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Climate Variability and Response Strategies among Smallholder Sweet Potato Farmers in Gatundu North Sub-County, Kiambu County, Kenya

Jemimah Wanjiru Gacheru[1]*, Evelyn Wemali (PhD)[2],Gladys Gathuru (PhD)[2]

[1]Kenya Meteorological Department, 30259-00100 Nairobi, Kenya

[2]Department of Environmental Science, Kenyatta University, Nairobi, Kenya.

Corresponding Authors:** ***Jemimah Wanjiru Gacheru, *Kenya Meteorological Department, 30259-00100 Nairobi, Kenya*

Abstract: Climate change and climate variability as manifested in prolonged droughts and frequent floods among other effects is a challenge world over, affecting climate sensitive sectors such as agriculture. Climate variability could be particularly damaging to smallholder farmers that are dependent on rain-fed agriculture including those that grow sweet potatoes in many parts of Kenya such as Gatundu North Sub-County of Kiambu County. The aim of this research was therefore to assess the relationship between smallholder sweet potato production and climate variability in Gatundu North Sub-County. The study used monthly rainfall totals, monthly average maximum and minimum temperatures, annual sweet potato production and responses fromselected smallholder sweet potato farmers. There was a decreasing trend in annual rainfall totals, this trend was however not significantbut the rainfall was highly variable. Annual average maximum and minimum temperatures had an upward trendbut variability was negligible. There was a downward trend in annual sweet potato production. Annual sweet potato production and annual rainfall/annual average maximum and minimum temperatures had a weak negative correlation. The coping strategies being utilized by smallholder sweet potato farmers included crop diversification, irrigation, planting fast-maturing varieties, cultivating in swampy areas, cultivating under other plants to provide shade and adjustment of planting dates. It was concluded that there was no significant relationship between changes in rainfall and temperature and sweet potato production in the study area implying that the coping strategies being used by surveyed farmers were effective in mitigating the deleterious effects of climate variability on the crop and should therefore be strengthened.

1. INTRODUCTION

Sweet potato (*Ipomoea batatas*) is a perennial creeping vine that is mainly grown for its leaves and storage roots. Its origins can be traced back to Latin America and it currently presents in various colours including orange, purple, white and yellow. The plant is a significant source of vitamin E, B and C aside from being used as a livestock feed. Sweet potato is ranked as the 5th most important food crop in developing countries (International Potato Center2019).

Sweet potatoes are grown in many parts of Kenya where average minimum temperatures are above 12^{0}C and average maximum temperatures are below 35^{0}C. Annual rainfall during the growing season is well distributed and ranges from 600mm to 1600mm annually. Moreover, soils are sandy-loam, well-drained and light. (Infonet-Biovision2019).

In Kenya, sweet potatoes have historically been neglected and underutilized in the country's efforts to attain food sufficiency. Unlike maize and other staple foods, they have not been aggressively championed as commercially viable crops (Ministry of Agriculture & Livestock Development2019). This is however changing as the Kenyan Government and other stakeholders implement measures to boost sweet potato production. There is therefore urgent need to understand the impact of climate variability on the crop if these measures are to succeed.

The impacts of climate variability on sweet potato farming cannot be fully appreciated without an in-depth evaluation of climatic patterns in the area of interest. Rainfall and temperature patterns in Kiambu County have previously been investigated (Kiptum 2017, Macharia 2017). Nevertheless, there is need to expand this pool of knowledge viaanalysis of recent data as was done in this study.

Moreover, smallholder farmers' perceptions on climate change and variability determine their willingness to adapt (Balasha et al. 2023, Fierros-González &López-Feldman 2021). These perceptions have for the most part not been evaluated in Gatundu North Sub-County. This study documents the impacts of changes in rainfall and temperature patterns on sweet potato production as observed by affected farmers; information that can be used to strengthen the adaptive capacity of such farmers and their peers.

Climate simulations indicated that by the year 2030 rainfall amounts over Central Kenya (where Gatundu North Sub-County lies) are likely to increase during the October-November-December "Short-Rains" season but decrease during the March-April-May "Long-Rains" season (Mati2000). The increased rainfall is likely to cause waterlogging of soils while the decrease is expected to shorten the growing season. Both these factors may adversely affect sweet potato production and exacerbate the vulnerability of smallholder farmers in the study area to climatic shocks.

The overall objective of this study was therefore to assess the relationship between smallholder sweet potato production and climate variability in Gatundu North Sub-County, Kiambu County, Kenya.The specific objectives were: to analyse temperature and rainfall trends and variability for the 30-year period between 1993 and 2022; to evaluate the relationship between climate variability and sweet potato production; and to assess the coping strategies adopted by smallholder sweet potato farmers against climate variability.

2. MATERIALS & METHODS

This section provides information on the study area with specific emphasis on its location, climate, economic activities and physiographic features. The section also delves into sampling procedures and size as well as data collection and analysis.

2.1. Study Site

The study site was Gatundu North Sub-County. Itis one of 12 Sub-Counties in Kiambu County in Central Kenya. The Sub-County lies between latitudes 0.806S and 1.024S and longitudes 36.656E and 36.981E as depicted in Figure 1. It covers an area of 286km^2 which is divided into4 Wards: Gituamba, Githobokoni, Chania and Mang'u(County Government of Kiambu2018). The most recent Kenya Population and Housing Census (Kenya National Bureau of Statistics [KNBS] 2019) indicated that Gatundu North Sub-County had a population of 109,870.

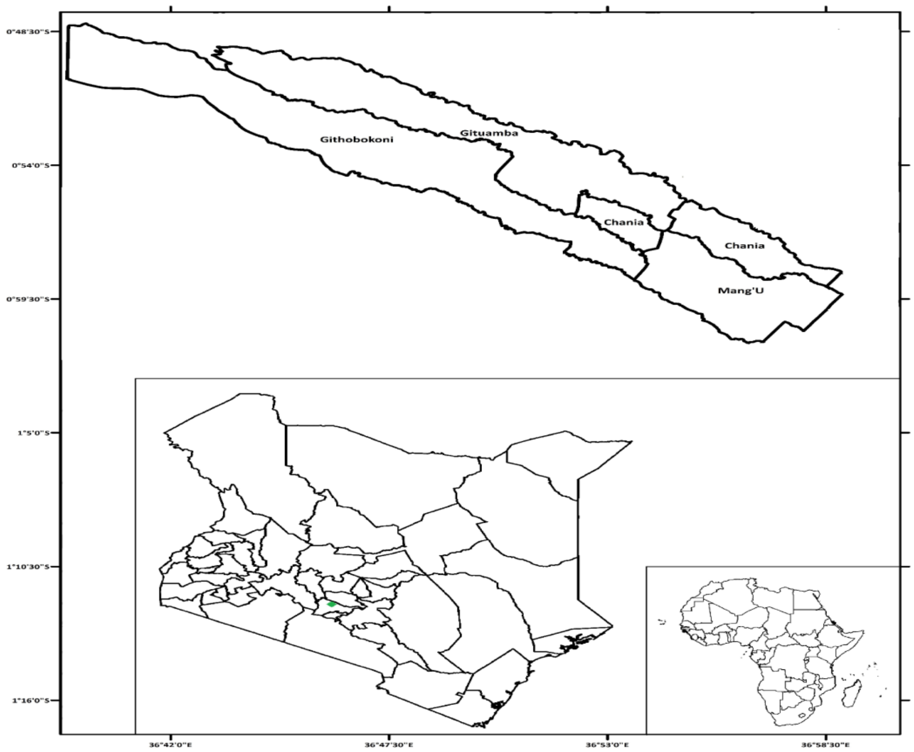

Figure1. *Gatundu North Sub-County and its wards. The Sub-County is represented by the green square in the map of Kenya.*

There are two distinct rainfall seasons in Gatundu North Sub-County. The Long Rains occur between March and May when an average of 620 mm of rainfall is recorded. The second season is the Short Rains which occurs between October and December when an average of 470 mm of rainfall is received. The annual average maximum temperature for the Sub-County is 24.3^0C while the annual average minimum temperature is 12.6^0C (Kenya Meteorological Department [KMD]Maproomsn.d).

Agriculture is the main economic activity in Gatundu North Sub-County. Smallholder farming households in the area grow coffee, beans, maize, potatoes, pineapples and vegetables for sale in local and international markets. Coffee estates and horticultural farms provide employment for casual workers.

Kiambu County has four topographical zones: Upper Highland, Lower Highland, Upper Midland and Lower Midland. Gatundu North Sub-County is generally in the Lower Highland Zone which has an altitude of between 1,500m and 1,800m above sea level. This zone is comprised of hills, high-elevation plains and plateaus. The Sub-County has fertile volcanic soils which are suitable for agriculture (County Government of Kiambu2018).

2.2. Sample Selection

Purposive sampling, using agro-ecological zoning of the study area, was carried out. It identified 17 sub-locations where sweet potato farming was likely to be carried out. The combined population of these sub-locations was 55,821 (KNBS2019) of which 14,328 family agricultural holdings were targeted for this study (KNBS2017). The sample size (1) was determined using the Yamane formula (Yamane, 1967).

$$n = \frac{N}{1 + N(e)^2} \tag{1}$$

n = Sample size

N = Total family agricultural holdings

e = Margin of error

= 0.05

$$n = \frac{14328}{1+14328(0.05)^2}$$

= **389.14**

A total of 389 smallholder sweet potato farmers were expected to take part in this research but only 292 were reached.

2.3. Data Collection

This study made use of both primary and secondary data. To determine rainfall and temperature trends, secondary data in the form of monthly rainfall totals and monthly average maximum and minimum temperatures for Thika Meteorological Station were obtained from KMD.

To investigate the relationship between climate variability and sweet potato production, secondary data in the form of annual sweet potato production data for 2010 to 2022 was obtained from the Gatundu North Sub-County Agricultural Office.The sweet potato production data covered the said time period because area of study was established in 2010 following the promulgation of Kenya's current constitution.

Coping strategies adopted by smallholder sweet potato farmers against climate variability were identified using primary data obtained via structured questionnaires. Key informants like agricultural and meteorological officers in the study area who have expert knowledge on sweet potato production were interviewed to collaborate the data collected from smallholder sweet potato farmers.

2.4. Data Analyses

The Real Statistics Resource Pack (Release 8.9.1; Zaiontz 2013) was used to carry out trend analysis on rainfall and maximum and minimum temperature data using the Mann-Kendall Test (2) for trend significance (Mann 1945, Kendall 1975) and Sen's Slope Estimator (3) (Sen, 1968) for trend magnitude.

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} sign(x_j - x_j) \tag{2}$$

$$z = \begin{cases} (S-1)/se, S > 0 \\ 0, \quad S = 0 \\ (S+1)/se, S < 0 \end{cases}$$

Where:

se = standard error

S>0 implies upward trend while S<0 indicates downward trend

$$Sen's\ slope = Median\left\{\frac{x_j - x_i}{j - i} : i < j\right\} \tag{3}$$

The coefficient of variation (CV) as seen in (4) was also calculated to determine the degree of monthly/annual rainfall and temperature variability in the study area.The coefficient of variation is a measure of dispersion that is given as the ratio of the standard deviation to the mean.

$$Coefficient\ of\ variation = \frac{Standard\ deviation}{Mean} \tag{4}$$

Pearson correlation was carried out to reveal the relationship between annual rainfall totals, annual average maximum and minimum temperatures and annual sweet potato production for the period between 2010 and 2022.The significance level (α) for statistical tests was set at 5%.

Survey analysis was done on data collected through structured questionnaires to isolate running themes on the coping strategies.Summations and percentages that depict the utility of various coping strategies within the study area were calculated.

3. Results

This section presents the results of time series analysis of rainfall, maximum and minimum temperatures and sweet potato production as well as their correlation. It also describes farmers' perceptions of changes in rainfall and temperature patterns in the study area.

3.1. Rainfall Trends

An analysis of annual rainfall totals for 1993 to 2022 indicated that the highest amounts of rainfall: 1598.8mm and 1568.4mm were recorded in 1997 and 1998 respectively (Figure 2.) The driest year was 2000 when 356.8mm of rainfall was recorded.

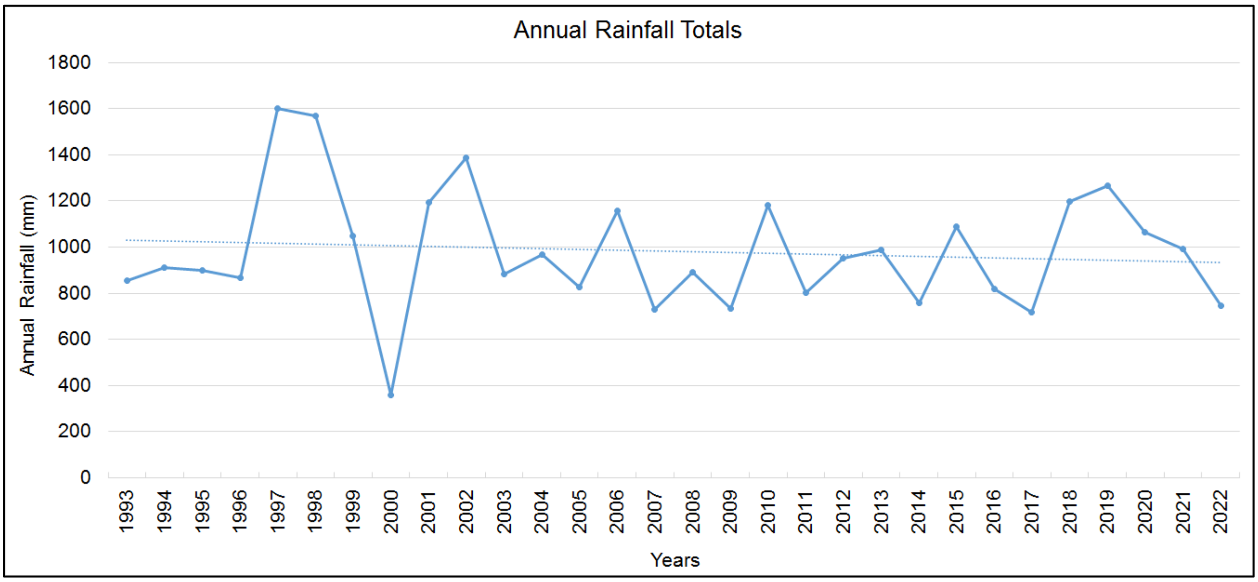

Figure2. *Annual rainfall totals for 1993 to 2022.*

Annual rainfall totals had a decreasing trend (slope = -2.555), this trend was however not significant (p-value = 0.669) as shown in Table 1.

Table1. *Trend statistics for annual rainfall*

Mann-Kendall Test					
alpha	*MK-stat*	*s.e.*	*z-stat*	*p-value*	*trend*
0.05	-25	56.051	-0.428	0.669	no
Sen's Slope					
alpha	*slope*	*lower*	*upper*		
0.05	-2.555	-12.327	7.611		

To assess rainfall variability in the study area, the coefficient of variation (CV) was calculated for annual and monthly rainfall (Table 2 and Figure 3). Annual CVs ranged from 0.71 in 2010 to 1.49 in 2013. Further evaluation of monthly CVs revealed that November had the lowest CV value of 0.48 while January had the highest value of 1.58.

Table2. *Coefficient of Variation (CV) for monthly rainfall.*

Month	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
CV	*1.58*	*1.01*	*0.69*	*0.51*	*0.78*	*1.21*	*1.29*	*0.97*	*1.44*	*0.90*	*0.48*	*0.81*

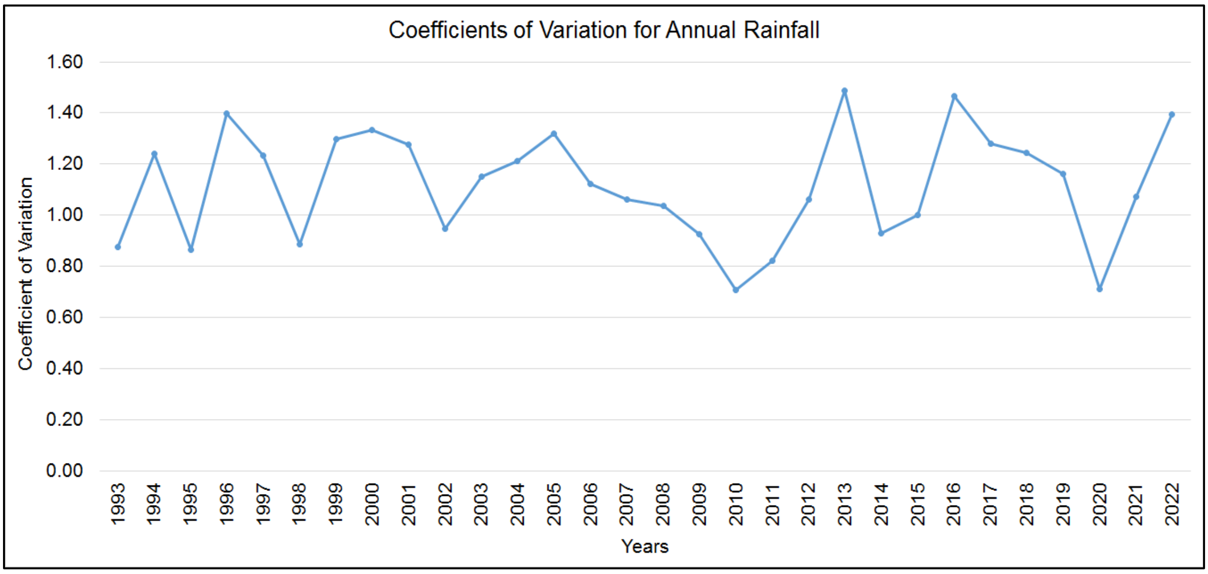

Figure3. *Coefficients of Variation for Annual Rainfall*

3.2. Maximum Temperature Trends

Figure 4 shows the annual average maximum temperatures for 1993 to 2022. The hottest years were 2009 and 2019 when the annual average maximum temperature was 27.4^{0}C. The coldest year was 1998 when average day-time temperatures were 24.8^{0}C.

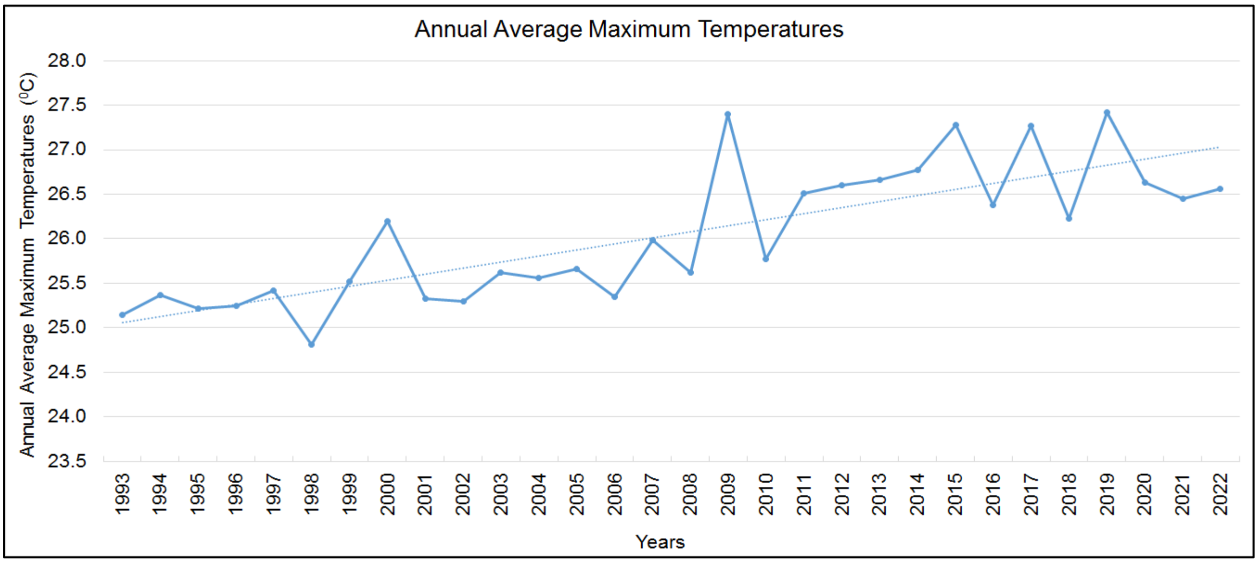

Figure4. *Annual average maximum temperatures for 1993 to 2022.*

Annual average maximum temperatures had an increasing trend with slope = 0.065 and p-value = 7.056E-07 (refer to Table 3).

Table3. *Trend statistics for annual average maximum temperatures*

Mann-Kendall Test					
alpha	*MK-stat*	*s.e.*	*z-stat*	*p-value*	*trend*
0.05	279	56.051	4.960	7.056E-07	yes
Sen's Slope					
alpha	*slope*	*lower*	*upper*		
0.05	0.065	0.046	0.085		

The coefficients of variation for average monthly maximum temperatures ranged from 0.03 to 0.05 while those of annual average maximum temperatures were between 0.04 and 0.09 (Table 4 and Figure 5).

Table4. *Coefficient of Variation (CV) for monthly maximum temperatures.*

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CV	0.05	0.04	0.05	0.04	0.03	0.04	0.05	0.05	0.03	0.04	0.04	0.03

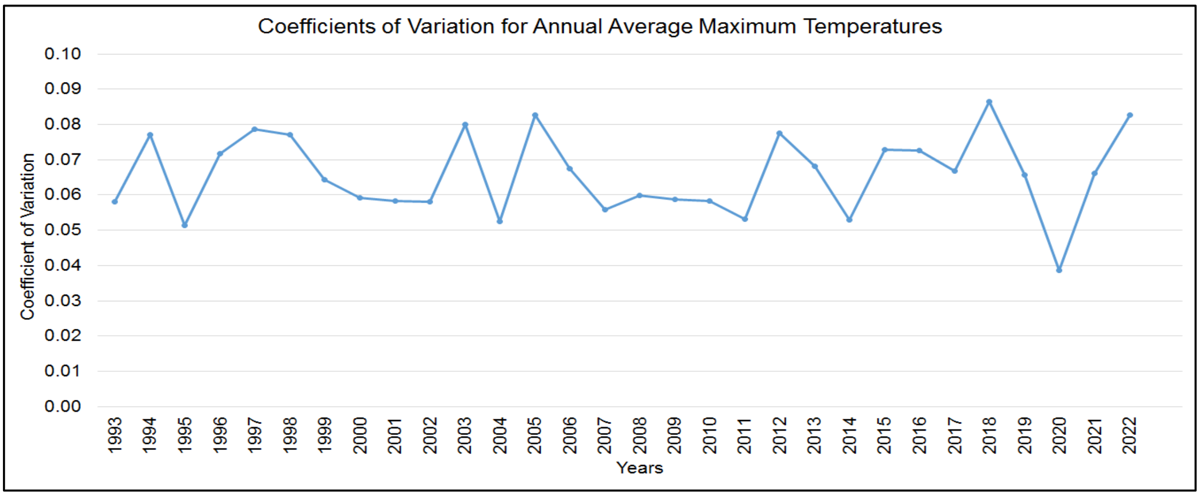

Figure5. *Coefficients of Variation for Annual Average Maximum Temperatures*

3.3. Minimum Temperature Trends

A time series analysis of minimum (night-time) temperature for the study area is displayed in Figure 6. The highest annual average minimum temperature (15.3°C) was recorded in 2022 while 1999 had the lowest average night-time temperature of 13.3°C.

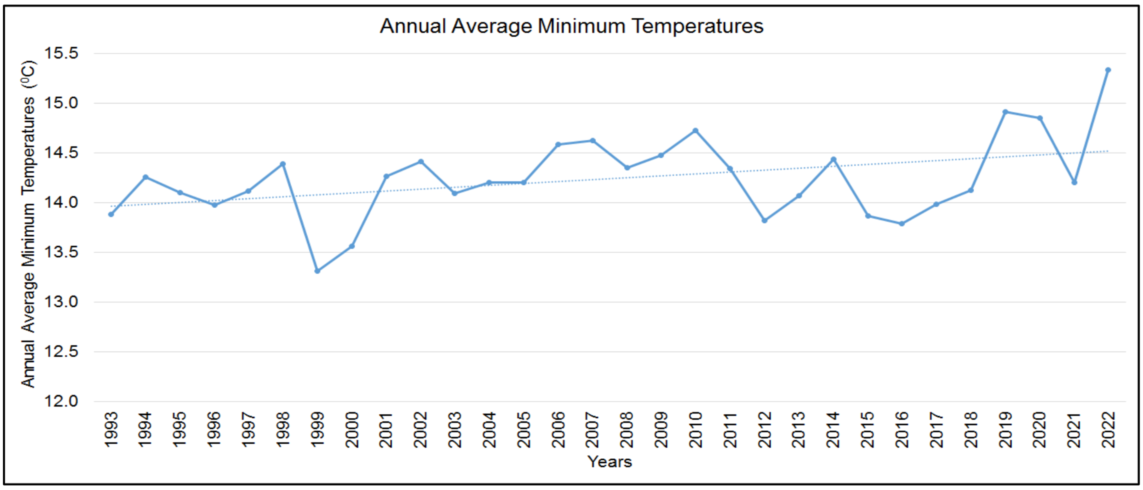

Figure6. *Annual average minimum temperatures for 1993 to 2022.*

Annual average minimum temperatures have and upward trend where the slope = 0.024 and p-value = 0.032 (see Table 5).

Table5. *Trend statistics for annual average minimum temperatures*

Mann-Kendall Test					
alpha	*MK-stat*	*s.e.*	*z-stat*	*p-value*	*trend*
0.05	121	56.051	2.141	0.032	yes
Sen's Slope					
alpha	*slope*	*lower*	*upper*		
0.05	0.024	0.001	0.039		

Average monthly minimum temperatures had greater variability than average monthly maximum temperatures(Table 6) with January and February having the highest CV values of 0.10 and 0.12 respectively. Moreover, CVs for annual average minimum temperatures were higher than those of annual average maximum temperatures with values of between 0.06 and 0.13 (Figure 7).

Table6. *Coefficient of Variation (CV) for monthly minimum temperatures.*

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CV	0.10	0.12	0.07	0.03	0.05	0.06	0.05	0.05	0.05	0.04	0.03	0.06

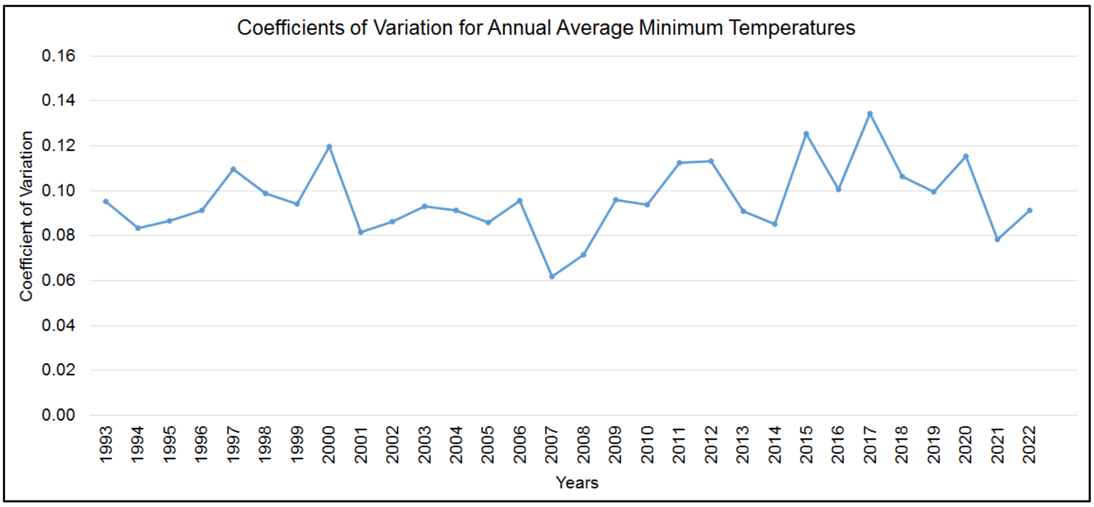

Figure7. *Coefficients of Variation for Annual Average Minimum Temperatures*

3.4. Effects of Climate Variability on Sweet Potato Production

This subsection describes smallholder sweet potato farmers' perceptions of changes in rainfall and temperature patterns in the study area as well as the impacts of these changes on sweet potato production. The results of statistical analysis of the relationship between sweet potato production and rainfall, maximum and minimum temperatures are also discussed.

Smallholder Sweet Potato Farmers' Perceptions of Changes in Rainfall Patterns

This study sought to find out if smallholder sweet potato farmers had observed any changes in the rainfall patterns of the Gatundu North Sub-County. 267 farmers reported that rainfall patterns had changed (Table 7). 23 respondents had not observed any changes while 2 respondents did not know if rainfall patterns had changed or not.

Table7. *Farmers' perceptions on whether rainfall patterns in Gatundu North Sub-County have changed*

Farmers perceptions on changes in rainfall patterns	Frequency	Percentage
Yes	267	91.44
No	23	7.88
Don't know	2	0.68

Respondents who had observed changes in rainfall patterns elaborated on the changes that they had noted (Table 8). The most dominant change, that had been highlighted by 191 respondents, was that seasons (and more specifically rainfall onset and cessation dates) were not as organised as they used to be decades ago.

Aside from changes in rainfall seasons, 100 farmers reported that rainfall amounts in the study area had decreased while 21 observed that dry spells had increased and become prolonged. Only 14 farmers perceived that rainfall amounts had increased.

Table8. *Observed changes in rainfall patterns*

Observed changes in rainfall patterns	Frequency	Percentage
Seasons (onsets and cessations) have changed	191	65.41
Amounts have decreased	100	34.25
Increased & prolonged dry spells	21	7.19
Amounts have increased	14	4.79

The effects of changes in rainfall patterns on sweet potatoes were also investigated (Table 9). It is worth noting that 129 respondents believed that the changes that they had observed in rainfall patterns in the study area had no effect on sweet potato production. On the other hand, 197 farmers reported that some common adverse effects of changes in rainfall onset and cessation dates are decreased production, infestation by worms, increased disease prevalence, wilting and slow maturity. Increased rainfall amounts had led to improved sweet potato production since worms and moles could not thrive in very wet soils.

Table9. *Effects of changes in rainfall patterns on sweet potatoes.*

Changes in rainfall patterns	Effects on sweet potatoes	Frequency	Percentage
seasons (onsets and cessations) have changed	no effect	90	30.82
	decreased production	42	14.38
	wilting	29	9.93
	infestation by worms	11	3.77
	slow maturity	8	2.74
	destruction by heavy rain	5	1.71
	delays in planting	3	1.03
	increased disease prevalence	2	0.68
	increased production	1	0.34
amounts have increased	no effect	4	1.37
	increased production	8	2.74
	decreased production	2	0.68

amounts have decreased	no effect	30	10.27
	wilting	28	9.59
	decreased production	14	4.79
	infestation by worms	9	3.08
	destruction by moles	9	3.08
	slow maturity	7	2.40
	delays in planting	3	1.03
increased & prolonged dry spells	no effect	5	1.71
	decreased production	8	2.74
	wilting	7	2.40
	infestation by worms	1	0.34

Smallholder Sweet Potato Farmers' Perceptions of Changes in Temperature Patterns

A vast majority of the respondents (235) had observed changes in temperature patterns in Gatundu North Sub-County. 54 respondents felt that temperature patterns had not changed while 3 respondents did not know if temperatures patterns had changed or not (Table 10).

Table10. *Farmers' perceptions on whether temperature patterns in Gatundu North Sub-County have changed.*

Farmers perceptions on changes in temperature patterns	Frequency	Percentage
Yes	235	80.48
No	54	18.49
Don't know	3	1.03

When asked to elaborate on the changes they had observed in the temperature patterns of the study area, 109 respondents reported that the area had become colder (Table 11). On the other hand, 82 smallholder farmers observed that temperatures had increased. 35 respondents noted that temperature extremes were more frequent and pronounced while 17 respondents felt that the cold season had become progressively longer.

Table11. *Observed changes in temperature patterns*

Observed changes in temperature patterns	Frequency	Percentage
Colder	109	37.33
Hotter	82	28.08
Extremes are more frequent & pronounced	35	11.99
The cold season is longer	17	5.82

Table 12 describes the effects of changes in temperature patterns on sweet potatoes. 172 respondents reported that changes in temperature patterns had no effect on sweet potatoes. There were however reports of some unfavourable effects of variations in temperature patterns on sweet potatoes. For instance, warmer conditions had resulted in wilting, decreased production, slow maturity, infestation by worms and difficulty in harvesting. Conversely, colder conditions had led to decreased production, frost damage and slow maturity.

Table12. *Effects of changes in temperature patterns on sweet potatoes.*

Changes in temperature patterns	Effects on sweet potatoes	Frequency	Percentage
hotter	no effect	45	15.41
	wilting	14	4.79
	decreased production	12	4.11
	increased production	3	1.03
	slow maturity	3	1.03
	infestation by worms	3	1.03
	difficulty in harvesting	2	0.68
colder	no effect	93	31.85
	decreased production	9	3.08
	frost damage	5	1.71
	slow maturity	2	0.68
extremes are more frequent &	no effect	17	5.82

pronounced			
	decreased production	9	3.08
	infestation by worms	4	1.37
	increased production	3	1.03
	destruction by moles	2	0.68
the cold season is longer	no effect	17	5.82

Relationship between Climate Variability and Sweet Potato Production

Annual sweet potato production for 2010 to 2022 in Gatundu North Sub-County is displayed in Figure 8. There had been a significant decline in production (slope = -1204.5, p-value = 0.001)that can be attributed to challenges that farmers are experiencing including pests, limited access to high yielding vines, changes in weather patterns and land fragmentation.

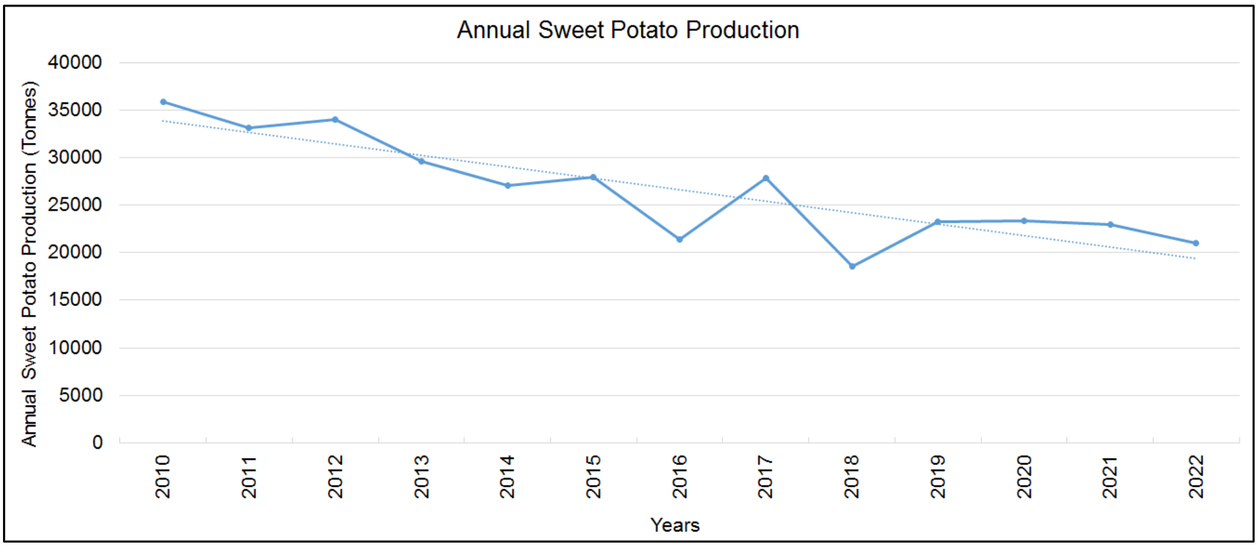

Figure7. *Annual sweet potato production for 2010 to 2022 in Gatundu North Sub-County*

The relationship between annual sweet potato production and climate variability was investigated for the years 2010 to 2022. There was a weak negative correlation between annual sweet potato production and annual rainfall (r = -0.052, p = 0.865). The correlation between annual sweet potato production and annual average maximum and minimum temperatures was also weak and negative with r = -0.254, p = 0.399 and r = -0.199, p = 0.512 respectively.

3.5. Coping Strategies Being Utilized by Smallholder Sweet Potato Farmers

Smallholder sweet potato farmers in Gatundu North Sub-County were using the coping strategies displayed in Table 13 to address the climate-related challenges that they were facing. The commonest coping strategy was crop diversification with 124 respondents growing more than 1 variety of sweet potatoes. Irrigation and planting fast-maturing sweet potato varieties were also popular with 40 and 23 farmers (respectively) practicing the same.

It is disconcerting to note that none of the surveyed farmers were using weather information (including forecasts and advisories) when making sweet potato farming-related decisions. This is in spite of the fact that the information was freely available. There is therefore need to empower farmers to receive, interpret and utilize weather information.

Table13. *Coping strategies being utilized by smallholder sweet potato farmers in Gatundu North Sub-County.*

Coping strategy	Frequency	Percentage
Crop diversification (growing more than one variety)	124	42.47
Irrigation	40	13.70
Planting fast-maturing varieties	23	7.88
Planting in the swamp	8	2.74
Cultivating under other plants (e.g. avocado trees & maize)	6	2.05
Adjustment of planting dates	5	1.71
Re-planting what dries	4	1.37

Crop insurance	0	0.00
Use of weather information	0	0.00

The reasons behind the choice of coping strategies were investigated. 282 respondents indicated that they relied on "past experience" when choosing coping strategies (Table14). 195 got ideas from either talking to other farmers or observing how their colleagues were coping (farmer-to-farmer extension). Only 9 farmers had received "expert advice" from non-governmental organizations (NGOs), community-based organizations (CBOs), National Government institutions or County Government entities on how to cope with the impacts of climate variability on sweet potato farming.

Table14. *Reasons for farmers' choices of coping strategies.*

Reasons for choice of coping strategies	Frequency	Percentage
Past farming experience	282	96.58
Farmer to farmer extension	195	66.78
Expert support	10	3.42

4. DISCUSSION

Annual rainfall totals have a decreasing trend that is not statistically significant. This deviates from previousfindings (Kiptum 2017) that annual rainfall amounts observed at Thika Meteorological Station had been increasing, though the increase was not statistically significant. The apparent change in trend direction could be due to the fact that the previous study did not include the years 2020 to 2022 when the study area experienced a prolonged drought. The wettest years were found to be 1997 and 1998 which is expected due to the strong El Nino phenomenon, which enhances rainfall in Eastern Africa (WMO n.d.),that was influencing the weather in the study area at that time. The driest year was 2000 which is also predictable since that year was part of the 1998/2001 "triple dip" La Niña event; an El Niño Southern Oscillation (ENSO) phase that results in depressed rainfall in Eastern Africa (WMOn.d.). Rainfall with CV values exceeding 0.3 is highly variable (Addisu et al. 2015). From the results described in section 3.1 it can be deduced that both annual and monthly rainfall in Gatundu North Sub-County is highly variable exposing smallholder farmers to losses associated with erratic rainfall.

Global mean near-surface temperatures for 2015 to 2023 have been the warmest on record (WMO 2023).This observation is true for Gatundu North Sub-County where 2009 and 2019 had the highest annual average maximum temperatures while 2022 was the peak for annual average minimum temperatures. 2009 is outside the WMO findings but the elevated temperatures could be attributed to La Nina conditions that occurred between 2007 and 2009 (Bureau of Meteorology [BOM] n.d.) resulting in depressed rainfall and reduced cloud cover that allowed temperatures to be higher than normal. Similarly,a La Nina phase was active during the northern hemisphere winter in1998to 2001 (BOM n.d.) leading to clear night skies and low annual average minimum temperaturesin the study area in 1999.On the other hand, the enhanced cloudiness and heavy rainfall experienced in the first half of 1998 (as inferred from the monthly rainfall data used in this study) contributed to that year having the lowest annual average maximum temperatures.An analysis of annual average maximum and minimum temperatures for Thika Meteorological Station between 1794 and 2006/2008 indicated a significant upward trend (Kiptum 2017). This trend has been sustained in the current study that utilised 1993 to 2022 data. There is negligible variation in mean temperatures at the tropics (Wang & Dillon 2014); the same can be said for Gatundu North Sub-County's maximum and minimum temperatures. However, both monthly and annual average minimum temperatures had greater variability than monthly and annualaverage maximum temperatures; an observation that requires further research.

More than a third of the surveyed smallholder sweet potato farmers believed that the changes that they had observed in rainfall and temperature patterns in the study area had no effect on sweet potato production. In their opinion, sweet potatoes are resilient crops that are not usually affected by climatic shocks. This observation has some scientific backing including FAO (2020) and Bovell-Benjamin (2007) who posit that sweet potatoes are drought tolerant and highly adaptable to diverse agro-ecological and climatic conditions.

The determination that there was no significant relationship between changes in rainfall and temperature patterns and sweet potato production in the study area implies that the coping strategies that were being used by surveyed farmers were effective in mitigating the deleterious effects of climate variability on the crop. This premise is in line with previous findings that adoption of adaptation measures (coping strategies) led to increased crop yields (Etana et al. 2021). Moreover, adjustments made by smallholder farmers in Nepal were effective in improving their agricultural productivity (Khanal et al. 2018).

The commonest coping strategy among smallholder sweet potato farmers in Gatundu North Sub-County was crop diversification with farmers growing more than 1 variety of sweet potatoes. Irrigation and planting fast-maturing sweet potato varieties were also popular. These findings are in line with past studies where adjustments in planting dates, crop diversification, irrigation, utilization of reliable weather information (that includes alerts and early warnings), income diversification and planting superior cultivars were identified as coping strategies being used by smallholder farmers (Mall et al 2017, Okonya et al. 2013).

The number of years that a person had been farming is one of the determinants of the coping strategies that he/she employs against climate change/variability (Obayelu et al. 2014). Farmer-to-farmer extension and support from government and non-governmental institutions are additional determinants (Ashraf et al. 2014). Farming experience and farmer-to-farmer extension were prevalent in the study area but support from government and non-governmental institutions was for the most part lacking.

5. CONCLUSION

This study was carried out in Gatundu North Sub-County, Kiambu County, Kenya where climate variability and response strategies among smallholder sweet potato farmers were investigated.

A statistically insignificant decreasing trend was noted in annual rainfall totals; the rainfall was however highly variable. Annual average maximum and minimum temperatures had increasing trends though variability was negligible. There was no significant relationship between changes in rainfall and temperature patterns and sweet potato production in the study area implying that the coping strategies being used by surveyed farmers were effective in mitigating the deleterious effects of climate variability on the crop. However, a lot more can still be done to ensure that farmers reap maximum benefits from all applicable coping strategies.

It is recommended that weather information including routine forecasts, bulletins and advisories should be disseminated to smallholder farmers in addition to empowering them to interpret and utilize this information. The reach of irrigation projects in Gatundu North Sub-County should also be extended since this is a popular coping strategy that can protect the livelihoods of many farmers.

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