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Climate-Driven Innovations: How Rainfall and Temperature Influence Pasture Technology Adoption in Isiolo County, Kenya

Climate-Driven Innovations: How Rainfall and Temperature Influence Pasture Technology Adoption in Isiolo County, Kenya

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Abstract
Pastoralism is the primary livelihood in Isiolo County's arid and semi-arid regions, but severe droughts and climate change frequently disrupt this way of life, causing food shortages for vulnerable communities. This study explored how pastoralists in Isiolo County adopt Technological, Innovation, and Management Practices (TIMPs) to boost pasture production, reduce land degradation, and enhance resilience to extreme weather. It specifically examined the impact of climatic factors on TIMP adoption, guided by Diffusion of Innovation Theory, which focuses on the adoption process of new technologies. Using a descriptive survey research design, the study sampled 382 heads of households and field extension officers from a population of 48,514. Data was collected through questionnaires, key informant interviews, and Focus Group Discussions (FGDs). A pilot test involving 20 household heads and 1 extension officer was conducted, achieving a reliability coefficient of 0.86 using the Cronbach Alpha formula. Data analysis was performed with Statistical Package for Social Sciences (SPSS) Version 2x, employing Multiple Linear Regression models. The results indicated that temperature had a positive correlation coefficient of 0.791 with TIMP adoption, showing that higher temperatures encourage technology adoption for survival, with a significant effect ($p<0.05$). Rainfall also had a positive correlation with TIMP adoption, but the relationship was statistically insignificant ($p>0.05$). Policymakers should therefore prioritize temperature-related interventions and reassess rainfall-related strategies to improve local resilience to extreme climatic conditions.

Introduction

Pastoralists in East Africa have faced significant livestock losses due to climate-driven impacts, such as recurrent droughts, threatening their livelihoods and food security (Mutiga, 2021). With rising temperatures and irregular rainfall, climate change exacerbates food insecurity and reliance on aid by affecting natural resource use and pasture production (Verschuur, Wolski & Otto, 2021). This increases poverty and inequality within pastoral systems (Habte et al., 2022; Codjoe & Atiglo, 2020).

In Kenya's ASAL regions, many people live in extreme poverty and are highly vulnerable to climate shocks (Opiyo, Wasonga & Nyangito, 2014). Over 50% live below the World Bank's $1-per-day poverty line, increasing disaster vulnerability (World Bank, 2018; Nyika, 2022). Dependence on natural resources for survival heightens this vulnerability (Praveen & Sharma, 2019). Resilience depends on adapting to climate changes and managing resource degradation (Thomas, 2019).

Community activities such as overgrazing, deforestation, and poor water management worsen climate threats in North Eastern Kenya. Households face frequent droughts, floods, and inadequate services, making adaptation difficult (Lindval et al., 2020). Most ASAL households lack sufficient assets for adaptation, increasing their risk without effective strategies.

Restoring pastures through reseeding builds resilience and boosts livestock productivity while mitigating climate shocks via carbon sequestration (Harrison, Cullen, & Rawnsley, 2016). However, productivity is hampered by poor feed quality and quantity (Mbuthia, Rewe, & Kahi, 2015). Reliable seed sources are essential for improvement (Ericksen & Crane, 2018; Gil, Garrett, & Berger, 2016).

Key technologies include range pasture establishment, natural pasture improvement, and pasture seed production. Initiatives like the World Food Programme's 2019 Food for Assets project in Isiolo County support these technologies (Mureithi, 2018). Despite these efforts, pastoralists remain vulnerable to extreme climate events. Selected TIMPs have been employed to boost pasture production against the perceived climate risks in Isiolo County. They include but are not limited to seed banks, access to crucial climate information, reseeding technology, provision of quality seeds, storage of pasture, access to pasture supplementary feeds, use of range pits/Zai pit for water conservation, seed bulking and management practices (Purity, at al., 2024).

The Range Management and Pastoralism Strategy (RMPS) 2021-2031 emphasises sustainable resource use in Kenya's ASALs, aligning with Kenya's Constitution (2010) and Vision 2030. Strategic investments in rangeland rehabilitation and management are vital for food security.

This study evaluates how climate variability affects the adoption of pasture production technologies in Isiolo County. It is guided by the Diffusion of Innovation Theory, which examines how new technologies spread through communities and informs policy development for enhancing resilience in Kenya’s arid and semi-arid lands (Rogers, 2003). Isiolo County, a northern rangeland area in Kenya's ASALs, is highly vulnerable to climatic extremes. Rising temperatures, unpredictable rainfall, and increased drought frequency threaten local livelihoods, impacting pasture production and livestock. The changing climate has significantly reduced cattle productivity. Investigating technology adoption for improving pasture production is crucial for understanding the micro-level effects of climate variability and informing effective policy for technological adaptation and pasture management.

Methods

The research was conducted in Isiolo County, which is located 285 kilometres to the north of Nairobi city in Kenya. Marsabit County bounds the County to the north, Samburu and Laikipia Counties to the west, Garissa County to the east, Wajir County to the north, to the south by Tana River and Kitui Counties, and the west by Meru County. The research was conducted in Isiolo County, 285 kilometres north of Nairobi, Kenya's capital city. It is situated between Longitudes 36^{0}.50′ and 39^{0}.50′ East and latitudes 0^{0}.00' south and 2^{0}.10′ North. It has a land area of about 25,700 km^2

Research Design

The study used a descriptive survey design due to its effectiveness in collecting qualitative and quantitative data. This approach facilitates clear recommendations for addressing research problems and is particularly suited for understanding rainfall, temperature variability, and technology adoption among pastoralists in Isiolo County. It is time-efficient and focuses on the research participants.

Sampling Frame

The accessible population comprised 48,514 households in Isiolo and Garbatulla sub-counties. Using the Krejcie and Morgan (1970) formula, a sample of 382 heads of households and field extension officers as key informants was determined.

The household heads were interviewed at their places of convenience. Focused Group Discussions (FGDs) were also conducted with the Key Informants' chosen locations.

Table 1: Accessible Population of the Study

Sub counties	Population	Households
Garbatulla	99,730	18,661
Isiolo	121,061	29,853
Total	99,851	48,514

Source: Kenya National Bureau of Statistics, 2019

Sampling Procedure and Sample Size

The study sample was chosen using a multistage sampling process. The first stage involved a purposive selection of the block of the two sub-counties (Isiolo and Garbatulla) based on their location, primary livelihood (pastoralism), and susceptibility to drought, as well as cross-country border effects from the neighboring count with ASAL conditions. Two extension officers were selected for the study through a simple random selection technique.

Heads of the Households

A sample is drawn proportionally as presented in the study's accessible population. The formula by Krejcie and Morgan (1970) was used to calculate the sample size for the heads of households, as shown below. A total sample size of 382 subjects was obtained from an accessible population of 48,514 from Isiolo and Garbatulla Sub-counties, as shown below and in Table 1.

S=X2NP(1-P) +X2P(1-P) d2(N-1)

Where *S* = the required sample size, *X2* = 3.841, *N* = 48,514, *P*= 0.50, d=0.05 at a 95% confidence level.

N= 48,514, X2= 3.841 P= 0.5 d=0.05P

S = 381.09 =382

Table 2: A sample size obtained proportionally from the two targeted sub-counties

Sub-county	No of households	Extension Officers	Sample Size
Isiolo	18,661	1	148
Garbatulla	29,853	1	236
Total	48,514		384

The heads of the households were selected by stratifying the family heads into two groups, as shown in Table 2. Each sub-county formed a cluster from which a proportional sample of family heads was drawn. A proportion of respondents in each sub-county was obtained by dividing the total population of the head of households by the accessible population. This gave 147 and 235 heads of households from Isiolo and Garbatulla, respectively; this information is presented in Table 2.

Data Collection

Data on TIMP adoption was collected through three methods. Questionnaires were given to household heads for quantitative data. Key Informant Interviews were held with experts on local pastoral practices. Focus Group Discussions (FGDs) were conducted with 8 participants per group, ensuring gender parity (3 men, three women, and two youths—1 male and one female) from sampled villages to validate household responses.

Data analysis

Data was analysed using Multiple Linear Regression models to determine the correlation between climatic variables (rainfall and temperature) and the adoption of TIMPs. Descriptive statistics provided summary measures, while inferential statistics identified significant relationships.

Results

The study sought to determine whether climatic factors had any influence on the adoption of TIMPs. The results are shown in Table 3.

Table 3: Regression Coefficient for Climatic Factors Influence on Adoption of TIMPs

Independent variables	Coefficient	Std. Error	Sig
Constant	0.839	0.125	0.000
Rainfall	0.021	0.029	0.472
Temperature	0.719	0.029	0.000

Source: Ground Data

From the Multiple Linear Regression model shown in Table 3, temperature has a significant effect on the adoption of TIMPs with a p-value of 0.000 (< 0.05), but rainfall's effect is not significant with a p-value of 0.472 (> 0.05). This implies that a unit increase in temperature leads to more farmers adopting technologies for survival. However, a very high increase in temperature might not necessarily lead to positive outcomes if it crosses a threshold detrimental to agricultural production.

The equation for the model is represented by:

Y= $\beta_0 + \beta_1 X_1 + \beta_2 X_2 + e_t$

Where Y – the adoption of technologies

X_1 –Temperature is confirmed by Usman and Hammar (2021), Balogun et al. (2020), Ntshangase, Muroyiwa and Sibanda (2018) that there is a positive correlation between the rise in temperature and the adoption of technologies.

X_{2}- Rainfall influence

B= Constant

e_t- Standard error

Rainfall positively correlated with TIMPs adoption, but it was statistically insignificant (coefficient 0.472, $p > 0.05$). This means that while there's a positive relationship, it's not strong enough to be considered significant. The relationship can be understood in two ways: reduced rainfall might decrease pasture availability, prompting households to adopt TIMPs to boost production, while increased rainfall could enhance pasture growth, leading to the need for better management and storage practices, thereby encouraging TIMPs adoption.

Influence of Rainfall Variability on Adoption of TIMPs

The results by the household respondents on information on rainfall variability are presented in Table 4.

Table 4: Information on Climate Variability

Items	Frequency	Percentage
Use of the Weather Forecast Information		
Make use of forecast information	367	98.39
Don't make use of weather information	6	1.61
Timeliness of the Information		
Yes	12	3.22
No	360	96.51
Others	1	o.27
Information the Respondent Would like to Receive in Future		
Onset of rains	5	1.34
End of the rainy season	7	1.88
Distribution of rainfall within the season	358	95.98
Occurrence of floods	3	0.80

Most (98%) of household heads use weather forecasts for livelihood decisions, showing high trust and practical application. This widespread use underscores how forecasts are integrated into daily and strategic planning for agriculture and pastoral activities. Only 2% face barriers such as understanding forecasts or socioeconomic constraints.

The timeliness of the information is a major concern, with 96.51% of respondents indicating that it is not timely. Only 3.22% find the information timely, and 0.27% selected "Others," reflecting very limited satisfaction with the current timeliness of weather information.

Respondents primarily want information on rainfall distribution within the season (95.98%), indicating a strong need for detailed planning. Additionally, 1.88% seek information at the end of the rainy season, 1.34% on the onset of rains, and 0.80% on flood occurrences. These preferences highlight the need for precise and timely weather updates to aid agricultural planning and risk management.

The results on the means of obtaining weather information were sought and presented in Table 5

Table 5: Means of obtaining the weather information

Sources	Frequency	Percentage
Radio	199	53.35
Television	157	42.09
Verbal Message	1	0.27
Mobile Phone	16	4.29

Most (60%) of respondents receive weather information via radio, the most common and accessible medium in the region. This indicates radio's broad reach and significant influence among the local population. Extension officers provide weather updates to 31% of respondents, highlighting their crucial role in directly communicating forecasts and engaging with households. Cell phones are used by 9% of respondents to receive weather forecasts. Although less prevalent, this method underscores the growing role of mobile technology in accessing important information. Understanding these sources can help tailor communication strategies to ensure the effective delivery of weather forecasts to the community. The results on the frequency of receiving information from the respondents are presented in Table 6.

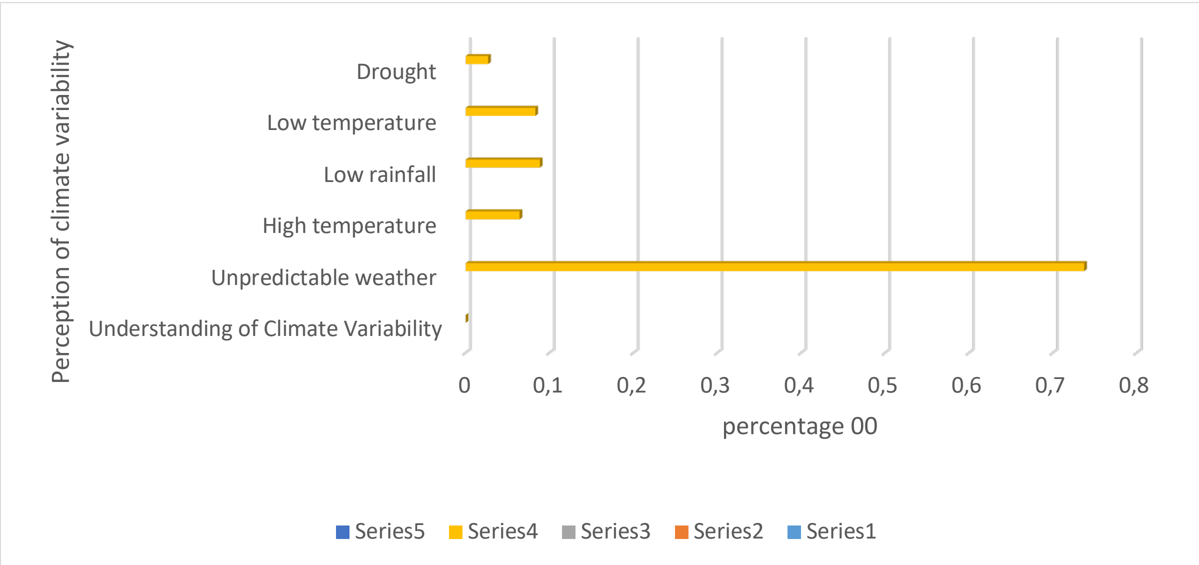
Table 6 Frequency of receiving Weather forecast

Time	Frequency	Percentage
Weekly	263	70.51
Daily	109	29.22
Others	1	0.27

Seventy per cent of respondents receive weekly weather forecasts, while 27% get them daily. Most households use weekly updates for short-term planning and farming or livestock management adjustments. These forecasts, often tied to radio schedules or extension officer visits, are reliable for regular planning and general agricultural adjustments.

Daily forecasts, accessed by 27% of respondents, enable finer adjustments and precise planning, which is particularly useful for managing daily agricultural tasks and reacting quickly to sudden weather changes. The demand for daily updates suggests a need for more immediate information, which could be provided through mobile alerts or increased extension officer interactions. The results in Figure 1 present the perception of climate variability by the respondents in Isiolo County.

Figure 1: Perceptions of Climate Variability



The analysis reveals that 73.73% of respondents cited unpredictable weather as the top concern. This majority indicates significant impacts on daily life, agriculture, and planning, highlighting the need for better weather forecasting and adaptive strategies.

Low rainfall (8.85%) and low temperature (8.31%) are significant concerns, emphasising water conservation and managing cooler temperatures. Low rainfall affects agriculture and water supply, while low temperatures impact energy use and health.

High temperatures concern 6.43% of respondents, highlighting the importance of addressing heatwaves and protecting vulnerable populations. Although drought is the least cited factor at 2.68%, it remains critical. Despite its lower percentage, drought still demands attention due to its severe impact on water shortages and agriculture. The study sought to establish the influence of rainfall on adopting TIMPs for pasture production. The results are shown in Table 7.

Table 7 Rainfall Influence on the Adoption of TIMPs for Pasture Production

Variable	Mean	St dev	Min	Max
Access to Information for Pasture Production technologies	2.49	1.29	1	5
Adoption of Reseeding Technologies	2.37	1.48	1	5
Most of the Pasture go to Waste During Wet Season	2.92	1.57	1	5
Access to Quality Seeds for Pasture Production	2.70	1.50	1	5
Availability of Seeds for Pasture Production	2.83	1.52	1	5
Provision of Timely Information on Pasture Improvement	2.84	1.54	1	5
Preservation of Excess Pasture	2.94	1.57	1	5
Access to Pasture Supplementary Feeds	3.05	1.57	1	5
Marketing of Pasture During Wet Season	2.87	1.62	1	5
Construction of Feed Conservation Structures	2.93	1.62	1	5
Use of Water for Pasture Production	2.78	1.53	1	5
Use of Prosopis juliflora Flour for Livestock	3.12	1.60	1	5
Seed Bulking and Management Practices	2.80	1.57	1	5
Use of Acacia tortilis Pods Supplement	3.26	1.63	1	5
Use of Range Pits for Water Conservation	2.75	1.55	1	5
Use of Irrigation for Pasture Production	3.30	1.71	1	5

The results in Table 7 show that access to information has a mean score of 2.49 and a standard deviation of 1.29, indicating moderate access but notable variability. Improving information dissemination could enhance adoption rates. Reseeding technologies have a mean score of 2.37 and a standard deviation of 1.48, indicating low adoption, possibly due to awareness or resource barriers.

Pasture wastage during the wet season has a mean score of 2.92 and a standard deviation of 1.57, highlighting significant wastage and the need for better management. Access to quality seeds scores 2.70 (SD: 1.50), indicating moderate access and the need for improved distribution. Seed availability has a mean score of 2.83 (SD: 1.52), showing slightly better availability but still needing improvement.

Timely information has a mean of 2.84 (SD: 1.54), suggesting a need for more accurate dissemination. Preservation of excess pasture scores 2.94 (SD: 1.57), indicating preservation challenges. Access to supplementary feeds scores 3.05 (SD: 1.57), indicating moderate to good access but significant variability.

Marketing of pasture during the wet season has a mean score of 2.87 (SD: 1.62), indicating challenges and the need for better market access. Engagement in constructing feed conservation structures is moderate, with a mean score of 2.93 (SD: 1.62), pointing to potential barriers like cost or technical know-how.

Water use for pasture production has a mean score of 2.78 (SD: 1.53), reflecting moderate use with significant variability. Prosopis juliflora flour for livestock has a higher mean score of 3.12 (SD: 1.60), suggesting effectiveness or availability.

Seed bulking and management practices have a mean score of 2.80 (SD: 1.57), indicating moderate engagement with variability. The use of Acacia Tortilis pods as a supplement scores 3.26 (SD: 1.63), indicating effectiveness or availability.

The use of range pits for water conservation scores 2.75 (SD: 1.65), suggesting potential for increased adoption. Irrigation use has the highest mean score of 3.30 (SD: 1.71), indicating significant use but also the highest variability, suggesting differing levels of access or effectiveness. The results highlight moderate to good adoption of various TIMPs with notable variability. Significant differences in practices and access levels suggest a need for targeted interventions to address specific barriers and improve overall adoption rates. The results of the Adaptation of TIMPs for Pasture Production are presented in Table 8.

Table 8: Adopted TIMPs for Pasture Production

Variable	Std. Dev	Mean	Min	Max
Access to Information on TIMPs	3.38	1.51	1	5
Adoption of Reseeding Technologies	3.60	1.46	1	5
Access to Quality Seeds for Pasture Production	2.71	1.42	1	5
Affordability of Quality Seeds	2.79	1.53	1	5
Timely Information on Pasture Improvement from Extension Officer	2.75	1.42	1	5
Preservation of Excess Pasture	3.27	1.51	1	5
Use of Indigenous Knowledge to Manage Land	2.97	1.47	1	5
Access to Pasture Supplementary Feeds	3.20	1.59	1	5
Construction of Conservation Structures	3.29	1.52	1	5
Soil Conservation	3.368	1.45	1	5
Use of Prosopis Juliflora Flour for Livestock	3.19	1.59	1	5
Seed Bulking and Management Practices	3.04	1.60	1	5
Use of Irrigation for Pasture Production	3.31	1.53	1	5
Use of Acacia Tortilis Pods Supplement	3.34	1.63	1	5
Use of Range Pits for Water Conservation	3.33	1.63	1	5

The data from Table 8 indicate generally low adoption and access to various adaptation technologies for pasture production, with significant variability among respondents. Access to information on Technological Innovations and Management Practices (TIMPs) is low (mean: 1.51) with a high standard deviation (SD: 3.38), indicating inconsistent access. Improved dissemination strategies are needed.

Reseeding technologies have a low mean score (1.46) and high variability (SD: 3.60), suggesting differences in awareness or resources. Access to quality seeds also scores low (mean: 1.42, SD: 2.71), reflecting variable seed distribution. Seed affordability is a barrier (mean: 1.53, SD: 2.79), indicating cost issues for many. Timely information from extension officers is insufficient (mean: 1.42, SD: 2.75).

Preservation practices for excess pasture score low (mean: 1.54, SD: 3.21), showing variable effectiveness. Indigenous knowledge of land management is low (mean: 1.49, SD: 2.97), reflecting regional and personal differences. Access to supplementary feeds is low (mean: 1.59, SD: 3.20), indicating a need for better distribution systems. Engagement in constructing feed conservation structures is low (mean: 1.52, SD: 3.29). Soil conservation practices are minimally adopted (mean: 1.45, SD: 3.37). The use of Prosopis Juliflora flour is low (mean: 1.59, SD: 3.19), showing varying utilisation.

Seed bulking and management practices score low (mean: 1.60, SD: 3.04). Irrigation use for pasture production has a low mean score (1.53, SD: 3.31). The use of Acacia Tortilis pods as a supplement is low (mean: 1.63, SD: 3.34). Range pits for water conservation are also used minimally (mean: 1.63, SD: 3.33). Adopting and access to adaptation technologies for pasture production are generally low, with high response variability.

Table 9: Effects of Rainfall Variability in Your Locality

Variable	Obs	Mean	Std.Dev	Min	Max
Severe storms/flooding	373	0.100	0.52	0	1
Increased Droughts	373	0.89	0.32	0	1
Loss of vegetation cover	373	0.90	0.69	0	1
More health risks	373	0.83	0.38	0	1
Lack of enough food	373	0.80	0.40	0	1
Migration	373	0.78	0.41	0	1
Increased livestock and pest disease	373	0.79	0.41	0	1
Poverty	373	0.73	0.41	0	1
Blockage of ditches and drainage channels	373	0.88	0.33	0	1
Lack of water	373	0.79	0.40	0	1
Inter Clan conflicts for pasture/water	373	0.87	0.34	0	1
Increased in pasture production	373	0.21	0.41	0	1
Increased deaths of livestock	373	0.82	0.39	0	1
Lack of enough water	373	0.76	0.43	0	1

Table 9 shows the impacts of rainfall variability as reported by 373 respondents, revealing widespread and varied effects. Severe storms or flooding are nearly universal, with a mean of 0.10 and high variability. Increased droughts are reported by 89%, with a mean of 0.89 and moderate variability. Loss of vegetation cover affects 90%, showing severe environmental impact with significant variability. Health risks due to rainfall variability concern 89% of respondents, with moderate variability in health impacts.

Food insecurity is 80%, with a mean of 0.80 and moderate variability. Migration due to changing rainfall patterns affects 78%, with moderate variability. Increased livestock and pest diseases impact 79%, indicating varying effects on livestock health and agriculture. Poverty is reported by 73%, reflecting economic hardships with varying levels of severity.

Blockages in ditches and drainage channels concern 88%, with low variability. Water scarcity is reported by 79%, indicating a critical issue with high variability. Conflicts over pasture and water resources are noted by 87%, with low variability. Only 21% report increased pasture production, showing rare positive outcomes with significant variability. Livestock deaths concern 82%, reflecting significant livelihood impacts with moderate variability. Insufficient water affects 76%, with high variability.

Most respondents experience negative effects from rainfall variability, with mean values mostly above 0.7. High variability in these impacts suggests widespread but differing severity among respondents. Addressing these challenges requires targeted interventions to effectively manage and mitigate the diverse impacts.

Influence of Temperature Variability on Adoption of TIMPs

The study sought information on the effects of temperature variability on the locals. The results on the mean and standard deviation are presented in Table 10.

Table 10: Effects of Temperature Variability on the Locals

Variables	Obs	Mean	Std. Dec	Min	Max
Severe sandstorms	373	0.99	0.89	0	1
Increased droughts	373	0.89	0.32	0	1
Loss of pasture	373	0.89	0.31	0	1
More health risks	373	0.84	0.37	0	1
Insufficient human food	373	0.83	0.37	0	1
Migration in search for water/pasture	373	0.85	0.36	0	1
Increased livestock pests and diseases	373	0.81	0.40	0	1
Increased poverty	373	0.80	0.41	0	1
Lack of water	373	0.77	0.40	0	1
Increased in pasture production	373	0.21	0.41	0	1
Increased deaths of livestock	373	0.79	0.41	0	1
Lack of enough water	373	0.80	0.40	0	1
Frequent heat waves	373	0.79	0.41	0	1
Interclan/tribal conflicts for water	373	0.88	0.32	0	1

Table 10 reveals the impacts of temperature variability on local populations. Severe sandstorms are reported by nearly all respondents (mean: 0.99), indicating a prevalent issue with high variability. Increased droughts are observed by 89%, with moderate variability.

Loss of pasture affects 88%, showing a significant impact on grazing lands with moderate variability. Health risks due to temperature variability are reported by 84%, with varied impacts. Insufficient human food is experienced by 83%, with moderate variability in food shortages. Migration for water or pasture affects 85%, indicating significant resource scarcity with moderate variability. Increased livestock pests and diseases are noted by 81%, with moderate variability. Increased poverty is reported by 79%, reflecting moderate variability in economic hardship.

A lack of water affects 77%, with moderate variability in severity. Only 21% report increased pasture production, indicating rare positive outcomes with significant variability. Increased livestock deaths are reported by 79%, showing a direct impact on livelihoods with moderate variability. Frequent heat waves are experienced by 79%, with moderate variability. Interclan or tribal conflicts over water resources affect 88%, with moderate variability. The results on the influence of temperature on adoption are presented in Table 11.

Table 11: Influence of Temperature on the Adoption of TIMPs

Variables	Obs	Mean	Std. Dev	Min	Max
Access to information on TIMPs	373	3.09	1.55	0	1
Reseeding technology on my farm	373	3.25	1.53	0	1
Access to quality seeds for pasture production	373	3.01	1.51	0	1
Timely information on temperature variability	373	3.20	1. 35	0	1
Marketing of pasture during dry period	373	3.17	1.43	0	1
Use of feeds conservation structure	373	3.12	1.51	0	1
Water harvesting for pasture production	373	3.23	1.61	0	1
Soil conservation for pasture production	373	4.18	1.50	0	1
Use of Prosopis Juliflora pods	373	2.99	1.19	0	1
Community-based seed bulking/management practices	373	3.31	1.57	0	1
Use of Acacia tortilis pods supplement	373	3.33	1.63	0	1
Drip irrigations for pasture production	373	2.97	1.67	0	1

Table 11 details the adoption of Technological Innovations and Management Practices (TIMPs) for pasture production. Access to TIMPs information has a mean score of 3.09 (SD = 1.55), indicating moderate access with variability. Reseeding technology adoption has a mean score of 3.25 (SD = 1.53), suggesting moderate to slightly high adoption rates.

Access to quality seeds scores 3.01 (SD = 1.51), reflecting moderate levels. Timely information on temperature variability is moderately available, with a mean score of 3.20 (SD = 1.35), indicating consistency among respondents. Pasture marketing during dry periods scores 3.17 (SD = 1.43), showing moderate efforts. Feed conservation structures also show moderate use with a mean score of 3.12 (SD = 1.51).

Water harvesting for pasture production scores 3.23 (SD = 1.61), indicating moderate adoption with significant variability. Soil conservation practices stand out with a high mean score of 4.18 (SD = 1.50), showing high adoption. The use of Prosopis Juliflora pods has a mean score of 2.99 (SD = 1.19), reflecting moderate usage with less variability.

Community-based seed bulking scores 3.31 (SD = 1.57), indicating moderate to slightly high adoption. The use of Acacia Tortilis pods scores 3.33 (SD = 1.63), suggesting moderate adoption. Drip irrigation for pasture production scores 2.97 (SD = 1.67), indicating moderate adoption with greater variability.

Conclusion

Temperature significantly influences farmers' adoption of TIMPs, while rainfall does not. Policymakers should focus on temperature-related strategies, evaluating rainfall's role, and adopting a holistic approach to support farmers. Climate variability's complexity involves unpredictable weather, low/high temperatures, low rainfall, and drought. Targeted measures and informed policy-making are crucial for better climate adaptation.

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