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# Smallholder Farmers' Perceptions of Climate Variability and Livestock Adaptability in the Eastern Cape Province, South Africa

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***ABSTRACT***

*Climate variability poses significant challenges for livestock farming, especially in areas where smallholder farmers depend on it. This study investigated farmers' perceptions of climate variability, validated these perceptions with empirical data, and assessed their perceptions of livestock species' adaptability. A cross-sectional survey of 495 livestock farmers in the Eastern Cape was conducted using a multistage sampling technique. Primary data were collected using a structured questionnaire and validated against climate data obtained from the South African Weather Services. Analysis involved descriptive statistics, trend analysis, and weighted rank indices. Findings reveal that farmers have observed reduced precipitation and rising temperatures over the past 20 years, aligning with empirical data showing increased temperatures and decreased rainfall. These climatic changes pose severe risks, including drought and low water levels, that impact productivity and household welfare. Farmers prefer goats, indigenous chickens, and sheep for their perceived resilience to heat, water scarcity, and feed shortages, reflecting their adaptive strategies. However, limited access to essential support services may hinder their ability to utilise these resilient options. The study recommends enhancing support for farmers by improving access to climate data, resources, and adaptation services, and by strengthening collaborations between farmers and meteorological institutions.*

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## 1. INTRODUCTION

Climate change refers to long-term changes in weather patterns over decades or longer, driven by natural processes and human activities, especially increased greenhouse gas emissions, leading to significant changes in temperature, precipitation, and wind patterns, such as global warming (Abbass *et al.,* 2022; Lieber *et al*., 2022). In contrast, climate variability involves short-term fluctuations in climate conditions around the long-term average, occurring over months to decades, and includes phenomena such as El Niño and La Niña, causing significant but temporary variations in weather patterns within a stable average climate (Lieber *et al*., 2022). Understanding these distinctions is crucial for assessing how farmers perceive climate variability and adapt their livestock management practices accordingly. The way farmers interpret and respond to these climatic changes and variability directly influences their decisions and strategies for maintaining and adapting their livestock production systems. Yang *et al*. (2021) argue that farmers' responses vary depending on whether they face short-term weather shocks or long-term climate change.

The perception of climate change and variability among smallholder farmers is a critical factor in their adaptation processes (Fierros-González & Lopez-Feldman, 2021; Abazinab *et al*., 2022). Studies (Popoola *et al*., 2019; Yang *et al*., 2021; Abazinab *et al*., 2022) have shown that farmers' awareness and understanding of climate phenomena are significant factors in their ability to implement effective adaptive measures. Fierros-González and Lopez-Feldman (2021) emphasise that farmers' responses to the impacts depend on the weight they assign to these perceptions. Farmers interpret and internalise changes in weather patterns and environmental conditions based on their experiences and observations, which, in turn, affect their agricultural practices, particularly livestock management. These perceptions encompass their comprehension, acknowledgement, and response to the effects of climate change on their animals, land, and overall livelihoods (Silvestri *et al*., 2012; Zampaligré *et al*., 2014; Popoola *et al*., 2019; Yang *et al*., 2021; Abazinab *et al*., 2022).

Although farmers' perceptions of climate change and variability are crucial, Abazinab *et al*. (2022) argue that these perceptions are often individualised and influenced by local conditions, highlighting the need to align them with actual climate data. Ayal and Leal Filho (2017) emphasise differences in observations between scientists and farmers, noting that their distinct

Vol. 54 No. 2, 2026: 215-240
10.17159/2413-3221/2026/v54n2a19265 (License: CC BY 4.0)

viewpoints shape their understanding of climate change and variability. Ayal and Leal Filho (2017) further explain that this divergence can lead to situations in which scientific findings align with some farmers' perceptions but differ from those of others.

Building on these insights into the individualised nature of farmers' perceptions and the divergence between scientific and local perceptions, it is essential to examine how farmers perceive the adaptability of different livestock species to climate variability. Studies across various African countries have reported farmers' preferences for livestock species in the face of climate change (Boru *et al*., 2014; Megersa *et al*., 2014; Kagunyu & Wanjohi, 2014; Opiyo *et al*., 2015; Watson *et al*., 2016; Wako *et al*., 2017; Cuni-Sanchez *et al*., 2018; Volpato & King, 2019; Zampaligré *et al*., 2014; Phiri *et al*., 2021). However, while there is significant research on climate change impacts and livestock preferences in Africa, there is a notable gap in understanding how farmers perceive the adaptability of different livestock species, specifically in relation to climate variability, especially in South Africa. These perceptions shape farmers' management strategies and decisions on livestock selection and adaptation. Therefore, investigating how farmers perceive livestock adaptability provides valuable insights into how they adjust their practices to cope with climate variability. This study has aimed to address this gap by exploring the following questions: (1) How do smallholder livestock farmers perceive climate change and variability? (2) How do farmers' perceptions of climate change align with historical climate data trends in the study area? (3) What are farmers' perceptions of the adaptability of different livestock species to climate change?

The paper is structured as follows: first, the study's introduction is provided. Second, the research methods are described. Third, the study's results are presented, followed by a discussion in the fourth section. The fifth section outlines the study’s limitations and suggests directions for future research. Finally, the conclusion is presented.

## 2. MATERIALS AND METHODS

### 2.1. Description of the Study Area

The study was conducted in the Eastern Cape Province. The Eastern Cape has the highest prevalence of agricultural households in the country, with 27.9% of households engaged in agriculture. Among these households, 45% solely own livestock, while 37.2% engage in mixed farming (Ngarava, 2019). Despite its agricultural significance, the Eastern Cape remains one

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of the poorest provinces in South Africa, with numerous households experiencing various levels of food insecurity (Stats SA, 2018). The Eastern Cape is presented in Figure 1.

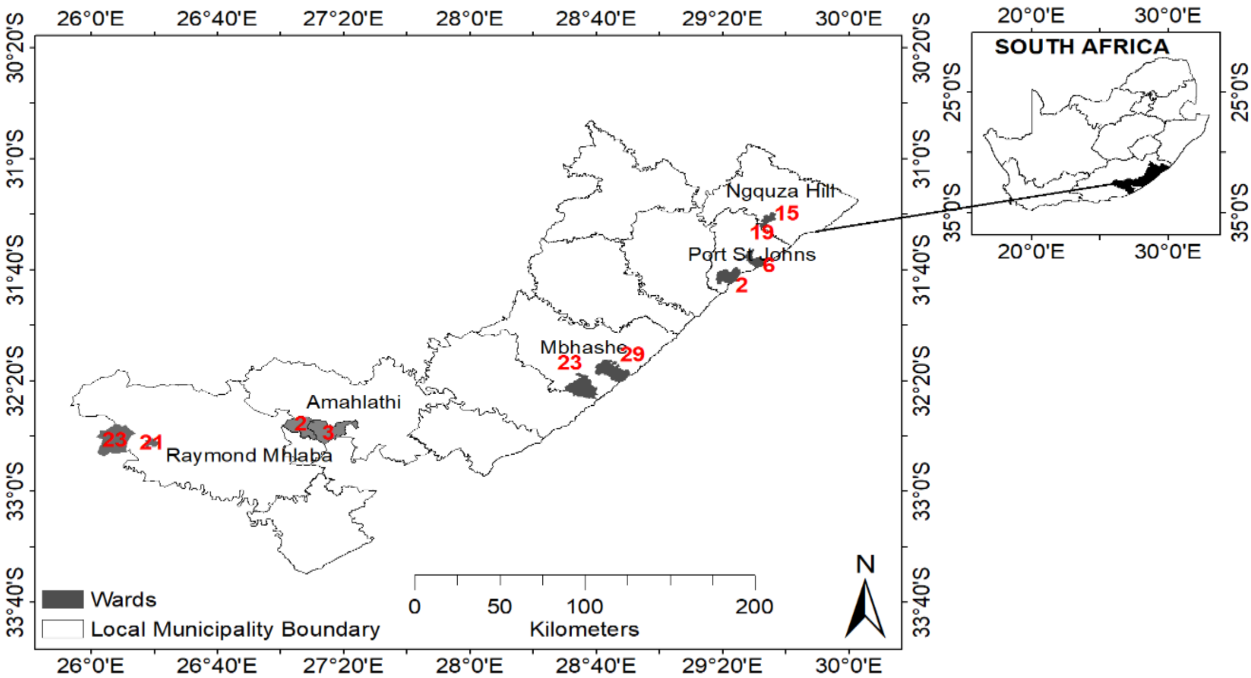


**FIGURE 1: Map of the Study Area – Located in the Eastern Cape (Source: Department of GIS, University of Fort Hare, 2023)**

*Note: The red numbers indicate wards*

The climate in the Eastern Cape is characterised by significant spatial and seasonal rainfall variability, influenced by proximity to the ocean and geographic direction. Coastal regions are generally wetter and milder, with warm-temperate to subtropical climates and occasional flooding (Taruvinga *et al*., 2022). In contrast, inland areas are drier and hotter, exhibiting arid to semi-arid conditions with annual rainfall ranging from 350 to 550 mm (Zengeni *et al*., 2016). These inland regions also endure periodic droughts (Archer *et al*., 2022). The Eastern Cape Province in South Africa stands out due to its diverse climate and numerous smallholder livestock operations (Graw *et al*., 2017; Goni *et al*., 2018), emblematic of these challenges. Farmers in this province confront evident changes in weather patterns, unpredictable rainfall, and rising temperatures, all of which disrupt conventional farming practices (Muller & Shackleton, 2014; Popoola *et al*., 2019). This intricate relationship between climate change and livestock farming presents a multifaceted challenge, necessitating a comprehensive understanding of how farmers perceive, adapt to, and strategise in response to these environmental shifts.

### 2.2. Research Design, Sampling Procedure and Sample Size

The study employed a cross-sectional design to evaluate livestock farmers' perceptions of climate change and their livestock selection. A multistage sampling procedure was used. Initially, the OR Tambo and Amathole districts were selected for their high concentration of livestock-owning households (StatsSA, 2016) and vulnerability to climate-related issues, having been declared drought disaster areas in 2018 (Mahlalela *et al*., 2020). Local municipalities within these districts were selected based on diverse agroecological zones and rainfall patterns, including high-, average-, and low-rainfall areas (Obi& Maya, 2021; Mahlalela *et al*., 2020). In OR Tambo, Ngquza Hill and Port St. Johns were selected (high rainfall) (Taruvinga *et al*., 2022), while in Amathole, Mbashe (average rainfall), Raymond Mhlaba, and Amahlathi (low rainfall) were chosen (Amathole District Municipality [ADM], 2020). The third stage involved randomly selecting two wards from each municipality and then randomly sampling agricultural households within these wards. A proportional sampling method was used, with a total population of 21,336 agricultural households in the selected wards (StatsSA, 2016). Using Yamane's (1967) formula with a 5% margin of error, a sample size of 393 was calculated, but to enhance accuracy, 495 livestock producers were selected.

### 2.3. Data Collection and Sources

Household survey data were collected through semi-structured interviews using a questionnaire developed from a thorough literature review. The questionnaire included sections on farmers' socioeconomic characteristics, perceptions of climate change and variability over the past 20 years, and livestock adaptability traits. A preliminary test was conducted with 20 households to refine the questionnaire based on feedback and improve its reliability. Data collection involved five trained enumerators from the Eastern Cape, selected for their understanding of the process, literacy, and translation skills in Xhosa to minimise social biases. Climate data on average monthly temperatures and precipitation was sourced from the South African Weather Services (SAWS).

## 2.4. Estimation Procedure

Descriptive statistics, such as frequencies and percentages, were employed to analyse data on livestock farmers' perceptions of climate change and variability. Tables and graphs were used to visualise the results. Microsoft Excel and Stata version 15 were used for data analysis.

### *2.4.1. Trend Analysis*

Trend analysis was used to evaluate fluctuations in temperature and rainfall from 1980 to 2020. The method utilised simple linear regression, which estimates the relationship between a single independent variable (quantitative) and a dependent variable via a straight-line equation (Eqn 1).

$$Y = \alpha X + \beta \qquad \text{[Eqn.1]}$$

Y represents the dependent variable (precipitation or temperature), while X represents the independent variable (years), with $\alpha$ denoting the slope of the regression line and $\beta$ indicating a constant value.

### *2.4.2. Weighted Ranked Indices*

In addition, drawing on previous scholarly work, the present study employed a weighted ranked indices methodology to evaluate farmers' assessments of livestock species' adaptability based on specific traits (Roessler, 2019; Tyasi *et al.*, 2022). The study considered five livestock species (cattle, goats, sheep, pigs and chickens) common in the study area (Taruvinga *et al.*, 2022). It assessed them against six significant adaptive traits for adapting to changing environmental conditions within the study area. The calculation of indices enables the ranking of adaptive trait preferences as presented in Eqn 2:

$$\text{Index}=\frac{TS_{t1}}{TS_{at}} \qquad \text{[Eqn 2]}$$

Where;

$$TS_{t1} = \sum(f_{t1} \times likert\ scale\ score\ weight) \qquad \text{[Eqn 3]}$$

$$TS_{at} = \sum(TS_{t1} + \cdots . TS_{tn}) \qquad \text{[Eqn 4]}$$

Where: $TS$ refers to the total score; $f_{t1}$ signifies the frequency of each Likert scale score (number of respondents) and the corresponding Likert scale score weight, denoted by strongly

Vol. 54 No. 2, 2026: 215-240
10.17159/2413-3221/2026/v54n2a19265 (License: CC BY 4.0)

disagree (1), disagree (2), neutral (3), agree (4) and strongly agree (5). The traits are presented as *t1* and *tn*.

## 3. RESULTS

### 3.1. The Characteristics of Livestock Farmers

The data in Table 1 reveal key characteristics of livestock farmers in the study area. Most farmers are female (59%) and have limited access to support services: only 36.77% have access to extension services, 20.61% to credit, and 10.71% to early warning climate information. However, a significant majority (82.02%) have access to indigenous climate information. The average farmer is 56.8 years old, with about 7.7 years of education and 13.96 years of farming experience. Their farms average 1.3 hectares in size.

**TABLE 1: Characteristics of the Livestock Farmers**

| **Categorical variables** | **Freq (N=495)** | **%** |
|---|---|---|
| Gender (F) | 293 | 59.19 |
| Extension access | 182 | 36.77 |
| Credit access | 102 | 20.61 |
| Farm group | 171 | 34.55 |
| Early warning inf | 53 | 10.71 |
| Indigenous climate info | 406 | 82.02 |
| Drought relief | 134 | 27.07 |
| **Continuous variable** | **Mean (St. Err.)** | |
| Age (years) | 56.80(0.54) | |
| Education (years) | 7.7(0.24) | |
| Farm size (ha) | 1.3(0.05) | |
| Farming experience (years) | 13.96(0.32) | |

### 3.2. Farmers' Perceptions of Climate Change and Variability

Table 2 presents livestock farmers' perceptions of climate change and variability in the study area. Results indicate that a substantial majority of farmers (95%) acknowledge the reality of climate change. Over the past two decades, they observed significant changes in climatic parameters, including diminished precipitation (77%), delayed onset of the rainy season (62%),

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shorter rainy seasons (67%), and insufficient rainfall (61%). Additionally, farmers noted rising temperatures (78%), more hot days annually (74%), elevated summer temperatures (80%), and milder winters (61%).

**TABLE 2: Smallholder Farmers' Perceptions of Rainfall and Temperature Changes in the Past 20 Years**

| Farmers' perceptions | Frequency | % |
|---|---|---|
| **Aware of climate change (climate change is real)** | | |
| Yes | 469 | 94.75 |
| No | 26 | 5.25 |
| **Rainfall patterns** | | |
| Increasing | 87 | 17.58 |
| Decreasing | 382 | 77.17 |
| No change | 26 | 5.25 |
| **The onset of the rainy season** | | |
| Early | 36 | 7.27 |
| Late | 307 | 62.02 |
| on time | 48 | 9.70 |
| irregular | 104 | 21.01 |
| **Duration of rain** | | |
| No change | 118 | 23.84 |
| too short | 341 | 68.89 |
| I don't know | 36 | 7.27 |
| **Amount of rain** | | |
| Too little | 300 | 60.61 |
| Enough | 160 | 32.32 |
| I don't know | 35 | 7.07 |
| **Temperature patterns** | | |
| Increasing | 388 | 78.34 |

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| | | |
|---|---|---|
| Decreasing | 14 | 2.83 |
| No change | 93 | 18.79 |
| **Hot days** | | |
| Increasing | 368 | 74.34 |
| No change | 52 | 10.51 |
| I don't know | 75 | 15.15 |
| **Summer temperature** | | |
| Warmer | 397 | 80.2 |
| No change | 84 | 17 |
| Cooler | 14 | 2.8 |
| **Winter temperature** | | |
| Warmer | 304 | 61.42 |
| No change | 120 | 24.24 |
| Colder | 71 | 14.34 |

### 3.3. Comparing Observed Climate Trends With Farmers' Perceptions

Figure 2 and Figure 3 present the observed rainfall and temperatures from 1980 to 2020, respectively. These are accompanied by Tables 3 and 4, which present the regression output for precipitation and temperature at various study sites.

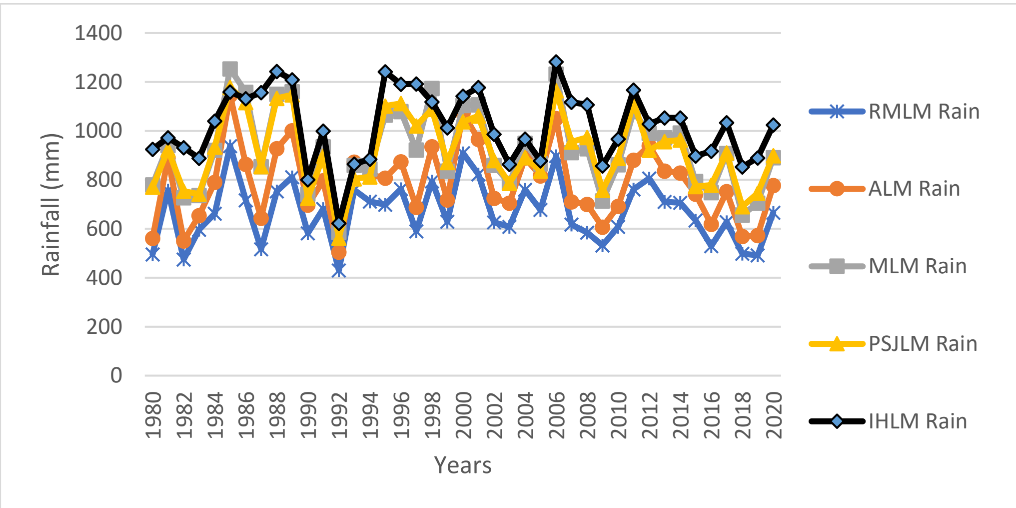


**FIGURE 2: Observed Rainfall Trends Between 1980 and 2020 in Selected Areas of the Eastern Cape**

Note: *RMLM=Raymond Mhlaba local municipality; ALM=Amahlathi local municipality; MLM=Mbashe local municipality; PSJLM= Port St. Johns local municipality; IHLM= Ngquza Hill local municipality.*

**Table 3: Rainfall trend regression results for selected municipalities (1980–2020)**

| Local municipalities | Coeff | Std. Err | t-stat | P-values |
|---|---|---|---|---|
| IHLM | -0.92516 | 1.928363 | -0.4798 | 0.63408 |
| PSJLM | -1.32213 | 2.004166 | -0.65969 | 0.513331 |
| RMLM | -0.84063 | 1.642114 | -0.51192 | 0.611595 |
| ALM | -1.33429 | 2.013545 | -0.66265 | 0.511449 |
| MLM | -2.01005 | 2.175005 | -0.9242 | 0.36109 |

Note: *RMLM=Raymond Mhlaba local municipality; ALM=Amahlathi local municipality; MLM=Mbashe local municipality; PSJLM= Port St. Johns local municipality; IHLM= Ngquza Hill local municipality.*

The results indicate a declining trend in annual rainfall across all selected study areas between 1980 and 2020, with regression coefficients ranging from -0.84 mm/year to -2.01 mm/year (Table 3). MLM exhibited the steepest decline. Despite this consistent downward trend, the regression outputs are not statistically significant, suggesting that the observed changes may result from natural variability rather than a consistent long-term trend.

Nonetheless, visual patterns in Figure 2 highlight notable interannual rainfall variability, with alternating years of higher and lower precipitation. While statistical significance is lacking, the observed decline may still carry practical and ecological relevance, particularly for climate-sensitive sectors such as smallholder farming systems. Reduced rainfall may reduce water availability, increase drought risk, especially in the Mbashe Local Municipality, and necessitate the implementation of adaptive strategies to mitigate potential adverse effects.

Vol. 54 No. 2, 2026: 215-240
10.17159/2413-3221/2026/v54n2a19265 (License: CC BY 4.0)

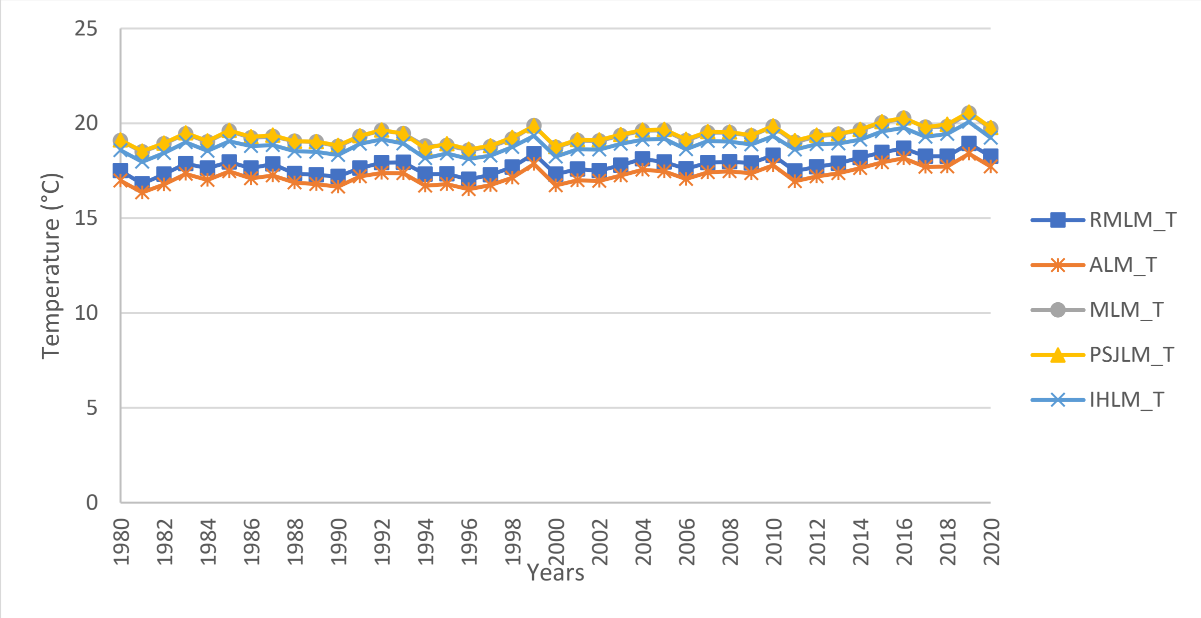


**FIGURE 3: Observed Temperature Trends Between 1980 and 2020 in Selected Areas of the Eastern Cape**

Note: *RMLM=Raymond Mhlaba local municipality; ALM=Amahlathi local municipality; MLM=Mbashe local municipality; PSJLM= Port St. Johns local municipality; IHLM= Ngquza Hill local municipality.*

The results presented in Figure 3 and Table 4 reveal a consistent and statistically significant upward trend in temperature across all study sites from 1980 to 2020. Unlike rainfall, which showed marked interannual and spatial variability, temperature remained relatively uniform across the sites, with no substantial variation observed between locations or years.

The regression coefficients for all municipalities are positive, ranging from 0.0228°C to 0.0247°C per year, indicating a steady increase in average temperatures over the 40-year period. All t-statistics exceed 4.7, and the corresponding p-values are highly significant ($p < 0.001$), confirming that the observed temperature increases are not due to random variation.

This consistent warming trend has critical implications for smallholder agricultural systems, particularly livestock production. Rising temperatures can affect animal health, water needs, forage availability, and the overall productivity of the sector. The statistically robust increase in temperature across all locations underscores the urgency of adaptation strategies to enhance the resilience of farming systems to sustained climate change.

Vol. 54 No. 2, 2026: 215-240
10.17159/2413-3221/2026/v54n2a19265 (License: CC BY 4.0)

**TABLE 4: Temperature Trend Regression Results for Selected Municipalities (1980–2020)**

| Local municipalities | Coeff | Std. Err | t-stat | P-values |
|---|---|---|---|---|
| IHLM | 0.0237 | 0.005 | 5.012 | 0.000 |
| PSJLM | 0.0234 | 0.005 | 4.922 | 0.000 |
| RMLM | 0.0247 | 0.005 | 5.362 | 0.000 |
| ALM | 0.0246 | 0.005 | 5.365 | 0.000 |
| MLM | 0.0228 | 0.005 | 4.793 | 0.000 |

Note: *RMLM=Raymond Mhlaba local municipality; ALM=Amahlathi local municipality; MLM=Mbashe local municipality; PSJLM= Port St. Johns local municipality; IHLM= Ngquza Hill local municipality.*

### 3.4. Farmers' Experience of Occurrences and Severity of Climate Extremes

Table 5 outlines the climate phenomena encountered by farmers and their perceived severity. The data reveal that all smallholder livestock farmers experienced drought, with 44% considering its impact on livestock production highly severe. Lower river and dam water levels were the second-most-frequently reported climate phenomenon, with approximately 38% of farmers reporting that these conditions severely affected agricultural production and household welfare. Although 57% of farmers encountered floods, the majority (54%) reported that these floods had minimal impact on livestock production or household welfare. In contrast, storms were rarely reported and had little impact, suggesting they pose a lesser risk than drought in the study area.

**TABLE 5: Climate Phenomena' Experienced and Perceived Severity in the Past 20 Years**

| Phenomena | Frequency | % | Not severe at all | Slightly severe | Average | Severe | Extremely severe |
|---|---|---|---|---|---|---|---|
| Drought | 495 | 100 | 15(3.03) | 59(11.92) | 70(14.14) | 133(26.87) | 218(44.04) |
| Floods | 284 | 57.37 | 47(9.49) | 268(54.14) | 49(9.9) | 110(22.22) | 21(4.24) |
| Lower water level | 398 | 80.4 | 96(19.39) | 43(8.69) | 76(15.35) | 187(37.78) | 93(18.79) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| storm | 142 | 28.69 | 85(59) | 20(14) | 11(8) | 14(10) | 12(9) |

*Note: only farmers who indicated having experienced the climate phenomena were asked how severe the effect on household welfare and livestock production was. Percentage values in parentheses.*

### 3.5. Farmers' Perceived Impacts of Climate Variability

Farmers' perceptions of the impact of climate variability on livestock production and their welfare are detailed in Figure 4. The results indicate that smallholder livestock farmers overwhelmingly recognise the risks posed by climate change. They strongly agree that climate change leads to water scarcity (52.28%), negatively affects vegetation, and reduces both the quantity and quality of feed (50.3%), ultimately compromising potential farm income (49.1%). Additionally, farmers acknowledge (agree) that climate change increases livestock diseases (43.8%), diminishes food security (41.6%), hinders reproduction (38.8%), causes livestock fatalities (32.48%), and impacts human health (30%).

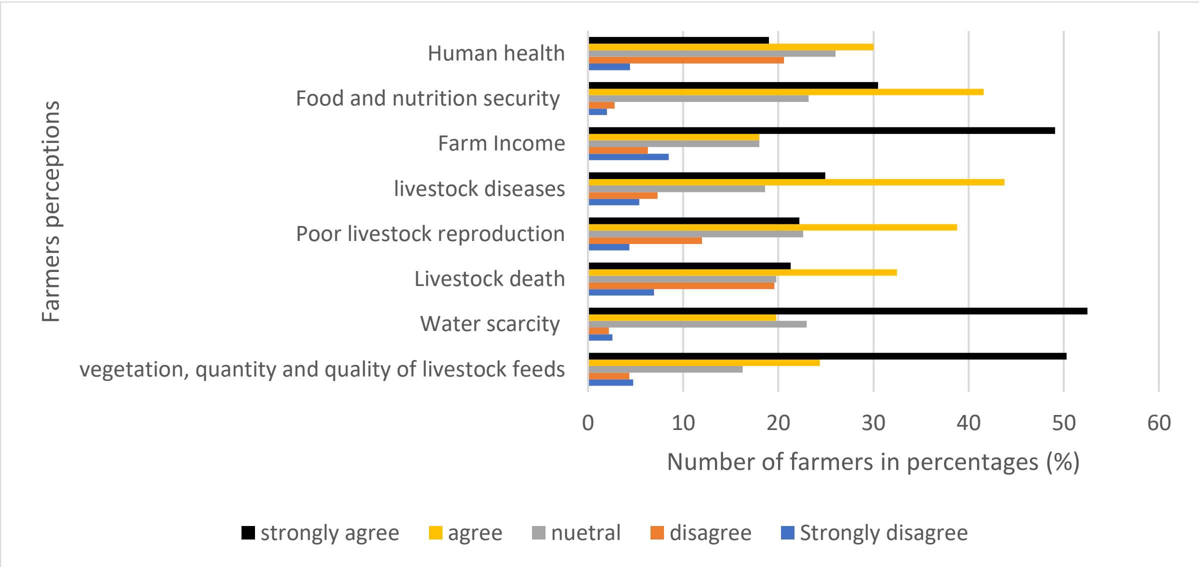


**FIGURE 4: Perceptions of the Impact of Climate Variability on Livestock Production and Farm Household Welfare**

Vol. 54 No. 2, 2026: 215-240
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### 3.6. Farmers' Perceptions of Livestock Species Adaptability

Table 6 offers an in-depth analysis of farmers' perceptions regarding the adaptability of various livestock species, focusing on specific traits that influence their choices in the context of climate-related challenges. The data reveal clear preferences among farmers regarding how well different livestock species handle environmental stressors.

The results indicate that indigenous veld goats are the most favoured species, with an adaptability score of 0.312. They are particularly valued for their ability to cope with feed scarcity (0.199), reproduce under climatic stress (0.178), and endure heat stress (0.177). Indigenous chickens rank second, with a score of 0.262, appreciated for their tolerance to high temperatures (0.194), resilience to water scarcity (0.186), and adaptability to feed shortages (0.165). Sheep rank third in preference, scoring 0.211, due to their endurance in managing feed scarcity (0.192), their ability to handle water scarcity (0.181), and their successful reproduction under harsh conditions (0.177). In contrast, cattle, despite their resilience to floods and resistance to parasites and diseases, face difficulties with reproduction under prolonged harsh conditions (0.144), water scarcity (0.145), and heat stress (0.146). Pigs, with a score of 0.073, are perceived to have reduced reproductive capabilities in severe climates (0.134), increased susceptibility to feed shortages (0.134), and extended heat stress (0.151).

Overall, farmers' preferences highlight key adaptability traits such as tolerance to feed scarcity, resilience to water scarcity, and capacity to withstand parasites and diseases. These traits are crucial in the selection of livestock species, reflecting the essential characteristics needed to manage climate variability effectively.

**TABLE 6: Farmers' Perceptions of Livestock Species Adaptability to Climate Change**

| Livestock species | Overall rank | Tolerance to heat stress (THS) | Tolerance to feed shortage (TFS) | Tolerance to water scarcity (TWS) | Reproduce under climate stress (RCS) | Tolerance to parasites and diseases (TPD) | Tolerance to floods (TF) |
|---|---|---|---|---|---|---|---|
| Goats | 1 | 0.177 (3) | 0.199 (1) | 0.167 (4) | 0.178 (2) | 0.158 (5) | 0.122 (6) |
| Chicken | 2 | 0.194 (1) | 0.165 (3) | 0.186 (2) | 0.163 (4) | 0.157 (5) | 0.135 (6) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Sheep | 3 | 0.152 (4) | 0.192 (1) | 0.181 (2) | 0.177 (3) | 0.148 (6) | 0.149 (5) |
| Cattle | 4 | 0.146 (4) | 0.147 (3) | 0.145 (5) | 0.144 (6) | 0.209 (2) | 0.209 (1) |
| Pigs | 5 | 0.151 (4) | 0.134 (5) | 0.160 (3) | 0.134 (5) | 0.167 (2) | 0.253 (1) |

*Notes: Each cell under trait columns provides the index value followed by the trait's rank for that species in parentheses. Overall rank represents the general ranking of each livestock species based on overall adaptability.*

The rankings reflect the preceding discourse on the distinct problems of adaptation these particular species encounter. Cattle, although demonstrating certain qualities, are considered less capable of effectively addressing the dynamic challenges posed by climate change. Similarly, pigs are considered vulnerable to climatic fluctuations, consistent with previous findings regarding their susceptibility to climatic stresses. The findings corroborate earlier studies indicating a general preference among smallholder livestock farmers in Africa for animals adapted to harsh environmental conditions (Habte *et al*., 2022; Boru *et al*., 2014; Kagunyu & Wanjohi, 2014; Fereja, 2016).

## 4. DISCUSSION

The findings reveal significant challenges for smallholder livestock farmers in the study area. The high proportion of female farmers suggests that women's unique experiences and constraints shape their perceptions of climate variability. These perceptions, in turn, influence how they assess the adaptability of different livestock species to changing conditions. The average age of farmers, coupled with their low levels of education and limited access to formal support services, likely impedes their ability to adopt climate-resilient practices. This limitation may affect their perceptions of climate variability and their readiness to implement effective adaptation strategies (Belay *et al*., 2017; Agholor & Ogujiuba, 2022).

Furthermore, limited access to credit and extension services, especially those providing climate information, exacerbates these challenges, aligning with studies in Africa that highlight how institutional gaps hinder adaptive capacity (Rakgase & Norris, 2015; Idrissou *et al*., 2020). Despite substantial access to indigenous climate information, which may offer some guidance on managing climate-related risks (Silvestri *et al*., 2012; Zampaligré *et al*., 2014), this traditional knowledge alone may not fully compensate for the absence of formal support.

Vol. 54 No. 2, 2026: 215-240
10.17159/2413-3221/2026/v54n2a19265 (License: CC BY 4.0)

Additionally, the small average farm size of 1.3 hectares reflects significant resource constraints, potentially limiting the ability to adapt livestock management strategies to changing climate conditions (Opiyo *et al*., 2016; Mairura *et al*., 2021).

## 4.1. Implications of Farmers' Perceptions of Climate Variability

The findings indicate that smallholder livestock farmers have observed reduced precipitation and increasing temperatures over the past 20 years, suggesting a shift towards more extreme weather patterns. This trend necessitates adaptations in livestock management practices, such as adopting drought-resistant forages and selecting more resilient livestock breeds. These observations are consistent with research by Kimaro *et al*. (2018) in Tanzania, Rapholo and Diko Makia (2020) in Limpopo, and Idrissou *et al*. (2020) in Benin, which document worsening precipitation conditions across Africa. Idrissou *et al*. (2020) further note that rising temperatures cause animals to seek more shade and water, behaviours that farmers might observe as indicative of increased temperatures. The direct experience of temperature changes aligns with findings from South African studies (Mandleni & Anim, 2011; Gandure *et al*., 2013; Muller & Shackleton, 2014; Popoola *et al*., 2019; Rapholo & Makia, 2020), affirming that smallholder farmers are acutely aware of climate variability in their regions.

The alignment between farmers' perceptions and long-term meteorological data, which also show decreasing rainfall and rising temperatures, confirms the accuracy of their observations. This concordance validates farmers' experiential knowledge as a valuable source of information on climate change, as supported by various African researchers (Rapholo & Diko Makia, 2020; Abazinab *et al*., 2022; Van Zuydam *et al*., 2023). This integration of local insights into climate research and policy development is crucial for crafting effective adaptation strategies. Recognising farmers' observations as early indicators of climate impacts facilitates timely, targeted adaptation measures, underscoring the need for a comprehensive approach that combines scientific data with local knowledge.

The results highlight significant climatic risks faced by smallholder livestock farmers, particularly the severe impacts of drought and low water levels on productivity and household welfare. This aligns with the literature identifying drought as a major stressor in smallholder livestock systems in the Eastern Cape (Mandleni & Anim, 2011; Popoola et al., 2019; Matlou et al., 2021), which affects vital water sources such as rivers and dams. Therefore, there is an urgent need to adopt drought-resistant livestock species and breeds that can thrive under limited water availability.

While floods are common in the study area, their effects appear less severe than those of droughts. Yang and Liu (2020) note that floods generally cause immediate, short-term disruptions, unlike the prolonged impacts of droughts. The severity of floods varies by timing and location, with South African floods being more intense in coastal regions than inland areas (Ngarava *et al*., 2021; Mashao *et al*., 2023). Consequently, farmers reporting minimal impacts may be in less affected inland regions. Ngarava *et al*. (2021) also found that agricultural lands in the Eastern Cape recover within one to two weeks after flooding, which likely mitigates the overall impact on livestock farming systems.

The findings reveal that smallholder livestock farmers are concerned about immediate issues, such as water scarcity and feed shortages, as well as long-term impacts, including reduced farm income and health risks. This is consistent with studies indicating that climate change exacerbates water scarcity and affects feed availability (Silvestri *et al*., 2012; Zampaligré *et al*., 2014; Popoola *et al*., 2019). The emphasis on feed availability reflects its direct impact on livestock health and productivity. Supporting literature confirms that climate change reduces livestock productivity, alters disease prevalence, and affects feed quality, thereby impacting livelihoods dependent on livestock (Morignat *et al*., 2014; Giridhar & Samireddypalle, 2015; Bett *et al*., 2017).

### 4.2. Implications of Farmers' Perceptions of Livestock Species Adaptability

The data reveal that farmers' preferences for livestock species are strongly influenced by their adaptability to climate-induced stressors. Indigenous veld goats and chickens are particularly favoured for their perceived robustness against key climate challenges. Goats and chickens are valued for their ability to cope with feed scarcity, endure heat stress, and, in the case of chickens, tolerate high temperatures and water shortages. This preference suggests that farmers prioritise livestock that can maintain productivity and health despite environmental stressors. Consequently, there is an opportunity to enhance breeding programmes to focus on traits such as feed efficiency and heat resistance. Providing targeted support, such as improved feed and water management systems, especially during drought periods, could optimise the performance of these highly adaptable species.

Vol. 54 No. 2, 2026: 215-240
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Sheep, although not as highly favoured as goats and chickens, still play a significant role in smallholder farming systems. This highlights the need for continued support for sheep farming, focusing on improving their resilience to climate stressors through better pasture management and improved access to water resources. Further research into sheep's adaptability to various environmental stressors could provide valuable insights into enhancing their overall resilience.

Conversely, cattle and pigs are perceived as less adaptable to severe climate conditions, facing challenges related to reproduction, water scarcity, and heat stress. While cattle are noted for their resilience to floods and diseases, they struggle with prolonged harsh conditions, and pigs are recognised for reduced reproductive capabilities and increased susceptibility to feed shortages and heat stress. These findings suggest a need for targeted interventions for cattle to address reproductive issues and improve resilience to water scarcity and heat stress. For pigs, strategies should focus on developing breeds better suited to extreme climates and improving housing and feed management to mitigate the effects of heat stress and feed scarcity.

These observations align with existing research, underscoring the importance of livestock adaptability in shaping farmers' preferences. For instance, studies have shown that while cattle are resilient to heavy rains and ticks, they are less favoured than camels and goats for handling water scarcity, feed shortages, and heat stress (Megersa *et al*., 2014). Research from Burkina Faso and Ethiopia highlights a preference for goats and camels due to their drought resistance (Zampaligré *et al*., 2014; Habte *et al*., 2022), and the adaptability of indigenous chickens to rising temperatures has been recognised in Limpopo (Nyoni *et al*., 2022).

## 5. LIMITATIONS AND DIRECTIONS FOR FUTURE RESEARCH

This study is limited by its geographic scope, focusing solely on selected areas in the Eastern Cape Province, which may restrict the generalisability of findings. The reliance on farmers' self-reported perceptions, while valuable, may be influenced by recall bias and recent climate events. Additionally, the cross-sectional design limits insights into how perceptions and adaptation strategies evolve. The study also provides a limited assessment of the institutional and policy environments that influence farmers' access to support services.

Future research should consider longitudinal designs to track changes in farmers' perceptions and responses over time. Comparative studies across different agroecological zones are also essential to capture regional variations in climate impacts and adaptive strategies. Additionally,

Vol. 54 No. 2, 2026: 215-240
10.17159/2413-3221/2026/v54n2a19265 (License: CC BY 4.0)

there is a need to empirically assess the productivity of different livestock species under climate stressors to validate farmers' perceptions of adaptability.

This study found that most farmers rely on indigenous climate information, with limited access to scientific sources. Future research could examine how this indigenous knowledge is transmitted across generations to better understand its sustainability and its role in climate adaptation. Moreover, integrating indigenous knowledge with scientific climate information and evaluating the effectiveness of policy and institutional support can help shape more responsive and inclusive adaptation strategies.

## 6. CONCLUSIONS

This study evaluated smallholder livestock farmers' perceptions of climate change, compared these perceptions with historical climate data, and assessed perceptions on livestock species adaptability. The study concludes that farmers' perceptions in the Eastern Cape Province, South Africa, are largely accurate and consistent with historical climate trends. Key challenges identified include drought and water depletion, which affect feed availability, water resources, livestock diseases, reproduction rates, and mortality.

The study also concludes that farmers prefer goats, indigenous chickens, and sheep over cattle and pigs because they perceive them as more resilient to heat, water scarcity, and feed shortages. This preference reflects farmers' adaptive strategies in response to climate stressors. However, limited access to essential support services, such as credit, extension services, and climate information, may hinder their ability to leverage the benefits of resilient livestock options.

The study recommends prioritising support for smallholder livestock farmers in adapting to climate change. This includes providing access to accurate climate data and resources for climate-smart agricultural practices. Integrating indigenous knowledge and early warning systems can enhance farmers' adaptability. Encouraging collaboration between farmers and meteorological institutions can improve data exchange, adaptation planning, and community resilience. Tailored support programmes addressing the specific needs of different livestock species should be developed, and knowledge sharing about the strengths and weaknesses of various livestock in the context of climate variability should be facilitated.

Vol. 54 No. 2, 2026: 215-240
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