***Original Research Article***

**Impact of Climate Change on Agriculture in Kenya**

**Abstract**

The agricultural sector is both a major source of economic growth and a sector that is negatively impacted by climate change in Kenya. Therefore, this study examines the impact of climate change on the growth of the agricultural sector in Kenya. This study scrutinizes these dynamics in Kenya using the Solow-Swan growth model and annual data from 1988 to 2023. Applying Phillips-Perron, Johansen cointegration, Ordinary Least Squares, and Granger causality tests, the findings reveal that climate change has a negative impact on the growth of the agricultural sector in Kenya. Granger causality tests reveal one-way causality running from temperature change to agricultural sector growth. The study underscores the importance of adapting climate-smart farming practices, diversifying crop selections, and enhancing water management strategies. These approaches can significantly bolster resilience and productivity amidst climate variability.

Keywords: Climate change, temperature, agriculture sector growth

JEL Classification: F18, F13, Q54, Q56

**Introduction**

Agriculture plays a crucial role in the economic structure of many countries, especially in the developing world. One of the key indicators of this role is agriculture’s contribution to Gross Domestic Product (GDP), which reflects the sector’s relative importance to national economies. Understanding the trends and significance of agriculture as a percentage of GDP is vital for evaluating economic dependency, development priorities, and structural transformation across the globe. Globally, agriculture accounts for a modest share of GDP, reflecting the gradual structural shift towards industrialization and services in most economies. As of 2022, agriculture contributed approximately 4% to global GDP, but this figure masks large differences between countries at varying stages of development (World Bank, 2023). In high-income economies, agriculture often contributes less than 2% of GDP, reflecting a shift toward more capital-intensive and diversified economic activities (FAO, 2021). In contrast, agriculture remains a dominant economic sector in low-income countries, where it can contribute more than 25–30% of GDP, often serving as the primary source of employment and livelihood.

In sub-Saharan Africa, agriculture continues to be a cornerstone of the economy. On average, it accounts for between 15% and 30% of GDP, although this share varies by country (African Development Bank [AfDB], 2022). In nations like Ethiopia, Sierra Leone, and Chad, agriculture contributes over 30% to GDP, reflecting high dependence on farming and limited diversification into other sectors. The high agricultural GDP share is often linked to subsistence farming and low levels of industrialization. While the sector employs more than 60% of the population in many countries, its contribution to GDP has remained relatively stagnant due to challenges such as low productivity, limited access to technology, and infrastructure deficits (FAO, 2022). The persistence of high agricultural GDP shares in the region underscores the importance of agriculture in economic planning but also reflects vulnerability to external shocks like climate change and global market fluctuations. The declining share of agriculture in global GDP is a natural outcome of economic transformation, climate change and productivity improvements in other sectors. However, in many developing countries, agriculture still holds significant weight, and its performance has substantial implications for poverty reduction, food security, and rural development.

In Kenya, agriculture remains a vital pillar of the economy. According to the Kenya National Bureau of Statistics (KNBS, 2023), the agricultural sector contributed approximately 21.2% to the country’s GDP in 2022. About 20–30% of Kenya's GDP comes from the country's agriculture industry, which also employs a sizable fraction of the workforce, especially in rural areas. With commodities like tea, coffee, and vegetables being important exports, it's essential for both internal food security and export revenue. But the agricultural industry also has to deal with issues like land fragmentation, climate change, and the need for better farming methods. When indirect linkages—such as those with agro-processing, trade, and transportation—are considered, the sector’s overall contribution rises to around 33%. This makes agriculture the single most important sector in terms of both output and employment. Kenya’s agriculture is largely rain-fed and dominated by smallholder farmers who account for about 75% of total agricultural output (Ministry of Agriculture, 2022). Despite its critical role, the sector’s contribution to GDP has shown fluctuations due to recurrent droughts, pest outbreaks, and market volatility.

According to Climate Prediction Centre data, average maximum temperatures in Kenya are warming, rising from 29.0°C in the late 1970s to 30.5°C by the early 2020s, a 1.5°C increase linked to global climate change (KMD, 2024; Kinuthia & Mose, 2024). Figure 1 depicts the average earth temperature in Kenya.



**Figure 1: Average mean surface temperature in Kenya 1979-2022**

Source: KMD (2024).

Kenya has launched programs such as the National Climate Change Action Plan and is committed to lowering emissions by the Paris Agreement. However, there is a scarcity of empirical studies assessing the contributions of climate change to agricultural sector growth in the nation (Chamma, 2024). In the long term, the Kenyan government aims to modernize the agricultural sector and reduce overdependence by encouraging industrial and service sector growth. The relatively high share of agriculture in GDP highlights the sector’s central role in economic resilience, poverty alleviation, and rural development. It also indicates that any adverse climate shocks to agriculture can have far-reaching economic implications for the country. This study aims to close that gap by using time series data from 1988 to 2023 to assess the impact of climate change on agricultural sector growth in Kenya.

**2 Literature Review**

The relationship between climate variables and agricultural output has long been explored through economic and environmental theories. Two dominant theoretical frameworks underpin this study: the Ricardian Approach and the Production Function Approach. The Ricardian Approach, developed by Mendelsohn, Nordhaus, and Shaw (1994), measures the economic impact of climate change by regressing land values or net farm revenue on climate variables while controlling for other socioeconomic and geographic factors (Deressa & Hassan, 2009; Kabubo-Mariara & Karanja, 2007) ). This approach assumes that farmers adapt optimally to climate conditions, and hence land values reflect the net productivity under given climate regimes. In warmer regions such as Kenya, where agricultural systems are more vulnerable and adaptive capacity is lower, increased temperatures are expected to reduce net farm revenue (Kurukulasuriya & Mendelsohn, 2008).

The Production Function Approach treats climate variables such as temperature and rainfall as inputs in the agricultural production process. Output is modelled as a function of traditional inputs—land, labour, and capital—alongside environmental factors. Higher temperatures may reduce yields by exceeding optimal thresholds for crop growth, thereby reducing total output and the sector's contribution to GDP (Schlenker & Roberts, 2009).

The Solow-Swan growth model asserts that, in the long run, the rate of output growth is determined by two exogenous factors: technical progress and the growth contributions of labour and capital (Kawalec, 2020). It operates on the premise of a neoclassical production function characterized by constant returns to scale and diminishing marginal returns to both capital and labour (Muthoni et al, 2019; Mbwambo et al., 2025). A crucial insight of the theory is that in the absence of technological progress, economies will ultimately reach a steady state where further capital investments yield no sustained growth (Daly, 2014). Technological progress, regarded as an exogenous factor, is viewed as the primary catalyst for enduring per capita income growth, making it vital to comprehend the mechanisms behind economic development over time (Solow, 1956). This model, while providing a foundational link between macroeconomic factors and output growth, has revealed certain limitations that have led to the emergence of alternative growth theories. Notably, the models proposed by Mankiw and Romer introduce additional exogenous variables. This study seeks to explore the relationship between economic variables and agricultural output by presenting models drawn from existing literature. These models will utilize a production function framework, incorporating factors such as capital, labour, technology, climate change, interest rates, and other pertinent inputs as potential explanatory variables. However, climate change can be incorporated into the Solow model by adding environmental damage as a factor that reduces production, investment, or consumption. This creates a "climate-solow model" that examines the impact of climate change on economic growth and the trade-offs between economic activity and environmental sustainability.

The assumption that human-generated greenhouse gas emissions are the primary driver of climate change is being challenged by emerging evidence suggesting that other human activities have a more significant impact (Sidiropoulos, 2023). The Human Climate Forcings theorem (Omotoso & Omotayo, 2024) demonstrates that factors such as land-use changes, deforestation, trade, agriculture, urbanization, and industrial practices substantially influence land and sea surface temperatures. Activities like logging, agriculture, trade, construction, and tourism disrupt ecosystems and alter water dynamics, affecting the climate. For instance, deforestation decreases CO2 sequestration, while urban expansion can lead to increased runoff and elevated temperatures.

In terms of past empirical studies, Globally, Lobell and Field (2007) found a significant negative correlation between temperature increases and crop yields in tropical countries, including sub-Saharan Africa. Their study used global datasets to demonstrate that each degree Celsius increase in temperature reduced maize and wheat yields by 10–17%, with the strongest effects observed in low-latitude countries. In a panel analysis of African countries, Deressa and Hassan (2009) used the Ricardian model and showed that temperature increases significantly reduced net farm income, with smallholder farmers in Ethiopia and South Africa being the most vulnerable due to limited access to adaptation technologies. Kurukulasuriya et al. (2006) extended this analysis to 11 African countries and observed that temperature rise, especially during the growing season, negatively affected crop productivity. They concluded that the economic value of agricultural land declined as a result of climate-induced heat stress.

In the Kenyan context, Kabubo-Mariara and Karanja (2007) employed a cross-sectional Ricardian model and found that higher temperatures significantly decreased crop yields and net revenue per hectare, especially in warmer agroecological zones. Their study highlighted the absence of effective adaptation strategies among smallholder farmers as a major contributor to vulnerability. Gicheru and Sang (2018) analyzed the effect of climate variability on agricultural GDP in Kenya using time series data from 1980 to 2015. Their results indicated that temperature anomalies negatively impacted agricultural productivity and subsequently reduced agriculture's share in GDP. They emphasized the need for irrigation, drought-resistant crops, and early warning systems as climate adaptation measures.

Njeru (2020) applied the Autoregressive Distributed Lag (ARDL) model to examine the impact of temperature changes on agriculture in Kenya between 1985 and 2018. The study confirmed both the short-run and long-run negative effects of rising temperatures on the agriculture sector's GDP contribution. The results suggested that temperature variability accounted for a significant proportion of the fluctuations in agricultural output over the study period. Mutunga and Wambugu (2021) conducted a cointegration analysis to investigate long-term relationships between climate variables and agriculture in Kenya. They found that while rainfall variability had mixed effects, rising temperatures consistently exhibited a negative impact on agricultural GDP. They recommended climate-smart agricultural investments and policy reforms to buffer the sector from adverse climate impacts.

**Materials and Methods**

The study adopted a correlation research design. Correlational research primarily uses numerical data and statistical analysis to quantify relationships between study variables. The investigation was done in Kenya from 1988 to 2023, yielding a total of 36 observations. Agriculture contributes a significant percentage to Kenya's GDP, directly and indirectly through linkages with other sectors like manufacturing and distribution.

 Data on agricultural output characterized by Agriculture, value added (% of GDP), were sourced from the World Bank's (WB) World Development Indicator database and Kenya National Bureau of Statistics. Data on climate change, characterized by rising temperatures, were collected from the World Bank's Climate Change Knowledge Portal (CCKP), which provides global information on climate change and development. Climate change impacts, such as droughts and floods, can disrupt production and damage crops. Furthermore, information on control variables, such as interest rates and technological advancements was obtained from the World Bank's World Development Indicators (WDI) database. Table 1 describes the factors used in this investigation.

**Table 1: Description and Measurement of Variable**

|  |  |  |
| --- | --- | --- |
| **Variable** | **Measurement**  | **Source of Data**  |
| Climate change (TEMP) | Average temperature (°C) | World Bank  |
| Interest rate (LIR) | Lending interest rate (%) | World Bank  |
| Technological innovation (TEC) | Patent applications (residents) | World Bank  |
| Agriculture sector growth (AGR) | Share of agriculture to GDP (%)  | World Bank  |

Source: Authors from World Bank (2025)

Empirical analysis uses the following econometric model

$AGR\_{t} =δ\_{0}+δ\_{1}TEMP\_{t}+δ\_{2}TEC\_{t}+δ\_{3}LIR\_{t}+ε\_{t}$(1)

where δ represents the elasticities of the variables in the regression model. t represents the time dimension and ε is the error term.

This study used descriptive, correlation, and regression analysis of time series data to investigate the impact of climate change on agriculture in Kenya. The study employed Ordinary Least Squares (OLS) to estimate the parameters of the model. It provides unbiased estimates of the model parameters, is easy to understand and implement, and is efficient when the underlying assumptions are met. To confirm the accuracy of the predicted results, the study first used the Phillips-Perron (PP) unit root test to assess each variable's stationarity. Following that, a cointegration test using the Johansen technique was used to evaluate the long-term associations between the time-related variables. To study the causal links between the variables, Granger causality tests were used. Finally, a battery of post-diagnostic tests, including the Jarque-Bera normalcy test, Breusch-Godfrey serial correlation tests, and the Breusch-Pagan heteroscedasticity test were used to confirm the model and results.

**Results and Discussion**

Descriptive analysis was performed to establish the characteristics and patterns of study variables. Table 2 shows the descriptive results.

**Table 2: Descriptive statistics results**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variable  | AGR | TEMP | TEC | LIR |
|  Mean |  23.241 |  24.999 |  90.500 |  18.472 |
|  Median |  23.469 |  25.035 |  44.500 |  16.536 |
|  Maximum |  28.744 |  25.540 |  356.000 |  36.240 |
|  Minimum |  16.254 |  24.310 |  1.000 |  11.995 |
|  Std. Dev. |  3.619 |  0.272 |  98.310 |  6.617 |
|  Observations |  36 |  36 |  36 |  36 |

Source: Authors’ computation (2025)

The period runs from 1988 to 2023, with a total of 36 observations. The secondary data analysis indicates substantial variability among the economic variables presented in Table 2. Kenya's temperature stability is minimal, as evidenced by its average temperature of 24.99 and moderate standard deviation of 0.27. Kenya's agricultural production output varies across the sample, with a mean value of 23.24% of GDP and significant standard deviations of 3.61. A pairwise correlation analysis was utilized to establish the link between agricultural productivity and climate change. Table 3 displays a matrix of data correlations for Kenya.

**Table 3: Correlation statistics results**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | AGR | TEMP | TEC | LIR |
| AGR | 1 |  |  |  |
| TEMP | -0.581\*\*\* | 1 |  |  |
| TEC | 0.491\*\* | 0.563\*\*\* | 1 |  |
| LIR | -0.650\*\*\* | -0.518\*\* | -0.498\*\* | 1 |

Source: Authors’ computation (2025).

Research indicates that climate change, through rising mean temperatures, adversely affects agricultural production, signifying that temperature levels significantly influence agricultural output in Kenya. Technological advancements have a positive association with agricultural output levels, implying that increasing technological innovation leads to higher agricultural output. Furthermore, access to credit has a negative association with agricultural output, meaning that lower lending rates and consequent credit access are associated with increased agricultural output. The study used the Phillips-Perron (PP) test statistic to determine the dependent and independent variables' stationarity. Table 4 shows the stationarity regression results.

**Table 4: Unit root test result**

|  |  |  |  |
| --- | --- | --- | --- |
| Variables | PP at Level | PP at First difference | Order  |
| Adj. t-Statistics  | P-value  | Adj. t-Statistics  | P-value  |
| AGR | -1.225 |  0.652 | -6.633\*\*\* |  0.000 | I(1) |
| TEMP | -5.512\*\*\* |  0.000 | - | - | I(0) |
| TEC |  0.884 |  0.994 | -6.810\*\*\* |  0.000 | I(1) |
| LIR | -1.560 |  0.491 | -5.825\*\*\* |  0.000 | I(1) |
| Notes: Null Hypothesis: variable has a unit root  Significance level \*\*\* p <0.01 |

Source: Authors’ computation (2025)

The results of the Phillips-Perron unit root test indicate uneven integration among the examined variables. According to the analysis, agricultural production, technological advancements, and finance access all show stationarity at the first difference, whereas climate change shows stationarity at the level. These results highlight the significance of giving careful thought to future econometric modelling and analysis, as they show a significant difference in the variables' integration quality.

To estimate long-term relationships via the Johansen cointegration method, all-time series variables in the model must be integrated into order one. However, the results of the Phillips-Perron test indicate that the variables exhibit mixed integration properties. This discovery suggests that the assumption of cointegration may not be applicable in this case. This result indicated that there is no long-run relationship between study variables.

The multivariate regression model was estimated via the ordinary least squares (OLS) regression method. Table 5 shows the regression results.

**Table 5: Estimated OLS Model**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variable | Coefficient | Standard error | t- Statistics | p –Value |
| TEMP | -0.732 | 0.064 | -11.326\*\*\* | 0.000 |
| ILR | -0.309 | 0.057 | -5.421\*\*\* | 0.000 |
| TEC |  0.008 | 0.004 |  1.7684\* | 0.086 |
| CONS |  0.549 | 0.147 | 3.720\*\*\* | 0.001 |
| Durbin-Watson statistics |  2.002 | R-squared = 0.913 |
| Breusch-Pagan Godfrey Test |  **χ2** (7) = 1.348 |  Prob> χ2 = 0.270 |
| Breusch-Pagan LM Test |  χ2 (2) = 0.509 |  Prob> χ2 = 0.607 |
| Jarque-Bera test  |  2.448 |  Prob=0.294 |
| Notes: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1 |

Source: Authors’ computation (2025)

Results indicate that the temperature increase and subsequent climate change have statistically significant negative effects on agricultural sector growth in Kenya at p-values of 0.000. The negative effect of this variable on agricultural sector growth means that, when this variables increase, agricultural sector growth decreases and vice versa. According to the study, increasing average temperature and subsequent climate change would result in a 73% decrease in Kenya's agricultural output. Increased temperatures negatively impact agricultural production by disrupting plant growth, development, and reproductive processes, reducing water availability, and altering soil conditions. These changes can lead to lower crop yields, reduced food quality, and increased vulnerability to other climate-related stressors. Lobell and Field (2007), Deressa and Hassan (2009), and Kurukulasuriya et al. (2006) showed that temperature increases significantly reduced net farm income, with smallholder farmers in Africa being the most vulnerable due to limited access to adaptation technologies. They concluded that the economic value of agricultural land declined as a result of climate-induced heat stress. Gicheru and Sang (2018), Njeru (2020) and Mutunga and Wambugu (2021) indicated that temperature anomalies negatively impacted agricultural productivity and subsequently reduced agriculture's share in GDP. They emphasized the need for irrigation, drought-resistant crops, and early warning systems as climate adaptation measures.

Technological innovations have a significant, positive impact on agricultural production. Technological innovations significantly boost agricultural production by increasing efficiency, resource utilization, and overall productivity. This includes advancements in machinery, biotechnology, data analysis, and precision farming, all of which contribute to higher yields, reduced costs, and more sustainable agricultural practices (Ouru & Mose, 2017).

High lending interest rate and subsequent access to credit has a significant and negative impact on agricultural output. High interest rates increase borrowing costs for farmers, making it harder to finance investments in land, machinery, or other improvements. This can stifle productivity growth and reduce the overall agricultural output in Kenya.

The model's adjusted R-squared value is 0.91, signifying that the independent variables in the model explain roughly 91% of the variability in the dependent variable. Furthermore, serial correlation is not a major concern in the dataset, as indicated by the Durbin-Watson value of 2.00 and further supported by the Breusch-Pagan LM Test. Furthermore, the findings of the Breusch-Pagan heteroscedasticity test show that heteroscedasticity is not a significant concern in this investigation. This therefore means that the estimated model has no heteroscedasticity or serial correlation problem.

The study applied pairwise Granger causality analysis to establish the association between study variables. Table 6 presents the causality result.

**Table 6: Granger Causality Test**

|  |  |  |  |
| --- | --- | --- | --- |
|  Direction | F-Stat. | Prob.  | Decision |
| TEMP AGR |  3.713 | 0.080 | One way causality  |
| AGR TEMP |  0.886 | 0.594 |
| Notes: lags 2; observations 34, Null hypothesis: does not granger cause |

Source: Authors’ computation (2025)

The study revealed a unidirectional causality between climate change and agricultural sector growth, specifically running from climate change to agricultural production. Changes in temperature, precipitation patterns, and extreme weather events disrupt established agricultural practices, leading to reduced yields, water scarcity, and increased vulnerability to pests and diseases. Rising temperatures can cause heat stress in livestock, reducing productivity and increasing mortality.

**Conclusion**

The study regression model has established that climate change through an increase in temperature slows agricultural production in Kenya. Climate change significantly impacts agriculture by altering temperatures and precipitation patterns and increasing the frequency of extreme weather events, leading to decreased crop yields, reduced livestock productivity, and increased vulnerability for developing countries. While some regions may see benefits from slightly warmer temperatures, the overall impact is negative, particularly for food security, malnutrition and the livelihoods of farmers.

To address the negative impacts of temperature fluctuations on agriculture in Kenya, it is advisable to adopt climate-smart farming practices, diversify crop selections, and enhance water management strategies. These approaches can significantly bolster resilience and productivity amidst climate variability. Climate-smart farming will incorporate practices that enhance soil health, minimize greenhouse gas emissions, and increase resilience to climate-associated stressors such as drought and heat. This may involve techniques such as crop rotation, cover cropping, and precision agriculture, which optimize resource utilization and improve water management. Transition towards a more diverse array of crops that are better adapted to changing climatic conditions. This shift can mitigate the risk of crop failures resulting from extreme weather events. Consider introducing drought-resistant varieties or crops that can thrive in elevated temperatures. Enhance water efficiency by employing techniques such as drip irrigation, rainwater harvesting, and optimizing canal systems. These methods can help conserve water resources and reduce the likelihood of crop losses due to drought. Adopt strategies to manage livestock during periods of elevated temperatures, such as offering shade and supplemental feeding. These practices can alleviate heat stress and help maintain livestock productivity.

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