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Original Research

Determinants of smallholder farmers' perceptions of climate change variability and its impacts on livestock production: evidence from Selamago district, South Omo zone, Southern Ethiopia

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Abstract

Climate change is no longer a distant concern for pastoral and agro-pastoral households in Selamago District, South Omo Zone, Southern Ethiopia; it is a tangible reality affecting livestock-based livelihoods. This study examined determinants of smallholder farmers' perceptions of climate change impacts on livestock production using a mixed-method cross-sectional design. Data were collected from 385 households through structured surveys, focus group discussions, and key informant interviews, and analyzed using descriptive statistics, Modified Mann–Kendall (MMK) trend test, and Partial Proportional Odds Model (PPOM). Results show that 53.77% of respondents perceived severe impacts on livestock, while 24.68% indicated climate change had completely transformed farming conditions, and only 4.16% reported no impact. Regarding climate trends, 51.98% of farmers perceived increasing temperatures, and 78.39% observed declining rainfall. MMK confirmed rainfall decreases in January (−1.03 mm/year) and November (−1.13 mm/year), increases in April (0.68), July (0.84), and December (0.42), while annual rainfall was stable (−0.034). Mean annual temperatures averaged 26–27°C, with localized cooling in April (−0.115°C), September (−0.077°C), and January (−0.090°C). PPOM results revealed that the age of the household head (OR=0.90, p=0.003) and farm size (OR=0.04) reduced the likelihood of higher climate impact perception, while livestock ownership (OR=1.86), male-headed households (OR=7.24), grazing land access (OR=8.59), institutional membership (OR=4.12), and prior climate awareness (OR=6.62) increased perception, whereas off-farm activity participation (OR=0.56) reduced it. Overall, findings indicate perceptions are shaped by climatic, socioeconomic, and institutional factors, highlighting the need for improved climate information services, extension support, and access to adaptive resources for resilience-building strategies enhancement.

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INTRODUCTION

Climate change is now widely recognized as one of the most serious global challenges of the 21st century, affecting agricultural productivity, food security, and the livelihoods of rural communities (IPCC, 2023). Across the world, rising temperatures, more frequent droughts and heatwaves, and increasingly unpredictable rainfall patterns are reshaping agricultural systems. These effects are especially pronounced in Africa, and particularly in sub-Saharan Africa, where agriculture is largely rain-fed and highly sensitive to climate variability (Ceccarelli *et al.,* 2022). Among the different agricultural sectors, livestock production is one of the most vulnerable because it depends directly on climate-sensitive resources such as pasture and water. As a result, climate change is contributing to feed shortages, declining pasture quality, water scarcity, increased disease outbreaks, and heat stress. Together, these challenges are reducing livestock productivity, affecting reproduction, and in many cases increasing livestock mortality.

In Ethiopia, livestock plays a vital role in the lives of rural households. It provides food, income, draft power, and serves as a form of financial security for millions of people (Gebremedhin & Peden, 2020). However, this important sector is increasingly under pressure from climate variability. Recurrent droughts, rising temperatures, and irregular rainfall are making it more difficult for farmers and pastoralists to sustain their animals (Belay *et al*., 2024). Evidence from different parts of the country shows that livestock production has been declining over time due to shortages of feed and water, as well as the spread of diseases. In many areas, pastoral households report losing more animals during drought periods compared to previous decades, leading to smaller herd sizes and reduced productivity. Studies from lowland areas also show that farmers clearly recognize these changes and directly link them to declining livestock performance (Alemayehu et al., 2025; Gashaw et al., 2014). For example, in Southern Ethiopia, more than 95% of households reported that increasing temperatures and decreasing rainfall have negatively affected their livestock, mainly through reduced pasture availability and increased heat stress (Megersa *et al.,* 2014).

Farmers' perceptions of climate change are not just theoretical—they are based on lived experiences. These perceptions play a crucial role in how households respond to environmental challenges. For instance, they influence decisions about herd size, livestock types, mobility patterns, and investments in feed and water management (Sunkemo, 2022). Previous research shows that perception is shaped by factors such as education, farming experience, access to climate information, and extension services. These factors also determine whether and how farmers adopt adaptation strategies (Yona et al., 2025). In pastoral areas, households with better access to information and extension support are often more aware of climate risks and more likely to take early action compared to those with limited access (Abegaz & Wims, 2024).

At the regional level, the effects of climate change are becoming increasingly visible in Southern Ethiopia, particularly in pastoral and agro-pastoral areas. In South Omo Zone, where livelihoods depend heavily on livestock, communities are experiencing frequent droughts, rising temperatures, and highly variable rainfall. These conditions have made it more difficult to access pasture and water, leading to reduced livestock productivity and increased disease problems. In Selamago District, the focus of this study, pastoralists report that keeping large herds has become much more difficult than in the past. Over the years, they have observed declining herd sizes, increased livestock illness and death, and reduced animal productivity. These local experiences are consistent with findings from other parts of Southern Ethiopia, where climate change is widely seen as a major challenge to livestock production and household well-being (Bekele & Yimer, 2024).

Despite the growing attention given to climate change in Ethiopia, there is still limited research on how rural households perceive its impact on livestock production, especially at the local level. Most studies tend to focus on climate data or general adaptation strategies, with less emphasis on the underlying factors that shape farmers' perceptions (Asrat & Simane, 2018). Yet, understanding these perceptions is essential because they strongly influence how farmers respond to climate risks and whether they adopt appropriate adaptation measures.

Therefore, this study aims to examine the factors that influence smallholder farmers' perceptions of climate change and its impact on livestock production in Selamago District, South Omo Zone. In addition, the study analyzes temperature and rainfall trends from 1993 to 2023 to better understand the local climate context. By identifying the key factors that shape farmers' perceptions, the study seeks to support the development of more effective extension services, improve access to climate information, and promote practical adaptation strategies. Ultimately, the goal is to contribute to strengthening pastoral resilience and supporting sustainable livestock production in the face of ongoing climate change.

RESEARCH METHODOLOGY

Description of the Study Area

Selamago District, located in the South Omo Zone of Southern Ethiopia, is mainly a rural area where people depend on pastoral and agro-pastoral livelihoods. The district has a hot and dry climate, with temperatures usually ranging between 25°C and 35°C, and it receives low and highly variable rainfall, typically between 400 and 800 mm per year. Rainfall is often unpredictable, with late starts and early endings, which frequently leads to drought (IPCC, 2023).

These climate conditions strongly affect livestock production, which is the main source of livelihood for most households. Animals such as cattle, goats, sheep, and camels depend heavily on pasture and water, both of which are affected by changes in temperature and rainfall (CSA, 2022). In recent years, rising temperatures and irregular rainfall have made it harder to find enough feed and water, leading to reduced productivity and increasing livestock illness and death (Thornton *et al.,* 2009; Gebremedhin & Peden, 2020).

The situation is made more difficult by limited infrastructure and poor access to climate information and extension services (Ceccarelli *et al.,* 2022). Because of this, it is very important to understand how farmers perceive changes in temperature and rainfall, as this influences how they manage their livestock and respond to climate challenges.

Research Design

This study adopted a cross-sectional mixed-method design, integrating both quantitative and qualitative approaches to capture a holistic view of smallholder farmers' perceptions. The quantitative component focused on structured household surveys to gather numerical data on socio-economic characteristics, livestock ownership, farm size, institutional access, and perceived climate impacts. The qualitative component, through focus group discussions (FGDs) and key informant interviews (KIIs), allowed for a deeper exploration of farmers' lived experiences, challenges, and coping strategies. By combining these approaches, the study was able to triangulate findings, ensuring that statistical results were enriched with contextual insights from the local community.

Sampling and Data Collection

A multi-stage sampling approach was employed to ensure representativeness and logical selection of study participants. In the first stage, kebeles within the district were purposively selected based on their livestock production potential and level of exposure to climate-related risks, recognizing that not all kebeles have equal livestock resources or vulnerability to climate variability. This step ensured that the study focused on areas where climate change impacts on livestock are most relevant.

In the second stage, households within the selected kebeles were stratified according to herd size to capture variation among livestock producers. Finally, a household list from each selected kebele was used as a sampling frame, and a total of 385 households were selected using simple random sampling (SRS) with probability proportional to size (PPS) to ensure representativeness across kebeles. The sample size was calculated using the formula developed by Cochran (1977).

$$n = \frac{Z^2 * p * q}{e^2}$$

Where: n = Sample size required, P = estimated variance in the population, as a decimal q = 1-p, Z = Z-score at the desired confidence level. Because the population variability may not be easy to determine in this case, we apply the conservative figure of 50% at 95% level of confidence, e = 0.05, and Z = 1.96. The expected basic sample size, therefore, was computed as below: $Sample\ size = \frac{(1.96)^2 * 0.5 * 0.5}{(0.05)^2}$ = 385 farm households

Data were collected through a combination of structured questionnaires, FGDs, and KIIs. The household survey gathered information on demographic characteristics, farm attributes, livestock ownership, access to grazing land, institutional memberships, and perceptions of climate change and its effects on livestock production. FGDs, comprising 8–12 farmers per group, offered a platform for participants to discuss their observations of climate variability, challenges in livestock management, and adaptation strategies. KIIs targeted community elders, extension officers, and veterinary staff to provide expert insights into institutional support, climate information access, and practical constraints faced by pastoral households. This integrated approach ensured that the study captured both numerical trends and rich qualitative experiences, offering a comprehensive understanding of the factors shaping farmers' climate perceptions.

Data Analysis and Trend Detection

The collected data were analyzed using both descriptive and advanced statistical techniques to provide a comprehensive understanding of smallholder farmers' perceptions of climate change and its impacts on livestock production. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were first used to summarize household characteristics, farm attributes, and perception patterns. Cross-tabulations and chi-square tests were conducted to explore associations between farmers' perceptions and their adoption of adaptive strategies.

For the econometric analysis, a Partial Proportional Odds Model (PPOM) was employed to identify the determinants of farmers' perception levels. The PPOM is particularly useful when some explanatory variables do not satisfy the proportional odds assumption, allowing for flexible modeling of ordered categorical outcomes such as perception levels ranging from no perceived impact to severe impact. The model was estimated using the GOLOGIT2 command in STATA with the AUTOFIT option, ensuring that variables violating the proportional odds assumption were properly handled while retaining constraints for others. Marginal effects were calculated to quantify the influence of each determinant on farmers' perceptions, providing a clear understanding of how socio-economic, institutional, and environmental factors shape climate awareness.

In addition to analyzing perception data, the study applied the Modified Mann–Kendall (MMK) trend test to examine long-term patterns in climatic variables, specifically rainfall and temperature. The MMK test accounts for autocorrelation in time-series data, producing more reliable trend detection than traditional methods. To complement this, Sen's slope estimator was used to measure the magnitude and direction of any observed trends. Rainfall variability was analyzed at monthly, seasonal, and annual scales to capture both short- and long-term changes, while temperature trends were examined monthly and annually to detect periods of warming or cooling. Integrating MMK results with perception data allowed for a comparison between observed climatic changes and local experiences, highlighting areas where farmers' observations align with measured trends and identifying potential gaps in climate information access.

This combined approach ensures a robust understanding of both the statistical trends in climate and how they are perceived by smallholder farmers, forming the basis for developing targeted interventions and adaptive strategies for sustainable livestock production under changing climatic conditions.

Ethical Considerations

Ethical considerations were strictly observed throughout the study. Informed consent was obtained from all participants, and respondents were assured of the confidentiality and anonymity of their responses. Participation was voluntary, and respondents were free to withdraw at any stage. Ethical clearance was obtained from the relevant university review board before data collection commenced.

Table 1: A Summary of the dependent and independent variables

Dependent variables	Description	Expected sign
Farmers' perception of climate change impact on agricultural production	ordinal categorical variable (1=No perceived impact otherwise, 2= Noticeable but not severe impact, 3= Noticeable with some impact, 4= Noticeable with severe impact)	
Explanatory variables		
Sex of household	Dummy (1, male 0, female)	+
Age of household	Continuous (year)	-
Educational level	Continuous (year)	+
Household size	Continuous (number)	+
Farm size	Continuous (ha)	+
Farming experience	Continuous (year)	
Perception of climate change	Dummy (1, if perceive 0, otherwise)	+ +
Access to extension services	Dummy (1, access 0, not access)	+
Farmer-to-farmer extension	Dummy (1, if farmer to farmer extension 0, otherwise)	+ +
	Dummy (1, if access 0,	-
Access to climate information	otherwise) Dummy (1, if member 0,	+ +
Membership in a local institution	otherwise) Continuous (km)	+
Market distance	Dummy (1, if access 0	+
Access to credit service	otherwise)	
Participation in nonfarm activities	Dummy (1, if participate 0 otherwise)	
Access to grazing land		
Livestock ownership	Dummy (1, access 0 not access) Continuous (TLU)	

Source: Own construction, 2026

RESULTS AND DISCUSSION

Descriptive statistics

Perceived Impact of Climate change on agricultural production

Table 2: Perceptions Of Small Holder Farmers About The Impact Of Climate Change On Livestock production

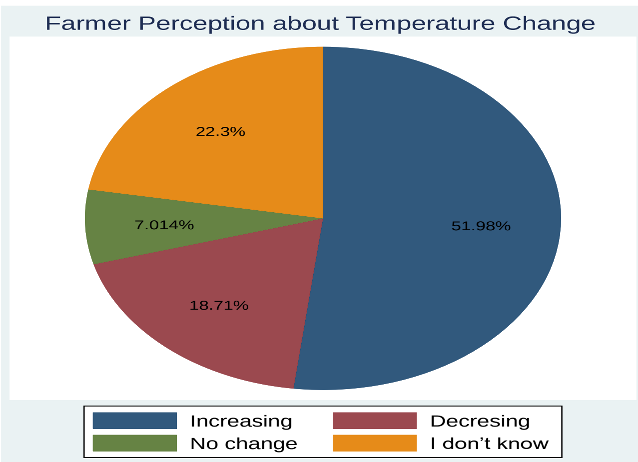
Perceived Impact on Livestock	Frequency	Percentage
No perceived impact	16	4.16
Noticeable but not severe impact	29	7.53
Noticeable with some impact	38	9.87
Noticeable with severe impact	207	53.77
Noticeable impact that completely change	95	24.68
Total	**385**	**100.00**

Source (Own computation from survey results, 2026)

Only 4.16% of respondents reported no perceived impact on Livestock, while 7.53% indicated a noticeable but not severe impact, and 9.87% reported a noticeable impact with some effect. Taken together, only 21.56% of respondents perceived no or mild impacts, suggesting that limited resilience or buffering capacity exists for a small proportion of households. Similar findings have been reported in many rural Ethiopian contexts, where a minority of farmers experience relatively stable production due to access to irrigation, diversified livelihoods, or favorable agro-ecological conditions.

In contrast, a substantial majority perceived serious impacts on agricultural activities. More than half of the respondents (53.77%) reported noticeable impacts with severe effects, while an additional 24.68% indicated that the impact had completely changed agricultural conditions. Cumulatively, 78.45% of respondents experienced severe or transformative impacts, underscoring the widespread vulnerability of the farming system. This pattern is consistent with empirical evidence from Ethiopia and other Sub-Saharan African countries, where climate variability, recurrent droughts, land degradation, and input constraints have significantly disrupted crop production, livestock productivity, and farming calendars.

Overall, the distribution is highly skewed toward the severe end of the impact scale, indicating that agricultural activities in the study area are strongly and adversely affected, as perceived by most respondents. Such skewness reflects structural challenges commonly documented in rain-fed agricultural systems, including high dependence on climate-sensitive resources, limited access to modern inputs, and weak institutional support. The findings therefore highlight the urgent need for targeted agricultural interventions, such as climate-smart agriculture practices, improved extension services, and supportive policy measures aimed at enhancing adaptive capacity and reducing farmers' vulnerability to ongoing and future shocks.



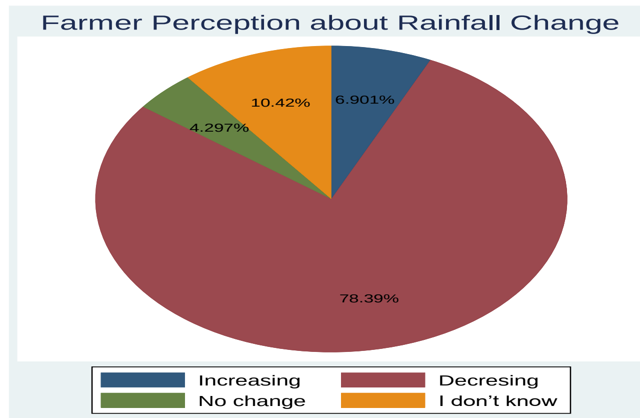
Source: Own computation results (2026)
Figure 1: Histogram of Farmer perception about temperature change

Perceptions of farmers about temperature change based on a four-point Likert scale of agreement (Increasing (1), Decreasing (2), Stable (3), I don't know (4))

The pie chart presents farmers' perceptions of temperature change using a four-point Likert scale (Figure 1): increasing, decreasing, no change, and "I don't know." The results show that a majority of farmers (51.98%) perceive temperature to be increasing, indicating a strong and widely shared view that temperatures have risen over time. This dominant perception suggests that rising temperatures are not only observable but are also directly experienced by farmers in their daily agricultural activities, particularly through increased heat stress on livestock, reduced pasture quality, and challenges in farm operations. Similar findings have been reported by scholars such as Asrat and Simane (2018) and Esayas *et al.* (2019), who found that most smallholder farmers in Ethiopia perceive a clear increase in temperature, often linking it to declining agricultural productivity and livestock performance.

In contrast, 18.71% of farmers perceive temperature to be decreasing, while 7.01% report no noticeable change. This variation highlights differences in local experiences, access to information, and individual interpretation of climate trends. Such heterogeneity in perception is also noted in studies by Berhanu *et al.* (2026), which emphasize that farmers' understanding of climate change can vary depending on personal experience, education, and exposure to extension services. Additionally, a considerable proportion of respondents (22.30%) indicated "I don't know," suggesting a gap in climate awareness or limited access to reliable climate information. This aligns with findings by Abid *et al.* (2019), who argue that inadequate access to climate information can constrain farmers' ability to accurately perceive and respond to climate variability.

Overall, while the majority of farmers recognize increasing temperatures, the presence of mixed perceptions and uncertainty among a significant portion of respondents suggests that improving access to climate information and extension services remains essential. Enhancing awareness can help ensure that farmers not only perceive climate change more accurately but are also better equipped to adopt appropriate adaptation strategies.



Source: Own computation results (2026)
Figure 2: Histogram Of Farmer Perception ABOUT RAINFALL Change

The pie chart depicts farmers' perceptions of rainfall change based on a four-point Likert scale (Figure 2): Increasing, Decreasing, Stable, and I don't know. The results clearly indicate that an overwhelming majority of farmers (78.39%) perceive rainfall to be decreasing, suggesting that declining rainfall is the dominant and most widely experienced climate-related concern in the study area. This perception is strongly supported by farmers' lived experiences, including delayed onset of rains, shorter rainy seasons, and frequent dry spells, all of which directly affect pasture availability, crop growth, and water access. Similar findings in Southern Ethiopia also report that rural households consistently associate reduced rainfall with declining agricultural productivity and increased livestock stress (Megersa *et al.,* 2014; Alemayehu *et al.,* 2025), reinforcing the credibility of these perceptions.

However, it is important to note that this dominant view is not universally shared. A small proportion of respondents perceive rainfall as increasing (6.90%) or remaining stable (4.30%), suggesting that some farmers experience localized or short-term rainfall improvements. These contrasting views may be explained by spatial variability in rainfall distribution, differences in agro-ecological settings, or access to irrigation and microclimatic advantages. Studies such as Berhanu *et al.* (2026) also emphasize that climate perception is not uniform and can vary significantly even within the same district due to micro-level environmental differences and individual farming experiences. In addition, 10.42% of respondents reported "I don't know," which highlights uncertainty and limited access to reliable climate information. This agrees with Abid *et al.* (2019), who argue that inadequate climate information services often lead to incomplete or uncertain perceptions among farmers.

Overall, while the dominant perception strongly supports the narrative of declining rainfall, the presence of alternative views and uncertainty suggests that climate perception is shaped by both actual climatic variability and differences in information access. This reinforces the need for improved climate communication systems, early warning services, and localized weather forecasting to ensure that farmers receive accurate and actionable information for decision-making.

Features of Temperatures and Rainfall Variability and Trends

Rainfall Variability and Trends

The analysis of rainfall in table 3 below reveals notable variability over time at monthly, seasonal, and annual scales. Monthly mean rainfall ranges from 74 mm in January to 87 mm in June, with standard deviations between 21 and 36 mm. The coefficient of variation (CV) ranges from 26% to 46%, indicating moderate to high variability in some months, particularly during the late rainy season in August and September. In contrast, seasonal totals are more stable: the CV for the Belg season (March–May) is 22%, and for the Kiremt season (June–September) it is 17%. Annual rainfall shows the lowest variability, with a CV of only 12%, suggesting that, although rainfall fluctuates considerably from month to month, the overall annual totals remain relatively consistent.

Trend analysis using the Modified Mann–Kendall test and Sen's slope estimator indicates that rainfall patterns are shifting in certain months. January and November show decreasing trends, with Sen's slopes of −1.03 mm/year and −1.13 mm/year, respectively, suggesting drier conditions at the start and end of the year. In contrast, April, July, and December exhibit statistically significant increases in rainfall, with slopes of 0.68 mm/year, 0.84 mm/year, and 0.42 mm/year, respectively. Other months, including February, March, May, June, August, September, and October, show small positive or negative changes, but these are not statistically significant, indicating no clear trend.

At the seasonal scale, both the Belg and Kiremt seasons show slight increases in rainfall, with Sen's slopes of 0.19 mm/year and 0.154 mm/year, respectively. However, these changes are not statistically significant, highlighting overall stability in seasonal rainfall totals. Similarly, annual rainfall exhibits a minimal decreasing trend (−0.034 mm/year), which is also statistically insignificant, confirming that total rainfall has not changed meaningfully over the study period.

Taken together, these results suggest that while total seasonal and annual rainfall has remained largely stable, there is clear evidence of intra-annual redistribution, with some months becoming wetter and others drier. This kind of variability, particularly during the early and late months of the rainy seasons, has important implications for agriculture, including the timing of planting, crop growth, and water resource management. Even without significant changes in total rainfall, shifts in the distribution and timing of rainfall can affect sowing periods, crop development, and the availability of water for both crops and livestock, underscoring the need for localized climate-informed planning.

Table 3: Descriptive and Modified Mann-Kendall trend statistics of rainfall variability

Variables	Mean	STD	CV	Max	Min	Sen's slope	Modified MK	P-value	sig
Jan	74	27	36	127	22	-1.03	-4.23	0.000	***
Feb	76	27	36	136	21	0.34	1.16	0.246	ns
Mar	81	30	37	127	1	-0.07	-0.79	0.424	ns
Apr	79	29	37	154	22	0.68	4.89	0.000	***
May	78	28	36	146	27	0.22	1.23	0.224	ns
Jun	87	29	34	162	29	0.01	0.00	1.000	ns
Jul	85	31	37	196	31	0.84	4.89	0.000	***
Aug	76	30	40	149	19	-0.12	-1.19	0.234	ns
Sep	78	36	46	144	-17	-0.80	-1.64	0.100	ns
Oct	84	25	30	144	21	0.12	0.96	0.339	Ns
Nov	84	24	28	143	24	-1.13	-7.06	0.000	***
Dec	79	21	26	126	21	0.42	3.16	0.0015	***
Belg	238	53	22	366	53	0.19	0.59	0.549	Ns
Kiremt	327	57	17	450	57	0.154	0.074	0.9409	Ns
Annually	963	112	12	1216	112	−0.034	−0.082	0.934	Ns

Note: *** means significant at 1 % and probability level.

Source (Own computation from survey results, 2026)

Mean temperature variability and trend

Table 4 presents the descriptive statistics and Modified Mann–Kendall (MMK) trend results for mean temperature at monthly, seasonal, and annual levels. Overall, the results indicate that mean temperatures in the study area have remained relatively stable over time, averaging around 26–27°C, with low variability (coefficient of variation mostly below 8%). This suggests that, despite widespread concerns about climate change, average temperatures have not shown substantial year-to-year fluctuations. Similar findings have been reported in station-based studies in southern Ethiopia, where mean temperature trends are often weak or statistically insignificant (Ateba *et al.,* 2024; Sunkemo, 2022).

At the monthly level, the MMK results reveal that most months do not exhibit statistically significant trends, indicating the absence of a consistent warming or cooling pattern throughout the year. However, some variations are evident. January shows a marginally significant decreasing trend, while April exhibits a strong and statistically significant cooling trend, suggesting noticeable temperature reductions during the pre-rainy season. September also shows a significant decline, indicating cooling toward the end of the main rainy season. These month-specific variations are consistent with findings by Thornton *et al.* (2009), who note that localized climatic conditions, such as increased cloud cover and rainfall, can lead to temporary cooling effects. Similarly, studies in the Omo–Gibe basin and Rift Valley regions have documented seasonal and monthly fluctuations in temperature that do not necessarily align with long-term warming trends (Gebremedhin & Peden, 2020).

Seasonal analysis further supports the overall stability of temperature. The Belg season shows a slight but statistically insignificant decline, while the Kiremt season indicates a weak cooling trend with only marginal significance. At the annual level, the trend remains minimal and statistically insignificant, with very low variability. This aligns with findings by Ateba *et al.* (2024), who reported that although extreme temperatures are increasing in some parts of Ethiopia, mean annual temperatures often show limited or non-significant changes at localized scales.

However, these localized results contrast with broader national and regional studies. For example, reports by the IPCC (2023) and indicate a general warming trend across Ethiopia, often ranging between 0.1°C and 0.3°C per decade, particularly in minimum temperatures. Studies conducted in the northern highlands and central plateau also show more pronounced warming trends compared to southern lowland areas (Belay *et al.,* 2024). This difference highlights the spatial variability of climate change, where national-level trends may not always reflect local realities.

In summary, the study area has experienced relatively stable mean temperatures over the past decades, with some localized cooling trends in specific months such as April and September. These findings are supported by empirical literature and emphasize that climate change impacts are not uniform across locations or time periods. Therefore, localized climate analysis remains crucial for effective agricultural planning, particularly in climate-sensitive systems like livestock production, where seasonal variations can be more important than long-term averages.

Table 4: descriptive and modified mann-kendall trend statistics of mean temperature

Variables	Mean	Max	Min	STD	CV	Sen's slope	Modified MK	P-value	sig
Jan	26	30	22	2.5	8.07	-0.090	-1.958	0.0503	*
Feb	26	32	21	2.5	7.95	0.006	0.110	0.9122	ns
Mar	26	30	21	2.03	6.56	0.020	0.456	0.6483	ns
Apr	26	30	21	2.40	7.73	-0.115	-2.752	0.0059	***
May	26	30	22	2.07	6.68	-0.041	-1.070	0.2844	**
Jun	26	28	23	1.50	4.83	-0.059	-2.086	0.0370	ns
Jul	26	31	23	2.23	7.18	-0.023	-0.558	0.5767	ns
Aug	26	30	22	2.22	7.17	-0.034	-0.795	0.4268	ns
Sep	27	30	23	2.00	6.31	-0.077	-2.095	0.0361	**
Oct	26	30	20	2.32	7.50	-0.036	-0.914	0.3609	ns
Nov	27	29	23	1.81	5.83	-0.020	-0.464	0.6426	ns
Dec	26	31	22	2.10	6.77	-0.019	-0.501	0.6164	ns
Belg	26	28	24	1.14	3.68	-0.0248	-0.9377	0.348	ns
Kiremt	26	28	24	1.01	3.29	-0.0386	-1.654	0.0981	*
Annually	26	27	24	0.64	2.08	-0.0118	0.9381	0.3481	ns

Note: *** means significant at 1 % and probability level

Source (Own computation from survey results, 2026)

Perception of Smallholder Farmers on Climate Change and Its Effects on Livestock Production

This section examines how smallholder farmers perceive climate change and its effects on livestock production over the past 31 years, using a Partial Proportional Odds Model (PPOM). The PPOM is particularly useful when some explanatory variables do not meet the proportional odds assumption, as it allows for a more flexible analysis of ordered outcomes (Williams, 2006). In this study, the dependent variable captures farmers' perceptions of the severity of climate change impacts on livestock production, classified into four categories: no perceived impact, noticeable but not severe impact, noticeable with some impact, and noticeable with severe impact.

Results of partial proportional odds model (PPOM)

The model was estimated using the GOLOGIT2 command in STATA, with the AUTOFIT option (Williams, 2006). This approach allows the partial proportional odds model (PPOM) to handle situations where some explanatory variables do not meet the proportional odds (parallel-lines) assumption, while keeping the restriction for variables that do. In simpler terms, the PPOM only relaxes the proportional odds constraint for the variables that need it, allowing for a more accurate and flexible estimation of farmers' perceptions.

The AUTOFIT procedure performs a series of Wald tests to check whether the proportional odds assumption holds for each explanatory variable. Variables that satisfy the assumption are then jointly tested using a global Wald test, with degrees of freedom equal to the number of parameters meeting the restriction.

Table 5 presents the results of the PPOM, showing how various factors influence farmers' perceptions of climate change impacts on agricultural production. The reference category used is "noticeable impact that completely changes agricultural production," providing a baseline for comparison across perception levels.

Age of Household Head (AGE_HH)

The analysis shows that the age of the household head significantly shapes how farmers perceive the impacts of climate change on livestock production. Older household heads are less likely to report low levels of perceived impact, which suggests that younger farmers are more sensitive to climate-related changes. This heightened awareness among younger farmers may stem from greater exposure to climate information through education, media, and extension services. Similar patterns have been observed in Ethiopia by Asrat and Simane (2018) and Esayas *et al.* (2019), where younger farmers tend to exhibit stronger climate risk awareness. On the other hand, some studies (e.g., Berhanu *et al.,* 2026) suggest that older farmers' long-term experience can improve the accuracy of their climate impact perceptions, indicating that age effects may vary depending on the socio-ecological context.

Farm Size (FARM_SIZE)

Farm size also plays a significant role, particularly in the category "no perceived impact." Farmers with larger landholdings are less likely to report no impact from climate change, implying that larger farms increase farmers' exposure to climate risks such as rainfall variability, soil degradation, and yield fluctuations. This aligns with findings by Amare *et al.* (2019) and Thornton & Herrero (2018), which show that larger landowners tend to be more conscious of climate-related production risks. However, Morton (2007) argues that smallholders may sometimes perceive climate change more acutely because they are more vulnerable, highlighting that land size can influence perception differently depending on livelihood security.

Tropical Livestock Units (TLU)

Ownership of livestock significantly raises the likelihood of perceiving climate change impacts. Households with larger herds are more aware of climate risks, likely because livestock are highly sensitive to drought, feed shortages, and heat stress. This result is consistent with studies by Rojas-Downing *et al. (*2017) and Ateba *et al.* (2024), which link livestock exposure to climate risk perception in African pastoral systems. Yet, Naod *et al*. (2020) note that livestock diversification can sometimes buffer households against climate shocks, potentially reducing perceived risk among wealthier herders.

Sex of Household Head (SEX_HH)

The sex of the household head strongly influences climate change perception. Male-headed households are more likely to perceive climate impacts, likely due to greater access to extension services, markets, and decision-making platforms. This finding echoes Ampaire *et al.* (2020) and Jost *et al.* (2016), who highlight gender disparities in adaptive capacity. Conversely, Haque *et al.* (2023) suggest that women may perceive climate risks more acutely because of their responsibilities for food and water provision, showing that gender effects can be context-specific.

Participation in Off-farm/Non-farm Activities (PARTOFFNON)

Households engaged in off-farm or non-farm activities are less likely to perceive climate change impacts. Diversifying income outside agriculture may buffer families against climate shocks, reducing their sensitivity to environmental changes. Similar conclusions are reported by Alobo Loison (2015) and Nyathi, (2025), who highlight the resilience benefits of livelihood diversification. However, Briggeman (2011) caution that excessive off-farm work may divert attention from on-farm climate signals, potentially lowering perception accuracy.

Access to Grazing Land (GLA)

Access to grazing land significantly increases the likelihood of perceiving climate impacts. Households with grazing land are more exposed to pasture degradation and water scarcity, making climate effects more tangible. Grossi *et al.* (2019) and Robinson *et al.* (2014) support this finding, showing that land-based livestock systems are highly sensitive to climate variability. Yet, Araoset *et* al. (2021) note that unequal land access can mediate perception, as wealthier households may absorb shocks more effectively.

Membership in Institutions (MEM_INST)

Being part of institutions like cooperatives or farmer organizations significantly improves climate change perception. Institutional membership provides access to information, training, and social networks, enhancing awareness of climate risks. This is consistent with Nyamwanza & Kujinga (2017) caution that the effectiveness of institutions can vary widely.

Perception of Climate Change (PERCC)

Finally, a farmer's own perception of climate change strongly shapes their understanding of its impacts on livestock production. Those who recognize climate variability are much more likely to perceive its agricultural consequences. This finding aligns with Ayal and Leal Filho (2017) and Abid *et al.* (2019), emphasizing that prior awareness is a key determinant of adaptive behavior. Still, Howe *et al.* (2015) reminds us that perception is also influenced by social and psychological factors, not just observable climatic changes.

Table 5: Partial Proportional Odds Model (PPOM) Of Farmers PERCEPTION ABOUT CLIMATE Change Impact On Agriculture Production

	Farmers Perception about Climate Change Impact on Agricultural production											
	No perceived impact			Noticeable but not severe impact			Noticeable with some impact			Noticeable with severe impact		
Variable	Odds Ratio	Std. Err.	P(>|z|)	Odds Ratio	Std. Err.	P(>|z|)	Odds Ratio	Std. Err.	P(>|z|)	Odds Ratio	Std. Err.	P(>|z|)
AGE_HH	0.903556	0.031039	0.003	0.9291	0.0194	0.000	0.9963	0.0137	0.786	1.0213	0.0133	0.106
EDU_LVL	0.884772	0.074941	0.148	0.9999	0.0516	0.999	1.0682	0.0431	0.102	1.0784	0.0421	0.053
HH_SIZE	1.081778	0.048747	0.081	1.0818	0.0487	0.081	1.0818	0.0487	0.081	1.0818	0.0487	0.081
FARM_SIZE	0.039236	0.037893	0.001	0.8330	0.3343	0.649	0.8889	0.2255	0.643	1.3968	0.3199	0.145
MKT_DIST	1.701799	0.634254	0.154	1.0108	0.1758	0.951	0.9554	0.1324	0.742	1.1361	0.1480	0.327
TLU	1.863523	0.356095	0.001	0.9883	0.0776	0.881	1.0820	0.0704	0.225	1.1163	0.0709	0.083
SEX_HH	7.243769	4.116587	0.000	2.1392	0.9382	0.083	1.0579	0.3473	0.864	1.7313	0.6477	0.142
CR_ACC	0.835988	0.476368	0.753	1.1459	0.3783	0.680	0.6557	0.1697	0.103	0.8367	0.2193	0.496
PARTOFFNON	0.564462	0.118356	0.006	0.5645	0.1184	0.006	0.5645	0.1184	0.006	0.5645	0.1184	0.006
EXT_ACC	1.117162	0.259859	0.634	1.1172	0.2599	0.634	1.1172	0.2599	0.634	1.1172	0.2599	0.634
GLA	8.586969	5.799511	0.001	1.1815	0.4124	0.633	1.0709	0.2954	0.804	0.7345	0.1939	0.242
FFE	0.928089	0.502555	0.890	1.0158	0.3214	0.961	1.0143	0.2578	0.955	0.7223	0.1831	0.199
MEM_INST	4.116511	2.738273	0.033	2.8551	1.1103	0.007	0.9583	0.2909	0.888	1.2454	0.4069	0.502
PERCC	6.618182	4.666798	0.007	1.4777	0.5753	0.316	1.1890	0.3242	0.525	0.6843	0.1817	0.153
CLIM_INFO	2.734082	1.507652	0.068	1.2375	0.4145	0.525	0.8248	0.2483	0.522	0.9000	0.2751	0.730
_cons	7.691119	15.68571	0.317	13.3874	14.763	0.019	0.9963	0.0137	0.367	0.0413	0.0356	0.000

Source: Own computation results (2026)

CONCLUSION

This study finds out that smallholder farmers in Selamago District view climate change as a major factor constraining livestock production, where the perception of climate impacts is influenced by socio-economic, institutional, and resource variables. Ownership of livestock, availability of grazing land, institutional membership, climate change awareness in the past, and male-headed households raise the probability of recognizing climate impacts, while older individuals, large-scale farming operations, and non-farm economic activities reduce this perception, suggesting that the presence of climate-sensitive assets and information are necessary conditions for understanding climate risks. Therefore, enhancing perception is an inherent process and calls for concerted measures aimed at improving access to relevant information on climate issues alongside institutional arrangements to facilitate knowledge sharing and learning processes. On the other hand, there is a need for livestock-based extension services to encourage adaptation through proper grazing practices, feeding, and herd management, considering that there are inequalities between different population segments in accessing information and resources.

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Conflict of Interest

The authors declare no conflicts of interest.

Data availability

The corresponding author may supply the data used to support the findings of the research upon request.

Ethical clearance

The research questionnaire and focused group discussion checklists, utilized for data collection were examined and authorized by the Jinka University College of Agriculture and Natural Resources Research and Ethical Review Committee.

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