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RESEARCH ARTICLE

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Smallholder farmers' perceptions of climate change and the perceived effectiveness of adaptation practices in Kitgum District, northern Uganda

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ABSTRACT

Climate change continues to disproportionately affect smallholder farmers, given their dependence on rain-fed agriculture and constrained adaptive capacity. This paper examines the smallholder farmers' perceptions of climate change and the perceived effectiveness of adaptation practices. Data were collected from a sample of 349 respondents using a structured survey questionnaire. Purposive sampling was used to select participants for key informant interviews and focus group discussions. Quantitative data were analyzed using descriptive statistics, multinomial logistic regression, and Friedman test, while thematic-content analysis was used to analyze qualitative data. All households were aware of climate change, mainly perceived as a decrease in rainfall and an increase in temperature over the past 30 years. Households with livestock production perceived a decrease in rainfall (p <0.000), and the age group ranging from 35 to 44 years perceived increase in temperatures (p < 0.036). Majority (95%) of the respondents reported planting drought-resistant varieties and using improved seeds (87%). Four paired adaptation practices were statistically significant (p <0.000) and perceived to be effective by households. The study recommends climate awareness programs through targeted climate education and awareness campaigns for younger farmers and women to bridge perception gaps and enhance effective adaptation practices.

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KEYWORDS
Climate change; perceptions; effectiveness; adaptations; smallholder; farmers

1. Introduction

Climate change is a global phenomenon with profound implications for food security, water availability, and rural livelihoods. The increased concentration of greenhouse gases to 1.5°C has raised the average temperature and altered the amount and distribution of rainfall globally (OECD, 2022; WMO, 2024). Smallholder farmers are the major contributors of the world's agricultural output but at the same time vulnerable due to their reliance on rain-fed agriculture. Adaptation to climate change is not merely a choice but a necessity for sustaining livelihoods and ensuring long-term food and income security,

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particularly smallholder farmers who generate about 70% of the GDP (World Economic Forum, 2022).

Sub-Saharan Africa (SSA) is considered one of the most vulnerable regions to climate change (Menghistu et al., 2020). The region's heavy dependence on climate-sensitive agriculture, coupled with high poverty rates, low adaptive capacity, and infrastructural deficits, exacerbates its exposure to climate impacts (Menghistu et al., 2020). Smallholder farmers across SSA have begun to adopt a range of local adaptation strategies, including changes in cropping systems, water conservation techniques, agroforestry, and indigenous knowledge practices (Ahn et al., 2022; Kassegn & Endris, 2021).

Uganda experiences climate change impacts as an agrarian economy, with over 70% of the population engaged in smallholder agriculture. Uganda has witnessed climate variability, including rising temperatures and erratic rainfall patterns. These affect crop yields, food availability, and rural incomes (Bamanyaki & Aogon, 2020). The Government of Uganda has responded by integrating climate change into its national development plan, promoting climate-smart agriculture (CSA) and strengthening early warning systems (Bamanyaki & Aogon, 2020; NPA, 2025). Nonetheless, empirical data on how smallholder farmers perceive the effectiveness of adaptation practices, especially at the local level, remains limited.

Northern Uganda experiences unique set of climatic challenges. The region is still recovering from the legacy of a prolonged civil conflict that disrupted agricultural systems, eroded community resilience, and weakened institutions for two decades (1986-–2006). Smallholder farmers' perceptions of climate change tend to vary and seem to be context specific (Atube et al., 2021; Atube, Okello, et al., 2022; Chombo et al., 2018; Okello et al., 2023). Kitgum District stands out as an underreported and marginalized area where climate change impacts are increasingly evident, yet systematic assessments of local adaptation efforts are scarce. Smallholder farmers in Kitgum are experimenting with various adaptation strategies to manage climate-related impacts, often under severe resource constraints.

1.1. Theoretical framework

This study is guided by the Theory of Planned Behavior (TPB) (Ajzen, 2014) and the Protection Motivation Theory (PMT), which together provide a comprehensive framework for explaining climate change adaptation behavior. The TPB posits that behavioral intention, which is the most immediate predictor of action, is shaped by attitudes toward adaptation practice, subjective norms, and perceived behavioral control relating to the environment (Mitter et al., 2019). In the climate change context, farmers' decisions to adopt strategies are influenced not only by their perception of the benefits of these practices but also by community expectations and resource availability (Atube et al., 2021; Atube, Okello, et al., 2022; Teklewold et al., 2018). The role of intention and behavioral control in influencing behavior has been previously studied (Ajzen, 2014; Eklund & Tenenbaum, 2014; Feng et al., 2017). Thus, TPB highlights how social influence and perceived capacity shape adaptation practices and outcomes.

PMT complements this by focusing on risk perception and protective motivation. It emphasizes that individuals appraise climate risks based on their perceived severity and vulnerability while simultaneously evaluating their capacity to respond effectively

through response efficacy, self-efficacy, and perceived cost. When individuals perceive climate change risks as severe and feel both capable and supported in implementing adaptive practices, they are more likely to take protective action (Jellema et al., 2022). PMT assumes that the perception of threat and the desire to avoid damage motivates people to change their behavior through adaption practices. Integrating TPB and PMT allows this study to capture both social-cognitive drivers, such as attitudes, norms, and control, and the risk-based motivations, providing a holistic understanding of why some households adapt while others remain constrained.

The importance of climate change perception in the adaptation process has long been recognized (Van et al., 2015). TPB has wide applications as a conceptual framework in the study of human action (Gordon et al., 2017). It has been applied successfully in different fields, such as climate change adaptation (Gordon et al., 2017; Mehedi et al., 2015; Mitter et al., 2019), food consumption, and health-related behavior. Few studies have applied TPB and PMT to climate change adaptation (Mehedi et al., 2015), with almost no application in the context of Kitgum District.

2. Materials and methods

2.1. Description of the study area

The study was conducted in Kitgum District, located in Northern Uganda. It is located between longitudes 32°30'E and 33°45'E and latitudes 03°13'N and 3°45'N. The district is bordered by a semi-arid region of Kotido District in the east. The area is characterized by bimodal tropical rainfall, with the first season lasting from March to June and the second season from July to November. The district receives a mean annual precipitation of 760–1300 mm and experiences dry-hot and windy weather from December to mid-March. The mean annual temperature is about 24.6°C. The average monthly maximum temperature is 27°C, and the average monthly minimum temperature is 17°C (Kitgum District Statistical Report, 2013). This study was conducted in the three subcounties of Orom, Omiya-anyima, and Namokora (Figure 1).

2.2. Sampling strategy and sample size

Kitgum District and the three studied subcounties of Orom, Omiya-anyima, and Namokora were purposively selected (Bhardwaj, 2019; Taherdoost, 2016) based on their drought-prone nature and location at the border of a semi-arid region in the north-eastern part of Uganda. Three parishes were selected, taking one from each subcounty: Loliya Parish in Orom, Pugoda-west Parish in Namokora, and Panyum-pella Parish in Omiya-Anyima. A simple random sampling technique using the lottery method was employed to select respondents at the household level to reduce bias (Bhardwaj, 2019; Taherdoost, 2016). The sampling frame, containing a list of households, was obtained from Local Council offices, and households were considered the unit of analysis.

The three studied parishes had 2763 households, and this was obtained from Uganda Bureau of statistics (UBOS, 2014). Using Yamane formula for sample size calculation (Kothari, 2004), data was collected from 349 households that were proportionately distributed in the three parishes. However, 336 completed

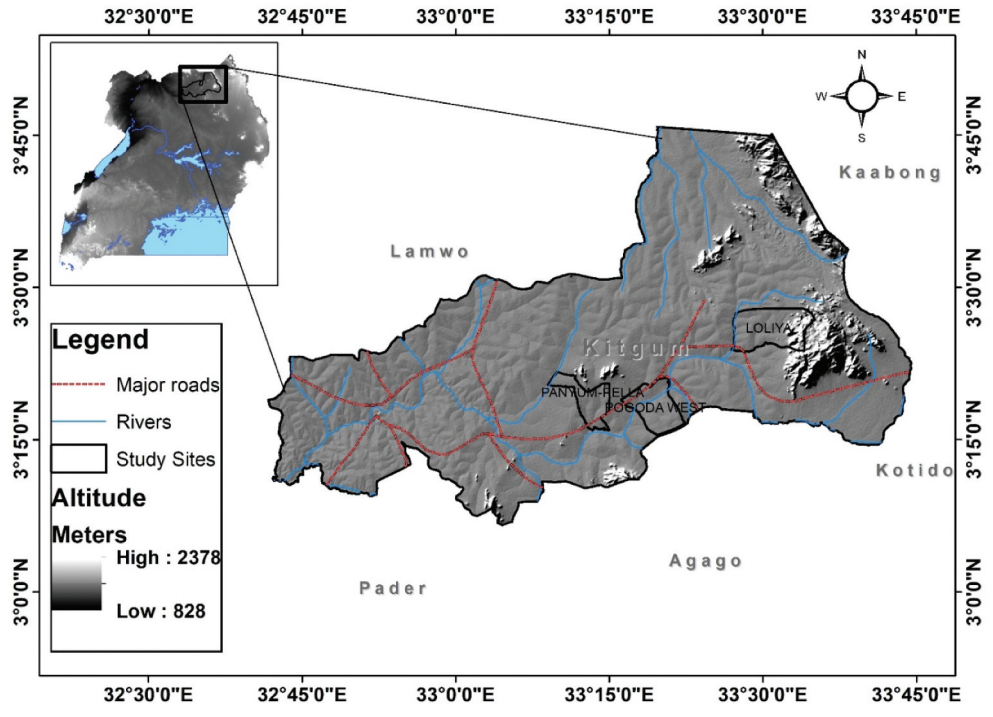

Figure 1. Location of the study area.

questionnaires were analyzed, representing a response rate of 96%. The 4% of the questionnaires were dropped during data entry due to inconsistent and incomplete data (six from Orom, four from Namokora, and three from Omiya-anyima). The survey was piloted at Kitgum Matidi subcounty in Kitgum District with 35 farmers (25 males and 10 females). The survey was carried out by the researcher and trained data enumerators.

2.3. Data collection

A cross-sectional research design was employed using a mixed-methods approach to collect data from the sampled population at a specific point in time (Kothari, 2004). Data collection took place from July to September 2018.

2.3.1. Household survey

The household survey, a quantitative method of data collection, was used to collect primary data using survey questionnaire. The data collected included socioeconomic characteristics of the respondents, climate change perceptions and its impacts, adaptation practices, and perceived effectiveness of the adaptation practices. Quantitative data were necessary to make generalizations of the findings (Kothari, 2004). The survey questionnaire was administered face-to-face to household heads or their equivalents of 35 years and above, who had experience with climate change and its impacts. The age choice was

because climate change is a long-term shift in temperatures and rainfall parameters due to natural or anthropogenic factors (WMO, 2024).

Questions on socioeconomic characteristics had dichotomous responses (1 = Yes, 0 = No). The socioeconomic characteristics of respondents included location, gender, age, education level, main agricultural activity, and major source of income.

Responses on perceptions of climate change covered a 30-year period (1988–2017). Respondents were asked whether they have noticed changes in climate and its impacts, such as changes in rainfall (increase, decrease, shift, or drought) and changes in temperature (increase, decrease, extreme heat stress, and don't know). Respondents were required to select only one response in each category using dichotomous responses (1 = Yes, 0 = No).

The questions on adaptation practices used multiple-choice responses. The variables for adaptation practices included mixed farming, change in planting dates, use of different crop varieties, planting drought-resistant varieties, and the use of improved seeds.

To measure the effectiveness of the adaptation practices, responses were obtained using 5-point Likert scale questions (1 – very ineffective, 2 – ineffective, 3 – neutral, 4 – effective, 5 – very effective). Respondents were able to rate each adaptation practice based on the Likert scale.

2.3.2. Key informant interviews (KIIs)

Key informant interviews are qualitative, in-depth interviews conducted with participants knowledgeable about the research topic to provide perspectives as an expert source of information (Islam & Niaz Ahmed Khan, 2022). To triangulate the survey data, a total of 12 key informants were purposively selected from the three subcounties: three agricultural extension facilitators (AEFs), three farmer group leaders, three subcounty production officers, and three community development officers (CDOs). An interview guide was used to guide the interviews.

2.3.3. Focus group discussion (FGDs)

A total of three FGDs were conducted, taking one from each study site, with varying number of participants. Orom had 13 participants (7 males and 6 females), Namokora has 6 (4 females and 2 males), and Omiya-anyima had 12 (8 females and 4 males). This was based on the procedure used by Tümen-Akyıldız and Ahmed (2021).

2.3.4. Climate data

To triangulate the primary data on perceptions of climate change, historical average annual rainfall and average annual temperature data for a period of 30 years (1988–2017) for the Kitgum District sub-station were obtained from Uganda Meteorological Authority (UNMA).

2.4. Data analysis

2.4.1. Perceptions of climate change and its impacts

Descriptive statistics involving frequencies and percentages (Kothari, 2004) were conducted in Statistical Package for the Social Sciences (SPSS) version 27 to obtain responses

on perceptions of climate change and its impacts. The variables for climate change perceptions included changes in rainfall and temperatures. The perceived climate change impacts included increase in rainfall, decrease in rainfall, shifts in rainfall patterns, drought, increase and decrease in temperature, extreme heat waves, and 'don't know' Responses are presented in bar graphs for easy interpretation.

2.4.1.1. Meteorological data on climate change. The Mann-Kendall (MK) non-parametric trend analysis was performed in Excel to assess the monotonic upward or downward trend in average mean annual rainfall and maximum and minimum temperatures (Chatterjee et al., 2014; Henry, 1945) over the past 30 years (1988–2017). The information is presented using a bar graph for rainfall and a line graph for temperature.

2.4.1.2. Influence of socioeconomic characteristics on perception of climate change impacts. Multinomial logistic regression analysis was conducted to determine how perceptions vary with socioeconomic characteristics of smallholder farmers. This analysis was conducted because the dependent variables were categorical with more than two levels. The dependent variables were increase in rainfall, decrease in rainfall, shift in rainfall, and drought for rainfall, while for temperature, the variables were increase in temperature, decrease in temperature, extreme heat stress, and 'don't know' to enable the analysis. The independent variables were socioeconomic characteristics, such as gender, age, education level, major source of income, and main agricultural activity.

The expected sign for the coefficient in the model was either negative or positive. A negative sign indicates an inverted U-relationship,and a positive sign reflects a normal U-relationship.

The logistic model accordingly is

$$Yi = In(Pj/P1) = \beta 0 + \beta 1\, X1 + \beta 2\, X2 + \beta 3\, X3 + \beta 4\, X4 + \beta 5\, X5 + \beta 6\, X6 + ei \quad (1)$$

where P1-P8 is the probability that a household will perceive changes in rainfall and temperature. Increase in rainfall and 'don't know' for temperatures were the reference points. Therefore, from the above formula, Yi is the dependent variable, ln is the natural log $\frac{Pj}{P1}$ is the log odd of household perceiving changes in rainfall and temperature over increase in rainfall and no change for temperature. β0 is the constant, β1-β6 is the coefficient of the dependent variable, indicating either a positive or negative direction of relationship, X1-X6 is the independent variable (socioeconomic charcteristics), and ei is the error term (influence of other factors).

2.4.2. Adaptation practices to climate change impacts

To establish the adaptation practices by smallholder farmers, frequencies and percentages were calculated using multiple-response options. During the analysis, variables were coded as dichotomies and counted at value 1 (yes responses).

2.4.3. Perceived effectiveness of the adaptation practices

Friedman Analysis of Variance (ANOVA) test was used to determine the difference in the mean rank of the ordinal variable (Rayner & Livingston, 2023). A significant Friedman test ($p \leq 0.005$) means we reject the null hypothesis that the distribution of these variables (perceived effectiveness of adaptation practices) is equal. Hence, pairwise

Wilcoxon signed-rank tests with Bonferroni correction test were performed as a post hoc test to determine which specific groups differ from each other, and two pairwise conditions were analyzed at a time and repeated for all pairwise comparisons.

2.4.4. Qualitative data analysis

Thematic-Content analysis was used to identify themes and patterns across data based on research objectives. FGDs and KIIs audio recordings were manually transcribed and deductive coding conducted to derive themes. Data are presented in narratives.

3. Results

3.1. Socio-economic characteristics of smallholder farmers

The findings revealed that majority (59.8%) of the respondents were males, while females comprised 40.2%. The majority (71.7%) were aged 31–44 years, and a few (28.3%) were age 18–30 years, 45–64 years, and 65 years and above. In terms of education levels, 44.3% had primary level of education, 37.2% had no formal education, and a few (18.5%) had both secondary and higher education. More than a half (57.4%) of the respondents were engaged in both crop and livestock production, while 41.1% were involved in only crop production and 1.5% had livestock productions. Crop farming was the main source of income 89.3% (Table 1).

3.2. Perceptions of climate change and its impacts by smallholder farmers

All (100%) respondents perceived that climate change has been experienced over the past 30 years in Kitgum District. Majority (52.4%) of the respondents perceived a decrease in rainfall, followed by drought (28.3%) and shift in rainfall patterns (14.0%), and less than 5.4% perceived increase in rainfall (Figure 2).

Focus group discussions confirmed the perceived changes in rainfall.

Table 1. Socio-economic characteristics.

Socio-economic characteristics		Frequency (n = 336)	Percent (%)
Sub-county	Orom	168	50.0
	Namokora	80	23.8
	Omiya-anyima	88	26.2
Gender	Male	201	59.8
	Female	135	40.2
Age	35–44 years	274	81.5
	45–54 years	44	13.1
	55+ years	18	5.4
Education level	No formal education	125	37.2
	Primary	149	44.3
	Secondary	48	14.3
	University/diploma	14	4.2
Main agricultural activity	Crop production	138	41.1
	Livestock production	5	1.5
	Both crop and livestock production	193	57.4
Major source of income	Crop farming	300	89.3
	Livestock rearing	27	8.0
	Others	9	2.7

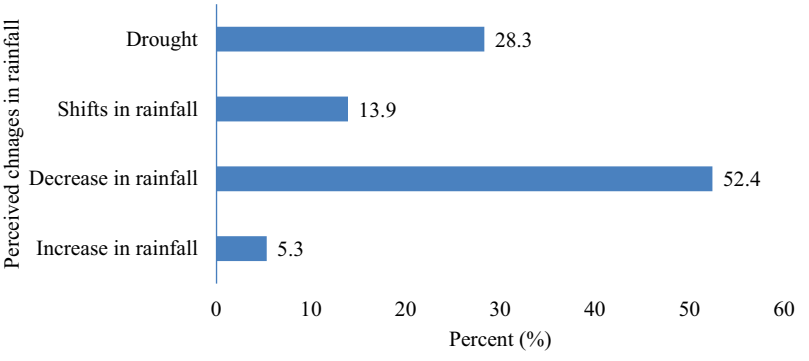

Figure 2. Perceived changes in rainfall.

> . . . Rainfall amount has greatly reduced for a long time. Seasonal rainfall sometimes stops even before the planting time and each time it rains; the soil remains dry as if there was no rain. Drought 'Aroo' has become so frequent for example in 2005 and 2016. FGD, Orom Sub county.

Majority (50.0%) of the respondents perceived an increase in temperature, and 33.0% perceived extreme heat stress over the past 30 years (Figure 3).

Results from FGDs showed agreement with survey data, showing that temperatures have increased and households are also experiencing extreme heat stress.

> . . . for so long daily temperatures are very high, it is very hot and too much heat stress on crops and animal. FGD, Omiya-anyima Sub county

3.2.1. *Mean annual rainfall for Kitgum District*

Meteorological data show that there was a sharp decrease in mean annual rainfall, with 22.3 mm in 1998 to 2017 (Figure 4).

Meteorological data revealed that the mean annual temperature increased to 0.2°C between 1989 and 1997, and the coldest year was 1998 (12.1°C) on average (Figure 5).

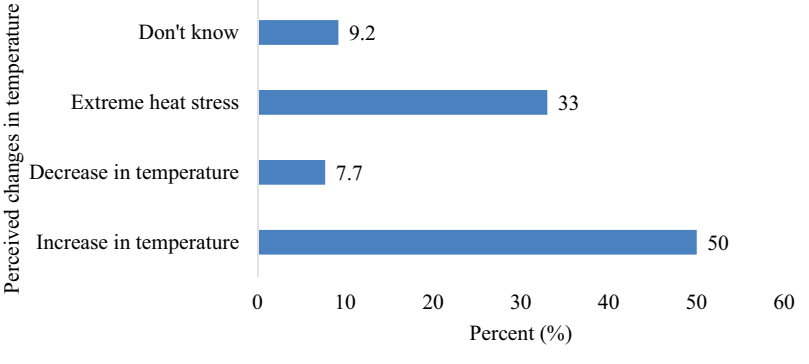

Figure 3. Perceived changes in temperature.

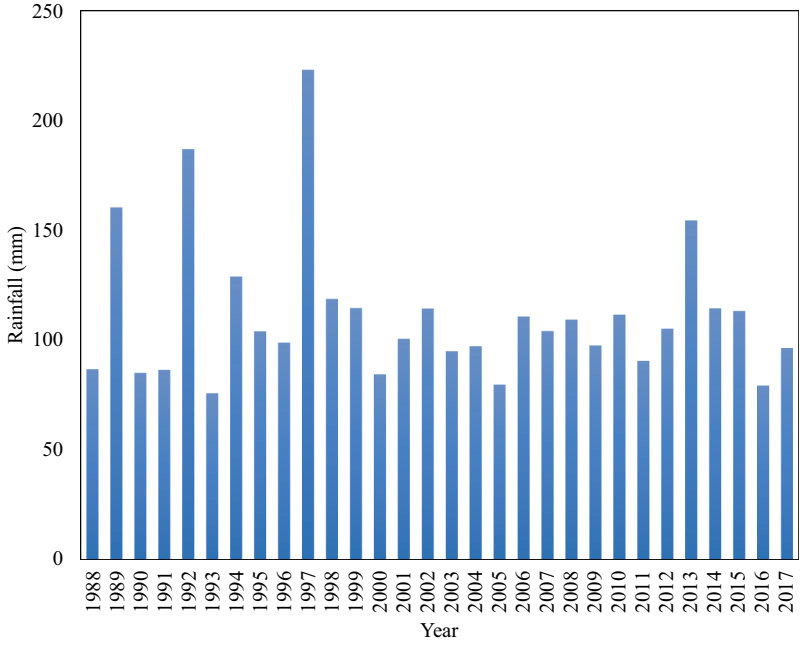

Figure 4. Average annual rainfall for the period 1988–2017 in Kitgum District. Source: UNMA.

3.2.2. *Influence of socioeconomic characteristics on perception of climate change impacts*

The finding revealed that livestock production was positively associated with the perception of decrease in rainfall (β = 16.404, $p < 0.000$), indicating that livestock farmers were more likely to perceive decrease in rainfall compared to those with both crop and livestock production (Table 2).

Crop farming and livestock rearing as main source of income were negatively associated with the perception of decrease in rainfall (β = −16.618, $p < 0.000$ and β = −16.629, $p < 0.000$, respectively). The negative coefficient indicates a reduced likelihood of perceiving a decrease in rainfall compared to their counterparts in the reference category (others) who were more likely to report a decrease in rainfall.

Crop farming had a negative coefficient and was statistically significant in predicting the likelihood of perceiving drought occurrences (β = −16.408, $p < 0.000$). This means that respondents with others as sources of income were more likely to predict drought compared to increase in rainfall.

Age (35–44 years) had a positive coefficient and was statistically significant (β = 1. 486, $p < 0.036$) in predicting the perceived increase in temperature. This means that older individuals were likely to perceive an increase in temperature. However, farming and livestock rearing had negative coefficient and statistically significant association with the likelihood of perceiving increase in temperature (β = −17.375, $p < 0.000$ and β = −18.153, $p < 0.000$, respectively). This means that those with trade as a major source of income were more likely to report experiencing an increase in temperature.

Households with no formal and primary level of education had positive coefficient and a statistically significant influence on perceiving decrease in temperature (β = 17.189,

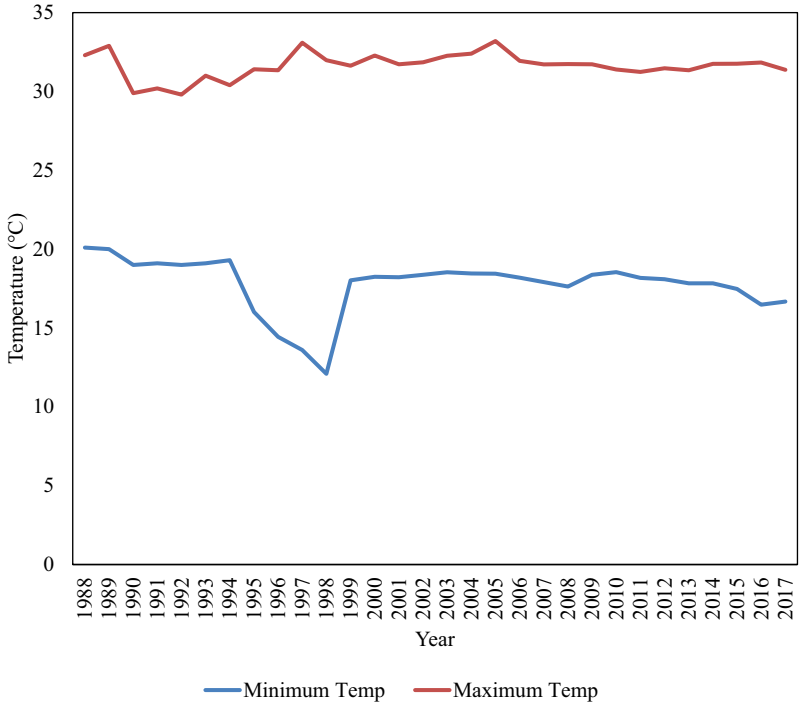

Figure 5. Average annual maximum and minimum temperatures for the period 1988–2017 in Kitgum District. Source: UNMA.

$p < 0.000$ and $\beta = 15.931$, $p < 0.000$, respectively). However, households with farming and livestock rearing had negative coefficient and was statistically significant ($\beta = -17.375$, $p < 0.000$ and $\beta = -18.153$, $p < 0.000$, respectively) in predicting perceived decrease in temperature. This means that respondents with other sources of income were more likely to report decreases in rainfall.

3.3. Adaptation practices to the perceived climate change impacts

Majority (94.9%) adopted planting of drought-resistant varieties, the use of improved seeds (86.6%), the use of different crop varieties (85.7%), and change of planting dates (69.9%), and only 44.3% adopted mixed farming (Figure 6).

3.4. Perceived effectiveness of adaptation practices

The results revealed statistically significant differences in perceived effectiveness between the use of improved seeds and planting drought-tolerant varieties ($z = -3.13$, $p < 0.010$), planting drought tolerant varieties, the use of different crop varieties ($z = -6.94$, $p < 0.001$), use of different crop varieties and change of planting dates ($z = -9.09$, $p < 0.001$), and use of improved seeds and mixed farming ($z = -5.96$, $p < 0.001$) (Table 3).

Table 2. Influence of socioeconomic characteristics in perceiving climate change impacts.

Variable	Category	Perception of changes in rainfall patterns						Perception of changes in temperature					
		Decrease		Shift		Drought		Increase		Decrease		Extreme heat stress	
		Coef	p	Coef	p	Coef	p	Coef	p	Coef	p	Coef	p
Subcounty	Omiya-anyima (RC)												
	Orom	0.160	0.608	0.824	0.231	0.347	0.588	0.925	0.072	0.877	0.183	0.502	0.340
	Namokora	0.475	0.769	0.527	0.551	0.678	0.394	0.379	0.503	−1.202	0.212	0.089	0.879
Gender	Female (RC)												
	Male	−1.090	0.103	−0.774	0.287	−1.239	0.070	0.311	0.464	−0.223	0.696	0.460	0.298
Age	55+ years (RC)												
	35–44 years	1.069	0.235	1.461	0.184	0.672	0.468	1.486	0.036*	1.939	0.106	1.450	0.056
	45–54 years	0.607	0.562	0.504	0.697	0.356	0.742	1.641	0.062	0.480	0.768	1.359	0.148
Highest education level	University/diploma (RC)												
	No formal education	0.198	0.821	1.200	0.364	0.482	0.608	−0.195	0.864	17.189	0.000*	0.171	0.884
	Primary	0.900	0.329	2.211	0.099	0.802	0.416	−0.923	0.400	15.931	0.000*	−0.736	0.517
	Secondary	0.949	0.347	2.335	0.097	0.911	0.396	−0.568	0.624	17.178	"~0"	−0.376	0.753
Main agricultural activity	Both crop and livestock production (RC)												
	Crop production	−0.236	0.654	−2.76	0.639	−0.409	0.456	−0.115	0.426	0.029	0.960	−0.274	0.534
	Livestock production	16.404	0.000*	0.355	1.000	16.471	"~0"	−0.280	0.837	−17.416	0.998	−17.986	0.997
Major source of income	Others (RC)												
	Farming	−16.618	0.000*	0.847	1.000	−16.408	0.000*	−17.375	0.000*	0.426	1.000	−16.751	0.000*
	Livestock rearing	−16.629	0.000*	0.016	1.000	−16.433	"~0"	−18.153	0.000*	−0.316	1.000	−17.513	"~0"

Reference category for outcome: increase in rainfall, and I don't know for temperature, coef (β) = coefficient either ±, *p (p-value) ≤0.05.
Reference category for predictors: sub-county 3, male, age (55+years), University/diploma education, both crop and livestockproduction, and other sources of income, "~0" indicates near-zero odds ratios due to very large negative coefficient (likely due tospare data).

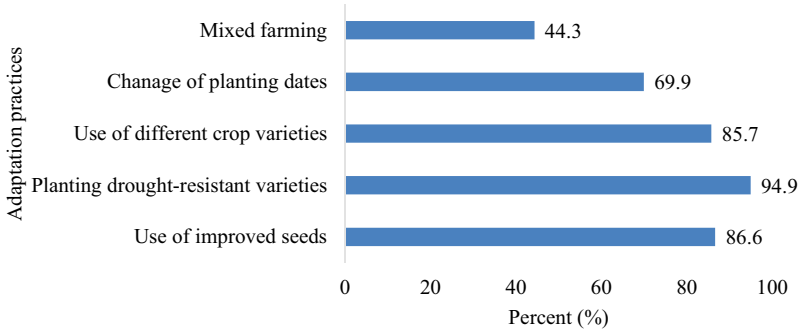

Figure 6. Smallholder farmers adaptation practices to climate change in Kitgum District in northern Uganda.

Table 3. Perceived effectiveness of adaptation practices in Kitgum District in northern Uganda.

Variables	Z	p (original)	P (adjusted)	Significant
Use of improved seeds and planting drought tolerant variety	−3.13	0.002*	0.010	Yes
Planting drought tolerant variety and use of different crop varieties	−6.94	0.000*	<0.001	Yes
Use of different crop varieties and change of planting dates	−9.09	0.000*	<0.001	Yes
Change of planting dates and mixed farming	−1.66	0.097	0.485	No
Use of improved seeds and mixed farming	−5.96	0.000*	<0.001	Yes

Note. Bonferroni correction was applied with an adjusted significancethreshold of $p < 0.01$.

4. Discussions

This section presents and interprets the research findings in comparison with other studies.

All households reported that climate change is occurring. The indicators reported to have changed were rainfall and temperature over the past 30 years. Smallholder farmers' beliefs and perceptions of the environment determine experiences regarding climate change. These changes are more likely to be attributed to the El Niño-Southern Oscillation (ENSO) phenomena, changes in the sea surface temperature gradients in the tropical Indian Ocean, and the influence of trade winds (Oriangi et al., 2019). The perceived climate change impacts were decrease in rainfall, shift in rainfall patterns, drought, and increase in temperature. Meteorological data also show a decrease in rainfall and an increase in temperatures from 1988 to 2017. The alignment between perceptions and meteorological evidence validates experience and indigenous knowledge. This finding is consistent with Atube, Malinga, et al. (2022) and (Oketcho et al., 2024), who report that smallholder farmers perceived a decrease in rainfall over three decades. The study also concurs with the finding that the least experienced climate change event was extreme heat waves (Kalele et al., 2021; Twinomuhangi et al., 2021).

Households with livestock productions were more likely to report a decrease in rainfall, while the age group of 35–44 years was more likely to report an increase in temperature. This means that older household heads were more likely to report an increase in temperature than younger household heads. Engaging in livestock rearing resonates with perceptions of a decrease in rainfall since they are able to experience pasture and water shortages for their animals. However, this finding negates from Assan

et al. (2020), who reported that perceptions of climate change through rising temperatures and increasing erratic rainfall were similar across gender. The finding disagrees with Jellason et al. (2019), who reported that age does not influence perceptions of a decrease in rainfall. This study agrees with Asrat and Simane (2018), who reported that the age of the household head significantly influenced farmers' perception of climate change in Ethiopia.

Although not significant, female gender was positively more likely to perceive drought than male smallholder farmers. Women are able to perceive drought due to their high engagement in farming activity to sustain the family, while men prefer off-farm activity. This finding negated from a finding that both men and women had similar perceptions of rising temperatures and increasing erratic rainfall (Assan et al., 2020). Male respondents were more informed about changes in climate parameters than female respondents (Jellason et al., 2019).

Households with no formal education were significantly more likely to perceive a decrease in temperature than their counterparts with university or diploma education. Uneducated people have less knowledge of climatic patterns, which makes it difficult to differentiate between changes in temperature conditions. The finding aligns with Atube, Malinga, et al. (2022), in which farmers reported a reduction in hot days. This finding negates from Twinomuhangi et al. (2021), who reported that education rather influences perceptions of change in rainfall. This finding also deviates from Chombo et al. (2020), where farmers revealed increases in temperatures.

The findings revealed that households with income source from farming and livestock rearing were significantly less likely to predict perceptions in changes in rainfall patterns and changes in temperature patterns. This means their counterparts with other sources of income like off-farm activity were more likely to perceive changes in rainfall and temperatures. Farmers with limited sources of income are often affected with changes in rainfall and temperatures since these could be businessmen dealing in farm products that are prone to climate change. Low supply of such farm produce enables perceptions of climate change than those with alternative sources of income such as livestock.

The majority of respondents are adapting to climate change impacts through planting drought-resistant varieties, use of improved seeds, use of different crop varieties, and change in planting dates. This resonates with the TPB and PMT that perceptions of climate change influence adaptation practices. The adaptation mechanisms employed by smallholder farmers in Kitgum District are likely to be due to limited financial, institutional, and farm technology. These smallholder farmers adaptation mechanisms have a close relationship with those carried out in other parts of the African continent. A study by Oketcho et al. (2024) in Kyoga agroecological zone reported that farmers have adapted to climate change through the use of fast-yielding varieties, adjustment of planting dates, mulching, soil conservation practices, tree planting, and diversification of farming activities.

Smallholder farmers adopted a combination of adaptation practices to climate change, including the use of improved seeds with planting drought-tolerant varieties; planting drought-tolerant varieties with the use of different crop varieties; the use of different crop varieties with changes in planting dates; and the use of improved seeds with mixed farming. Engaging in multiple enterprises helps reduce the adverse effects of climate change among smallholder farmers. In Ghana and Uganda, perceived effective adaptation

practices were on-farm in nature (Atube et al., 2021), while Gyimah et al. (2020) reported changing crop varieties, changes in planting dates, and crop diversification.

5. Conclusion

Household perceptions revealed that climate change has occurred in the Kitgum District over the past 30 years. The perceived climate change impacts are decrease in rainfall, shift in rainfall, droughts, increase in temperature, and extreme heat waves. These were confirmed by the meteorological recordings, which show a decrease in rainfall and increase in temperature. This finding implied that government, non-governmental organizations, smallholder farmers, and other interested stakeholders need to promote water conservation and the use of crop and livestock varieties that are tolerant to such weather extremes in the region.

Planting drought-resistant varieties, use of improved seeds, use of different crop varieties, and change in planting dates were adopted. A combination of adaptation practices that were both statistically significant and perceived as effective included the use of improved seeds with planting drought-tolerant varieties; planting drought-tolerant varieties with the use of different crop varieties; the use of different crop varieties with changes in planting dates; and the use of improved seeds with mixed farming.

The study recommends climate awareness programs through targeted climate education and awareness campaigns for younger farmers and women to bridge perception gaps and enhance effective adaptation practices. Livelihood support should be provided to livestock farmers, including early warning systems and drought-resistant fodder. Farmers' long-term indigenous knowledge of climate change should be taken into account, and local adaptation practices should be incorporated to enhance relevance and effectiveness. Further research using longitudinal methods is needed to track how climate change perceptions evolve and how these perceptions translate into adaptive behaviors that are effective over time for smallholder farmers.

6. Limitation of the study

This study is not without limitations. First, the reliance on self-reported data to capture respondents' perceptions may be subject to response bias, as participants could underreport or overstate their experiences to align with social expectations. Second, the study was conducted in Kitgum District, and while the finding provides valuable insights into the dynamics of climate change and its impacts in a semi-arid border, caution should be exercised in generalizing the results to other regions with different climatic conditions. Despite these limitations, the study contributes important evidence on the perceptions of climate change and its impacts and perceived effectiveness of adaptation practices among smallholder farmers in Kitgum Districts.

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Author contributions

Adoch: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data Curation, Writing-Original Draft, Writing-Review & Editing, Visualization, Project administration.

Twinomuhangi: Conceptualization, Methodology, Writing-Review & Editing, Supervision, Validation. Mfitumukiza: Conceptualization, Methodology, Writing-Review & Editing, Supervision, Validation. Oriangi: Conceptualization, Methodology, Review & Editing.

Data availability statement

Data will be made available on request from the corresponding author.

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