Influence of Climate Variability on Food Security in Nyamira County, Kenya

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https://doi.org/10.62049/jkncu.v5i1.163

Abstract

Climate change and climate variability threaten global food security, especially in sub-Saharan Africa, where agriculture is central to income generation and the economy. Nyamira County in Kenya, despite its high agricultural potential, experiences challenges arising from climate change and climate variability. This study aimed to establish rainfall and temperature trends and patterns affecting food security in Nyamira County, Kenya. The study adopted a descriptive research design. Rainfall and temperature data for Nyamira station was obtained from the Kenya Meteorological Department (KMD). These data were analyzed using the Mann-Kendall test analysis for the various seasons (MAM, JJA, SON, and DJF). The study findings revealed that the rainfall trends for Nyamira station covering the seasons MAM ($y = 0.2769x + 177.3$), SON ($y = 2.2095x + 104.43$), and JJA ($y = 0.109x + 131.63$) were increasing. The station exhibited statistically significant trends in maximum and minimum temperatures (p-value < 0.05). The study recommends continually researching and monitoring local climate patterns to understand and respond effectively to changing weather trends. Collaborating with the Kenya Meteorological Department, research institutions, policymakers, local communities, and environmental agencies can provide valuable data and insights to inform decision-making and adaptation strategies for farmers.

Keywords: Climate Change, Climate Variability, Rainfall, Temperature, Food Security

Introduction

Climate variations and changes may be defined as the alterations and fluctuations in climate over a long period. Concerning the role of climate system analysis, it should be stated that climate patterns and trends can help explain human activities' impact on the climate and set the foundation for climate change prevention strategies. Kenya's tropical country has recently witnessed unfavorable weather conditions, such as severe droughts, floods, and landslides. For instance, the drought of 2016-2017 was perhaps one of the most severe that the Kenyan population has faced, impacting more than 3 million people and causing crop failure and animal deaths (Opiyo *et al*., 2018). Flooding was experienced in 2019, where over 100,000 people experienced losses, including loss of lives, property, and crops (UNOCHA, 2019). The dynamics of climate change are likely to lead to extreme weather conditions in Kenya, hence complicating its vulnerability (Opiyo *et al*., 2018).

Regarding adaptation to the effects of climate change in Kenya, several works have been conducted to establish strategies to cope with the same. Such measures are water capture and storage, land and water management, drought-tolerant crops, and better livestock practices (Muthama *et al.*, 2020). However, the following challenges are observed: low funding, poor awareness of the strategies, and insufficient policy support (Olang *et al*., 2020). This paper focuses on the climate's rainfall and temperature factors.

Weather conditions are expected to become more frequent and severe due to global warming; among them are heat, drought, flood, and hurricanes (IPCC, 2014). For instance, the heat wave that occurred in Europe in 2003, which took 70,000 lives, was established to have been four times likelier due to climate change (Scott *et al.*, 2004). In like manner, it was concluded that anthro-genic climate change caused the 2010 floods in Pakistan, whereby over twenty million people suffered (Herring *et al.*, 2014). Hence, it can be logically concluded that climatic conditions and their fluctuation are the aspects most vital that expose the impacts of human interference with nature. Speaking of climate change has been accentuated in this review as one of the biggest challenges of the modern world that requires countries to stop and reduce it.

Climate change affects agricultural productivity due to Low yield, Pests and diseases, and Water availability impacts. The literature review indicates that there has been a decline in rainfall, which has muddled tea and banana farming, hence reducing the income of farmers (Muthama *et al*., 2020). Other impacts have been managed through regulation and adaptation measures in the County, including water conservation and irrigation (Opiyo *et al*., 2018). Climate change significantly impacts Nyamira County's economy, especially agriculture, which is the primary livelihood source for most of the population.

According to the Intergovernmental Panel on Climate Change (IPCC), the global average temperature rose by 0.85°C from 1880 to 2012 (IPCC, 2014). The warming trend has accelerated since the beginning of this sort in the recent decades; 1981-2010 has been considered the warmest 30-year period in the Northern Hemisphere in the past 1400 years. Even with human impacts like burning fossil carcinogens and felling of trees, gases such as carbon dioxide continue to build up in the atmosphere, raising the average global temperature (IPCC, 2014).

Results from current data and meteorological station temperature data on Kenya reveal that there has been warming over the past few decades, with 1990–2016 being portrayed as the warmest. The mean temperature in Kenya, with many indicators for the last 3 decades, has risen to about 0.3 degrees Celsius per decade since the 1960s. The warming trend is attributed to increased greenhouse gas emissions, land-use change, and urbanization (Muthama *et al.*, 2020). According to the Government of Kenya (GoK, 2016), temperatures in Kenya are also likely to rise further, with a projected increase of 1.7 degrees Celsius by the 2050s and approximately 3.5°C by the end of the century. There is also expected to be an increase in extreme temperatures, including hot days and nights, where 'hot days' are projected to range between 19% and 45% of days mid-century.

Similarly, hot nights are expected to rise rapidly, with projections indicating they will transpire on 45%–75% of nights by mid-century and on 64%–93% of nights by the end of the century. Conversely, cold days and nights are predicted to become increasingly rare. Across all emissions scenarios, temperatures in Kenya are anticipated to persist upward (GoK, 2015).

Studies by Kogo *et al.*, (2021) warn that climate change is a significant threat to farming worldwide. Island nations in the Pacific, similar to those near Singapore, are especially at risk, according to Barnett (2020). Climate change disrupts food security in these areas in several ways. It can reduce food production on land and at sea, limit a country's ability to buy food from other countries and make it harder for people to afford food. In Africa, climate change is already impacting food security, as Alemu and Mentistu (2019) noted. The changing climate is leading to concerns about achieving food security in the region, with environmental changes like shifts in rainfall patterns, drought, fluctuating temperatures affecting growing seasons, and alterations in land cover all playing a role. These climate-related factors can disrupt agriculture and livestock production, causing erratic rainfall, floods, and droughts that impact food security.

Research by Kabubo-Mariara & Mulwa (2019) shows that climate change is seriously disrupting weather patterns and seasons in Kenya, hurting how much food farmers can produce. To address this, they recommend several farm strategies, such as planting new types of crops, raising a wider variety of crops and animals, and using technologies to collect rainwater. These steps are expected to boost food production and improve food security, especially for small farms that grow food for their families.

Building on research by Kogo *et al.* (2021), climate change is a significant concern for global agriculture. The biggest threats come from changes in temperature, rainfall, sea levels, and carbon dioxide in the air. However, farmers can increase crop production and improve food security by adopting successful adaptation strategies. This emphasizes the importance of tackling climate challenges in agriculture.

The Kenyan Ministry of Environment and Natural Resources (2016) predicts climate change will bring more extreme weather. Floods are expected to become more frequent and intense, while average rainfall will increase overall. However, this won't be evenly distributed, and some areas will likely experience more frequent droughts. Heightened rainfall intensity and ensuing flooding could elevate the susceptibility to mudslides and landslides, particularly in mountainous terrain. The escalation in extreme rainfall events is expected to contribute to increased soil erosion and waterlogging of crops, thereby diminishing yields and exacerbating food insecurity.

Moreover, rising temperatures are projected to extend periods of aridity in northwest regions, potentially reducing water storage capacities as prolonged droughts become more prevalent. This scenario could lead to considerable economic losses, agricultural land and infrastructure damage, and human casualties. Furthermore, the compounding effects of recurrent floods, including land degradation and soil erosion, are poised to negatively impact agricultural productivity, disproportionately affecting the livelihoods of rural communities, particularly the economically disadvantaged (GoK, 2016).

Statement of the Problem

Nyamira County is one of Kenya's counties. It is situated in the country's western region and is mainly an agricultural-based economy. The County is vulnerable to the impacts of climate change, including changing temperature and precipitation patterns, which affect the agricultural sector. Temperature records from meteorological stations in Nyamira County show an overall warming trend over the past few decades, with 1990–2016 being the warmest on record (Muthama *et al*., 2020). The findings revealed that the average temperature that has been recorded in the County has risen to about 0.2°C of the total rise in global temperature. This has been increased from the 1960s to the present (Opiyo *et al*., 2018). The warming trend is caused by rising international greenhouse gas emissions, changes in land usage, and urbanization.

Using climate models, researchers have estimated that the global precipitation is set to rise by 1-2 cents for every degree of warming. However, precipitation will be irregular and intensive, so the number of droughts and floods in the area will increase during specific years (IPCC, 2014). For example, Nicholson (2013) claimed that the African Sahel region received only 30 percent of the rainfall it used to in the 1950s and presently experiences severe droughts and food insecurity. On the other hand, there are areas where the intensity and frequency of rainfall have increased, and regions like Southeast Asia experience more frequent cases of flooding (Hirabayashi *et al*., 2013).

Global climate change is arguably one of the most well-documented issues in the world today, and one of its effects is the rise in sea level; this is a result of the melting of the ice caps, glaciers, and ice shelves as well as the thermal expansion of seawater (IPCC, 2014). It is confirmed that the global sea level increased by 0.19 meters from 1901 to 2010, and the accelerating rate of rise was 1.7 mm/year in the pre-industrial era to 3.2 mm/year from 1993–2010 (IPCC, 2014). In this respect, global climate change also raises the sea level, a growing danger to low coastal areas and accelerates their erosion, putting coastal structures and inhabitant shelters at risk (IPCC, 2014).

Rainfall in Kenya is comparatively irregular, although a large part of the country experiences two seasons of rainfall, falling between March and May and between October and December. Research reveals that the cumulative annual precipitation in Kenya has reduced in the recent past, viz., some areas reporting abysmal pinch (Olang *et al.*, 2020). For instance, Muthama *et al*. (2020) opined that parts of this region, namely Kenya, have been experiencing low rainfall for the last few decades, with the level going down to about 30 percent. On the other hand, portions of the western Kenyan areas have received enhanced rainfall intensity and frequency; therefore, frequent flooding incidents are witnessed (Olang *et al.*, 2020). As observed and analyzed by the Climate Change Knowledge Portal (CCKP, 2020), Kenya's environmental precipitation will likely remain unpredictable due to climate change impacts. Depending on the season of appeal, there is also a forecast of a progressive rise within mid-century average rainfall, particularly for the 'Short Rain' season, between October and December. Besides, it will be noted that the number and intensity of intense rainfall events will rise, their duration will be longer, and more will contain heavy rainfall. However, the distances between the occurrence of the heavy rainfall days will also increase. Notably, rainfall over the arid zones of Kenya is ubiquitously expected to decline.

Nyamira County experiences two major rainfall seasons: The first is the long rainfall season, which occurs early in the year between March and May, while the second is the short rainfall season between the extremes of a calendar year, usually between October and December. Research into the climatic changes shows that the total rainfall per year in the concerned County has reduced over the last few years in some country regions (Olang *et al.*, 2020). For instance, Nyamira County in 2016 faced severe drought that influenced agricultural productivity and shortage of water supply (Muthama *et al*., 2020). Some factors include climate change, deforestation, and land-use change, which have reduced rainfall. The economy of Nyamira County is characterized by farming, and two main cash crops are tea and bananas.

Research Objective

The research objective of the study was to determine the rainfall and temperature trends and patterns on food security among small-scale farmers in Nyamira County, Kenya.

Research Question

What are the rainfall and temperature trends and patterns on food security among small-scale farmers in Nyamira County, Kenya?

Methodology

Research Site

Nyamira County is among the forty-seven counties in Kenya. From the North, it borders Homabay County, while to its West is Kisii County, Bomet County to the Southeast and Kericho County to the east. Nyamira County covers an area of 899.4 square kilometers and is located between latitudes 00° 30' and 00° 45' South and longitudes 34° 45' and 35° 00' East (Figure 1). Notably, the County does not share borders with any foreign nation and lacks significant water bodies within its territory (GoK, 2018).

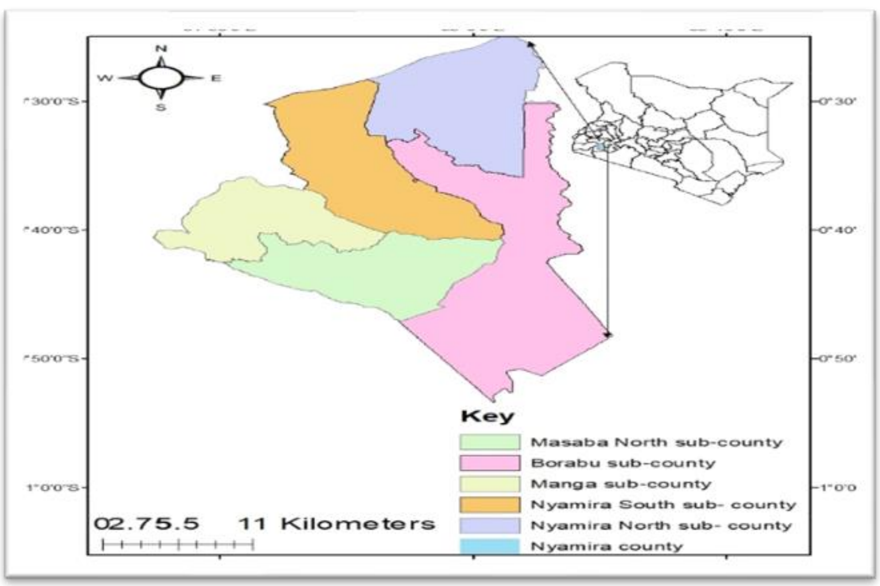

Figure 1: Map of the Study Area Showing the Geographical Location of Sub-Counties of Nyamira County, Kenya
Source: KMD (2023)/ Researcher (2023)

Rainfall Characteristics

Nyamira County experiences a bimodal annual rainfall pattern characterized by well-distributed, reliable, and sufficient rainfall for various crops. The annual precipitation ranges from 1200 to 2100 mm per year. The two distinct rainy seasons in the County are March to May (Long Rains season), receiving the highest amounts of rainfall with a rainfall peak in April, while October to December (short rains season) has relatively high amounts of rainfall registered annually with a seasonal monthly rainfall peak in November. These seasons lack a distinct dry spell separating them. The maximum daytime temperatures typically range around 28.7°C, while nighttime temperatures drop to about 10.1°C. This results in an average normal temperature of 19.4°C, creating favourable conditions for agricultural and livestock production (GoK, 2018).

Nyamira County holds significant potential for producing food crops and dairy products to meet local needs and supply neighbouring counties. Major cash crops in the County include tea, pyrethrum, coffee, bananas, and horticultural products, indicating a high potential for horticulture. In terms of food crops, maize, vegetables, beans, sweet potatoes, sorghum, cassava, and millet are among the main crops cultivated in the region (GoK, 2018).

Despite changing climatic conditions, the diversity of food crops grown reflects the County's capacity for multifaceted agricultural production. However, climate change has disrupted the traditional bimodal rainfall pattern, making it challenging to predict the timing of short and long rains. This uncertainty affects farmers' planning and land preparation, reducing crop yields. Given the heavy reliance of small-scale farmers in Nyamira County on weather-dependent agriculture, adopting CSA practices is a solution to address the issue of low agricultural yields, ensuring sustainable food security within the County. According to the GoK report of Nyamira County, Department of Environment (2023) on participatory climate risk assessment report, Nyamira County is divided into three major climatic zones, namely;

Zone 1 comprises the following wards: Borabu, Nyansiongo, Esise, and Mekenene. These zones experience an annual average rainfall of between 1400 and 1500mm. Zone 2 comprises Kiabonyoro, Rigoma, Gesima, Gachuba, Bosamaro, Itibo, Magwagwa, and Bokeira. The wards under this zone experience an average yearly rainfall of between 1500 and 1750mm.

Zone 3: Kemera, Manga, Magombo, Bosamaro, Bonyamatuta, Bogichora, Township, Bomwagamo. Each zone has similar weather /climate characteristics. This zone has a long-term average annual rainfall of between 1750 and 1900mm.

Research Design

The study utilized a descriptive survey research design. According to Kothari (2004), a descriptive research design involves a systematic empirical investigation in which the researcher lacks direct control over independent variables because they have already occurred or are inherently unalterable. Furthermore, as Walingo and Ngaira (2008) suggested, descriptive research helps determine the frequency with which something happens or is related to something else.

Data Collection

Secondary Data Sources

A secondary data source was used to obtain rainfall and temperature data from Kenya Meteorological Department datasets. This was used to achieve the objective of determining rainfall and temperature trends and patterns. The daily dataset for daily rainfall minimum and maximum temperature obtained from KMD for two stations was utilized from 1990 to 2019. The daily datasets for rainfall and temperature were manipulated into monthly and annual datasets for easy analysis. After that, the data sets were transferred from MS Excel to R-INSTAT software for analysis. The seasons were divided into four seasons: March-May (MAM), June-August (JJA), September-November (SON), and December-February (DJF). The rainfall and temperature trends and patterns were achieved by manipulating the datasets using the Mann-Kendall.

Mann-Kendall Non-Parametric Test

Secondary data from KMD included daily rainfall and temperature data to analyze trends and patterns. The trends and patterns were examined using the Mann-Kendall (MK) test. According to Yue *et al.*, (2002), the MK test is a ranked hypothesis test used to establish the nature of the trend in a time series without the need for it to be a linear increasing or decreasing trend. This test can identify all varieties of monotonicity, whether or not they are escalating or diminishing, relating to different types of climate data, environment data, or hydrologic data. In addition, the MK test checks if the observed tendency is statistically significant (Asfaw *et al*., 2018). Mugalavai & Kipkorir (2013) opine the same, pointing out that the Mann-Kendall test can be used when the data don't have to be normally distributed. This test determines whether the y-values tend to increase or decrease over the x-values in a monotonic manner, which is an approach of a non-parametric test of increasing or decreasing trend of y over x.

There were two results: the S-value, the statistic value, and the Z-value, the probability value. A positive S value depicts an upward trend, a negative S value depicts a downward trend further, and an S value equal to zero depicts no trend (Ahmad *et al.*, 2015). In this case, the standard deviation of rainfall was used to arrive at the Z value using the given data. In addition, the probability value based on the S value and the chosen sample size was calculated to test the significance of the trend observed in the S value.

Findings & Discussion

Rainfall Trends and Patterns

The rainfall data was analyzed based on the four seasons of planting in Nyamira station (MAM, JJA, SON, and DJF). The research aimed to determine the rainfall trends and patterns in Nyamira station from 1990 to 2019 using gridded daily precipitation and temperature data obtained from the station. The rainfall data was sourced from the Kenya Meteorological Department (KMD). Figure 2 illustrates the study's findings, indicating a steady rise in the annual rainfall levels for Nyamira station.

The rainfall data shows an upward trajectory, represented by the linear trendline $y=0.6467x+127.78$. This trendline suggests a gradual increase in rainfall over the study period, with an exceptionally sharp spike in 2019, where rainfall levels exceeded 200 mm. However, the R-squared value 0.0668 indicates a weak correlation between time and rainfall increase. This suggests that while rainfall appears to be increasing, this pattern lacks strong statistical significance and may not be reliably predictive.

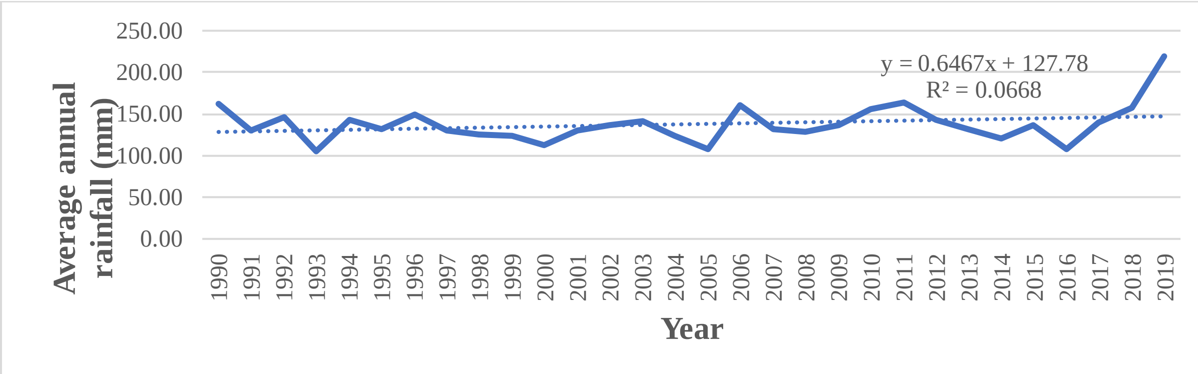

Figure 2: Time Series Analysis for average annual rainfall received in the Nyamira station (1990-2019)
Source: Researcher (2023)

The rainfall trends were analyzed based on the four seasons in the study area: MAM, JJA, SON, and DJF. The results are shown in Figures 3, 4, 5 and 6. Figure 3 shows that Nyamira station from 1990 to 2019 provides insight into seasonal rainfall trends, though the results reveal neither strong nor statistically significant patterns. In the Nyamira station (Figure 3), there is a slight upward trend in MAM rainfall, represented by the trendline $y=0.2769x+177.3$. However, the R-squared value of 0.0041 indicates that this increase is negligible. Rainfall levels in Nyamira fluctuate considerably from year to year, with sharp peaks and drops across the period under study. This variability suggests that while there may be occasional increases in rainfall, there is no consistent upward trajectory over time.

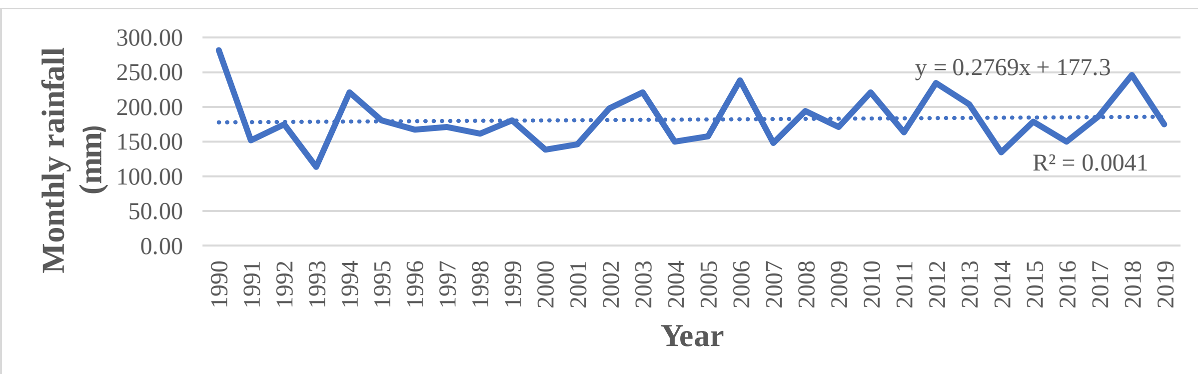

Figure 3: Time Series Analysis for Nyamira station for MAM season
Source: Researcher (2023)

Figure 4 shows the DJF rainfall for Nyamira. The data displays significant fluctuations, with periods of high and low rainfall. The trend line has a slight negative slope of -0.0085, as indicated by the equation $y=-0.0085x+97.773$ and an R^2 value of 6E-06. This minimal negative slope suggests a nearly flat trend over time, with almost no significant increase or decrease in rainfall.

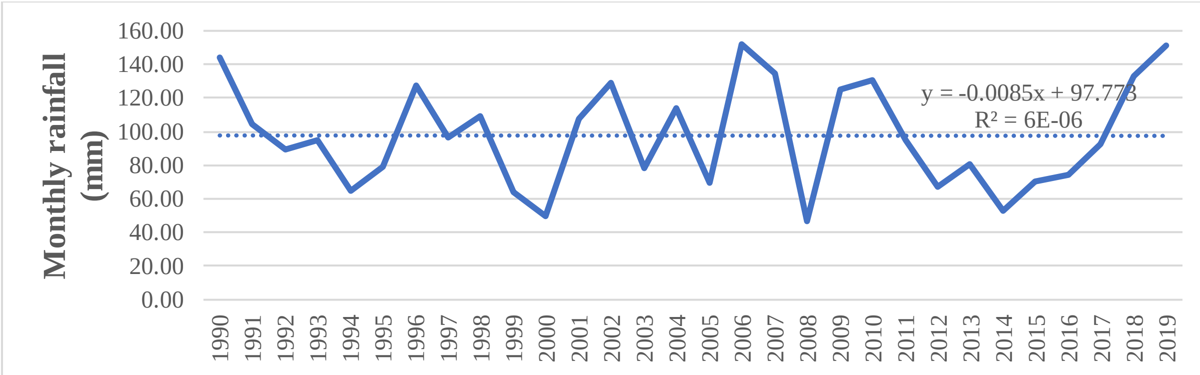

Figure 4: Time Series Analysis for Nyamira station for DJF season

Source: Researcher (2023)

The graph in Figure 5 shows the monthly Rainfall in Nyamira over the years during the JJA period. The rainfall data exhibits variability, with several peaks and dips across the years. A trend line is included, with a slight positive slope of 0.109, suggesting a minimal upward trend in rainfall over the period. The y=0.109x+131.63 and R^2=0.0017 indicate that while there is a slight increase, it's not strongly correlated.

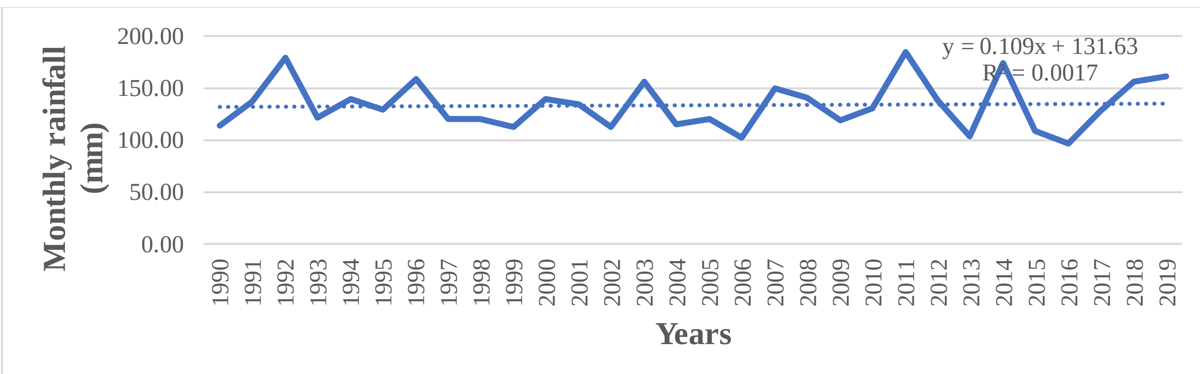

Figure 5: Time Series Analysis for Nyamira station for JJA season

Source: Researcher (2023)

Figure 6 displays the SON rainfall data for Nyamira. There is notable variability over the years, with a distinct spike towards the end of the period, suggesting a significant increase in rainfall in recent years. The trend line, with an equation of y=2.2095x+104.43 and an R^2 value of 0.1278, indicates a more noticeable upward trend compared to the JJA season in Nyamira. The higher slope (2.2095) and R^2 suggest a stronger increasing trend over time.

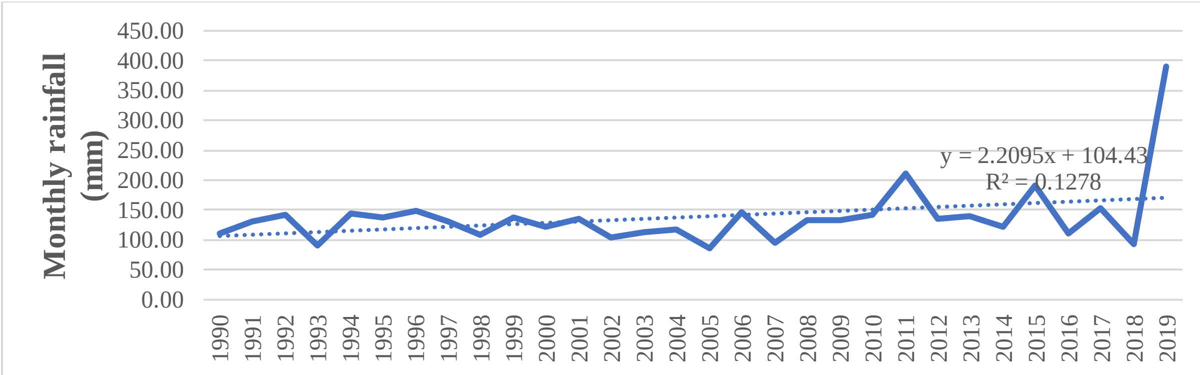

Figure 6: Time Series Analysis for the Nyamira station for the SON season

Source: Researcher (2023)

Maximum and Minimum Temperature Trends and Patterns for Nyamira Station

The study sought to determine the impact of temperature trends and patterns of Nyamira station for the period 1990-2019. The trends and patterns of both maximum and minimum temperatures for Nyamira station are shown in Figure 6. The mean annual temperature for Nyamira ranges from 19.04^{0}C (minimum) to 22.41^{0}C (maximum), with an average yearly temperature of 19.70^{0}C. Over the three-decade period, maximum temperatures exhibit a slight upward trend. The trendline with the linear equation y=0.0789x+24.264 and an R^2 value of 0.2522 suggests that maximum temperatures have been increasing at an average rate of about 0.0789°C per year. Although the upward trend is apparent, the relatively low R^2 value indicates that the correlation between time and maximum temperature is weak, meaning this trend line doesn't explain considerable variability in the data. Notably, there is a distinct rise in maximum temperature around 2019, which may signal an anomaly or an emerging pattern of warmer years.

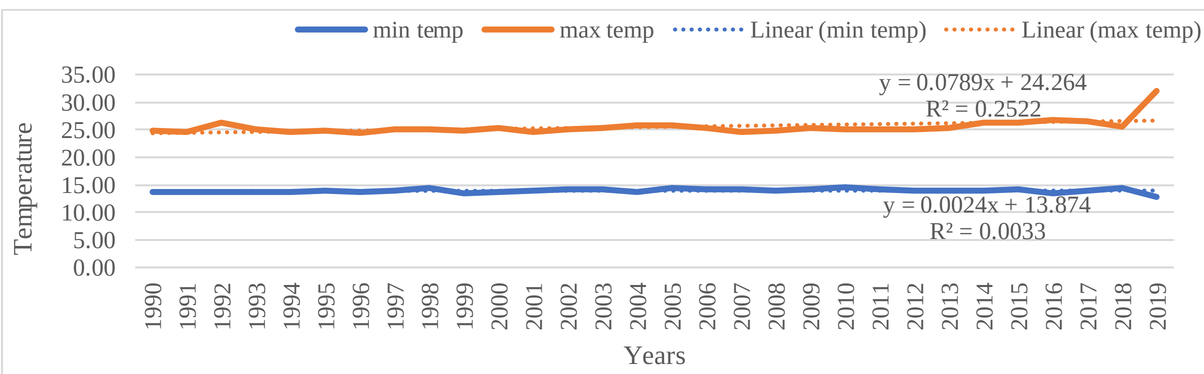

Figure 7: Time Series Analysis for Maximum and minimum temperature trends for Nyamira station (1990-2019)
Source: Researcher (2023)

On the other hand, for the minimum temperature for Nyamira station, the slope of the regression line was 0.0114 (Figure 7). This shows that the station is experiencing an upward trend for minimum temperature for the period under study. The dashed trend line for minimum temperature has the equation y=0.0024x+13.874 with an R^2 value of 0.0033. This equation indicates a negligible upward slope, implying that minimum temperatures have barely changed. The very low R^2 value reinforces this, suggesting no significant trend in minimum temperatures across these years. These results agree with Yvonne *et al.*'s (2020) research, which investigated climate variable trends, specifically temperature and rainfall, and local perceptions of climate change in Lamu, Kenya.

Yvonne *et al.*, (2020) found that a significant majority of respondents (96%) reported having observed changes in temperature in Lamu County over the preceding decade (2006 to 2016). This is in tandem with the findings from the interview with the key informants and the focus group discussion in the area, who stated that the area has been experiencing increased temperature over the years. Compared with the previous years, the temperature was not that high, a clear indicator of climate change in the area. Temperature is a critical component in crop production; therefore, crop productivity is impeded when high temperatures reduce farm produce. This corresponds with the research conducted by Parthasarathi *et al.*, (2022), which identified that high-temperature situations lead to a significant reduction in yield.

Additionally, according to Samwel *et al*. (2021), a study conducted in Kisii County on the effects of climate variability on food security found that rising temperatures increase the atmosphere's capacity to hold water. This enhanced water-holding capacity leads to greater evapotranspiration from the surface, thereby reducing soil moisture. A lack of soil moisture can diminish agricultural production in Kisii County. This is similar to Nyamira County since it is also a food basket for Kenya, and the small-scale farmers depend on rain-fed agriculture. Additionally, higher temperatures are linked to increased crop pests and diseases, which negatively influence food production. Elevated temperatures also threaten underground water resources, such as springs and wetlands, by increasing evaporation rates, thus reducing water availability for irrigation (IPCC, 2014).

Mann- Kendall Test for Rainfall and Temperature

Annual average readings of Rainfall and minimum and maximum temperature were calculated for the Nyamira station and then analyzed using the Mann-Kendall (MK) test. The analysis was based on the categories (MAM, JJA, SON, and DJF) of the growing season over the study area. Trend analysis of the analyzed seasons for the station showed increasing Rainfall for MAM, SON, and DJF. During the JJA season, the station experienced a decreasing amount of rainfall.

The rainfall for the station changed either upward or downward, but the change was not significant since the p-values (MAM-0.5925, JJA- 0.9431, SON-0.3008 and DJF- 0.9715) for the seasons were greater than 0.05 (Table 1). The Mann-Kendall analysis done on maximum and minimum temperature showed a rising trend for both maximum and minimum in the station, which was significant as the p-value was less than 0.05. Therefore, the data shows that there has been a statistically significant increase in maximum temperature at Nyamira station.

Table 1: Annual MK result of temperature and Rainfall for Nyamira station

Variables	**Statistic**	**Nyamira station**
R_{MAM}	Zs	0.53523
	p-value	0.5925
	S	3.100000e+01
	varS	3.141667e+03
	Tau	7.126437e-02
	n	30

R_{JJA}	Zs	-0.071364
	p-value	0.9431
	S	-5.00000000
	varS	3141.66666667
	Tau	-0.01149425
	n	30
R_{SON}	Zs	1.0348
	p-value	0.3008
	S	59.0000000
	varS	3141.6666667
	Tau	0.1356322
	n	30
R_{DJF}	Zs	0.035682
	p-value	0.9715
	S	3.000000e+00
	varS	3.141667e+03
	Tau	6.896552e-03
	n	30
T_{max}	Zs	3.4612
	p-value	0.0005379*
	S	195.0000000
	varS	3141.6666667
	Tau	0.4482759
	n	30
T_{min}	Zs	1.5343
	p-value	0.1249
	S	87.000
	varS	3141.667
	Tau	0.200
	n	30

*0.05 significance level
Source: Researcher (2023)

Crop Yield Production

The study looked at the yield production for 10 years from 2012 to 2021, available on the Ministry of Agriculture and Livestock Development (MoAL) website. The results are presented in Table 2. From the estimates, 2012 and 2021 had the highest maize yield (2.02 tons/ ha) for the period under study. There was a decline in maize production in Nyamira County from 2012 to 2013, which increased in 2014. Since the start of the NARIGP project in 2017, Maize production has increased gradually up to 2019 with a crop yield of 1.74 tons/ha. In 2020, there was a drop to 1.44 tons/ha and then in 2021, the productivity again increased to 2.02 tons/ha. On the other hand, bean yields were impressive in 2014 at 2.01 tons/ha, dropping significantly in 2016 to just 0.49 tons/ha. Since the NARIGP project began, bean production has shown little change, with steady yields between 2017 and 2021.

Other crops like cassava have recorded low yields over the period, with 2018,2019 and 2020 recording 0 tons/ha, while 2015,2016 and 2017 recorded the highest yield of cassava at 25 tons/ha. Irish potatoes have recorded a gradual yield increase from 9.15 tons/ha in 2012 to 10.86 tons/ha in 2021. Millet was relatively low, with a gradual increase from 2014 to 2016, with yields of 1.04 tons/ ha to 1.34 tons/ha. The year 2021 recorded the lowest millet yields at 0.66 tons/ha. Sweet potatoes have shown increased production, with 2019 recording the highest yields of 27.15 tons/ ha.

Table 2: Estimated Crop yields between 2012-2021 for Nyamira County expressed in Tons/ Ha

Year	Maize	Beans	Cassava	Irish potatoes	Millet	Sweet potatoes
2012	2.02	0.8	10	9.15	0.67	11.7
2013	1.17	0.8	10	8.41	0.8	16.1
2014	1.5	2.01	2.78	5.99	1.04	10.8
2015	1.33	0.72	25	5.93	1.04	12.2
2016	1.45	0.49	25	5.91	1.34	16.88
2017	1.51	0.87	25	10.32	1.09	10.86
2018	1.72	0.73	0	9.27	0.72	10.51
2019	1.74	0.72	0	11.59	0.73	27.15
2020	1.44	0.83	0	10.85	1.36	10.88
2021	2.02	0.61	10	10.86	0.66	11.03
Mean	1.59	0.858	10.778	8.828	0.945	13.811

Source : GoK (2021)

Conclusion & Recommandations

Conclusions

The study sought to establish the rainfall and temperature trends and patterns in Nyamira County, Kenya, between 1990 and 2019. The study concludes that there have been increased maximum and minimum temperatures in Nyamira County, indicating that it has experienced climate change, which calls for adaptation by adopting CSA practices. Additionally, there has been an increased rainfall trend in Nyamira station. This shows that the rainfall patterns are erratic and affect crop productivity in the region.

Recommendations

The study recommends continually researching and monitoring local climate patterns to understand and respond effectively to changing weather trends. Collaborating with the Kenya Meteorological Department, research institutions, policymakers, local communities, and environmental agencies can provide valuable data and insights to inform decision-making and adaptation strategies for farmers. Specifically, strategies should be developed to mitigate and adapt to the effects of climate change, including increased rainfall and temperature variability, which may affect various sectors such as agriculture.

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