Impact of Climate Change on Maize Production in Wushishi Local Government of Niger State, Nigeria

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ABSTRACT

This study was carried out to investigate the impact of climate change on maize production in Wushishi local government area of Niger State .Climate data (rainfall, maximum and minimum temperature and humidity) for period of 10years 92005-2014) was acquired from the Nigeria Meteorological Agency Minna (NiMeT) while maize data was acquired from Niger State Agricultural Development Authority in order to understand crop and climate relationship to validate the impact of climate change on maize production. The climate data was analyzed using regression analysis and with the aid of charts. Result showed a generally rising trend in temperature across the study area. It shows that rainfall is not only more variable. But its onset and cessation patterns have shifted and its occurrence very inconsistent. A significant relationship between weather conditions and maize yield. The R Square value of 0.624 suggests that approximately 62.4% of the variance in maize production can be explained by the weather parameter there is the need to provide the farmers with local climate Information and the development of high maize varieties better suited to changing climate conditions in the study area.

Keywords: Climate change, Rainfall, Maize, yield, Wushishi Local Government.

Background to the Study

Climate change is one of the most complex and severe risks affecting agriculture, with an impact on crop yields, food security, and rural livelihoods. According to (FAO, 2022) 73% of the African population living in rural areas depend on agriculture for their livelihoods. Climate change is a major constraint to agricultural production, with a significant impact on food security and livelihoods(Ogunpaimo *et al.*, 2021)This made farmers in Africa vulnerable to droughts. Understanding the patterns of drought is essential because it informs decision-making processes for possible adaptive measures (Libanda *et al*., 2019).Climate change has been drastic over the past few years (Srivastava *etal.,*2018). Currently, it is not only a cause for concern for humanity, but it is also a threat to life on earth due to the increasing frequency of droughts, increased temperatures and global warming

This trend has negative impacts, as rural farmers in Nigeria largely depend on rain-fed agriculture (Ebenehis *et al.*,2020). The effects of drought variability on crop yield in the Guinea Savanna region of Nigeria with Niger State in particular, like rainfall have a significant impact on the yields of major crops such as maize, soybean, and groundnut (Sule *et al.*, 2020). Niger state has witnessed a decrease in rainfall, a shortened growing season due to late onset of rainfall and quick rainy season cessation, as well as its variability (Ibrahim *et al.*, 2020).These vulnerability factors make the study urgent in response to the challenge of climate change in a comprehensive and systematic manner that would addresses broader development priorities.

Climate change has global impact on crops yields in rural areas leading to underdevelopment of rural agriculture (Bako *et al*., 2020). Climate change in Niger State, particularly in the rural areas has resulted in crop failures, food shortages, hunger and poverty (Eze *et al.*, 2020). However, there is a scarcity of empirical information that specifically analysed the impact of drought on farmers' livelihoods and delineate sensitivity spots in Niger state.

Existing studies (Eze *et al.*, 2020.; Ibrahim *et al.*, 2020) focused on the significant impact of drought on crop yields and farmer perception, but they do not comprehensively address the combined impact of this climate change on crop yields, farmer livelihoods and delineate the drought sensitive spots in Niger State. In Niger State, there are variations in rainfall, relative humidity and temperature pattern within the year. The area experiences two distinct seasons namely the wet and the dry season. It is pertinent to know the variations in rainfall, relative humidity and temperature in the study area have a resultant effect on the production of maize since it will affect the time of planting of maize.

There is generally too little information on climatic factors influencing maize production in the tropics especially Nigeria. A study of this nature is therefore necessary to close up the gap existing in the knowledge of the change on maize production in the country with particular reference to Niger State. This knowledge gap determines decision making and leaves farmers vulnerable to drought impacts resulting from unpredictable rainfall and fluctuating crop yields, which threaten livelihoods and economic stability. This study aims to address this knowledge gap by analyzing the impact of climate change on crop yields, farmers' livelihood and delineation of drought sensitivity spots in Niger State.

In Niger State and the savanna region of Nigeria, climatic variables such as rainfall, temperature and relative humidity are the primary control of crop yield. Therefore, the analysis of climate change of the study area will constitute a useful tool in planning, not only for maize cultivation but will also produce data in relation to other crops. Lack these information in turn have contributed to Africa's weak adaptive capacity, increasing the continent's vulnerability to projected climate change. His study revealed the impact of rainfall, temperature and relative humidity variability on maize yield in Wushishi Local Government.

Materials and methods

Data used and study area location

Wusishi Local Government Area covers approximately 1,779 km2 of Land mass, lies between latitude 9^0 54`N and $9^0$ 27’N, and longitude $6^0$ 38`E and 6^0 51’E . It is situated 50 km from Minna, thee Niger State Capital. The Local Government Area is bounded by Rafi Local Government Area to the North, Mashegu Local Government Area North-West, LavunLocal Government Area to West, Gbako Local Government Area to South and Bosso Local Government Areato the West.

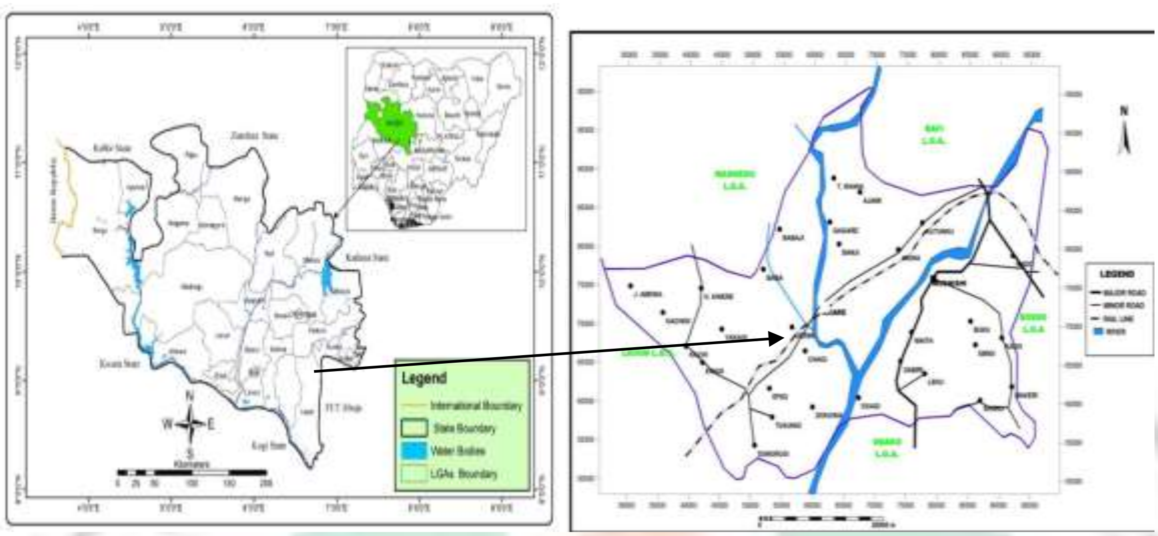

Figure 1: Niger State showing the study Local Government area

Rainfall, temperature and relative humidity of the study area spanning over the period of 10 tears were acquired from Nigeria Meteorological Agency. These climate data sets were used to examine climate trends in Wushisi during the study peri

Available maize yield data of Wushishi Local Government Area spanning over the period of 10 years (2005-2014) was obtained from Niger State Agricultural Development Project (NSADP) and used for analysis in the period under reviewed.

Data Analysis

The descriptive statisticswere employed theseinclude the use of mean, standard deviation, tables and graphs to describe the climatic parameter and maize yield. Regression analysis was used in showing relationship between climatic variable and maize yield. Rainfall data were used to analyze the pattern of the rainfall distribution. Microsoft excel was used to conduct the correlation and regression between climatic variables and maize yield

Regression equation for calculating trends;

$b=\sum (x-\bar{x})2\sum(x-\bar{x})(y-\bar{y})$

Where:

y the rainfall amount for a given year.

x is the year (which could be represented as 1 for 2005, 2 for 2006, and so on up to 10 for 2014).

a is the intercept (the estimated rainfall at the starting point of the trend line).

b is the slope (the rate of change in rainfall per year).

Results and Discussion

Maize yield and climatic information of the area of study between 2005 and 2014.

A set of climatic variables (rainfall, maximum and minimum temperature, relative humidity) were collected from Nigeria Meteorological Agency. It shows the analysis of the climatic variables after using descriptive statistic to get their summation and average.

Table 1: Maize yield and Climatic Variability from 2005 to 2014

years	Rainfall (mm)	maize yield (tones)	Maximum temperature (^{0}C)	Minimum temperature (^{0}C)	Relative humidity (%)
2005	1756.4	2.68	28.7	22.4	84.5
2006	1906	2.63	33.2	23.9	78.9
2007	1796.3	1.85	33.3	23.8	76.8
2008	1790.4	1.73	33.2	23.7	76.2
2009	1765.8	1.68	33.1	23.7	94,,0
2010	1841.7	1.62	38.8	24.4	72.2
2011	2924.3	1.46	33.5	22.0	70 ,0
2012	1647.9	1.29	33.1	22.8	67.8
2013	1635.1	1.28	33.5	23.5	73.7
2014	1819.3	0.95	33.2	22.6	44.4

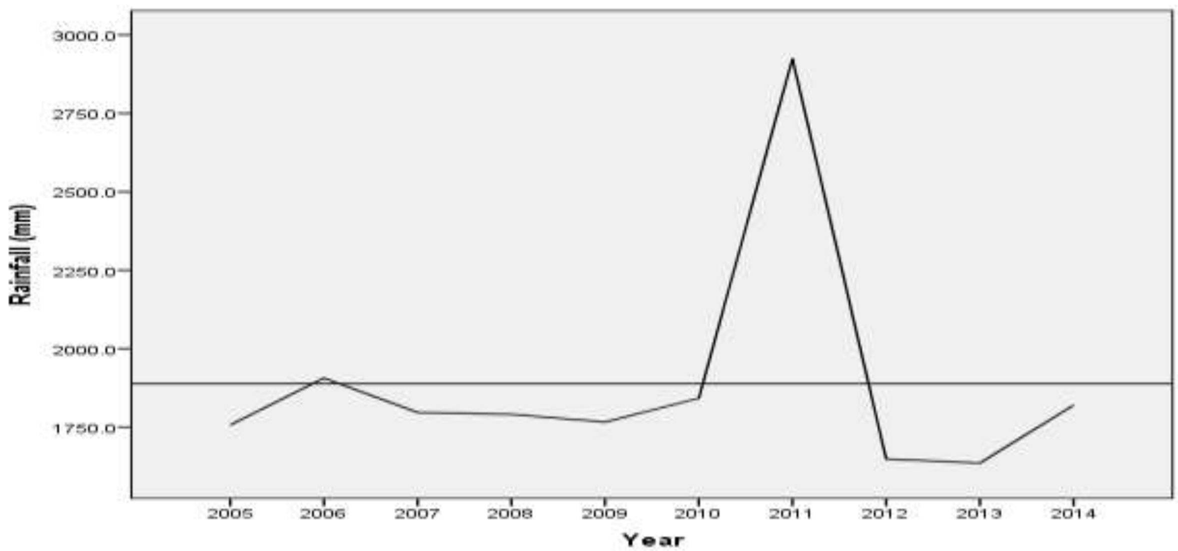

Fig.1 Rainfall trend between 2005 and 2014

Figure 1 illustrates the annual rainfall (measured in millimeters) from 2005 to 2014. The data reveals a general trend of fluctuation in rainfall amounts over the years. Between 2005 and 2010, the rainfall remained relatively stable, with minor increases and decreases, ranging from 1,635.1 to 1906mm. However, in 2011, there was a significant spike, with rainfall reaching approximately 2924.3mm, indicating an unusually wet year. Following this peak, the rainfall sharply declined in 2012, dropping to its lowest point within the period studied. After 2012, the rainfall levels started to recover slightly by 2014 but did not return to the earlier peak levels. The graph highlights a period of extreme weather variability within this decade.

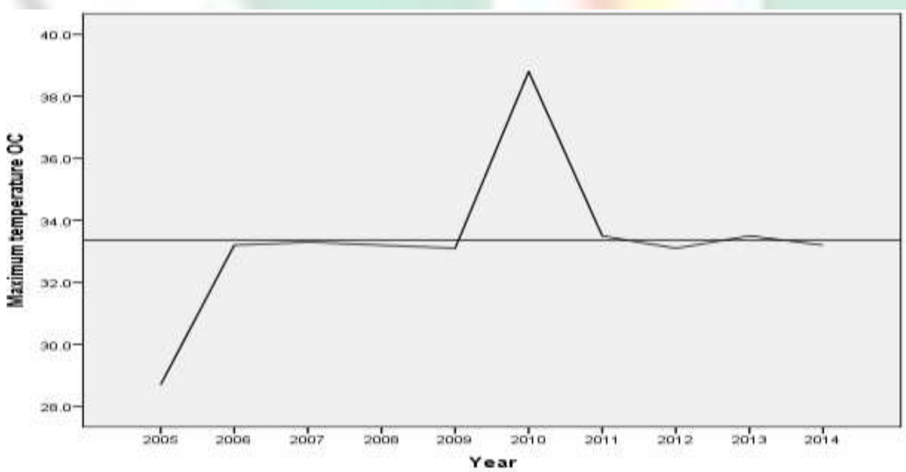

Fig. 2 Maximum Temperature Trend

Figure 2 presents the maximum temperature (in degrees Celsius) recorded annually from 2005 to 2014. The data shows a significant variation in temperature over this period. From 2005 to 2009, the maximum temperature gradually increased, stabilizing around 34°C. However, 2010 experienced an unusual spike, with the temperature reaching nearly 38.8°C, indicating an extremely hot period during that year. Following this peak, the temperature sharply declined in 2011, returning to levels slightly above the long-term average observed earlier. From 2012 to 2014, the maximum temperature fluctuated slightly but generally remained stable, just above 34°C.

This figure highlights a period of significant temperature variability, particularly in 2010, which stands out as an anomaly in the decade. The data may suggest an episode of extreme weather, possibly linked to broader climate variability or other environmental factors affecting the region during that time.

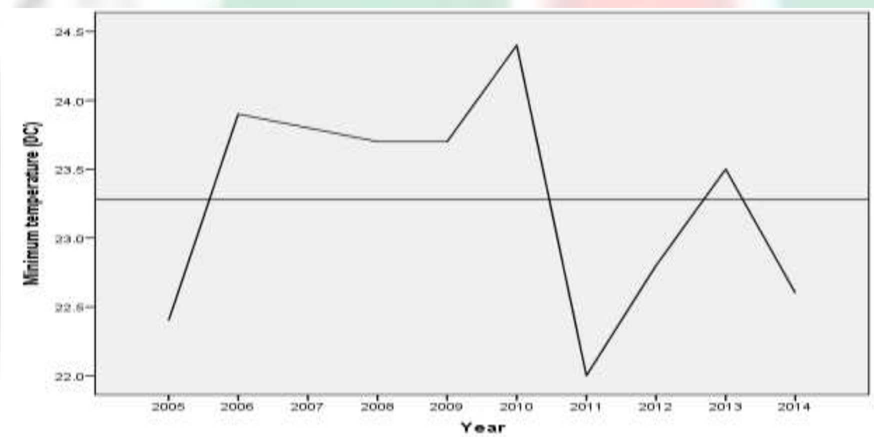

Fig. 3 Minimum Temperature Trend between 2005 and 2014

Despite the minimum temperature (in degrees Celsius) recorded annually from 2005 to 2014. The graph shows fluctuations in the minimum temperatures throughout this period. From 2005 to 2007, the minimum temperature gradually increased, reaching about 23.8°C by 2007. This upward trend stabilized slightly, but from 2008 to 2010. However, a notable decline occurred in 2011, where the minimum temperature dropped sharply to around 22°C, the lowest point within the decade.

Following this dip, there was a quick recovery in 2012, with temperatures climbing back up to previous levels. The minimum temperature peaked again in 2010, approaching 24°C, before experiencing another drop in 2014. This pattern reflects significant variability in the minimum temperatures over the years, with 2011 being an especially cold year. The data suggests possible climatic or environmental factors causing these fluctuations in minimum temperatures during the decade.

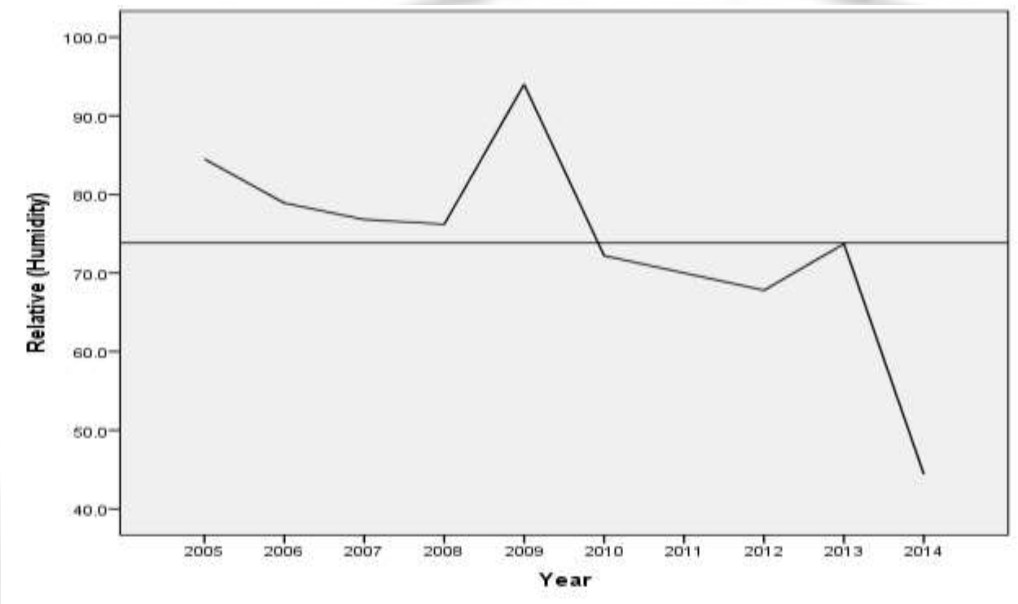

Fig.4 Relative Humidity Trend between 2005 and 2014

Despite the changes in relative humidity over a period from 2005 to 2014 relative humidity starts at approximately 84.5% in 2005, then, shows a gradual decline over the next few years, reaching around 76.8% by 2008. A sharp increase was observed in 2009, where relative humidity peaks at approximately 94%, which is the highest point in the graph. However, this was followed by a rapid decline, with humidity dropping to around 67.8% in 2012. The trend shows a slight recovery in 2013 rising to about 73.7%, but then plunges dramatically to around 44.4% in 2014, marking the lowest point in the entire period.

This fluctuation indicates a significant variation in relative humidity over the years, with periods of both gradual and sudden changes, culminating in a sharp decrease towards the end of the observed period.

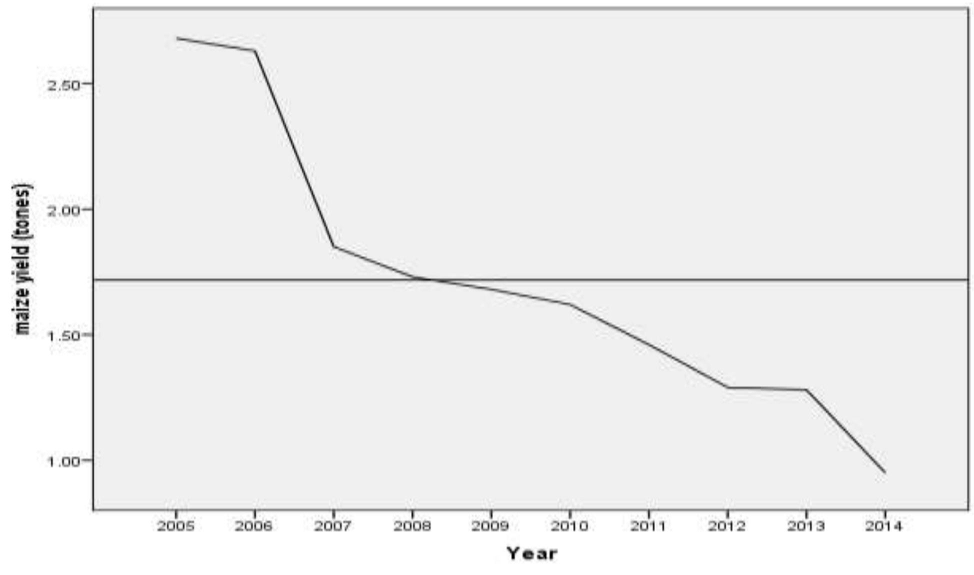

Fig.5 Trend in maize yield, measured in tones, from 2005 to 2014. Starting at approximately 2.68 tons in 2005, maize yield shows a consistent decline over the years. By 2008, the yield drops sharply to around 1.73 tones, marking a significant decrease. This downward trend continues, with the yield slightly stabilizing between 2009 and 2010 at around 1.62 tones. However, another decline occurs after 2011, with the yield dipping below 1.46 tones. By 2012, the yield further decreases, and this reduction becomes more pronounced towards 2014, where it plummets to approximately 0.9 tones, the lowest point on the graph.

The consistent decline in maize yield over the observed period suggests challenges in agricultural productivity, which could have been influenced by various factors such as climatic conditions, soil fertility, or farming practices. The steep decline toward the end of the period indicates a critical reduction in maize output.

The equation employed for descriptive statistics are as follows;

Mean (Average)

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

Where:

n is the number of data points.

X is represents each individual data point.

Standard Deviation

$$s = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2}$$

Where:

σ is the population standard deviation.

s is the sample standard deviation.

x¯ is the mean of the data points.

Xi represents each individual data point.

n is the number of data points.

Table 2: Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
Minimum temperature (0C)	10	22.0	24.4	23.280	.7757	-.375	.687
Maximum temperature OC	10	28.7	38.8	33.360	2.3936	.605	.687
Relative (Humidity)	10	44.4	94.0	73.850	12.8264	-1.071	.687
Rainfall (mm)	10	1635.1	2924.3	1888.320	373.1095	2.876	.687
Valid N (listwise)	10						

The descriptive statistics in Table 1 provides an overview of the climatic data, including minimum and maximum temperatures, relative humidity, and rainfall. The data includes 10 observations for each variable. The minimum temperature recorded ranged from 22.0°C to 24.4°C, with a mean of 23.28°C and a standard deviation of 0.7757, indicating a relatively stable temperature range. The skewness of -0.375 suggests a slight leftward skew, implying that most temperatures were above the mean.

The maximum temperature varied between 28.7°C and 38.8°C, with a mean of 33.36°C and a standard deviation of 2.3936, reflecting greater variability. The skewness of 0.605 indicates a moderate rightward skew, suggesting that higher temperatures were more frequent.

Relative humidity had a wider range, from 44.4% to 94.0%, with a mean of 73.85% and a standard deviation of 12.8264, indicating significant variability. The skewness of -1.071 shows a leftward skew, meaning lower humidity levels were more common.

Rainfall varied significantly, with a minimum of 1635.1 mm and a maximum of 2924.3 mm, averaging 1888.32 mm and a standard deviation of 373.1095. The high skewness of 2.876 indicates a strong rightward skew, suggesting that extremely high rainfall events were outliers in the dataset.

Table3: Descriptive Statistics for Maize Data

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
Maize yield (tones)	10	.95	2.68	1.7170	.55948	.814	.687
Valid N (listwise)	10						

The descriptive statistics for maize yield, based on 10 observations, show a minimum yield of 0.95 tons and a maximum of 2.68 tons, with a mean yield of 1.717 tons. The standard deviation of 0.55948 indicates moderate variability in the yield data. The skewness of 0.814 suggests a rightward skew, meaning higher yields were more frequent, though some data points were notably above the mean. Overall, the data reflects a range of maize yield outcomes with a tendency towards higher yields.

Table 4: Relationship between Weather Parameters and Maize Production

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.790[a]	.624	.323	.46035

a. Predictors: (Constant), Relative (Humidity), Rainfall (mm), Maximum temperature OC, Minimum temperature (0C)

Regression equation is mathematically given as;

$$b = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sum_{i=1}^{n}(x_i - \bar{x})^2}$$

Where;

$\bar{x}$ is the mean of the independent variable x.

$\bar{y}$ is the mean of the dependent variable y.

n is the number of data points.

xiandyi are individual data points for x and y, respectively.

The relationship between weather parameters and maize production is captured by the model's R value of 0.790, indicating a strong positive correlation between the variables. The R Square value of 0.624 suggests that approximately 62.4% of the variance in maize production can be explained by the weather parameters included in the model, namely relative humidity, rainfall, maximum temperature, and minimum temperature. However, the Adjusted R Square, which accounts for the number of predictors in the model, is slightly lower at 0.323, indicating that when adjusted for the number of variables, the model explains about 32.3% of the variance. The standard error of the estimate is 0.46035, reflecting the average distance that the observed values fall from the regression line. Overall, the model shows a significant relationship between weather conditions and maize yield, though other factors may also influence maize production.

Conclusion

With the findings, it is necessary to establish the need for a lot of planning in the face of climate events. For better maize yields in Wushishi Local Government Area, Niger State, it is important to improve on the following:

i. The policy implication of this finding is the need to provide the farmers with local climate Information and the need for vigorous pursuance of the development of high maize varieties better suited to changing climate conditions in the study are by research institutes another relevant agencies.
ii. As regard to climatic condition, it is usually profitable to introduce variety of maize with short growing season to enhance greater crop yields.
iii. Credit and incentive facilities should be provided in the region, in order to help the farmers with capitals investment will improve maize yields within the region.
iv. Proper education of the farmer on the effect of climate change on agriculture and environment through agricultural programmes.

If these recommendations are fully and properly implemented, maize production will serves as source of revenue to Wushishi local government area. Therefore, understanding impact of climate change is crucial for developing adaptive strategies to mitigate the adverse impact on maize yields.

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