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The Impact of Climate Variability On Maize Production in Rwanda, A Case of Nyagatare District from 2015-2023

Niwamanya Angel[12], Dr. Nsanzumukiza Martin Vincent[2] & Joseph Singirankabo

[1]Rwanda Meteorology Agency, **P.O. Box** 898 Kigali, Rwanda

[2]University of Lay Adventists of Kigali. **P.O. Box** 6392 Kigali, Rwanda

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Abstract

Climate variability significantly affects agricultural productivity, influencing food security and economic stability. This study investigates the impact of climate variability on maize production in Nyagatare District, using maize yield records from 11 cooperatives in Nyagatare District from 2015-2023 and climate data (rainfall and temperature) from five weather stations with in Nyagatare District between 1983- 2023. The Mann-Kendall test and Theil-Sen's slope estimator were applied to assess the historical trend of climate variability of rainfall and temperature from 1983-2023. The results got from Mann-Kendall indicates positive increase in climate patterns over time. The level of maize production was evaluated using standard deviation, revealing fluctuations between 2015 and 2019, followed by a steady increase from 2020 to 2023. To assess the impact of climate variability on maize production, ANOVA was used, revealed that temperature had a statistically significant effect on maize production ($F = 45.10$, $P < 5.2*10^{-24}$), indicating that variations in temperature levels strongly influenced yield outcomes. In contrast, rainfall did not significantly affect maize production during the same period ($F = 1.00042$, $P = 0.4879$), suggesting that the amount or distribution of rainfall was not a major limiting factor in the study area.

Keywords: *Climate Variability, Maize Production, Nyagatare District, Rainfall patterns, Temperature Trends, Yield Variability, Agriculture*

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1. Introduction

One of agriculture's core disciplines is crop production. The foundation for supplying feed to the livestock business and the general public is crop production (Utouh1, 2024). Moreover, crop products serve as plant-based raw materials for a variety of industries, including food, textile, medicinal, and fuel (Oksana Mamai, 2020). Maize as one of the crops is grown worldwide and has an energy density of 365 Kcal/100 g. Its composition is roughly 72% starch, 10% protein, and 4% fat (Peter Ranum, 2014). With a major impact on the agri-food system, maize is an essential crop for the world,197 million hectares of land are farmed for this commodity every year, making it the second most extensively planted crop globally (Haque, 2024).

The majority of Rwanda's economy is derived from the semi-subsistence, small-scale, increasingly dispersed farms that produce food through rain farming. It has a limited, uncompetitive industrial sector and few natural resources that can be exploited (Gaspard, 2017). At the moment, Rwanda's national food security is mostly determined by maize, the country's main food crop. Regarded as the second cereal after sorghum, maize (Zea mays) is one of the most significant staple crops in Rwanda. Roughly 32 percent of Rwanda's cereal-producing area was planted with maize (Gaspard, 2017). At the moment, maize is essentially an intercropped with bean that is farmed in all five (5) provinces of Rwanda. In Rwanda, maize ranks third in terms of cultivated area and production (14%), after beans (21.2%) and bananas (19.6%) (minagri, 2009/2010) .

The district of Nyagatare is semi-arid and situated in Rwanda's eastern province. Nyagatare is located at an elevation of 1414 meters above sea level. The region experiences erratic rainfall of 827 mm annually, with an average temperature ranging from 25.3 to 27.7 degrees. The grassy savanna and vertisols, which are rich in nutrients and mineral components but deficient in organic matter, have tightened the humified layer of the soil, giving it certain properties (Mwongera, 2019), importantly, the Nyagatare district produces about a quarter (25%) of Rwanda's total maize production, demonstrating its noteworthy contribution to the country's maize production (Nsamaza, 2024).Based on data from the National Institute of Statistics of Rwanda, the country produced more than 482,000 tons of maize in 2021, Climate variability issues, including droughts, have traditionally put the district at risk (Gaspard, 2017). Rainy seasons are no longer a reliable source of food for humanity, as a result of climate change and the inefficiency of old agricultural practices. For this reason, the only way to combat the dry season and boost food yield is to implement irrigation systems (Pierre, 2022).Therefore, this study aims to assess the impact of climate variability on maize production in Nyagatare District and determine flexible tactics to improve the productivity and resilience of agriculture.

2. Materials and Methods

2.1. Area of the study

Nyagatare District, located in the Eastern Province of Rwanda, generally experiences low and irregular rainfall compared to other regions of the country. The district receives an average annual rainfall ranging between 800 to 1000 mm. Rainfall is often bimodal, with two main rainy seasons: the long rains from March to May and the short rains from September to December. However, there is significant variability in the distribution of rainfall, with droughts being a common occurrence during the dry season.

Nyagatare has a semi-arid climate due to its location in the eastern lowlands of Rwanda. The climate is characterized by relatively high temperatures and limited rainfall. The region often experiences temperatures that range between 25°C and 30°C throughout the year, with hotter conditions prevailing during the dry season. The district's semi-arid conditions make it more prone to droughts, which affect agricultural productivity and water availability. The district's elevation ranges from about 1,400 meters to 1,800 meters above sea level. The relatively low elevation contributes to its warmer climate, compared to the higher and cooler regions of Rwanda. The area's topography is generally flat, which makes it ideal for large-scale farming, but also susceptible to climatic challenges like drought.

Nyagatare district, which is in Rwanda's Eastern Province, served as the study site. Examining how climate variability affected the district of Nyagatare's maize production was its main goal. Given that maize is one of the national crops for which it is suggested as a key priority crop in Nyagatare district**.** (RWIBASIRA, 2019) . Nyagatare is one of the seven districts that make up the Eastern Province, Nyagatare is divided into 14 sectors: Rukomo, Rwempasha, Rwimiyaga, Tabagwe, Kiyombe, Matimba, Mimuli, Mukama, and Musheli. These sectors are further divided into 630 Villages and 106 Cells. Tanzania borders Nyagatare District on the east, Uganda

borders it on the north, Gicumbi District borders it on the west, and Gatsibo District borders it on the south. With a total surface area of 1,919 km², Nyagatare is the largest district in Rwanda**.** (Nyagatare, 2019**).**

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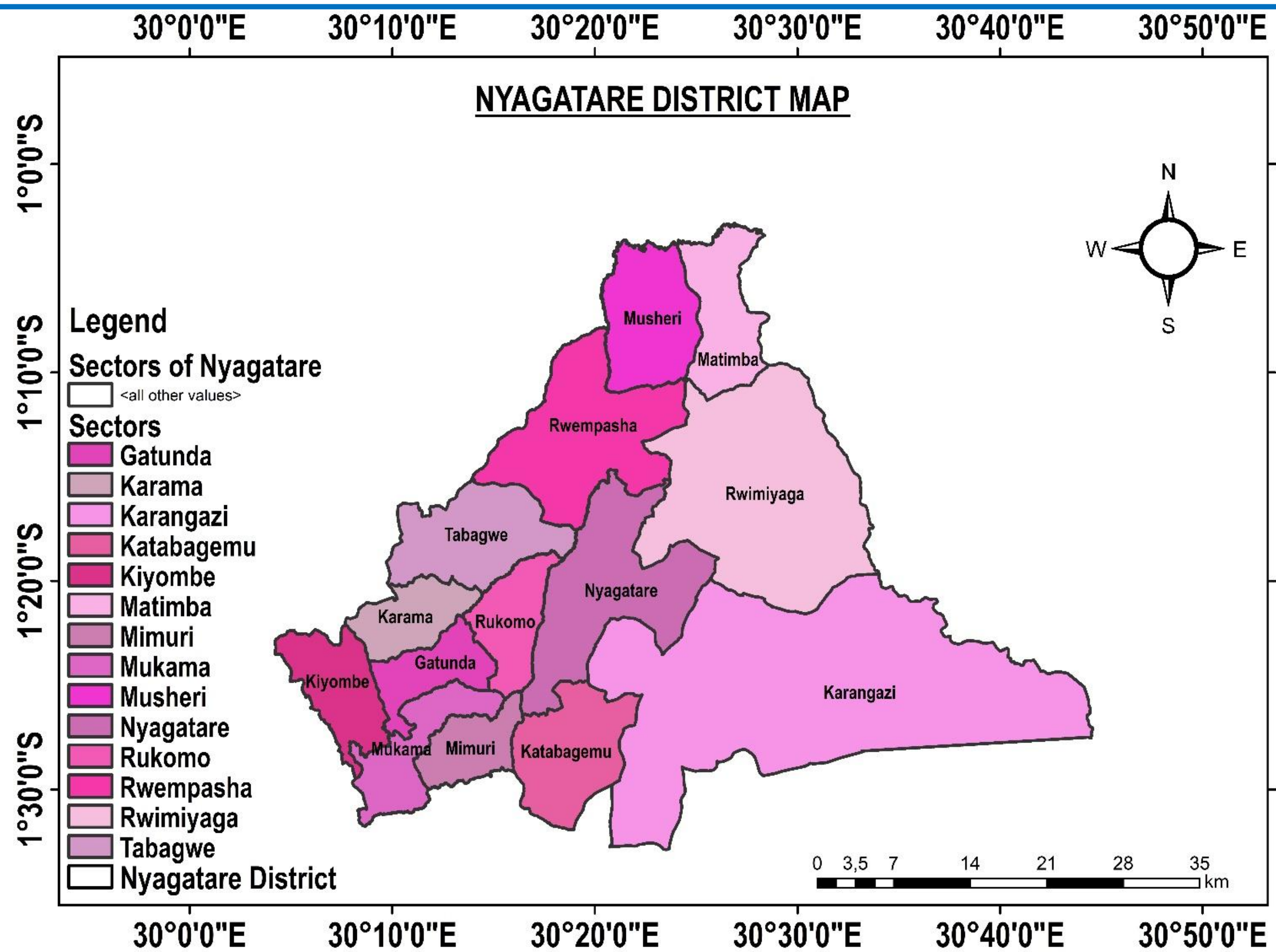

Figure 1. Map showing Nyagatare District with its sectors.

Source; Researcher (2025).

The Nyagatare District experiences fewer precipitation and greater temperatures than other regions of the nation. Comparatively speaking to other parts of the nation, the land is not farmed as much. Animal husbandry and agriculture production constitute Nyagatare District's main economic pursuits. It is noteworthy that 29% of households in Nyagatare District own agricultural land with a size of less than 0.3 hectares per household, according to the EICV3, NISR (2011). 1513.5 meters above sea level, the district is situated in a low granite valley. An essential potentiality for contemporary, mechanical agriculture is this type of topographical arrangement**.**

2.2. Sampling Methods and Analysis

Reliable and long -term rainfall records are crucial for climate analysis and related applications. In many parts of the world, rainfall data collected from weather stations are often insufficient due to limited or inconsistent networks and gaps in gauge data reporting (Joseph, 2023). Before the mid-1990s, Rwanda had a wide network of functioning meteorological stations. However, this number significantly decline around the time of the 1994 genocide against the Tutsi and remained low until around 2010 (Siebert, 2019).The Enhancing National Climate Services(ENACTS) initiative addresses this issue by integrating station-based rainfall records with satellite -derived

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estimates, helping to overcome spatial and temporal data gaps in Rwanda. Satellite data were adjusted using bias correction techniques, resulting in a merged dataset that provide comprehensive rainfall coverage across the country, from 1983-2023, at a fine spatial resolution of about 4-5 kilometer (Siebert, 2019) (Joseph, 2023).The 1983-2023 period was selected to meet the World Meteorology Organization's recommendation of minimum of 30 years(WMO 2003). The stations used in this study are presented in Table 1, where latitude and longitude are in degree while elevation is in meter (m).

Table 1. The meteorological stations used and theirs coordinates.

Stations	Longitude	Latitude	Elevation
Nyagatare	30.31	-1.28	1,377mm
Nyakigakarama	30.3	-1.21	1,614mm
Karangazi	30.38	-1.42	1,393mm
Gatunda	30.21	-1.36	1,591mm
Rwampasha	30.15	-1.36	1,532mm

Source; the researcher (2025)

Also, data from eleven cooperatives that were selected from six sectors in Nyagatare District were used to assess the level of maize production in Nyagatare District. Table 2 shows cooperatives.

Table 2. cooperative used in the study.

S/N	Sector	Cell	Cooperatives Name
1.	Rukomo	Rurenge	Camaru
		Gahurura	Rudemako
		Rurenge	Coamn
2.	Tabagwe	Nyagatoma	Tcp
		Nkoma	Codemata
3.	Karama	Bushara	Kohiika
		Bushara	Kohumuka
4.	Mukama	Rugarama	Codepcum
5	Mimuri	Gakoma	Twungubumwe Iwacu
		Mahoro	Coopama
6	Nyagatare	Gakirange	Ejo Heza

Source; the researcher (2025)

Assessing historical trends of climate variability involves the use of statistical and graphical techniques to examine changes in climatic factors such as rainfall and temperature over time. These methods help to identify patterns, detect anomalies, and evaluate the magnitude of variability, which are essential for understanding the impacts of climate change and variability on agricultural productivity and livelihoods. The Mann-Kendall trend test, was employed to confirm the significance of observed trends, while spatial analysis tools provide insights into geographic variations. The MK test shows a descending slope when negative values indicate a declining trend. Positive values indicate an increasing trend and threshold of significance (p-value or alpha) of 0.05 was used to report the statistical significance (Ndakize, 2018). The standard deviations and coefficient of variation was utilized to assess the level of maize production, lastly ANOVA was used to determine the impact of climate variability on maize production in Nyagatare District from 2015-2023.

3.0. Results and Discussion

The results section summaries and discuss the obtained results from assessing annual rainfall and temperature from 1983-2023, assessing level of maize production in Nyagatare District from2015-2023 and the impact of climate variability (rainfall and temperature) on maize production in Nyagatare District from 2015-2023.

3.1 Rainfall trend analysis.

The results obtained using graphical method indicated an increasing trend in annual rainfall totals across all stations over the 40-year period. For instance, rainfall at Nyakigakarama increased from 673 mm in 1981 to 1116 mm in 2023, indicating a notable rise in precipitation levels. Similarly, Rwempasha's rainfall rose from 505 mm to 1112 mm, and Gatunda's from 600 mm to 1002 mm during the same period. Inter-annual variability is evident, with some years experiencing significantly higher or lower rainfall compared to the average. For example, the peak year for Nyakigakarama was 1991 with 1478 mm, while the lowest was in 2017 with only 203 mm at Nyagatare.

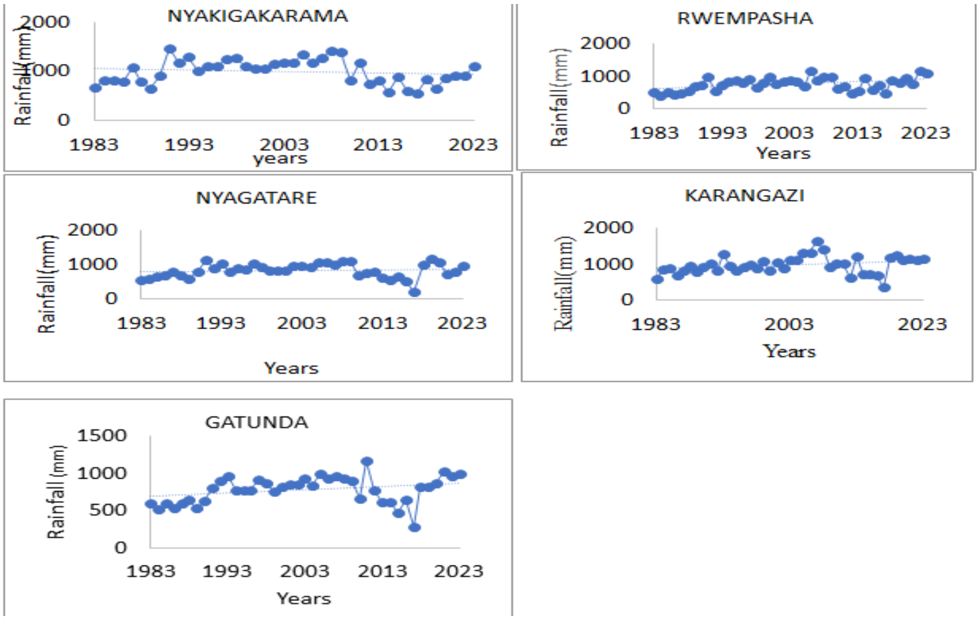

Figure 2. The rainfall trend in annual rainfall total.

Source; Rwanda Meteorology Agency.

According to Rwanda Meteorology Agency annual report of 2017, the Eastern Province recorded below-average rainfall in both the long rainy season (March-May) and the short rainy season (September-December) of that year. Generally, there is drastically increase of rainfall in year of 2020 and 2021. In 2020, Nyagatare District, along with other parts of Rwanda, experienced significant rainfall events that led to flooding and windstorms. Between March 3 and 5, 2020, extensive rainfall resulted in flooding in several districts, including Nyagatare. These events were part of a broader pattern of heavy rainfall across East Africa during this period, influenced by

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climatic anomalies such as a positive Indian Ocean Dipole, which led to above-average rainfall (REMA, 2021).

The Mann–Kendall trend analysis (Table 3) indicate that Nyakigakarama shows a stronger positive trend, but the sen's slope indicates a decrease in rainfall over time, other stations Rwempasha, Gatunda, Nyagatare, and Karagazi all show moderate to a strong increasing trends with statistically significant results, rainfall is increasing at slow rate but consistent rate over time at these station.

Table 3: Statistical Test of significance of trend (5%) at all stations used in this study

Stations	Lon	Lat	Test Z	Signific.	Sen'slope
Nyakigakarama	30.3	-1.218333	0.81055		-3.11
Gatunda	30.21	-1.36	2.480524	*	0.56
Nyagatare	30.31	-1.28	1.887112	+	0.85
Rwempasha	30.56	-1.63	2.637118	**	0.35
Karangazi	30.38944	-1.428889	2.504236	*	0.81

3.2. Maximum temperature trend analysis.

The trend of the total annual maximum temperature for all the stations in Nyagatare District shows close variations except Rwempasha and Nyagatare which shows 99% and 95% positive statistical significance increase respectively compared to other stations. Results indicate that the average annual maximum temperature is 27.7 decrees, and the lowest is 23.8 that was recorded in 1985 and 2001 which is found in Rwempasha, the maximum temperature was recorded in 2005 which is 28.6 as shown in Figure 4.3.

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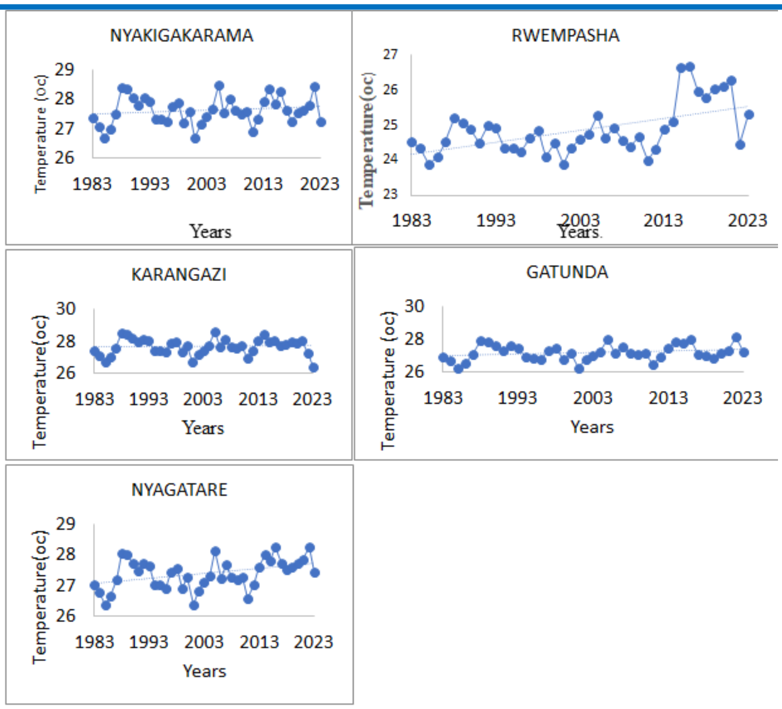

Figure 3. The maximum temperature trend in annual temperature total.

Source; Rwanda Meteorology Agency.

3.3. To assess the level of maize production.

When analyzing the variability in maize production levels over time, Standard Deviation (SD) and Coefficient of Variation (CV) are key statistical measures that help in understanding the degree of fluctuation and risk involved. Table 4 shows the standard deviation and coefficient of variation of different cooperatives in different years.

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Table 4. Level of maize production in tons.

YEARS	RUDEMACO	CAMARU	KOHUMUKA	KOHIIKA	TWUNGUBUMWE IWACU	COOPAMA	CODEPCUM	EJOHEZA	COAMN	TCP	CODEMATA
2015	24012	114564	6245	82420	5200	63142	122277	40000	7245	140134	42138
2016	26832	180500	9210	215447	18225	25139	337666	370122	8142	144124	64456
2017	28234	206950	10124	148000	20954	32182	179644	38124	10156	108108	52242
2018	27176	80000	11241	1237560	33243	42000	380000	152210	12112	216357	78119
2019	122961	169200	11000	166504.8	20089	49145	555986	310242	11214	224231	82192
2020	68109	124566	8483	1089460	28945	45079	304469	290011	7124	17162	60124
2021	205125	155045	16500	875880	33517	42396	145798	250022	10134	252140	72316
2022	170436	122045	9124	924123	38642	44542	148843	390010	11025	201254	61254
2023	168253	100124	10254	800125	37542	46662	142996	320056	10524	191254	60256
Mean	93459.78	139221.6	10242.33	615502.2	26261.89	43365.22	257519.9	240088.6	9741.778	166084.9	63677.44
Standard deviation.	73664.5	41221.61	2786.894	457315.4	10974.7	10605.31	147679.8	133154.1	1803.306	72352.58	12507.51
CV.	78.82%	29.61%	27.21%	74.30%	41.79%	24.46%	57.35%	55.46%	18.51%	43.56%	19.64%

Source; maize cooperative administration.

The Coefficients of Variation (CV) values for maize production, ranging from 18.51% to 78.82%, reveal varying degrees of variability across different years. The higher CV values (above 50%), such as 78.82%, 74.3%, and 57.35%, suggest significant fluctuations in maize yields. These high levels of variability can often be attributed to climatic factors such as erratic rainfall patterns, extreme temperature fluctuations and unexpected droughts, which disrupt the regular growth cycle of maize. Additionally, the impact of pests and diseases can cause sudden reductions in crop yields, further contributing to these high CV values. Other external factors like soil fertility and consistent farming practices they also contributing to these significant yield fluctuations.

The level of maize production trends in Nyagatare District, particularly increases in 2020 and 2021, and this increase could be caused by Rwanda's Crop Intensification Program (CIP), introduced in 2007, focuses on improving agricultural productivity through the use of improved seeds, fertilizers, and better farming practices, the continued implementation and scaling of such programs have contributed to increased maize yields (Minagri, 2021). The agricultural seasons in 2020 and 2021 experienced favorable climatic conditions, contributing to improved maize yields. The Seasonal Agricultural Survey reported an increase in cultivated area and production for cereals, including maize, during these years (NIST, 2021).

3.4. Impact of rainfall and temperature on maize production.

To determine the impact of climate variability on maize production, the ANOVA was used. This takes maize yield as the dependent variable, with temperature and rainfall as independent variables. This study utilized rainfall and temperature records from five weather stations located within Nyagatare District. For each of the 11 cooperatives, the climate data from the nearest weather station were selected, recognizing the potential influence of localized weather patterns on crop yield. By aligning each cooperative's maize production data with the corresponding station's climate data and this captures the most pertinent climatic factors impacting local farming conditions. The distribution was as follows, Nyagatare Station: Rudemako, Camaru, Twungubumwe Iwacu, and Copama. Karangazi Station: Ejo Heza. Nyakigakarama Station: Coamn, Kohiika, and Kohumuka. Gatunda Station: Codepcum. Rwempasha Station: TCP and Codemata.

Table 5: ANOVA Summary for Rainfall and Temperature Effects on Maize Production

Source	SS	DF	MS	F	P-value	Fcrit
Rainfall	1.2281	98	12531	1.00042	0.4879	1.2990
Temperature	1.695	3	5.650	45.10	$5.2*10^{-24}$	2.635
Error	3.6857	294	12.526			
Total	6.605	395				

Source; the researcher.

The table 5 revealed that temperature had a statistically significant effect on maize production ($F = 45.10$, $P < 5.2*10^{-24}$), indicating that variations in temperature levels strongly influenced yield outcomes. In contrast, rainfall did not significantly affect maize production during the same period ($F = 1.00042$, $P = 0.4879$), suggesting that the amount or distribution of rainfall was not a major limiting factor in the study area**.** The increase in maize production from 2020 to 2023 is closely tied to the statistically significant effect of temperature on crop yield, as shown in the ANOVA results. The district likely experienced favorable temperature conditions that enhanced maize growth, coupled with improvements in farming techniques and technologies. This underscores the importance of monitoring temperature trends as a crucial factor for future crop management and planning in the face of climate variability.

4. Conclusion

The statistical analysis of historical rainfall data over Nyagatare District of the eastern province of Rwanda used daily rainfall data collected from Rwanda Meteorology Agency (Meteo Rwanda) where 40 years periods of data for five stations and eleven maize cooperatives of Nyagatare District was used. The trend analysis was examined using graphical method, the significance test was performed using Mann Kendell on annual rainfall totals, coefficient of variation and standard deviation to assess the level of maize production, and ANOVA was used to determine the impact of climate variability on maize production. The Mann–Kendall trend analysis for rainfall indicate that Nyakigakarama shows a stronger positive trend, but the sen's slope indicates a decrease in rainfall over time, other stations Rwempasha, Gatunda,Nyagatare, and Karagazi all show moderate to a strong increasing trends with statistically significant results, rainfall is increasing at slow rate but consistent rate over time at these station, The trend of the total annual maximum temperature for all the stations in Nyagatare District shows close variations except Rwempasha and Nyagatare which shows 99% and 95% positive statistical significance increase respectively compared to other stations. On maize production their Coefficients of Variation (CV) values for maize production, ranging from 18.51% to 78.82%, reveal varying degrees of variability across different years. The higher CV values (above 50%), such as 78.82%, 74.3%, and 57.35%, suggest significant fluctuations in maize yields. These high levels of variability can often be attributed to climatic factors such as erratic rainfall patterns, extreme temperature fluctuations and unexpected droughts, which disrupt the regular growth cycle of maize. Additionally, the impact of pests and diseases can cause sudden reductions in crop yields, further contributing to these high CV values. Other external factors like soil fertility and consistent farming practices they also contributing to these significant yield fluctuations. The ANOVA reveals that variations in temperature levels strongly influenced yield outcomes. In contrast, rainfall did not significantly affect maize production during the same period, suggesting that the amount or distribution of rainfall was not a major limiting factor in the study area**.** The increase in maize production from 2020 to 2023 is closely tied to the statistically significant effect of temperature on crop yield, as shown in the ANOVA results. The district likely experienced favorable temperature conditions that enhanced maize growth, coupled with improvements in farming techniques and technologies. This underscores the importance of monitoring temperature trends as a crucial factor for future crop management and planning in the face of climate variability.

References

Ayanlade, A. O. (2022). Extreme climate events in sub-Saharan Africa. *" Climate Services, vol. 27, Article ID 100311*, 3.

Epule, T. E. (2022). Recent patterns in maize yield and harvest area across. *Agronomy,*, 374.

FAO. (2005). THe State Of Food And Agriculture. *Food And Agriculture Organization Of The United Nations*.

Gaspard, N. (2017). *An economic analysis of the factors influencing maize productivity and efficiency in Rwanda: a case study of Gatsibo District.* Kenya: Jomo Kenyatta University Of Agriculture.

Theil. (1950). A rank-invariant method of linear and polnomial regresion analysis. *Indagationes Mathematicae*.

Haque, M. A. (2024). Boron Impact on Maize Growth and. *International Journal of Plant & Soil Science*, 2.

Herve, M. (2016). *invistigating the effect of climate variability and change on maize yield in Rwanda.*

Joseph, S. (2023). Spatial and Temporal Analysis of Rainfall Variability andTrends for Improved Climate Risk Management in KayonzaDistrict, Eastern Rwanda. *Advances in Meteorology*, 1-2.

Minagri. (2009/2010). *Annual Report* . Ministry of Agriculture and Animal Resources.

Minagri. (2021). *Crop Intensification Program and Agricultural Productivity.* Ministry of Agriculture and Animal Resource.

Moses Ojara, H. B. (2022). Evaluation of Drought, Wet Events, and Climate Variability Impacts on Maize Crop Yields in East Africa During 1981–2017. *International Journal of Plant Production* .

Mwongera, C. J. (2019). Climate risk assessment for selected value chain commodities in Rwanda. *International Center for Tropical Agriculture, Cali, Colombia.*, 10.

Ndakize, S. (2018). *Spatial-Temporal Varibilty And Projected Rainfall Over Rwanda.*

NIST. (2021). *Seasonal Agriculture Survey 2020-2021.* NIST.

Nsamaza, S. (2024, june 28). *Rwanda dispatch* . Retrieved june 28, 2024, from https://rwandadispatch.com/: https://rwandadispatch.com/

Oksana Mamai, V. P. (2020). The system of effective management of crop production in . *BIO Web of Conferences*.

Peter Ranum, J. P.-R.-C. (2014). Global maize production, utilization, and consumption. *Annals Of The New York Academy Of Sciences*.

Pierre, N. J. (2022). *A Study Of Water Content In The Soil For Irrigation Conducted In.* Kigali: African Centre Of Excellence In Internet Of Things.

REMA. (2021). *National Adaptation Plan Baseline Report.* REMA.

Rwibasira, E. (2019). *Effect Of Crop Intensification Programe: Analysis Of Its Contribution To Input Use Andextension Services In Nyagatare District,Rwanda.*

Sen, P. K. (1968). Estimates of the Regression Coefficient Based on Kendall's Tau. *Journal of the American Statistical Association*.

Siebert, A. D. (2019). Evaluation of ENACTS-Rwanda : A . *International Journal of* .

Twahirwa, C. O. (2023). Assessing Variability and Trends of Rainfall and Temperature for. *Advances in Meteorology*.

Utouh1, H. M. (2024). Factors Affecting Maize Production in Kiteto District, Manyara Region, Tanzania: Cross Sectional . *http://sciencemundi.net*, pp. 52-62.