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Effects of climate change among paddy farmers in Kahama district, Tanzania

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Abstract
Global agricultural productivity is affected by various factors, including climate change and fluctuations. In Tanzania's Kahama District, where paddy farming is crucial, the impacts of changing climatic patterns are particularly significant. This study aims to identify the main challenges faced by farmers and assess the specific effects of climate variability and change on paddy output and productivity in the district. Analysis of historical climate data, including temperature and rainfall patterns, is conducted to examine the trends and suitability of paddy cultivation in Kahama District. The study investigates the impact of climate change on paddy output, productivity, and farmers' livelihoods through surveys and interviews with paddy farmers. The results demonstrate changing climate trends, with increasing temperatures and variable rainfall patterns. These changes have both positive and negative effects on paddy output, with accelerated crop growth and shortened maturity period in warmer climates but increased heat stress and decreased yields due to excessive heat. Variability in rainfall patterns leads to water stress, affecting water availability, irrigation methods, and ultimately, paddy output. The study also identifies various challenges to productivity and paddy output in Kahama District, including inadequate irrigation infrastructure, limited access to improved farming techniques, crops, and financing, as well as insufficient technical expertise for climate-smart agriculture methods. The paper suggests interventions to address these issues and enhance paddy yield and productivity, such as promoting climate-smart agricultural practices, investing in climate-resilient irrigation infrastructure, and expanding access to better crops, farming equipment, and financial resources. Additionally, improving technical skills and knowledge through training programs and knowledge sharing initiatives is crucial. Understanding the impacts of climate variability and change on paddy farming in Kahama District is vital for building resilience and sustaining the livelihoods of farmers. Policymakers, agricultural professionals, and stakeholders can utilize the findings of this study to develop strategies and policies aimed at increasing paddy production and productivity in the district.

Keywords: Climate change and variability (CCV), Paddy farming (PF), CCV impact on PF

1. Introduction

Given that paddy is the primary food source for more than 50% of the world's population, a sustainable paddy production system is a global concern under changing environmental, market, and socioeconomic dynamics (Jamal *et al*., 2023; Khanom, 2016) [10, 12]. Given that it is consumed by the vast majority of the world's poor, this leading cereal crop is also essential for ensuring global food security (Samal *et al*., 2022) [16]. With an annual production of 509 million tons (Mt) from 16 million hectares (ha) of rice land in more than 100 countries in 2020 (FAO, 2021) [8] paddy is the most commonly consumed food crop. Governments in many nations interfere with paddy production, stock, and supply as a critical food commodity because of its significance for food security, income, and employment through input subsidies, incentives, imports, minimum support prices, public procurement, and trade regulations (Mobarok *et al*., 2021) [13]. 75–80% of the paddy produced worldwide is irrigated (Jamal *et al*., 2023; Jiang *et al*. 2019) [10, 11]. However, the lack of freshwater in nations where paddy is grown may have a negative impact on targets for attaining sustainable development goals (Thakur *et al*., 2022) [17]. Due to the expanding world population as well as rising per capita consumption in South America, the Middle East, and Sub-Saharan Africa (OECD, 2021; Samal *et al*., 2022; Jamal *et al*., 2023) [15, 16, 10], the demand for paddy is expected to rise globally.

Global and Tanzania land use are changing as a result of climate change (Chen *et al*., 2020; Dey *et al*., 2020; Bhattacharya *et al*., 2019; Adnan *et al*., 2020) [6, 7, 5, 2].

The effects of climate change are posing significant obstacles to meeting the sustainable development goals (SDGs 1 and 2) and food security, in addition to economic and market shifts (Barrett, 2021) [4], population pressures, and demographic trends (Alexander *et al*., 2015) [3]. According to the Food and Agriculture Organization, there are over 820 million hungry people in the globe, and 2 billion people have moderate to severe food insecurity (FAO, 2019) [9]. According to a recent FAO projection, to feed the world's population of 9 billion people in 2050, food output must increase by 60% (FAO, 2021) [8]. In light of the world's food insecurity, environmental changes, and population pressure, resilient paddy systems are crucial for both developing and developed nations (Mondal *et al*., 2019) [14].

Global concerns about climate change now include agriculture as well as other industries. Tanzania is especially susceptible to the negative effects of climate change as a nation that depends heavily on agriculture. Due to shifting climatic circumstances, paddy farming, an important agricultural activity in Kahama District, is facing major difficulties. For the district's farmers to successfully cultivate paddy, predictable weather patterns are crucial. However, the disruption of their farming practices and threats to their way of life posed by climate change-related changes in temperature, rainfall patterns, and extreme weather events. It is essential to comprehend the precise impacts of climate change on paddy farmers in Kahama District in order to devise tailored interventions aimed at boosting agricultural productivity and boosting their resilience.

1.2 Statement of the problem

Although it is clear that climate change would have an impact on paddy cultivation in Kahama District, insufficient research has been done to fully analyze and comprehend these effects. The district's paddy farmers are unable to develop efficient solutions for coping with and mitigating the effects of climate change due to the current literature deficit. Furthermore, little research has been done on the unique goals, difficulties, and vulnerabilities faced by paddy farmers in adapting to climate change. To enable evidence-based decision-making and the creation of suitable policies and initiatives, it is imperative to close this knowledge gap.

This paper attempts to offer insightful perspectives on how climate change is affecting paddy farmers in Kahama District. The research will help us comprehend the difficulties paddy farmers confront, guide the creation of specialized climate change adaptation solutions, and promote sustainable agriculture in the face of varying climatic conditions. The study's findings can help agricultural stakeholders, decision-makers, and policymakers implement the right strategies for resilience development and promoting the well-being of paddy farmers in Kahama District.

1.3 Objectives

1.3.1 Overall objective

The overall aim of the study is to examine effects of climate change and variability in paddy production areas of Tanzania using Kahama District in Shinyanga Region as a study case.

1.3.2 Specific objectives

Specifically, the study intends to:

1. Analyse climate parameters trends for past three decades in the study area
2. Determine suitability of climate parameters trend on paddy production in the study area
3. Determine main constraints of paddy production and productivity in the study area

2. Materials and Methods

2.1 Materials

The study was conducted at Kahama District in Shinyanga Region. Kahama District formed with three councils namely Kahama, Msalala, and Ushetu. Data have been collected in five wards of Mondo, Kagongwa, Ntobo, Chela, and Nyamilingano specifically in two villages purposely selected in each ward namely Mondo, Bumbiti, Kagongwa, Gembe, Ntobo A, Kalagwa, Chela, Chambaga, Nyamilingano, and Ididi respectively (Figure 1). Selected villages are leading in paddy production and highly affected with CCV.

2.2 Methods

2.2.1 Data collection methods

Both primary and secondary data were collected. Semi-structured questionnaire for household questionnaire survey, checklist of questions for in-depth interview with key informants, checklist of themes for focus group discussions, and checklist of things/indicators for direct field observation. Data set for climate obtained from Tanzania Metrological Authority (TMA). Documentary review used to collect secondary data.

Sample and Sampling Procedures

Five wards were purposely selected from three councils (Kahama, Msalala, and Ushetu) forming Kahama District. The selected wards were Mondo, Kagongwa, Ntobo, Chela, and Nyamilingano. Two villages were purposely selected from each ward for a detailed study, namely, Mondo, Bumbiti, Kagongwa, Gembe, Ntobo A, Kalagwa, Chela, Chambaga, Nyamilingano, and Ididi respectively. The sampling frame of the study was the list of households in study villages. Sampling unit of the study is the household. Household is defined as a group of people living together and choose the authority of one person as a household head. The sampling frame was useful in determination of sample size and selection of a representative sample. It was found that the selected villages had a total of 8,832 households. Judgmental sampling technique was used to select 20 key informants. Table 1 present distribution of sampling frame in study villages.

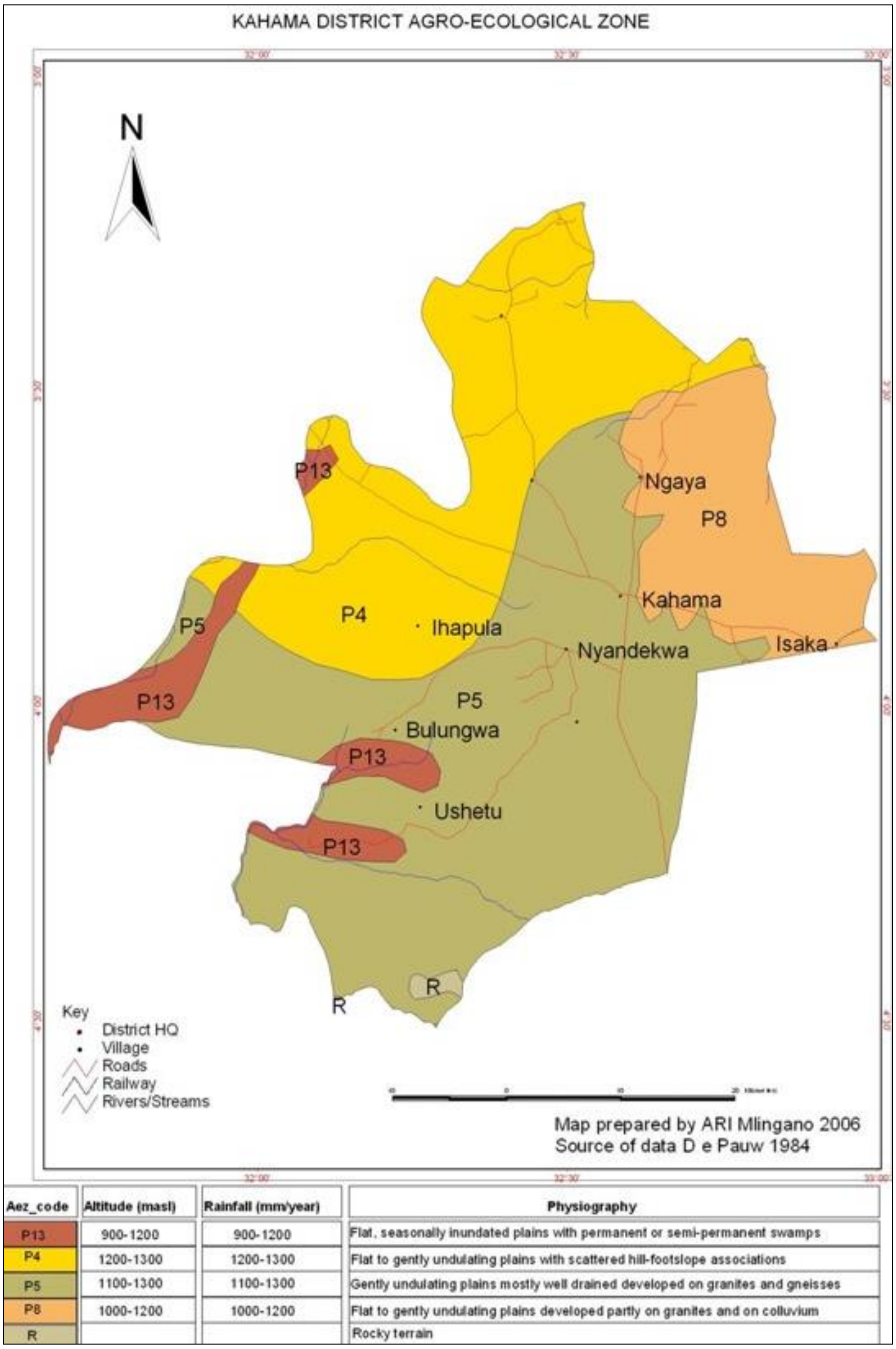


Fig 1: The map of study area

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

Sample size was determined using the equation for determination of sample size for known population and proportion by (Kothari, 2004) which is given as:

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

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, 312 respondents were interviewed during structured interviews. Number of respondents from each village was determined through proportionate stratified sampling which allowed for sampling of the proportional number of respondents from each village according to its population size. The following equation for proportionate sampling was used:

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

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

These sample units in each village was randomly selected using rottenly system from updated village households list.

2.2.2 Data analysis

Quantitative data from household survey were analysed statistically using SPSS and excel softwares. Descriptive statistical analysis used to obtain measures of central tendencies and dispersion. Climatological data from TMA were analysed statistically using excel software. Qualitative data from key informants' interview (KII), focus group discussions (FGDs) and direct field observation were analysed contently.

3. Results and Discussions

3.1 Socio-demographic characteristics of respondents

Socio-demographic characteristics of the respondents is important in various parameters of climate change. Age of respondents, for instance influences experience and perceptions on climate change together with ways to adaptation to its impacts. Besides, sex and household size may affect access to various resources and adaptive capacity which may impact adaptation to climate change negatively or positively. The socio-economic characteristics of the respondents in this study are presented in Table 3. Of the household heads interviewed, 73.7% have age range 25-54 years old. This implies that active working force dominate agriculture activities in the study area and have historical patterns of climate change and variability. Also, 81.1% of interviewed respondents are men and all married. This is important to culture of the study area where the producer (men) to be recognized as grown up person have to engage in marriage. This is justified as 96.5% of respondents are households' heads. This is important to the climate change adaptation and mitigation because this group are aware of the historical trend of the study area as well as existing indigenous technical knowledge (ITK).

The study indicates that 84.3% of respondents lived in the study villages for at most 30 years. This is important as climate variability can be determined and documented for any period range compared to climate change which shall be at least past 30 years. Besides, study villages found to have large household sizes. Results show that 54.5% have 4-6 persons per household and 44% have at least 6 persons. This is due to the culture of marrying many wives (polygamy) which results into a lot of dependents to feed and take care of. Education background of the surveyed population was at most primary education (77.3%). This is due to shortages of schools especially primary schools resulting into children walking long distances to school. This implies that, low education level provides low payment employment opportunities to other sectors different from agriculture.

The study indicates that most of the respondents (80.1%) are immigrants who born outside the village but within the district. Thus, there are pooling factors attracted them to settle in the study villages includes favorable weather condition for agriculture activities compared to their origin villages as supported by 73.7% of immigrants (Table 4). Besides, households of the study villages found to have average income per month resulted mostly from small-scale farming. Results show that 83.6% have income of at least TZS 100,000 which means at least TZS 3,500 per day (Table 3). This shows that households in the study villages are living nearby poverty line and small-scale farming is somehow rewarding; however, there is a need of commercializing and improve agriculture production and productivity to sustain human wellbeing and welfare.

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											
1-3 Persons	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	4 (1.3)	0(0)	0(0)	(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	0(0)	0(0)	(8)25	0(0)	(2.2)7	3(1)	0(0)	0(0)	0(0)	3(1)	38(12.2)
Born in the village											
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)

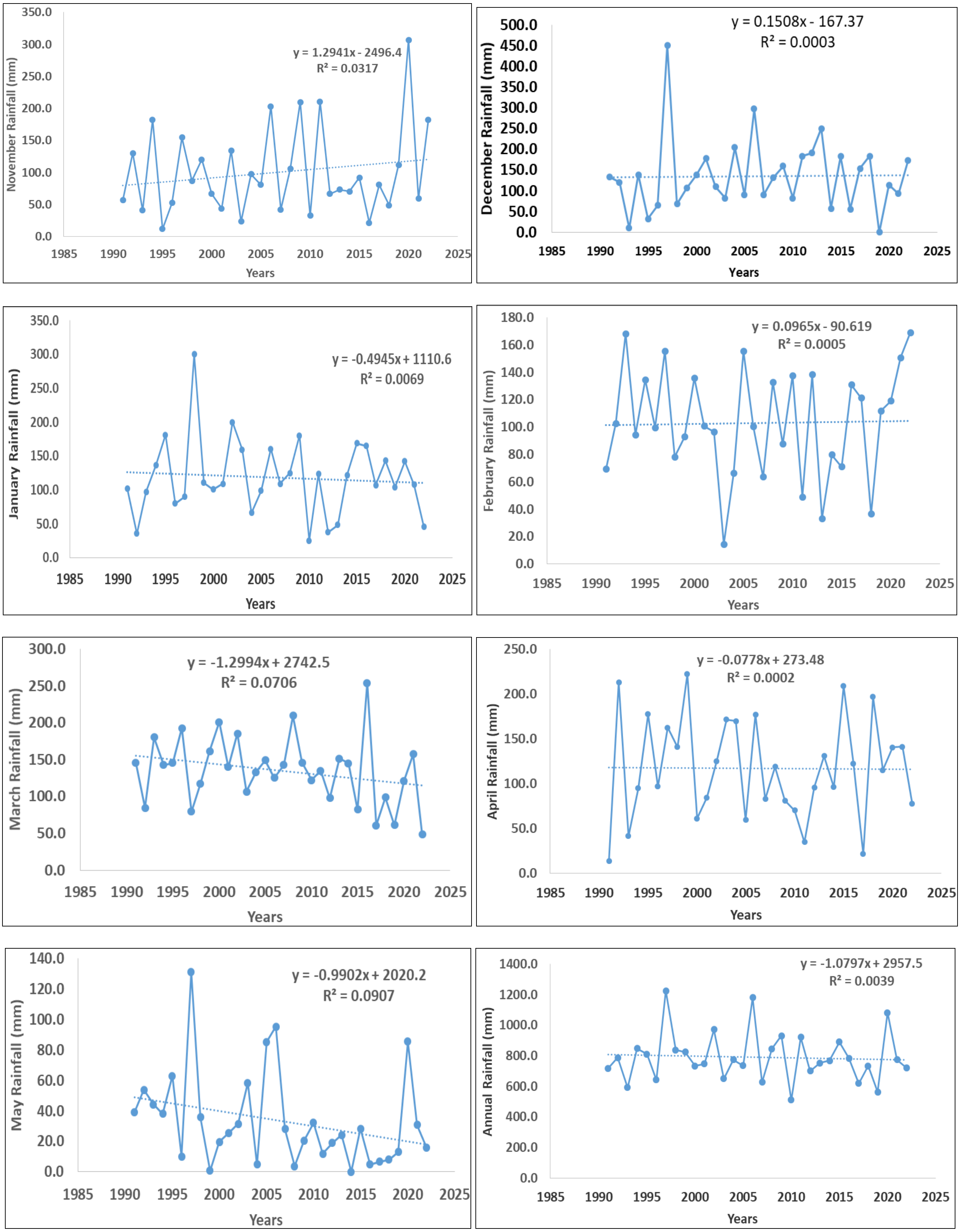
[1] Figures outside and inside the parentheses are frequencies and percentages respectively

3.2 Effects of climate change on paddy farming

3.2.1 Climatic trends at Kahama District

The study found that annual rainfall and monthly rainfall in rains season in the area decreases with fluctuating rate throughout the study period (Figure 2). On the other hand, the minimum average monthly rainfall for the rain seasons found in the years 2005 (49 mm), 2010 (64.9 mm) and 2013 (65.6 mm); and maximum average monthly rainfall found in the years 2009 (130 mm), 2019 (127.4 mm) and 2020 (185.3 mm).

The study found that annual average minimum temperature are increasing compared to the deceasing annual maximum temperature throughout the study period (Figure 3). The annual maximum temperature increases for the period 1991 – 2002 (0.6 ºC), 2003 – 2012 (0.3 ºC), and 2013 -2022 (0.8 ºC); and annual minimum temperature decreases for the period 1991 – 2002 (0.2 ºC), 2003 – 2012 (0.8 ºC), and increases for the period 2013 -2022 (0.4 ºC)

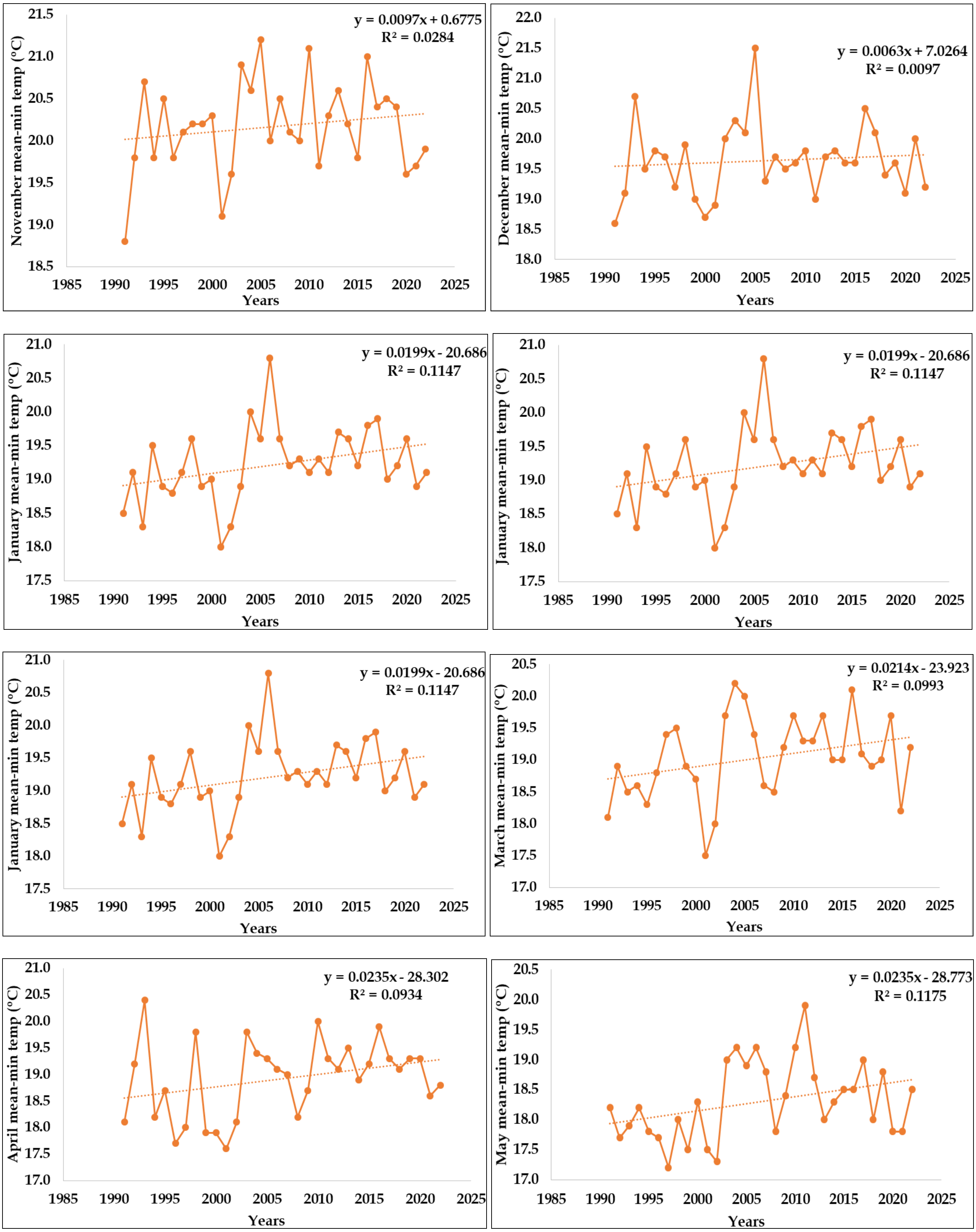


Source: Tanzania Meteorological Authority (TMA) (2023)

Fig 2: Kahama District annual and monthly (January – May & November-December) rainfall (mm) for the period 1991-2022

Source: Tanzania Meteorological Authority (TMA) (2023)

Fig 3: Kahama District annual and monthly (January – May & November-December) mean maximum temperature (ºC) for the period 1991-2022



Source: Tanzania Meteorological Authority (TMA) (2023)

Fig 4: Kahama District annual and monthly (January – May & November-December) mean minimum temperature (ºC) for the period 1991-2022

3.2.2 Paddy production

The study revealed that paddy production per acre is fluctuating (88.1%) for past 30 years (Table 4). Paddy yield per acre in last season is mostly less than 1000 kg (78.5%) compared to past 30 years yields of at least 1000 kg (65.3%) as indicated in Table 4. This implies that paddy production per acre under rainfed scenario declined for past years due to changing climate and variability (CCV). Thus, changing production scenarios to cope with CCV is undisputable. Moreover, households in the study villages involved in growing other crops for various reasons includes food and cash as indicated in Table 5. This implies that, communities are uncertain on paddy production due to CCV then engaging in alternative crops production that can refuge their livelihoods when paddy de-produced.

Table 4: Historical patterns of households' paddy production

Information	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
30 years' patterns of paddy production per acre: Increasing	8 (2.6)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.3)	9 (2.9)
Decreasing	0(0)	0(0)	0(0)	0(0)	14 (4.5)	3 (1)	9 (2.9)	0(0)	0(0)	2 (0.6)	28(9)
Fluctuating	19 (6.1)	21 (6.7)	127 (40.7)	25 (8)	14 (4.5)	20 (6.4)	14 (4.5)	21 (6.7)	8 (2.6)	6 (1.9)	275(88.1)
Last season paddy yield per acre: < 1000 kg	26 (8.3)	10 (3.2)	127 (40.7)	25 (8)	14 (4,5)	20 (6.4)	0 (0)	10 (3.2)	8 (2.6)	5 (1.6)	245(78.5)
1000 – 2000 kg	1 (0.3)	11 (3.5)	0(0)	0(0)	7 (2.2)	0(0)	18 (5.8)	11 (3.5)	0 (0)	3 (1)	51(16.3)
>2000 kg	0 (0)	0 (0)	0(0)	0(0)	7 (2.2)	3(1)	5 (1.6)	0 (0)	0 (0)	1 (0.3)	16(5.1)
Past 30 years' paddy yield per acre: < 1000 kg	17 (5.4)	6 (1.9)	51 (16.3)	5 (1.6)	7 (2.2)	8 (2.6)	0 (0)	10 (3.2)	0 (0)	4 (1.3)	108(34.6)
1000 – 2000 kg	10 (3.2)	15 (4.8)	76 (24.4)	20 (6.4)	7 (2.2)	12 (3.8)	9 (2.9)	11 (3.5)	8 (2.6)	5 (1.6)	173(55.4)
>2000 kg	0 (0)	0 (0)	0(0)	0(0)	14 (4.5)	3(1)	14 (4.5)	0 (0)	0 (0)	0 (0)	31(9.9)

Table 5: Other crops grown and their reasons

Crops grown and reasons	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
Maize: Food	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0(0)	0 (0)	8 (2.6)	6 (1.9)	14 (4.5)
Food and cash	27 (8.7)	21 (6.7)	127 (40.7)	25 (8)	28 (9)	23 (7.4)	23 (7.4)	21 (6.7)	0 (0)	0 (0)	298 (95.5)
Beans: Food	0(0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	6 (2)	3 (1)	9 (2.9)
Not grown	27 (8.7)	21 (6.7)	127 (40.7)	25 (8)	7 (2.2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	303 (97.1)
Cowpeas: Food	0 (0)	0 (0)	0 (0)	0 (0)	14 (4.5)	3 (1)	0 (0)	0 (0)	0 (0)	0 (0)	17 (5.4)
Food and cash	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.3)	1 (0.3)
Not grown	27 (8.7)	21 (6.7)	127 (40.7)	25 (8)	14 (4.5)	20 (6.4)	23 (7.4)	23 (7.4)	8 (2.6)	6 (2)	294 (94.3)
Sunflower: Food	27 (8.7)	21 (6.7)	102 (32.7)	25 (8)	28 (9)	23 (7.4)	18 (5.7)	21 (6.7)	8 (2.6)	3 (1)	282 (90.3)
Not grown	0 (0)	0 (0)	25 (8)	0 (0)	0 (0)	0 (0)	5 (1.7)	0 (0)	0 (0)	0 (0)	30 (9.7)
Sweet potato: Food	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)	7 (2.2)	310 (99.4)
Not grown	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (0.6)	2 (0.6)
Vegetable: Food	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	4 (1.2)	0 (0)	0 (0)	4 (1.2)
Not grown	27 (8.7)	21 (6.7)	127 (40.7)	25(8)	28 (9)	23 (7.4)	23 (7.4)	17 (5.4)	8 (2.6)	9 (2.9)	308 (98.8)
Cotton: Cash	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (0.6)	2 (0.6)
Not grown	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)	7 (2.2)	310 (99.4)

3.2.3 Main constraints for paddy production and productivity

The revealed results in Table 6 indicates ranked main constraints for paddy production and productivity and the top three chronologically ranked constraints includes climate change and variability, prolonged droughts, and inadequate extension services.

Table 6: Main constraints for paddy production and productivity

Constraints	Descriptive statistics for constraints priority (N=312)		
	Minimum	Maximum	Mean ± SD
Unavailability of improved seeds/breeds	2	6	4.08 ±0.39
Unavailability of industrial fertilizer/FYM	3	6	5.02±0.26
Floods	7	11	9.00±0.55
Inadequate extension services	1	7	3.12±0.73
Climate change and variability	1	3	1.06±0.26
Unavailability of insecticides)	3	11	7.77±1.61
Prolonged drought	1	6	2.00±0.50
Increased crop pests)	2	9	6.02±0.88
Increased crop/plant diseases	6	11	7.15±0.53
Increased livestock pests	2	11	10.55±0.98
Increased livestock diseases)	10	11	10.10±0.30

4. Discussions

4.1 Climatic trends and their suitability for paddy production in Kahama District

Since water availability, temperature, and precipitation patterns are critical for effective paddy cultivation, the climate has a significant impact on paddy productivity. Over time, the climate patterns of Kahama District have undergone several notable variations. The average temperature throughout the growing season is increasing, according to analysis of historical climate data, which shows an increasing trend in temperature. The output of paddy may be impacted in both positive and negative ways by this. Warmer temperatures can shorten the maturation period and speed up growth, but they can also cause water stress and make plants more susceptible to pests and diseases.

In Kahama District, rainfall patterns have changed more frequently, fluctuating in both amount and distribution. Paddy production is hampered by this fluctuation since it has an impact on when and how much water is available for irrigation. Reduced yields, a greater risk of crop failure, and water scarcity are all effects of droughts and periods of low rainfall. On the other hand, flooding and severe rain can result in lodging losses, soil erosion, and waterlogging.

Paddy production in Kahama District has been affected by changing climatic trends in a variety of ways. Warmer temperatures and quicker maturity times, for example, may be advantageous to paddy farmers, but the increasing variability and extremes in rainfall patterns provide serious difficulties.

4.2 Paddy production and productivity

In the Kahama District, paddy farming is a significant agricultural activity that supports numerous farmers' lives and helps ensure local food security. However, the productivity of paddy farming is impacted by climate variability and its repercussions.

Variability in precipitation patterns influences when and how much water is available for irrigation, which could result in water stress during crucial growth stages. Reduced crop yields and decreased overall production may follow from this. Furthermore, extreme weather conditions like droughts and floods can harm paddy fields significantly, leading to crop losses, soil erosion, and infrastructural damage.

Temperature variations can also impact the growth and development of paddy crops. Warmer temperatures can speed up growth and shorten crop duration, but too much heat can cause heat stress and have a detrimental effect on yields.

4.3 Main constraints for paddy production and productivity

Due to additional difficulties faced by farmers, the effects of climate variability on paddy yield and productivity in Kahama District are magnified. These limitations consist of:

a) **Limited access to dependable irrigation infrastructure:** Dependence on rainfed agriculture can be difficult in the face of unpredictable rainfall patterns. The inability of farmers to effectively control and regulate the water flow to their paddy fields is a result of inadequate irrigation infrastructure.

b) **Limited accessibility to better seeds and farming techniques:** Access to the availability of high-quality paddy seeds and contemporary farming techniques are essential for increasing productivity and reducing risks associated with climate change. However, farmers' capacity to maximize crop yields and adjust to shifting climatic circumstances is constrained by restricted access to new seeds and technologies.

c) **Lack of access to finance and financial resources:** Farmers need sufficient financial resources to purchase inputs like fertilizer, insecticides, and machinery. Farmers' ability to deal with climate-related difficulties and apply adaptation solutions is hampered by limited access to credit.

d) **Limited technical capacity and knowledge:** Farmers' inability to adapt to climatic unpredictability and increase paddy productivity is further hampered by their lack of knowledge and training in climate-smart agriculture practices and adaptive farming techniques.

5. Conclusion and Recommendations

5.1 Conclusion

In Tanzania's Kahama District, climate fluctuation significantly hinders paddy output and productivity. The availability of water, crop growth, and general farming conditions are negatively impacted by the rising temperatures, unpredictable rainfall patterns, and extreme weather events. Numerous limitations, such as restricted access to irrigation infrastructure, better seeds, money, and technical knowledge, add to these difficulties.

5.2 Recommendations

Several suggestions can be made to solve these issues and improve paddy productivity in the face of climate variability:

a) Prioritize improvements in irrigation systems, including small-scale water storage and distribution facilities, to ensure dependable access to water for paddy cultivation, especially during times of water scarcity. a) Invest in climate-resilient infrastructure.

b) Encourage farmers to use climate-smart agricultural practices by offering training and extension services on methods including enhanced water management, soil conservation, and crop diversification. Farmers will be able to lessen the effects of climate fluctuation on paddy output and adapt to it better as a result.

c) Enhance availability, affordability, and accessibility of premium paddy seeds as well as suitable farming equipment in order to increase access to enhanced seeds and technology. Farmers will be able to increase resilience to climate fluctuation, optimize yields, and fight pests and illnesses as a result.

d) Increase financial assistance and credit availability: Put in place procedures to increase farmers' access to credit and money for investments in equipment, infrastructure, and climate-resilient technologies. Farmers will be better able to adjust to climate change and lessen its effects on the production of paddy as a result.

e) Enhance knowledge and capacity building: Offer training courses and seminars on current agricultural methods, sustainable farming methods, and adaptation to climate change. As a result, farmers will have a better grasp of climate change and will be better prepared to put adaptive measures into practice.

f) Foster partnerships and collaborations between researchers, agricultural extension services, and farmers to perform applied research on the effects of climate change and adaptation measures specifically relevant to paddy cultivation in Kahama District.

A multifaceted strategy incorporating climate-resilient infrastructure, climate-smart agricultural practices, improved access to inputs and financial resources, knowledge sharing, and capacity building is thus required to address the effects of climate and variability on paddy production and productivity in Kahama District. The district can strengthen the resiliency of rice farmers, enhance food security, and lessen the negative effects of climate change on paddy output by putting these ideas into practice.

6. Compliance with Ethical Standards

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6.2 Disclosure of conflict of interest

The author has no any conflict of interest for publishing this paper.

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