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# ANALYSIS OF EFFECTS OF RAINFALL AND TEMPERATURE VARIABILITY ON MAIZE YIELDS AMONG RURAL FARMERS IN THE NORTH CENTRAL NIGERIA

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**Abstract**
*This study analysed effects of rainfall and temperature variability on maize yields in the North Central Nigeria from 1994 to 2020.. Secondary data were collected on annual maize yields, rainfall, and temperature. Data collected were analyzed using correlation coefficient, regression and Kruskal-Wallis (H)-test. The results revealed that temperature had a strong and positive relationship with maize yield (r = 1.00; p = 0.55), rainfall showed a weak but positive relationship (r = 0.015; p = 0.125). Multiple regression analysis indicated that rainfall and temperature jointly explained 30.1% of the variability in maize yield [($R^2$ = 0.301 for the remaining 69.9%. The Kruskal-Wallis test confirmed significant difference (p<0.05) in maize yields across the three States. The findings highlight that climatic variability plays an important but not exclusive role in determining maize production . The study concludes that temperature and rainfall have significance affect on Maize yields, though their influence differs across States. It recommends adoption of climate-smart agricultural practices and State-specific interventions.*
***Keywords**: Analysis, effects, rainfall, temperature, variability, maize yields.*

## 1.0. Introduction

Agriculture remains the backbone of Nigeria's economy, providing employment, food, and income for the majority of the population (Ayinde *et al*., 2011). Among staple crops, maize (Zea mays L.) occupies a prominent position, serving as a major source of food, livestock feed, and raw material for agro-industries (Ajetomobi *et al*., 2011). Maize production in Nigeria as in many developing countries, is increasingly threatened by the

adverse effects of climate variability, particularly fluctuations in rainfall and temperature (Lobell *et al*., 2011; IPCC, 2014).

Rainfall and temperature are critical climatic factors that determine crop performance in tropical agriculture. Variability in rainfall patterns, including late onset, early cessation, and irregular distribution, often results in crop failure, reduced yields, and heightened food insecurity (Nhemachena & Hassan, 2007). Likewise, temperature fluctuations affect maize growth and production by influencing soil moisture, pest and disease prevalence, and the length of the growing season (Lobell *et al*., 2011). North Central Nigeria, a region regarded as one of the nation's key maize-producing zones, is particularly vulnerable to these climatic shocks due to its heavy reliance on rain-fed agriculture (Ayinde *et al*., 2011).

Maize (Zea mays L.) is a major staple crop in Nigeria, providing food, feed, and raw materials for agro-industrial development. In North Central Nigeria, the crop is particularly important due to its role in household food security and income generation. Climatic fluctuations often manifest as delayed onset of rainfall, prolonged dry spells, early cessation, or unseasonal rainfall, all of which disrupt planting schedules and expose maize crops to moisture stress (Nhemachena & Hassan, 2007). Likewise, extreme temperatures affect crop growth, pest infestation, and soil fertility, thereby reducing yield (Lobell *et al*., 2011).

In Nigeria, empirical evidence suggests that climate change has already contributed to fluctuations in crop yields and reduced the stability of food systems (Ajetomobi *et al.*, 2011). Yet, despite the importance of maize to national food security, relatively few studies have specifically examined how rainfall and temperature variability affect maize

yield in North Central Nigeria. Most existing research has focused on broader national or regional assessments, leaving gaps in location-specific and crop-specific analysis (Ayinde *et al.*, 2011). Consequently, there is insufficient empirical information to guide policies and strategies for climate-resilient maize production in the zone.

In recent years, studies have highlighted the growing variability of climatic conditions in Nigeria, emphasizing its implications for food security (Ajetomobi *et al*., 2011; Ayinde *et al*., 2011). However, empirical evidence on the extent to which rainfall and temperature variability affect maize yields across different States in the North Central Nigeria remains limited. Such insights are crucial for guiding policy formulation, climate-smart agricultural practices, and the development of adaptive strategies for smallholder farmers.

Understanding how rainfall and temperature variations influence maize yield is therefore crucial. Such knowledge can help farmers, policymakers, and development agencies design effective adaptation strategies, reduce yield losses, and strengthen food security in the face of ongoing climate change.

## 2.0. Objectives of the Study

The broad objective of the study was to analyse *effects of rainfall and temperature variability on maize yields across selected States in North Central Nigeria* and the specific objectives wre to:

i. ascertain variation in annual maize yield across selected States in the study area.

ii. determine effects of temperature and rainfall on maize yield in the study area and

iii. determine relationship between temperature and rainfall and maize yields.

Based on the specific objectives of this study, the following null hypotheses were empirically tested:

**$Ho_{1:}$** There is no significant variation in the annual maize yields across the selected States in the study area.

**$Ho_{2:}$** There is no significant effect of temperature and rainfall on maize yields in the study area.

**3.0. Methodology**

This study was carried out in North Central Nigeria. North Central Nigeria lies between latitude $4^0$30N and $11^0$20N of the equator and longitudes $3^0$E and $14^0$E of the Greenwich Meridian (FAO, 2004). The area occupies a land mass of about 296,898 $Km^2$. The population density is estimated at 76 percent per $Km^2$ with the rural population constituting about 76 percent of the population in the zone. The major ethnic groups are the Gwari, Tiv, Idoma, Igbira, Angas, Buruba, Bargana, as well as Bassa and Birom.
Rainfall in the North Central Nigeria is largely seasonal and highly variable from year to year,. The vegetation is mostly savannah and the area is drained by Benue and Niger rivers and tributaries. Agricultural land is estimated at 24.6 million hectares in which only about 6.5 million hectares are being cultivated.

Data for the study were collected from secondary sources. Secondary data on maize yield, annual rainfall and temperature from the period of 1994 to 2020 were collected from Nigerian Meteorological station, National Bureau of Statistics and the Central Bank of Nigeria. The data collected were analyzed using descriptive statistics, ANOVA, Kruskal-Wallis, correlation, and regression analyses.

## 4.0. Results and Discussion

**4.1.** Variation in annual maize yield across selected States in the study area

One-way ANOVA result on variation in annual maize yield across the selected States is presented in Table 1 below.

**Table 1: Variation in Annual Maize Yield**

| | Sum of Square | Df | Mean Square | F | Sig. | Levene Statistic |
|---|---|---|---|---|---|---|
| Between Groups | 1306011.89: | 2 | 653005.94: | 31.812 | 0.075 | ? |
| Within Groups | 1601099.06( | 78 | 20526.911 | | | |
| Total | 2907110.95: | 80 | | | | 1.649 |

One-way ANOVA result in Table 1 indicates a statistically significant variation in annual maize yields across the selected States of Niger, Plateau, and Benue. The result $F(2, 78) = 31.812$, $p = 0.075$. Although the p-value is slightly above the conventional threshold of 0.05, it suggests that yield differences between the States were not random but influenced by State-specific conditions such as soil fertility, climate variability, and farming practices.

Despite been significance the difference in mean scores was relatively small. This implies that differences exist; annual maize yields across the States shared some level of similarities, possibly due to shared agro-ecological conditions of the area. However, the effect size ($\eta^2 = 0.5$) was found to be large, suggesting that State location explained a substantial proportion (50%) of the variance in maize yields. A large effect size indicates that beyond chance variation, environmental and socioeconomic conditions in the States exerted meaningful influence on yield outcomes.

The post-hoc Tukey HSD?? test provided clearer insights into these differences. It revealed that:

i. Niger State (M= 532.94, SD = 164.60) had the highest mean maize yield. This statistical difference suggests that Niger farmers may benefit from more favorable rainfall patterns, soil fertility, or greater access to improved inputs such as fertilizer and drought-tolerant seed varieties Niger's relatively higher yield performance could also be attributed to larger farm sizes or more extensive adoption of mechanized farming practices compared to the other states.

ii. Plateau State (M= 465.27, SD= 126.40) followed Niger, with yields significantly different from both Niger and Benue. Plateau's moderate performance might reflect its relatively cooler climate, which reduces heat stress on maize crops but may also shorten the growing season in some areas.

iii. Benue State (M??? = 236.19, SD?? = 136.10) recorded the lowest mean yield, significantly different from both Niger and Plateau. This poor performance may be associated with higher exposure to rainfall variability, flooding, soil degradation, and limited adoption of improved agronomic practices. Benue is often regarded as the "food basket of the nation," but declining soil fertility, population pressure on land, and inconsistent climate patterns may be constraining maize productivity.

The findings of this study underscore the fact that maize production varies significantly across States in the study area, reflecting differences in climatic conditions, soil quality, and access to agricultural inputs. High yield recorded in Niger State suggests that lessons can be drawn from its farming systems such as input use, extension services, or irrigation practices that could be adapted in lower-yielding states like Benue. The significant gap between Benue and the other States highlights the need for targeted interventions, including soil fertility management programs, improved seed distribution, and climate-

smart farming strategies tailored to the region's challenges. Furthermore, since rainfall and temperature differ across the three States, these climatic variations may account for part of the observed yield differences, corroborating existing literature that emphasizes the sensitivity of maize production to climate variability in sub-Saharan Africa (Lobell *et al*., 2011; Nhemachena & Hassan, 2007).

The Levene's test for homogeneity of variances ($p = 0.20$) confirmed that the assumption of equal variances was not violated, meaning the ANOVA results are statistically valid. This strengthens the reliability of the conclusion that real differences exist in maize yields across the states, rather than the results being influenced by unequal variance distributions.

### 4.2. Relationship between Temperature, Rainfall and Maize Yields

Table 2 described the relationship between maize yield and the climatic variables of temperature and rainfall. Table 2 indicates that temperature has a correlation coefficient of 1.00 with a significance value of 0.55, indicating a strong and positive association with maize yield. This implies that increases in temperature within the observed range are associated with higher maize yields. The finding depicts the role of temperature as a key driver of maize production in North Central Nigeria. This outcome is consistent with the findings of Lobell *et al.* (2011) that maize yields can respond positively to moderate temperature increases, particularly when such increases enhance physiological processes such as germination, nutrient uptake, and grain filling.

Rainfall, on the other hand, presented a correlation coefficient of 0.015 with a significance value of 0.125. This result reveals a positive but very weak relationship

with maize yield, although the relationship was statistically significant. Wrong interpretation of result. The weak correlation suggests that rainfall, while critical for maize production in rain-fed systems, explains little of the variation in yield across the study area Wrong interpretation of result. This may be due to the uneven distribution of rainfall across the growing season, which is often more important for crop development than the total amount received. Previous studies have emphasized that rainfall variability, particularly in timing and intensity, exerts a greater influence on maize yields than annual rainfall totals (Nhemachena & Hassan, 2007). Thus, while rainfall is indispensable for crop production, its effect on maize yield in this study appears to be less stable compared to temperature.

Table 2 Relationship between Temperature Rainfall Variability and Maize Yield

**Correlations**

| | | Maize | temperature | Rainfall |
|---|---|---|---|---|
| Pearson Correlation | Maize | 1.000 | .549 | .130 |
| | temperature | .549 | 1.000 | .242 |
| | rainfall | .130 | .242 | 1.000 |
| Sig. (1-tailed) | Maize | . | .000 | .125 |
| | temperature | .000 | . | .015 |
| | rainfall | .125 | .015 | . |
| N | Maize | 81 | 81 | 81 |
| | temperature | 81 | 81 | 81 |
| | rainfall | 81 | 81 | 81 |

Table 2 provides insights into the combined influence of temperature and rainfall on maize yield. The R-value of 0.549 indicates a moderate correlation between the independent variables (temperature and rainfall) and the dependent variable (maize yield). This suggests that climatic factors jointly play a meaningful role in determining maize yield outcomes in the study area.

Table 2 shows that an $R^2$ value of 0.301, meaning that temperature and rainfall together

explained 30.1% of the total variation in maize yield across the selected States. The remaining 69.9% of the variation can be attributed to other factors not included in the model, such as soil fertility, pest and disease prevalence, input use, and access to improved agricultural technologies. This finding reinforces the multidimensional nature of maize production, where both climatic and non-climatic factors interact to influence yields. Similar evidence has been reported by Ntat and Ojoy (2018) that temperature and rainfall positively influenced maize yields across Nigeria, their effects varied in intensity from one place to another, depending on local climatic conditions and farming practices.

The implication is that climatic variables, particularly temperature, influence maize yield outcomes in North Central Nigeria. The stronger correlation with temperature suggests that maize production in the study area is highly sensitive to heat variations, while rainfall, though essential, exerts a less consistent effect. These findings imply that adaptation strategies could not only address rainfall variability through improved water management but also prioritize temperature-related conditions. Such strategies may include the planting of heat-tolerant maize varieties, agroforestry practices to moderate temperature, and climate-smart farming practices designed to enhance resilience to climatic fluctuations.

### 4.2 Effect of Temperature and Rainfall on Maize Yields

The regression analysis in Table 4 showed that the calculated p-value (0.97) was greater than the threshold value of 0.05. This outcome implies that the null hypothesiswhich stated that temperature and rainfall have no significant effect on maize yieldwas rejected, and the alternative hypothesis was accepted. In other words, both climatic variables were found to exert a meaning effect on maize yield in the study area.

The p-value was relatively high, the acceptance of the alternative hypothesis points to the reality that temperature and rainfall fluctuations, either individually or in combination, play a critical role in influencing maize production . Temperature affects physiological processes such as germination, photosynthesis, and grain filling. When temperatures exceed optimal thresholds, maize plants experience heat stress, leading to shortened growing periods and reduced yields (Lobell *et al.*, 2011). Conversely, moderate increase in temperature, especially during early growth, may accelerate development and enhance yield if moisture is not limiting.

Rainfall, on the other hand, determines soil moisture availability, which is crucial for nutrient uptake and crop development. Inconsistent rainfall patternssuch as late onset, early cessation, or intra-seasonal dry spellshave been identified as major constraints to maize production in sub-Saharan Africa (Nhemachena & Hassan, 2007). The weak but significant relationship observed between rainfall and maize yield in this study suggests that rainfall contributes to yield outcomes, its effect may affect other factors such as soil quality, irrigation use, and the adoption of drought-tolerant maize varieties.

**Table 3: Effect of Temperature and Rainfall on Maize Yields**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | T | Sig. | 95.0% Confidence Interval for B | | Correlations | | | Collinearity Statistics | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | | Lower Bound | Upper Bound | Zero-order | Partial | Part | Tolerance | VIF |
| 1 | (Constant) | -492.327 | 164.183 | | -2.999 | .004 | -819.190 | -165.464 | | | | | |
| | Temperature | 28.480 | 5.051 | .550 | 5.638 | .000 | 18.423 | 38.536 | .549 | .538 | .534 | .942 | 1.062 |
| | Rainfall | -.021 | .599 | -.003 | -.035 | .972 | -1.213 | 1.171 | .130 | -.004 | -.003 | .942 | 1.062 |

## 5.0 Conclusion and Recommendations

### 5.1 Conclusion

This study assessed effects of rainfall and temperature variability on maize yields across selected States (Niger, Plateau, and Benue) in North Central Nigeria from 1994 to 2020. The study highlighted notable spatial and temporal variations in maize yields. Niger consistently recorded higher yields compared to Plateau and Benue States, indicating significant State-level disparities.

The findings of this study demonstrate that climatic variability, particularly changes in temperature and rainfall, significantly influences maize yields in North Central Nigeria. Temperature was found to be a stronger determinant of yield compared to rainfall. However, the moderate coefficient of determination ($R^2 = 0.301$) indicates that while climate is an important factor, maize production The variability in yields across states underscores the need for localized interventions that consider state-specific climatic realities and farming systems.

### 5.2 Recommendations

Based on the findings, the following recommendations wre made:

i. Adoption of climate-smart agricultural practices: Farmers should be encouraged to adopt practices such as drought-tolerant maize varieties, mulching, conservation tillage, and efficient water management to minimize the risks posed by rainfall variability.
ii. Improved access to inputs and technology: Governments and which? stakeholders should ensure timely and affordable access to fertilizers, improved seeds, and mechanization, particularly in states with relatively low yields such as Benue. and

iii. Strengthening agricultural extension services: Extension systems should be enhanced to provide farmers with timely climate information and technical guidance on adaptive practices to optimize maize production under variable climatic conditions.

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