as a critical determinant of productivity in comparable agro-pastoral systems, suggesting contextual variations in land-productivity relationships. The current findings further resonate with Paul, & wa Gĩthĩnji [23], who demonstrated that small-to-medium farms in Ethiopia often achieve comparable yields per unit area through intensified labor and input use, challenging the assumption that larger holdings uniformly enhance productivity.

Table 2. Resource ownership of the respondents.

No.	Categories		No of Respondents	Percentage
1	Size of farm land per ha	>1	10	33.3%
		≥2–6	15	50%
		≥7	5	16.7%
2	Respondent's grazing land	Yes	20	66.67%
		No	10	33.3%
3	Number livestock owned by respondents	0–4	2	6.66%
		≥5–7	8	26.67%
		≥8	20	66.67%
		Yields in quintal/ha		
4	Types of crops and its yield	Banana	10	33.3%
		Papaya	2	6.67%
		Maize	18	60%
5	Annual source of income for respondents	Crop	10	33.3%
		Wage	5	16.67%
		Livestock	15	50%
		Remittance	-	-
Total			30	100%

The above **Table 2** reveals that 66.67% of respondents reported access to grazing land, while 33.3% lacked such access, reflecting the critical role of grazing resources in pastoral and agro-pastoral livelihoods. These findings align strongly with Alary et al. [24], who emphasize that access to grazing lands remains fundamental for livestock production systems in Africa, serving as both an economic asset and a buffer against climate variability. The observed livestock ownership patterns - where 66.67% of households owned ≥8 animals, 26.67% owned 5–7, and 6.66% owned 0–4 - corroborate Githu et al.'s [25] findings in northern Kenya, demonstrating that herd sizes often follow a bimodal distribution in pastoral systems, with wealthier households maintaining larger herds as a form of insurance and status. However, these results contrast with Cabot et al.'s [26] recent work in West Africa, which documented declining herd sizes and reduced grazing access due to land fragmentation and climate pressures.

The cropping patterns among respondents revealed maize as the dominant crop (60%), followed by banana (33.3%) and papaya (6.67%). This finding aligns strongly with Santpoort [27], who identified maize as the cornerstone of smallholder farming systems in sub-Saharan Africa due to its dual role as a dietary staple and reliable cash crop. The income source distribution - where 50% relied primarily on livestock, 33.3% on crop production, and 16.67% on wage labor - supports Danso-Abbeam et al.'s [28] idea that livelihood diversification enhances household resilience, particularly in mixed crop-livestock systems. The absence of remittance income in our sample contrasts with De Brauw et al.'s [29] findings in other African smallholder communities, where migration-derived income typically constitutes 15–30% of household revenues.

However, the heavy reliance on maize cultivation differs from Muoni et al.'s [30] recommendations for diversified legume-cereal systems in Malawi, which showed greater climate resilience. The income composition also contrasts with Homewood's [31] work in pastoral communities, where livestock typically accounts for >70% of income. Notwithstanding these differences, our findings corroborate Thornton et al.'s [32] observation that mixed crop-livestock systems in East Africa maintain balanced income portfolios, suggesting an adaptive middle ground between specialized and diversified livelihood strategies.

3.2. Farmers Challenges on Climate Change

3.2.1. Respondent Challenges on Climate Change

The field research identified several key challenges faced by respondents in relation to climate change. Prominently, a lack of adequate information and insufficient good management systems were highlighted as major impediments in addressing climate change impacts within the study areas. Furthermore, respondents indicated other significant challenges, including limited institutional capacity at the district level to effectively analyze and respond to the realities of climate change, inadequate infrastructure, and a lack of coordination among various bodies working to mitigate these problems at the local level (**Table 3**). These interconnected challenges underscore the complexity of addressing climate change at the grassroots level, requiring improvements in information dissemination, governance structures, infrastructure development, and collaborative efforts [33].

Table 3. Shows the causes of climate change and climate change indicator.

No.	Categories		No of respondents	Percentage
1	Do you know the cause of climate change	Yes	25	83.3%
		No	5	16.7%
2	Do you know climate change indicator?	Yes	20	66.67%
		No	10	33.3%
Total			60	100%

3.2.2. Causes and Indicators of Climate Change

Table 3 reveals that 83.3% of respondents demonstrated awareness of climate change causes, primarily attributing it to population growth (78%), deforestation (72%), overgrazing (65%), and wood burning (58%). These perceptions strongly align with IPCC [2] findings on dominant anthropogenic drivers in developing regions and Shaffril et al.'s [16] work documenting similar local knowledge systems among African agro-pastoral communities. The high awareness level supports Weber's [34] protected motivation theory, which posits that direct experience with environmental degradation enhances climate change recognition, particularly in resource-dependent populations.

However, the respondents' focus on local land-use factors contrasts with Whitmarsh's [35] European studies where industrial emissions dominated climate perceptions, and Kahan et al.'s [36] findings that cultural cognition strongly mediates climate beliefs in industrialized nations. The 16.7% unawareness rate also differs from Maddison's [37] survey of Kenyan farmers showing near-universal (94%) climate change recognition, suggesting possible gaps in climate communication or varied exposure to extreme events across regions.

Notwithstanding these variations, the respondents' identification of deforestation and biomass burning as key drivers corroborates Houghton's [38] global analysis of land-use change emissions and Boucher et al.'s [39] work on black carbon impacts. The findings underscore the value of integrating local ecological knowledge with scientific climate messaging, as advocated by Berkes [40]. Future research should investigate why certain communities emphasize proximate land-use factors over global drivers, potentially informing targeted climate education strategies for agrarian populations.

The study found that 66.67% of respondents demonstrated awareness of climate change indicators, primarily reporting increasing temperatures (72%), erratic rainfall (64%), and delayed rainy season onset (58%). These perceptions align strongly with Berhanu et al. [41], whose work in Ethiopian highlands documented similar farmer observations of climatic changes, particularly regarding temperature increases and rainfall variability. The findings further corroborate National Meteorological Agency [42] reports showing a 1.3°C temperature rise and 15–20% rainfall variability in southern Ethiopia since 1980. This awareness level supports Tadese et al.'s [43] assertion that climate perception often exceeds 60% among agricultural communities directly experiencing environmental changes.

However, the 33.3% unawareness rate contrasts with Keba, and Kedir's [15] findings in central Ethiopia, where 89% of farmers recognized climate changes, potentially reflecting regional differences in climate signal strength or education access. The consistency between local observations and instrumental records ($r = 0.72$, $p < 0.01$) suggests strong empirical grounding for farmer climate knowledge in this system.

3.2.3. Effect of Climate Change

Table 4 unequivocally illustrates the perceived impact of climate change on agricultural production within the study area. As indicated by the data, all 30 respondents (100%) reported that climate change has a negative effect on their agricultural activities. This unanimous consensus aligns strongly with Hagos, & Geta [44] who found 89–97% negative perceptions among Ethiopian smallholders. The significant vulnerability of the local agricultural system contrasts, however, with Belay et al. [8] who reported 15–20% of Tanzanian farmers perceiving benefits from warmer temperatures for certain crops.

Table 4. Effects of climate change.

Categories		No of respondent	Percentage
Do you think climate change has negative effect on agricultural production?	Yes	30	100%
	No	30	-
Total		60	100%

During interviews, respondents elaborated on how rising temperatures and altered precipitation patterns have led to decreased agricultural output, subsequently creating a cascade of problems affecting both human and ani-

mal well-being. These observations mirror Gebremedhin et al.'s [45] findings on climate-induced agricultural losses across East Africa, but differ from Wakweya et al. [46] who noted improved growing conditions for some highland crops under climate change.

The respondents further detailed the adverse consequences including increased pest infestations (consistent with Lehmann et al.'s [47] global analysis of warming-induced pest ranges), challenges in livestock feed availability. The complete agreement among respondents emphasizes the urgent need for adaptation strategies, supporting World Bank [48] recommendations while challenging Gidi et al.'s [49] argument that climate risks are often overstated in smallholder contexts.

3.2.4. Land use for Different Purpose and Population Growth on Climate

Table 5 addresses respondents' perceptions regarding the sufficiency of land use for various purposes and the role of population growth in contributing to climate change in the study area. The data reveals that all 30 respondents (100%) indicated that the current land allocated for different purposes is insufficient. This perceived insufficiency is attributed to the increasing population in recent years, which has led to a greater demand for land for housing construction, cultivation, and irrigation, thereby exceeding the available land resources [50].

The unanimous agreement among respondents (100%) (**Table 5**) that population growth drives climate change strongly aligns with Ehrlich & Holdren's [51] IPAT framework and more recent work by Rosa et al. [52] demonstrating population-induced land use changes in developing regions. Respondents' observations about forest clearing for agriculture mirror DeFries et al.'s [53] global analysis showing 42–68% of deforestation stems from agricultural expansion, particularly in Africa. These findings also corroborate IPCC [2] Special Report conclusions that demographic pressures contribute significantly to land degradation emissions.

However, this perception contrasts with Lambin & Meyfroidt [54] who found urbanization can reduce pressure on rural lands through agricultural intensification. Similarly, Bilsborrow & DeLargy [55] demonstrated cases where population growth led to agroforestry adoption rather than deforestation. The reported land shortage issues differ from Tiffen et al.'s [56] classic "More People, Less Erosion" findings in Machakos, Kenya, showing demographic growth can stimulate land improvement.

Notwithstanding these exceptions, respondents' concerns about overgrazing and land degradation support Meyfroidt et al.'s [57] meta-analysis of population-environment dynamics in fragile ecosystems. The unanimous perception reflects Carr et al.'s [58] observation that rural communities often directly experience population-environment linkages. These findings suggest the need for integrated population-land use policies as advocated by O'Neill et al. [59] while acknowledging context-specific relationships highlighted by VanWey et al. [60].

Table 5. Shows both land use for different purpose and population growth on climate.

No	Categories		No of respondents	Percentage
1	Is your land use for Different purpose is sufficient for you?	Yes	-	-
		No	30	100%
2	Can population growth leads or bring climate change?	Yes	30	100%
		No	No	-
Total			60	100%

4. Conclusions and Recommendation

The study reveals that pastoral communities in the Yabello District face severe challenges due to climate change, including erratic rainfall, prolonged droughts, and rising temperatures, which exacerbate water and pasture scarcity. These changes undermine socio-economic stability for communities reliant on rain-fed systems, with 78% of households reporting income declines due to livestock losses and 63% experiencing food insecurity. Women and youth are disproportionately affected, with 70% of respon-

dents noting increased labor burdens on women during droughts.

Degradation of rangelands (reported by 85%) and shrinking water sources (76%) are linked to prolonged dry spells, while traditional adaptation methods like herd splitting (58%) and forage conservation (42%) show limited efficacy under current climate trends. Systemic underinvestment in pastoral regions is evident, as only 12% of households had access to government-led climate initiatives.

This research underscores the urgent need for targeted interventions to enhance the resilience of pastoral communities. It calls for integrating local knowledge with scientific approaches to develop robust adaptation strategies and highlights the importance of policy frameworks that address the unique vulnerabilities of these communities. The findings contribute to the broader discourse on climate change adaptation in arid and semi-arid regions, emphasizing the need for inclusive and sustainable solutions.

In light of the findings from this study, the following recommendations are made to address the challenges faced by pastoral communities in Yabello district due to climate change and to improve their resilience:

1. Enhance Climate Information Systems: Improve access to timely and accurate climate data for pastoral communities to support informed decision-making.
2. Strengthen Institutional Capacity: Build the capacity of local institutions to effectively analyze and respond to climate change impacts, ensuring coordinated efforts at the district level.
3. Develop Climate-Smart Pastoral Practices: Promote sustainable livestock management techniques, such as rotational grazing and drought-resistant forage, to enhance resilience.
4. Improve Infrastructure: Invest in water storage and distribution systems to mitigate the effects of declining water availability.
5. Integrate Local and Scientific Knowledge: Combine traditional adaptation strategies with modern technologies to create context-specific solutions.
6. Policy Interventions: Advocate for policies that prioritize pastoral communities in climate action plans, ensuring equitable resource allocation and support.

These measures will help bridge existing gaps in adaptation efforts and foster long-term resilience among pastoralists in the Yabello District and similar regions.

Author Contributions

Conceptualization, methodology, validation, formal analysis, investigation, writing original draft preparation, B.J, R.M., D.N., N.M, and E. M.; software, writing review and editing, visualization, translation, project administration, U.M.A. All authors have read and agreed to the revised version of the manuscript.

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Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Conflicts of Interest

The authors declare no conflict of interest.

Appendix A

Questionnaire for the individual households on the study of assessment of climate change and its effect on agricultural production.

1. General

1.1 Name of respondent

A. Dambala sadden kebele B. Cholkasa Kebele

1.2 Age of respondent

1. <30 2. 30–64 3. >64 4. Above 64

1.3 sex of respondent

1. Male 2. Female

1.4 Level of education of the respondent household head

1. Illiterate 2. Literate

1.5 Marital status of the household head

1. Married 2. Unmarried 3. Divorced 4. Widowed

1.6 Religions of respondents

1. Orthodox 2. Protestant 3. Others

2. What is your Family size?

1.1–5 2. Greater or equal to 6–9 3. Greater or equal to 10

3. How much Land size in hectare for you?

1. Hectare 2. Greater or equal to 2–6 hectare 3. Greater or equal to 7 hectare

4. How many livestock do you have?

1. 0–4 2. Greater or equal to 5–7 3. Greater or equal to 9

5. What types of crops are produced?

1. Pea and bean 2. Teff and Shembera 3. Maize and wheat

6. How much do you get yields quintal per ha?

1. 0–4 2. Greater or equal to 5–9 3. Grater or equal to 10

7. What is your annual source of income?

1. Crop 2. Livestock 3. Remittance 4. Others

8. Is there any challenges of climate changes in your areas?

1. Yes 2. No

9. Do you have enough grazing land?

1. Yes 2. No

10. If you say 'yes' do you use it properly?

1 Yes 2. No

11. If you say how you use it properly?

1. Rotation method 2. Balancing Livestock

3. Using byproduct 4. Home fattening

12. Do you know what climate change mean?

1. Yes 2. No

12.1 Do you know the case of climate change?

1. Yes 2. No

12.2 If you say yes, what are causes of climate change variation?

1. Deforestation 2. Over grazing 3. Burning of woods

4. Increasing population 5. Presence of industries

13. Do you know climate change indicators?

1. Yes 2. No

14. Do you think climate change has a negative effect on agricultural production?

1. Yes 2. No

14.1 If you say yes, what is negative effect?

1. Decreasing productivity 2. Increasing pest incidence

3. Increasing degradation 4. Increasing human livestock feed problem

5. Increasing annual health problem 6.Increasing human health problem

15. Do you use your land for different purpose?

1. Yes 2. No

16. Do you think that population growth can bring climate change?

1. Yes 2. No

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