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Adaptation strategies of paddy farmers to build resilience to climate change in kahama district, Tanzania

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Abstract

The study investigates the adaptation strategies used by the paddy farmers in Kahama District to increase their adaptability to climate change. The study focuses on four main objectives, including changed farming practices, changes in cropping practices, strategies used to adapt to climate change, and desired interventions to improve agricultural production and resilience to climate change. A mixed-methods strategy is used in the study to collect both quantitative and qualitative data. According to the data, paddy farmers in Kahama District have used a number of climate change adaptation strategies. These adaptations include modifications to irrigation techniques, timing adjustments for planting, seed variety changes, and fertilizer treatment adjustments. The study also reveals a change in crop systems, with farmers choosing drought-tolerant cultivars, intercropping, and crop diversification; increased water management practices, increased soil conservation practices, and informed decision-making through the use of climate information services are some of the strategies used by paddy farmers to adapt to climate change. The study also identifies the interventions that farmers want to see implemented, such as enhanced irrigation systems, workshops on climate-resilient farming techniques, access to resilient seed varieties, and dependable weather forecasting and climate information services. These findings show the paddy farmers in the Kahama District's proactive response to the problems posed by climate change and help to better understand the adaptation measures they have used. The study highlights the importance of assisting farmers in advancing their current strategies and knowledge while also attending to their unique requirements. Implementing desired actions, such as expanding climate information services, supplying training and access to robust seed varieties, and enhancing irrigation infrastructure, can significantly increase agricultural productivity and the region's resistance to climate change. For politicians, extension services, and development organizations looking to promote climate change adaptation and sustainable agriculture, these research findings have real-world applications. Paddy farmers' ability to adapt, agricultural output, and livelihood security in the face of climate change problems can all be improved by matching interventions and policies with their recognized needs and goals. Such activities can support attempts to achieve food security and sustainable development in the Kahama District and other areas, as well as the agricultural sector's overall resilience.

Keywords: Climate change and variability (CCV); CCV adaptation strategies (CCVAS); Paddy farming (PF); CCVAS on PF

1. Introduction

Tanzania has experienced a rapid population growth, reaching 61.7 million by 2022, with an annual increase of approximately 1.2 million over the past 32 years (NBS, 2022). Agriculture contributes around 30% to the country's GDP, and three-quarters of the workforce is engaged in the sector (ITA, 2022). However, agricultural productivity has been

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modest, especially among smallholder farmers who heavily rely on rainfall for irrigation. Challenges such as land acquisition hurdles, limited access to technology, storage facilities, markets, and credit have hampered the sector's growth. To address these challenges, the Tanzanian government has introduced subsidies for farmers and investors and eliminated levies that impede sectoral growth. Foreign financing has also been secured for the Southern Agricultural Growth Corridor of Tanzania (SAGCOT) project, aimed at developing the region's agricultural potential. These efforts are expected to normalize production levels and enhance value-added processing in the near future.

Maize, wheat, rice, sweet potatoes, bananas, beans, sorghum, and sugar cane are among the most common food crops in the country. Cash crops include coffee, cotton, cashew nuts, tobacco, tea, and sisal. The choice of crops by farmers is influenced by various factors, including physical conditions like soil quality and water availability, economic factors like market demand and seed prices, personal preferences, crop characteristics such as yield and pest resistance, and resource availability like machinery and fertilizer (ITA, 2022). However, Tanzania's agriculture is highly vulnerable to extreme weather variations and climate change impacts. Climate variability is already affecting the country, resulting in less predictable and more severe climatic patterns. Changes in rainfall reliability, onset, and cessation can lead to crop failure, food insecurity, and other challenges such as land degradation and insecurity of land tenure. The Tanzanian government has developed a comprehensive legislative and policy framework for climate change and environmental management, aligned with international conventions. The Initial National Communication (INC) submitted to the UNFCCC in 2003 provides an assessment of vulnerability and adaptation to climate change, along with policy options for mitigation and adaptation.

This paper focuses on enhancing climate change adaptation in paddy production, as Tanzania is the largest paddy producer in the East Africa region. Paddy production is a crucial component of agricultural development in the country, with the potential to improve food security and rural incomes. The Ministry of Agriculture, supported by non-governmental organizations, provides technical training and support for paddy farmers. The government is also investing in irrigation schemes and encouraging the efficient use of fertilizers through the National Rice Development Strategy Phase II (NRDS-II). The strategy aims to increase paddy cultivation area, double on-farm productivity, and reduce post-harvest losses.

Besides, rice consumption in Tanzania is projected to increase due to changes in dietary preferences, affordability compared to wheat, urbanization, population growth, and availability. Dar es Salaam is the primary market for rice, accounting for approximately 60% of consumption. While rice imports are expected to decrease, seasonal shortages in domestic supplies lead to reliance on imports. Paddy cultivation in Tanzania takes place in rain-fed lowlands, uplands, and irrigated systems. The country possesses vast land resources and abundant water resources suitable for paddy cultivation (Ricepedia). Paddy cultivation is highly vulnerable to climate change due to its significant water requirements, and failure to adapt to climate change impacts could have significant consequences for the entire Tanzanian economy, given the dependence of multiple sectors on agriculture (URT, 2009; IIED, 2009).

1.1 Statement of the Problem

The need to comprehend and assist rice farmers' adaptation efforts in the face of climate change problems is the issue that the study attempts to address. In order to improve agricultural productivity and climate change resilience in the Kahama District, the study looks into the specific problem areas associated with altered farming practices, altered cropping techniques, adaptation strategies, and desired interventions. In Kahama District, paddy farmers must contend with weather patterns that are more and more unpredictable, including inconsistent rainfall, protracted droughts, and greater temperature variability. The productivity of agriculture and farmers' means of subsistence are seriously threatened by these climatic changes. Farmers change their agricultural operations and cropping systems using a variety of adaptation strategies to meet these problems. Regarding the precise adjustments made and the efficacy of these strategies, there is a dearth of thorough knowledge and empirical data.

Additionally, a variety of factors, including as farm management practices, crop choices, water management techniques, and access to climate information services, are included in the identified strategies utilized by paddy farmers and their desired interventions. For focused interventions, policies, and services to successfully address the problems encountered by paddy farmers in Kahama District, it is essential to comprehend these particular problem areas. As a result, the study emphasizes the need to look into and analyze the adaptation strategies used by paddy farmers, as well as the modifications made to their farming methods and cropping systems, as well as the specific strategies they used and the interventions they wanted to implement to increase agricultural productivity and build their resilience to climate change. In order to encourage sustainable agricultural practices, strengthen farmers' resilience, and guarantee food security in the face of climate change in the Kahama District, the research intended to address these issue areas.

Objectives

- Main objective

The overall objective of the study was to explore the adaptation strategies used by paddy farmers to increase their resistance to climate change and variability using Kahama District, Tanzania as a study case.

- Specific objectives

Specifically, the study intended to

- Investigate the changed farming practices adopted by paddy farmers in response to climate change in Kahama District.
- Examine the changes in cropping practices implemented by paddy farmers in relation to climate change in Kahama District.
- Ascertain the specific strategies used by paddy farmers in Kahama District to adapt to climate change and mitigate its impacts.
- Determine the desired interventions expressed by paddy farmers in Kahama District to improve agricultural production and enhance resilience to climate change.

1.2 Significance of the study findings

The results of the study offer significant insights and justification for the significance of comprehending and aiding farmers' adaptation efforts in the face of climate change.

Firstly, modified farming practices for climate change adjustment: The findings of modified farming techniques illustrate the paddy farmers in Kahama District's pro-active response to climate change. Due to the fact that they show farmers' awareness of and ability to adapt to climate change concerns, these adaptations can be used to illustrate the need for research and interventions that support and build upon these existing practices.

Secondly, modifications in cropping methods due to climate change: The research on cropping methods emphasizes farmers' adaptability and capacity to diversify their crops or implement innovative techniques in order to lessen the effects of climate change. Given that farmers have already shown they are capable of applying such methods in response to climate variability and change, this explanation highlights the significance of evaluating and promoting cropping systems that are climate resilient.

Thirdly, strategies used to adapt to climate change: The findings on strategies used by paddy farmers to adapt to climate change provide justified evidence of the resourcefulness and innovation of farmers. These strategies, such as water management techniques, improved soil conservation practices, and the use of climate information for decision-making, validate the need to support and enhance these adaptive capacities through targeted interventions.

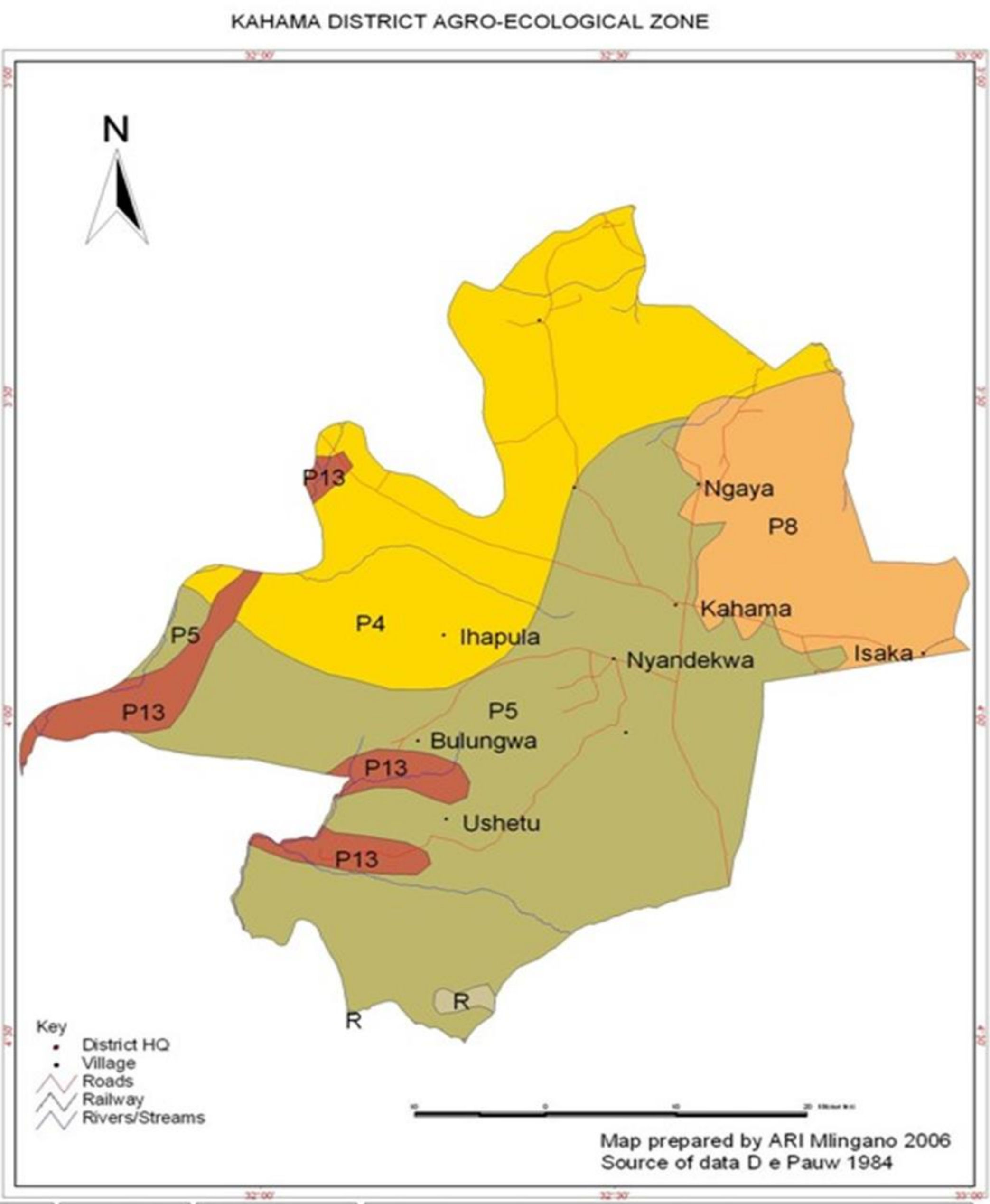
Fourthly. ideal interventions to boost agricultural production and climate change adaptation: The findings about farmers' intended interventions show their requirements and goals for boosting agricultural output and climate change resilience. The importance of coordinating research, policy, and development interventions to address these particular needs and priorities of farmers is highlighted by these desired interventions, which include better irrigation systems, training on climate-resilient farming practices, access to resilient seed varieties, and better weather forecasting and climate information services. Justifying the significance of these desired interventions serves as a foundation for policy creation and resource allocation to help farmers' adaptation efforts in an efficient manner.

Overall, the results of this study on the adaptation strategies used by paddy farmers in Kahama District proved how important it is to comprehend, encourage, and promote agricultural adaptation to climate change. Building on farmers' current knowledge and practices while attending to their unique needs and ambitions is crucial. This is demonstrated by the farmers' proactive adaptation measures, changes in cropping techniques, strategies used, and requested interventions. In order to support sustainable agriculture, strengthen farmers' resilience, and ensure food production in the face of climate change difficulties, these insights can be used to inform policy decisions, agricultural extension services, and development initiatives.

2. Materials and methods

2.1 Materials

The study was carried out in Shinyanga Region's Kahama District. Three councils—Kahama, Msalala, and Ushetu—combined to establish the Kahama District. The five wards of Mondo, Kagongwa, Ntobo, Chela, and Nyamilingano each included two villages that were specially chosen for data collection, namely Mondo, Bumbiti, Kagongwa, Gembe, Ntobo A, Kalagwa, Chela, Chambaga, Nyamilingano, and Ididi (Figure 1). Selected communities top the nation in paddy output and are severely impacted by CCV.



Aez_code	Altitude (masl)	Rainfall (mm/year)	Physiography
P13	900-1200	900-1200	Flat, seasonally inundated plains with permanent or semi-permanent swamps
P4	1200-1300	1200-1300	Flat to gently undulating plains with scattered hill-footslope associations
P5	1100-1300	1100-1300	Gently undulating plains mostly well drained developed on granites and gneisses
P8	1000-1200	1000-1200	Flat to gently undulating plains developed partly on granites and on colluvium
R			Rocky terrain

Figure 1 The map of study area

2.2 Methods

2.2.1 Data collection methods

Data were gathered from primary and secondary sources. checklist of items/indicators for direct field observation, checklist of questions for in-depth interviews with key informants, checklist of themes for focus group discussions, and semi-structured questionnaire for household questionnaire survey. Climate data were gathered from the Tanzania Metrological Authority (TMA). Review of documents was utilized to get secondary data.

2.2.2 Sample and Sampling Procedures

From the three councils (Kahama, Msalala, and Ushetu) that make up Kahama District, five wards were specifically chosen. Mondo, Kagongwa, Ntobo, Chela, and Nyamilingano were the chosen wards. Two villages from each ward, namely Mondo, Bumbiti, Kagongwa, Gembe, Ntobo A, Kalagwa, Chela, Chambaga, Nyamilingano, and Ididi, were specifically chosen for a full examination. The list of households in the study villages served as the sample frame for the study. The household serves as the study's sampling unit. A household is described as a collection of individuals who reside together and elect one person to serve as the head household. The sampling frame was helpful in choosing a representative sample and determining the sample size. It was discovered that there were 8,832 households altogether in the chosen communities. Twenty key informants were chosen using a judgmental selection technique. Distribution of the sample frame in the study communities is shown in Table 1.

Table 1 Distribution of households in study villages

Council	Wards	Villages	Number of households
Kahama	Mondo	Mondo	770
		Bumbiti	608
	Kagongwa	Kagongwa	3,585
		Gembe	698
Msalala	Ntobo	Ntobo A	802
		Kalagwa	665
	Chela	Chela	638
		Chambaga	597
Ushetu	Nyamilingano	Nyamilingano	216
		Ididi	253
Total			8,832

The equation for calculating sample size for a known population and proportion is given by Kothari (2004) and is as follows:

$$n = \frac{z^2 \cdot p \cdot q \cdot N}{e^2\,(N-1) + z^2 \cdot p \cdot q}$$

Where:
n = Sample size
z = Standard variate at a given confidence level (which is 1.96 at 95% confidence level basing on table of area under normal curve)
p = Sample Proportion

$$q = 1 - p$$

N = Size of population (Number of farmer households)
e = Precision (acceptable error)

Data for the calculation were:

$$z = 1.96$$

p = 0.7 (Population varies in terms of practicing paddy farming or otherwise)

$$q = 0.3$$

$$N = 8{,}832$$

$$e = 5\%\ (0.05)$$

Inserting data into the equation:

$$n = \frac{(1.96)^2 (0.7)\ (0.3)\ (8832)}{(0.05)^2 (8832)\ +\ (1.96)^2\ (0.7)\ (0.3)} = 311.32 \approx 312$$

Thus, structured interviews with 312 respondents were conducted. Through proportionate stratified sampling, which allowed for sampling of the proportional number of respondents from each village according to its population size, the number of respondents from each village was established. Salland (2010)'s equation for proportionate sampling was utilized.:

$$P_i = \frac{N_i}{N} n$$

Where,
P_i = Proportional sample of each village
N_i = Number of household in each village
N = Total household forming the sampling frame
n = Sample size.

The computations and sample size for each study village depicted in Table 2.

Table 2 Proportional sample in study villages

Villages	**Mondo**	**Bumbiti**	**Kagongwa**	**Gembe**	**Ntobo A**	**Kalagwa**	**Chela**	**Chambaga**	**Nyamilingano**	**Ididi**	**Total**
Number of households	770	608	3,585	698	802	665	638	597	216	253	8,832
Sample size	770/8832 x 312 = 27	608/8832 x 312 = 21	3585/8832 x 312 = 127	698/8832 x 312 = 25	802/8832 x 312 = 28	665/8832 x 312 = 23	638/8832 x 312 = 23	597/8832 x 312 = 21	216/8832 x 312 = 8	253/8832 x 312 = 9	312

The updated village households list was used to choose these sample units at random from each village.

2.2.3 Data analysis

Statistical analysis was done on quantitative data from a household survey using the SPSS and Excel programs. Measures of central tendencies and dispersion were obtained using descriptive statistical analysis. Utilizing Excel, climatological data from TMA were statistically analyzed. Direct field observation, focus group discussions, and key informant interviews were used to gather qualitative data that was then subjected to content analysis.

3. Results and discussions

3.1 Socio-demographic characteristics and climate status of the study area

3.1.1 Socio-demographic characteristics of respondents

The sociodemographic makeup of the respondents is crucial for a number of climate change indicators. Age of respondents, for example, affects experience with and perceptions of climate change, as well as strategies for coping with its effects. Additionally, access to resources and capacity for adaptation are influenced by sex and family size, which may have a favorable or negative effect on adaption to climate change. Table 3 displays the socioeconomic traits of the respondents to this survey. 73.7% of the household heads whose ages were recorded fell between 25 and 54. This suggests that active laborers dominate agricultural operations in the study area and have a history of climatic variability and change. Additionally, all 81.1% of the respondents that were surveyed are married men. This is significant to the culture of the studied area since it requires marriage for the producer (men) to be accepted as an adult. Given that 96.5% of respondents are heads of households, this is justified. Because this group is knowledgeable of the historical trends of the studied area as well as the current indigenous technical knowledge (ITK), it is crucial for the adaptation and mitigation of climate change.

According to the survey, 84.3% of respondents spent no more than 30 years living in the study villages. This is significant because, unlike climate change, which must have occurred within the last 30 years, climatic variability may be identified and documented for any time frame. In addition, it was discovered that study communities had substantial household sizes. According to the findings, 54.5% of households contain 4-6 people, and 44% have at least six people. This is because polygamy is practiced in this culture, which leaves numerous dependents who need to be fed and cared for. The majority of the population in the poll had only received a primary education (77.3%). Children must walk a great distance to school as a result of the lack of schools, particularly basic schools. This suggests that industries other than agriculture are offered low-paying work opportunities due to low education levels.

According to the study, the majority of respondents (80.1%) are immigrants who were born inside the district but outside the hamlet. Thus, a combination of variables, including better weather for agricultural operations in the study villages than in their home villages, prompted them to migrate there (73.7% of immigrants agree; see Table 4). Additionally, it was shown that the majority of the households' average monthly income in the study communities came from small-scale farming. According to the data, 83.6% of respondents make at least TZS 100,000 per year, or TZS 3,500 per day (Table 3). This demonstrates that households in the study villages are just above the poverty line and that small-scale farming can be somewhat fulfilling. However, in order to maintain and improve human wellbeing and welfare, it is necessary to commercialize and increase agriculture production and productivity.

Table 3 Socio-demographic characteristics of respondents

Information	**Kahama**				**Msalala**				**Ushetu**		**Total N=312**
	Mondo		**Kagongwa**		**Ntobo**		**Chela**		**Nyamilingano**		
	Mondo n=27	**Bumbiti n=21**	**Kagongwa n=127**	**Gembe n=25**	**Ntobo A n=28**	**Kalagwa n=23**	**Chela n=23**	**Chambanga n=21**	**Nyamilingano n=8**	**Ididi n=9**	
Age class: 15-24 Years	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	2(0.6)	2(0.6)
25-34 Years	9(2.9)	0(0)	0(0)	10(3.2)	7(2.2)	4(1.3)	0(0)	6(1.9)	2(0.6)	2(0.6)	40(12.8)
35-44 Years	0(0)	5(1.6)	25(8)	10(3.2)	14(4.5)	3(1)	4(1.3)	5(1.6)	2(0.6)	3(1)	71(22.8)

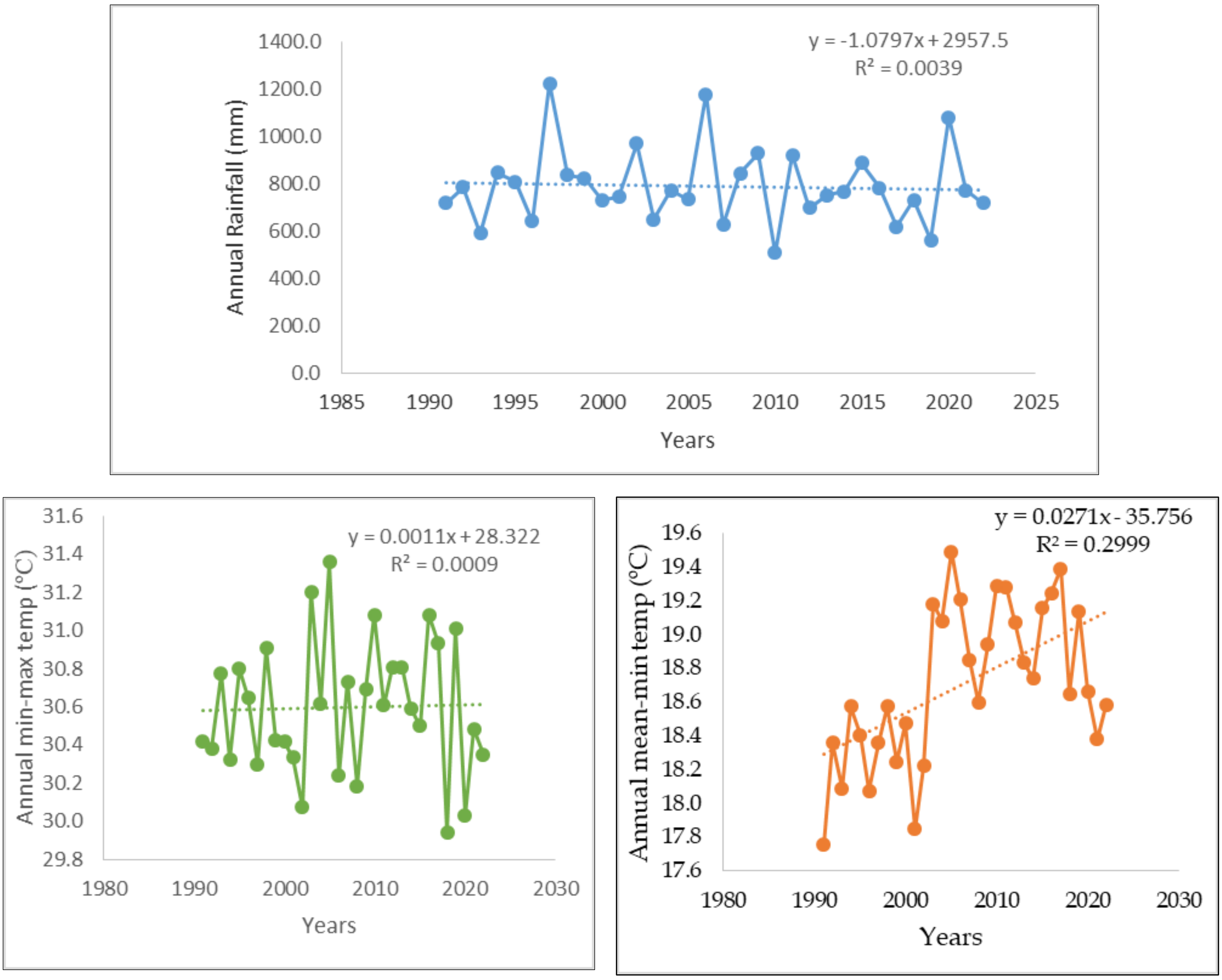
45-54 Years	8(2.6)	7(2.2)	76(24.4)	0(0)	0(0)	4(1.3)	10(3.2)	10(3.2)	4(1.3)	0(0)	119(38.1)
55-64 Years	1(0.3)	5(1.6)	0(0)	5(1.6)	7(2.2)	8(2.6)	9(2.9)	0(0)	0(0)	1(0.3)	36(11.5)
≥ 65 Years	9((2.9)	4(1.3)	26(8.3)	0(0)	0(0)	4(1.3)	0(0)	0(0)	0(0)	1(0.3)	44(14.1)
Sex of respondent: Male	18(5.8)	16(5.1)	102(32.7)	25(8)	21(6.7)	23(7.4)	23(7.4)	21(8.7)	2(0.6)	2(0.6)	253(81.1)
Female	9(9.7)	5 (1.6)	25 (8.0)	0(0)	7(2.2)	0(0)	0(0)	0(0)	6(1.9)	7(2.2)	59(18.9)
Marital status: Married	27(8.7)	21(6.7)	127(40.7)	25(8)	28(9)	23(7.4)	23(7.4)	21(6.7)	8(2.6)	9(2.9)	312(100)
Status of the respondent: Head	27(8.7)	16(5.1)	127(40.7)	25(8)	28(9)	23(7.4)	23(7.4)	21(6.7)	8(2.6)	3(1)	301(96.5)
Spouse	0(0)	5(1.6)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	5(1.6)	10(3.2)
Brother/sister	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	1(0.3)	1(0.3)
Household size: 1-3 Persons	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	4(1.3)	0(0)	0(0)	1(0.3)	5(1.6)
4-6 Persons	19(6.1)	13(4.2)	75(24)	20(6.4)	7(2.2)	19(6.1)	0(0)	10(3.2)	2(0.6)	5(1.6)	170(54.5)
7-9 Persons	0(0)	8(2.6)	0(0)	5(1.6)	14(4.5)	4(1.3)	10(3.2)	11(3.5)	6(1.9)	3(1)	61(19.6)
≥ 10 Persons	8(2.6)	0(0)	52(16.7)	0(0)	7(2.2)	0(0)	9(2.9)	0(0)	0(0)	0(0)	76(24.4)
Education background: Incomplete primary	1(0.3)	16(5.1)	51(16.3)	18(5.8)	0(0)	16(5.1)	0(0)	0(0)	0(0)	4(1.3)	106(34)
Complete primary	17(5.4)	5(1.6)	26(8.3)	7(2.2)	21(6.7)	3(1)	23(7.4)	21(6.7)	8(2.6)	4(1.3)	135(43.3)
Incomplete secondary	9(2.9)	0(0)	50(16)	0(0)	7(2.2)	4(1.3)	0(0)	0(0)	0(0)	0(0)	70(22.4)
Complete secondary	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	(0.3)	1(0.3)
Village's living period: 1-10 Years	0(0)	0(0)	0(0)	0(0)	7(2.2)	0(0)	0(0)	0(0)	0(0)	2(0.6)	9(2.9)
11-20 Years	18(5.8)	21(6.7)	76(24.4)	20(6.4)	14(4.5)	20(6.4)	4(1.3)	0(0)	8(2.6)	0(0)	181(58)
21-30 Years	9(2.9)	0(0)	26(8.3)	5(1.6)	0(0)	0(0)	9(2.9)	21(6.7)	0(0)	3(1)	73(23.4)
31-40 Years	0(0)	0(0)	0(0)	0(0)	7(2.2)	3(1)	10(3.2)	0(0)	0(0)	2(0.6)	22(7.1)
41-50 Years	0(0)	0(0)	25(8)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	1(0.3)	26(8.3)
> 50 Years	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	1(0.3)	1(0.3)
Place of origin: Born in the village	0(0)	0(0)	25(8)	0(0)	7(2.2)	3(1)	0(0)	0(0)	0(0)	3(1)	38(12.2)
Born outside the village but within the district	27(8.7)	21(6.7)	102(32.7)	25(8)	21(6.7)	20(6.4)	0(0)	21(6.7)	8(2.6)	5(1.6)	250(80.1)
Born outside the region	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	23(7.4)	0(0)	0(0)	1(0.3)	24(7.7)
Average household's income per month: ≤ TZS 100,000	0(0)	0(0)	0(0)	0(0)	7(2.2)	0(0)	4(1.3)	0(0)	0(0)	9(2.9)	20(6.4)
TZS 100,001-199,999	26(8.6)	12(3.8)	102(32.7)	25(8)	7(2.2)	12(3.8)	5(1.6)	6(1.9)	8(2.6)	0(0)	203(65)
TZS 200,000-299,999	1(0.3)	9(2.9)	25 (8)	0(0)	7(2.2)	8(2.8)	9(2.9)	15(4.8)	0(0)	0(0)	67(21.5)
≥TZS300,000	0(0)	0(0)	0(0)	0(0)	7(2.2)	3(1)	5(1.6)	0(0)	0(0)	0(0)	22(7.1)

[1] Figures outside and inside the parentheses are frequencies and percentages respectively.

3.1.2 Climatic trends of Kahama District

According to the study's findings (Figure 2), the area's yearly and monthly rainfall throughout the rainy season drops at varying rates. On the other side, the years 2005 (49 mm), 2010 (64.9 mm), and 2013 (65.6 mm) had the lowest average monthly rainfall for the wet seasons, while the years 2009 (130 mm), 2019 (127.4 mm), and 2020 (185.3 mm) had the highest average monthly rainfall.

Through the course of the study, it was discovered that the annual average minimum temperature was rising while the annual maximum temperature was falling (Figure 2). The annual maximum temperature increased from 1991 to 2002 by 0.6 oC, from 2003 to 2012 by 0.3 oC, and from 2013 to 2022 by 0.8 °C. The annual minimum temperature decreased from 1991 to 2002 by 0.2 oC, increased from 2013 to 2022 by 0.4 °C.



Source: Tanzania Meteorological Authority (TMA) (2023)

Figure 2 Kahama District annual rainfall (mm), mean maximum temperature (ºC), and mean maximum temperature (ºC) for the period 1991-2022

3.2 Adaptation strategies pursued by paddy farmers in Kahama District as resilience to climate change

3.2.1 Changed farming practices for climate change adjustment

According to Table 4, the results show that livestock production, methods of land preparation, crop production, and weeding are the changed farming techniques that minorities prefer to use to adapt to climate change. Tanzania's Kahama area has seen a substantial change in farming practices as a result of climate change. One of the most popular adaptations made by farmers to deal with climate change is the production of livestock. Other popular adaptations include tactics for crop production, weeding techniques, and site preparation.

Production of livestock has gained popularity as a method of coping with climate change since it gives farmers a variety of sources of revenue and increases the resilience of their farms as a whole. By introducing animals into their agricultural systems, farmers are able to access alternate revenue streams through the production of milk, meat, and other livestock-related items, which decreases their dependence on the production of rain-fed crops. Likewise, in order to more effectively adapt to shifting climatic circumstances, land preparation techniques have also been altered. Hoeing and hand plowing have been replaced by more automated processes, such as tractor plowing, by farmers. This modification enables more efficient soil preparation, enabling farmers to plant their crops earlier and take advantage of favorable weather.

Crop production methods have been modified to promote drought tolerance and maximize water use. Farmers have started using practices like mulching, which increases soil richness, reduces the effects of temperature stress, and the use of superior, drought-resistant seed varieties. The creation of agroforestry systems, where crops are grown alongside trees, is a common strategy for producing shade. However, practices for weeding have changed as a result of shifting climatic circumstances. Nowadays, farmers employ integrated weed management approaches, which mix chemical and physical weed control methods. Weed control can therefore be carried out more successfully with fewer manpower and expense.

As a result, farmers in the Kahama district have modified their weed-control, land-clearing, and cattle-raising techniques in reaction to climate change. The popularity of these changes demonstrates how effective they are at enhancing productivity and increasing agricultural resilience in the face of climate change.

Table 4 Changed farming practices for climate change adjustment

Farming practices changed*:	**Kahama**				**Msalala**				**Ushetu**		
	Mondo		**Kagongwa**		**Ntobo**		**Chela**		**Nyamilingano**		
	Mondo n=27	**Bumbiti n=21**	**Kagongwa n=127**	**Gembe n=25**	**Ntobo A n=28**	**Kalagwa n=23**	**Chela n=23**	**Chambanga n=21**	**Nyamilingano n=8**	**Ididi n=9**	**Total N=312**
Crop production	27 (8.7)	21 (6.7)	102 (32.7)	25 (8)	14 (4.5)	20 (6.4)	5 (1.6)	21 (6.7)	8 (2.6)	6 (1.9)	249(79.8)
Livestock production	27 (8.7)	21 (6.7)	127 (40.7)	25 (8)	28 (9)	23 (7.4)	23 (7.4)	21 (6.7)	8 (2.6)	9 (2.9)	312(100)
Ways of land preparation	27 (8.7)	21 (6.7)	127 (40.7)	25 (8)	28 (9)	23 (7.4)	23 (7.4)	21 (6.7)	8 (2.6)	9 (2.9)	312(100)
Use of agricultural inputs (e.g. fertilizers)	0(0)	0(0)	51 (16.3)	5 (1.6)	14 (4.5)	19 (6.1)	23 (7.4)	0(0)	4 (1.3)	7 (2.2)	123(39.4)
Pest control	18 (5.8)	13 (4.2)	50 (16)	0(0)	14 (4.5)	16 (5.1)	0(0)	21 (6.7)	2 (0.6)	0(0)	134(42.9)
Weeding	18 (5.8)	21 (6.7)	102 (32.7)	25 (8)	14 (4.5)	16 (5.1)	0(0)	10 (3.2)	8 (2.6)	1 (0.3)	215(68.9)
Agricultural mechanization	18 (5.8)	5 (1.6)	25 (8)	0(0)	14 (4.5)	3(1)	18 (5.8)	0(0)	2 (0.6)	3(1)	88(28.2)

*Multiple response answers

3.2.2 *Changes in cropping practices related to climate change*

The results presented in Table 5 provide insights into the changes in cropping practices preferred by respondents in Kahama District. These changes are listed chronologically according to their perceived effectiveness in improving agricultural outcomes. Firstly, sunken beds, tie ridges, and water harvesting techniques have been identified as preferred practices to optimize water use and improve soil moisture management. These techniques aid farmers in water conservation, drought mitigation, and crop resilience. Secondly, timing of farm operations, including sowing, weeding, and harvesting, has been adjusted to align with favorable weather conditions. Farmers can enhance crop growth and reduce the hazards posed by extreme weather occurrences by properly planning these actions. Thirdly, ways of land preparation, such as mechanized techniques like tractor plowing, have been adopted to improve efficiency and ensure timely planting. This change enables earlier planting and improved seedbed preparation to take advantage of the best growing conditions.

Moreover, fourthly, the use of agricultural inputs, including fertilizers and pesticides, has increased to enhance crop productivity. The proper use of these inputs aids in soil nutrient replenishment, disease and insect control, and healthy plant growth. Among responses, small-scale irrigation techniques have become more common. Farmers can lessen the effects of erratic rainfall patterns and enhance overall crop health and yields by supplying additional water to crops. Fifthly, planting early maturing and drought-tolerant crop varieties reduces the risk of yield loss from drought and ensures crop maturity before the onset of unfavorable weather conditions. Sixthly, increased crop rotation, where different crops are grown in a sequence, helps improve soil fertility, break pest and disease cycles, and diversify farmers' income sources. Seventhly, pest control measures, such as integrated pest management (IPM) practices incorporating cultural, biological, and chemical control methods, have been implemented to minimize pest damage and reduce reliance on harmful pesticides. Lastly, planting high-yielding crop varieties has been embraced to enhance overall productivity and profitability for farmers.

It is crucial to remember that respondents in Kahama District did not like some climate change adaptation techniques such agroforestry, mulching, and terracing. This result implies that these measures are not extensively used despite their potential to increase soil moisture retention, decrease erosion, and increase resilience to extreme weather. This might be as a result of things like low awareness, scarce resources, or societal and cultural hurdles that prevent the adoption of certain practices. It is essential to educate farmers on the advantages and suitability of agroforestry, mulching, and terracing in the local context in order to promote their adoption. Additionally, encouraging the adoption of these techniques and fostering agricultural resilience to climate change can be accomplished by offering assistance in the form of training, resources, and legislative incentives.

Table 5 Changes in cropping practices related to climate change

Practices changed*	**Effectiveness of changes**				**Rank (n=312)**
	ME	**E**	**LE**	**NE**	
Increased Crop rotation	7(2.2)	244(78.2)	7(2.2)	54(17.3)	9
Ways of land preparation	11(3.5)	301(96.5)	0(0)	0(0)	5
Use of agricultural inputs	0(0)	311(99.7)	1(0.3)	0(0)	6
Pest control	50(16)	202(64.7)	60(19.2)	0(0)	11
Water harvesting	239(76.6)	71(22.8)	2(0.6)	0(0)	3
Small scale irrigation	18(5.8)	291(93.3)	3(1)	0(0)	7
Timing of farm operations	66(21,2)	246(78.8)	0(0)	0(0)	4
Planting drought tolerant varieties	5(1.6)	239(76.6)	68(21.8)	0(0)	10
Planting early maturing varieties	1(0.3)	267(85.6)	0(0)	44(14.1)	8
Planting high yielding varieties	48(15.4)	81(26)	118(37.8)	65(20.8)	12
Agro-forestry	0(0)	2(0.6)	0(0)	310(99.4)	14
Mulching	0(0)	0(0)	2(0.6)	310(99.4)	15
Terracing	0(0)	0(0)	6(1.9)	306(98.1)	13
Tie ridges	282(90.4)	26(8.3)	2(0.6)	2(0.6)	2
Sunken beds	287(92)	25(8)	0(0)	0(0)	1

ME= Most effective, E= Effective, LE= Less effective, and NE= Not effective at all ; *Multiple response answers

Overall, respondents in Kahama District's preferred cropping practices show their pro-active approach to climate change problems. These techniques show a shift in thinking towards climate-resilient strategies that can increase farm productivity, strengthen resiliency to climatic variability, and support the region's sustainable agricultural growth.

3.2.3 Strategies used to adapt to climate change

The results presented in Table 6 shed light on the adaptation strategies employed by respondents in Kahama District to address the challenges posed by climate change. The preferred adaptation strategies, as indicated by the majority of respondents, are selected based on their perceived effectiveness. These strategies encompass a range of approaches aimed at enhancing resilience and improving agricultural outcomes in the face of climate change impacts.

Firstly, timing of farm operations is a crucial adaptation strategy employed by respondents. Farmers can take advantage of the best growing circumstances and reduce the dangers associated with extreme weather events by timing important agricultural tasks like planting, weeding, and harvesting with favorable weather conditions. Secondly, planting drought-tolerant varieties is preferred to mitigate the effects of water scarcity and irregular rainfall patterns. Farmers boost the likelihood of successful yields even under difficult climatic conditions by choosing crop varieties that can tolerate extended dry spells and use less water. Thirdly, planting early or fast-maturing varieties allows farmers to take advantage of shorter growing seasons or erratic rainfall patterns. Farmers can lessen their exposure to late-season droughts or erratic weather changes by growing crops that develop more quickly. Fourthly, planting high-yielding varieties is a preferred strategy to optimize crop productivity and maximize yields. Farmers can raise their agricultural output and improve food security despite changing environmental conditions by selecting crop types with increased yield potential. Fifthly, practicing mixed cropping involves growing multiple crops together, which can help diversify income sources and minimize the risks associated with crop failure. By distributing risks and lowering reliance on a single crop, this tactic improves resilience.

Furthermore, sixly, rainwater harvesting techniques enable farmers to capture and store rainwater for agricultural purposes. Farmers can supplement irrigation needs during dry seasons and lessen reliance on unpredictable rainfall by gathering and storing precipitation. Seventhly, irrigation is considered an effective adaptation strategy for ensuring water availability and crop sustainability. Farmers can lessen the effects of water scarcity and fluctuation by giving additional water to crops through irrigation systems, permitting reliable agricultural production. Eighthly, tie ridging involves creating ridges or mounds in the field to conserve water and improve soil moisture retention. This method improves water infiltration, reduces soil erosion, and increases the drought resistance of crops. Ninthly, sunken water beds, also known as water-harvesting pits or basins, are used to capture and retain water in the soil. This method enhances soil moisture, lowers runoff, and maintains crop development throughout dry spells. Tenthly, expansion of agricultural activities represents a strategy adopted by respondents to diversify and expand their farming activities. Farmers can maximize resource use and adjust their farming operations to shifting climatic circumstances by experimenting with new agricultural techniques or growing extra crops. Eleventh, movement to key resource areas, or diversification, involves exploring new geographical areas or resources to establish alternative farming practices or livelihood options. Using this approach, farmers can lessen their reliance on susceptible agricultural systems and adapt to changing agricultural conditions. Lastly, social networking and rural-urban linkages are important adaptation strategies that facilitate knowledge sharing, information exchange, and collaboration among farmers. Farmers can gain access to important information on climate-smart practices, technologies, and market prospects by networking with other people or organizations.

These favored adaption techniques show how farmers in the Kahama District have risen to the challenges given by climate change. Farmers hope to increase their adaptability to climate change, increase agricultural productivity, and safeguard their livelihoods by implementing these techniques. The results in Table 17 show that, in order to effectively address the effects of climate change in Kahama District, it is crucial to deploy a variety of adaptation techniques. These tactics emphasize streamlining agricultural procedures, improving water management, expanding crop options, and encouraging farmer cooperation networks. Farmers in the district may improve their adaptability to climate change, maintain agricultural production, and safeguard their livelihoods by implementing and promoting these preferred techniques. Additionally, it's crucial to give farmers the tools, information, and support systems they need to apply these techniques successfully. In order to promote and scale up these adaptation strategies and assure the agricultural sector's long-term viability and resilience in Kahama District, cooperation between farmers, policymakers, and agricultural institutions is essential.

Table 6 Strategies used to adapt to climate change

Strategies used to adapt to climate change*	Applications		Effectiveness of the strategies			
	Yes	No	ME	E	NE	DK
Timing of farm operations	312(100)	0(0)	116(37.2)	169(53.8)	28(9)	0(0)
Planting drought tolerant varieties	252(80.8)	60(19.2)	89(28.5)	157(50.3)	14(4.5)	52(16.7)
Planting early / fast maturing varieties	252(80.8)	60(19.2)	78(25)	170(54.5)	12(3.8)	52(16.7)
Planting high yielding varieties	247(79.2)	65(20.8)	89(28.5)	89(28.5)	57(18.3)	77(24.7)
Crop rotation	5(1.6)	307(98.4)	31(9.9)	9(2.9)	5(1.6)	267(85.6)
Reducing areas cultivated	0(0)	312(100)	26(8.3)	9(2.9)	30(9.6)	247(79.2)
Practicing mixed cropping	238(76.3)	74(23.7)	94(30.1)	105(33.7)	18(5.8)	95(30.4)
Practicing Agroforestry	3(1)	309(99)	11(3.5)	9(2.9)	5(1.6)	287(92)
Rain water harvesting	293(93.9)	19(6.1)	130(41.7)	101(32.4)	40(12.8)	41(13.1)
Irrigation	262(84)	50(16)	74(23.7)	158(50.6)	39(12.5)	41(13.1)
Mulching	0(0)	312(100)	26(8.3)	9(2.9)	5(1.6)	272(87.2)
Terracing	59(18.9)	253(81.1)	26(8.3)	29(9.3)	41(13.1)	216(69.2)
Tie ridging	308(98.7)	4(1.3)	76(24.4)	216(69.2)	17(5.4)	3(1)
Sunken water beds	298(95.5)	14(4.5)	80(25.6)	202(64.7)	19(6.1)	11(3.5)
Emphasis on livestock keeping instead of crops	32(10.3)	280(89.7)	26(8.3)	20(6.4)	37(11.9)	229(73.4)
Buying supplementary foods	2(0.6)	310(99.4)	35(11.2)	0(0)	5(1.6)	272(87.2)
Expansion of agricultural activities	233(74.7)	79(25.3)	148(47.4)	101(32.4)	27(8.7)	36(11.5)
Collecting wild foods	32(10.3)	280(89.7)	26(8.3)	41(13.1)	12(3.8)	233(74.7)
Increased exploitation of forests	0(0)	312(100)	0(0)	35(11.5)	7(2.2)	270(86.5)
Increased exploitation of water resource areas	8(2.6)	304(97.4)	2(0.6)	36(11.5)	5(1.6)	269(86.2)
Movement to key resource areas (diversification)	239(76.6)	73(23.4)	122(39.1)	102(32.7)	29(9.3)	59(18.9)
Social networking	298(95.5)	14(4.5)	172(55.1)	67(21.5)	60(19.2)	13(4.2)
Rural-Urban linkage	303(97.1)	9(2.9)	74(23.7)	183(58.7)	53(17)	2(0.6)

ME= Most effective, E= Effective, LE= Less effective, and NE= Not effective at all; *Multiple response answers

3.2.4 Desired interventions to improve agricultural production and resilience to climate change

The findings presented in Table 7 provide valuable insights into the desired interventions supported by respondents in Kahama District to enhance agricultural production and resilience in the face of climate change. These interventions encompass a range of areas and practices aimed at improving agricultural outcomes and enabling farmers to adapt to the challenges posed by a changing climate. Firstly, disease and pest management interventions are crucial for protecting crops from the detrimental impacts of pests and diseases. Farmers may reduce output losses and their reliance on toxic pesticides by putting effective disease and pest control techniques first, which will support sustainable farming practices. Secondly, seed production is an essential intervention to ensure the availability of quality seeds adapted to changing climatic conditions. Farmers can increase their ability to tolerate climate-related problems and increase agricultural productivity by encouraging the production and distribution of hardy and high-yielding seed varieties. Thirdly, enhanced extension services play a vital role in providing guidance, knowledge, and technical support to farmers. Farmers may access the most recent data and industry best practices through enhancing extension services, enabling them to make educated decisions and use climate-smart tactics. Fourthly, training in improved horticultural production is critical for diversifying agricultural practices and enhancing productivity. Horticulture can increase food security and offer new sources of income. Productivity and resilience can be raised by giving farmers knowledge and expertise in cutting-edge horticulture techniques, such as better cultivar selection, effective irrigation, and post-harvest handling. Fifthly, fish farming interventions can contribute to food security and income generation while reducing pressure on land-based agricultural systems. Farmers can diversify their sources of income and help with local food supply by encouraging sustainable aquaculture methods and offering training and tools.

Table 7 Desired interventions to improve agricultural production and resilience to climate change

Desired interventions*:	**Kahama**				**Msalala**				**Ushetu**		
	Mondo		**Kagongwa**		**Ntobo**		**Chela**		**Nyamilingano**		
	Mondo n=27	**Bumbiti n=21**	**Kagongwa n=127**	**Gembe n=25**	**Ntobo A n=28**	**Kalagwa n=23**	**Chela n=23**	**Chambanga n=21**	**Nyamilingano n=8**	**Ididi n=9**	**Total N=312**
Disease and pest management	27 (8.7)	19 (6.1)	127 (41)	25 (8.1)	28 (9)	23 (7.4)	23 (7.4)	21 (6.8)	8 (2.6)	9 (2.9)	310(99.4)
Seed production	27 (8.7)	19 (6.1)	127 (41)	25 (8.1)	28 (9)	23 (7.4)	23 (7.4)	21 (6.8)	8 (2.6)	9 (2.9)	310(99.4)
Enhanced extension service	18 (6.7)	19 (7.1)	102 (37.9)	25 (9.3)	21 (7.8)	23 (8.6)	23 (8.6)	21 (7.8)	8 (3)	9 (3.3)	269(86.2)
Training in improved horticultural production,	9 (81.8)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	2 (18.2)	11(3.5)
Fish farming	9 (21.4)	0(0)	25 (59.5)	0(0)	7 (16.7)	0(0)	0(0)	0(0)	0(0)	1 (2.4)	41(13.5)
Fruit propagation and tree planting	18 (7.9)	19 (8.3)	102 (44.7)	25 (11)	14 (6.1)	20 (8.8)	0(0)	21 (9.2)	8 (3.5)	1 (0.4)	228(73.1)
Improved practices of producing high quality vegetables	27 (11.4)	19 (8)	102 (43)	25 (10.5)	14 (5.9)	20 (8.4)	0(0)	21 (8.9)	8 (3.4)	1 (0.4)	237(76)
Market information	27 (8.7)	19 (6.1)	127 (41)	25 (8.1)	28 (9)	23 (7.4)	23 (7.4)	21 (6.8)	8 (2.6)	9 (2.9)	305(97.8)
Improved animal management	27 (8.9)	21 (6.9)	127 (41.6)	25 (8.2)	28 (9.2)	23 (7.5)	23 (7.5)	21 (6.9)	8 (2.6)	2 (0.7)	310(99.4)
Information on Climate change and link with agriculture production	27 (8.7)	19 (6.7)	127 (40.7)	25 (8)	28 (9)	23 (7.4)	23 (7.4)	21 (6.7)	8 (2.6)	9 (2.9)	312(100)

Moreover, sixly, fruit propagation interventions focus on the expansion of fruit cultivation to diversify agricultural production and enhance nutrition. Farmers may raise yields, expand their options for employment, and contribute to food security by offering assistance and resources for fruit tree planting and propagation. Seventhly, tree planting interventions help enhance ecosystem services, conserve soil moisture, reduce erosion, and provide shade for agricultural crops. Farmers can increase their farms' resiliency to climate change and contribute to environmental sustainability by encouraging tree planting efforts. Eighthly, improved practices for producing high-quality vegetables can enhance productivity, marketability, and competitiveness. Improved vegetable quality, more market access, and greater earnings can result from interventions that concentrate on educating farmers about contemporary farming techniques, managing pests and diseases, and post-harvest handling. Ninthly, access to market information is crucial for farmers to make informed decisions and optimize their agricultural production. Farmers may organize their production and find lucrative market prospects with the help of interventions that deliver fast and reliable market information. Tenthly, improved animal management interventions target livestock practices, including animal health and nutrition. Farmers can increase livestock productivity and resilience by offering training and tools for better animal management, contributing to the sustainable and economic production of livestock. Eleventh, information on climate change and its link with agricultural production is valuable in raising awareness and understanding among farmers. Farmers may make educated decisions and put suitable measures in place to handle climate-related difficulties with the help of interventions that give knowledge and education on the effects of climate change, adaption techniques, and climate-smart practices.

Farmers in Kahama District may increase agricultural output, increase resistance to the effects of climate change, and promote sustainable and varied farming systems by supporting these targeted initiatives. Pest and disease management, seed production, extension services, horticulture, aquaculture, fruit propagation, tree planting, vegetable production, market access, animal management, and information on climate change are just a few of the agricultural topics covered by these interventions. In order to give farmers the tools, training, and assistance they need, government agencies, agricultural institutions, and development organizations must work together to implement these interventions. Stakeholders may collaborate to create a more resilient and sustainable agriculture sector in Kahama District that can survive the challenges brought on by climate change by investing in these initiatives and encouraging their adoption.

4. Conclusion

The study has examined a number of significant features of the paddy farmers in the Kahama District's adaptation strategies to climate change. The study's results offer important new understandings of the altered farming and cropping methods, the adaptive strategies employed, and the required interventions to boost agricultural production and climate change resistance. The following conclusions and counsel can be made in light of these findings:

Firstly, modified farming practices to adjust to climate change: According to the research's findings, paddy farmers in Kahama District have implemented a variety of climate-adaptive farming techniques. Changes in irrigation techniques, early or late planting, changing seed types, and fertilizer treatment adjustments are a few examples.

Secondly, cropping techniques have changed due to climate change: The study found that cropping techniques have changed due to shifting climatic circumstances. To reduce the risks brought on by climate change, farmers are diversifying their crop rotations by intercropping or adding drought-tolerant plants.

Thirdly, climate change adaptation strategies: Paddy farmers in Kahama District use a variety of adaptation strategies to deal with climate change, including enhanced soil conservation techniques, water management methods, and the use of climatic data for decision-making.

Fourthly, desired interventions to enhance access to improved irrigation systems, training on climate-resilient farming practices, access to drought-resistant and high yielding seed varieties, and better weather forecasting and climate information services: The study highlighted farmers' desires for interventions that enhance access to these resources.

Recommendations

Based on these conclusions, the following recommendations are made:

- Strengthening Irrigation Systems: To maintain enough water availability for paddy production all year long, efforts should be made to enhance irrigation infrastructure and encourage effective water management methods.
- Capacity-Building Programs: Farmers should get training and extension services to improve their knowledge and abilities in climate-resilient farming practices, such as suitable cropping calendars, soil conservation methods, and effective water usage.
- Improved Access to Resilient Seed Varieties: Farmers in the Kahama District should have better access to high-yielding, climate-resilient seed varieties that are ideal for paddy farming. Crop yield and resistance to climatic challenges may both benefit from this.

- Climate Information Services: By establishing and improving weather forecasting and climate information services, farmers will be better able to decide how to plant, irrigate, and manage their crops, which will help them adapt to climate change.
- Collaboration and Knowledge Sharing: Fostering collaboration and knowledge sharing among farmers, extension agents, regional agricultural councils, and other pertinent stakeholders can make it easier to share best practices and firsthand knowledge regarding coping with climate change. Farmer field schools, farmer-to-farmer learning networks, and knowledge-dissemination platforms can help with this.
- Policy Support: The study emphasizes the significance of policies that support agriculture that is climate resilient. With an emphasis on smallholder farmers in the rice farming sector, policymakers should take into account incorporating climate change adaptation techniques and practices into agricultural policies and programs.

Compliance with ethical standards

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