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CLIMATE CHANGE EFFECT ON GRAIN CROPS YIELDS IN KWARA STATE, NIGERIA

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ABSTRACT

Crop yield data were obtained from Kwara State Agricultural Development Project (KWADP), Ilorin and National Bureau of Statistics (NBS), Lagos on the crops considered in this study, while climate data were sourced from the Nigeria Meteorological Agency (NIMET), Oshodi, Lagos and National Bureau of Statistics (NBS), Lagos for a decade (2002 – 2011). These data were analyzed using SPSS 16.0 and Microsft Excel in order to evaluate the impact of climate on the yield on selected crops in Kwara State, Nigeria. Multiple regression, trend analysis, correlation analytical and ANOVA techniques were used to analyze the data. This study was necessitated by the decline observed in the production of cash crops in the state. The result obtained showed that the impact of climate on crop yield was significant for maize and rice yield at 95% probability level. While the impact of climate on the yield of millet, sorghum and cowpea was insignificant. The climate had no significant effect on sorghum and cowpea because both have high tolerance to harsh weather conditions, while maize and rice are less tolerant. As a result, it is recommended that investment should be made to intensify the cultivation of crops on which climate had no significant impact on their yield.

Keywords: Agriculture; climate; grain-crops; yield; multiple regression.

1. INTRODUCTION

Agriculture is the practice of crop cultivation and livestock keeping within a boundaries. The choice of what to produce, where to produce and how to produce it is determined by the culture, traditions, market, water supply, climate, soil condition, plot size and distance from home (Abdul-Aziz, 2002 & Wiebe, 2003).

Climate is a long-term average weather conditions that directly or indirectly affects agricultural production. Climate determines the choice of what plant to cultivate, how to cultivate it, the yields of crops and nature of livestock to keep. Ajadi (2011) reported that solar radiation, temperature, moisture and other climatic parameters determine the global distribution of crops and livestock as well as crop yield and livestock productivity. Reuben and Barau (2012) observed that rainfall distribution and the occurrence of moisture stress during the vegetative period are critical for the yield of cassava crop.

, Odjugo (2010) opined that available pieces of evidence show that each day brings fresh proofs of climate change effects and these effects include increasing temperatures, decreasing rainfall in the continental interiors, drought, desert encroachment, melting ice, extreme weather, floods, sea level rise, sinking of Islands, water scarcity, health and agricultural problems. Excessive increases in temperature results in low agricultural productivity and this may lead to depletion of soil nutrients and destruction of soil structure and organisms which contribute to the fertility of the soil. Ordinarily, rainfall can be considered to have positive effect on agricultural productivity except where it leads to flooding, erosion and leaching.

Rainfall amount and high temperatures are the most important elements of climate change in Nigeria as a result the northeast region of Nigeria is increasingly becoming an arid environment at a very fast rate occasioned by the fast reduction in the amount of surface water, flora and fauna resources on land. Consistent reduction in rainfall leads to a reduction in the regeneration rate of land resources. The northern zone therefore faces the threat of desert encroachment. The southern area of Nigeria, which was largely known for high rainfall, is currently confronted by irregular rainfall and high temperatures (Obioha 2008;).

The impact of climate change on agricultural production in Nigeria has received limited attention despite the fact that over 60% of the active population of Nigerians are farmers. Studies on climate change globally and in Nigeria have revealed that the potential impacts of climate change will include every aspect of the four dimensions of food security; food availability (production and trade), food accessibility, food stable supplies, and food utilization (Nwafor, 2007).

Olarenwaju (2012) reported that many of the problems facing agricultural production are climate related. It is against this background that this paper is put forward to ascertain the impact of climate on grain crop yield in Kwara State. The objectives are to: Examine the relationship between selected climatic elements and the yield of the three major grain crops in the state and examine the contribution of climatic element to the trends and variability of grain crop yield over the decade under review.

2. MATERIAL AND METHODS

Study Area

The study area is Ilorin, Kwara State. Ilorin lies between latitudes 8° 05`N and 10° 05`N and longitudes 2° 50`E and 6° 05` E and located at an altitude of 340 m above mean sea level (Ejieji and Adeniran, 2009). The state has an elongated shape covering an area of about 32,500 sq. km. The state is bounded by River Niger long its northern and eastern boundaries and shares a common boundary with Niger State in the north, Kogi State in the east, Oyo, Ekiti and Osun States in the south and an international boundary with the Republic of Benin in the west. The soils of Ilorin are loamy and clay (KWADP, 2012).

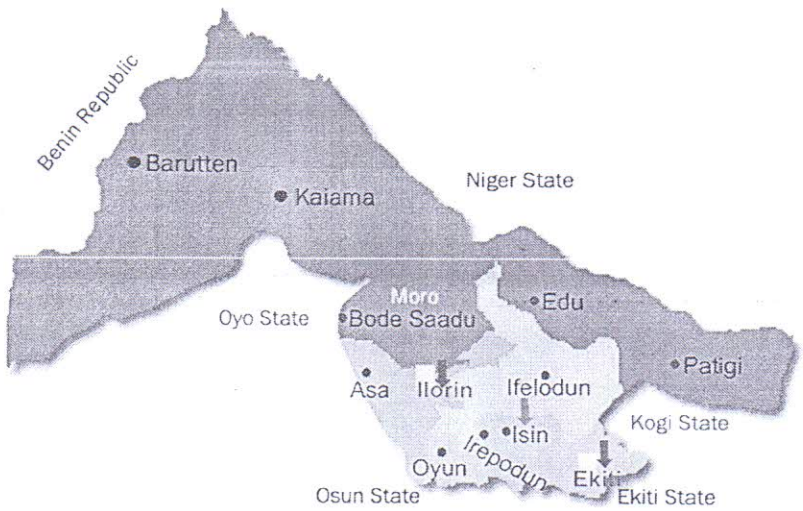


Fig.1. Map ofKwara State

Kwara State is located in the North central area of Nigeria and lies in the region termed the Middle Belt of Nigeria. It is located in the forested savannah and enjoys moderate dry and wet seasons. The derived guinea savannah grasslands dominate the Northern parts of the state while the Southern part falls within the rain forest.

The climate of Ilorin is tropical with annual rainfall of about 1500 mm, average maximum temperature of 38 °C, average relative humidity of 77.50 % and 7.1 hours of sunshine daily (Olanrewaju, 2009). The rainy season begins at about the end of March and lasts until early September, while the dry season begins in early October and ends in early March. This attribute predisposes the people to make farming their major occupation. Food crops produced in the state include white yam, cassava, water yam, sweet potato, groundnut, sorghum, millet, maize and cowpea (Ajadi, *at. al.*, 2011).

There are three methods of establishing agriculture - climate relationships and these methods include: plant growth and development - climate relationship, agricultural products yield data - climate parameters relationship and plant - climate relationship under controlled environment (Olarenwaju 2012). However, the method of studying the relationship of agricultural product yields data and climatic parameters was employed in this research.

Ten years climatic data (rainfall, maximum temperature, minimum temperature, evaporation, relative humidity, sunshine hours, soil temperature) were obtained from the Nigeria Meteorological Agency, Oshodi, Lagos and National Bureau of Statistics (NBS), Lagos. While, crop yield data were obtained from National Bureau of Statistics (NBS), Lagos and Kwara State Agricultural Development Project (KWADP), Ilorin on maize (*Zea mays*), sorghum (*Sorghum bicolor*), rice (*Oryza sativa*), millet (*Pennisetum americanum*) and cowpea (*Vigna unguiculata*). The choice of the aforementioned climatic parameters was based on their vital role to the selected crop yield and the evaluation of a decade data is based on statistical theories.

Data obtained were analysed using Statistical Package for Social Sciences (SPSS). Mean separation was done using Duncan's new multiple range tests. Both descriptive and inferential statistical techniques were employed in data analysis. While simple correlation, stepwise multiple regressions and analysis of variance (ANOVA) were used in showing the relationship between climatic parameters and crop yield and showing the trend and variation in crop yield. These statistical techniques were employed in the analysis of both crop yield data and climatic parameters because of their peculiarity in revealing the relationship and variation among variables.

3. RESULTS AND DISCUSSION

Pattern of Agro-climatic Variables in Ilorin City (2002– 2011) is as shown in Table 1. From Table 1, it can be clearly seen that the maximum temperature and rainfall ranged between 31 °C and 38 °C, and 800 mm and 1500 mm respectively. The high maximum temperature resulted in high soil temperature, which does to a large extent inhibits crop cultivation. Tables 2 and 3 respectively show the yield and descriptive analysis of the yield data of the crops under consideration between 2002 – 2011. Out of the five selected crops, Cowpea has the least mean value (2.5). This is followed by Millet (17.98) while Rice has the highest mean value (216.45). This shows that within the years under study, Rice had the highest yield parameters

Table 1: Meteorological Data (2002 – 2011)

Year Rainfall (Mean)	Rainfall (mm)	Sunshine Hour (Hr)	Evaporation	Maximum Temperature (^{O}C)	Minimum Temperature (^{O}C)	Relative Humidity (%)	Soil Temperature (^{O}C)
2002	1028.5	5.6	3.6	36.44	20.30	77.00	29.6
2003	811.75	5.7	5.9	31.17	17.50	83.00	29.3
2004	1597.4	6.4	5.4	33.33	20.15	82.00	29.2
2005	1144.5	6.3	5.7	35.90	23.90	82.50	29.9
2006	1236.99	6.2	5.7	36.47	22.79	81.40	28.8
2007	1481.63	6.7	6.0	37.08	22.50	78.60	29.9
2008	1381.9	6.0	6.2	36.00	22.00	84.00	29.1
2009	1526.57	6.3	6.2	38.00	23.40	87.10	29.7
2010	1165.7	5.5	6.7	36.00	23.30	87.40	29.0
2011	1253.4	6.8	7.1	36.10	22.91	84.42	29.4

(Source: NBS, 2012).

Table 2: Grain Crops Yield (Tons), Area Cultivated (Ha) and Yield (Tons/Ha)

S/NO	CROPS	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1.	**Maize**										
	Ton	70.91	100.40	86.74	113.40	150.38	149.89	164.53	189.78	196.56	210.70
	ha	57.66	57.66	64.05	82.9	110.42	109.20	114.66	126.22	133.27	141.16
	yield (tons/ha)	1.30	1.47	1.25	1.35	1.58	1.37	1.43	1.50	1.47	1.49
2.	**Sorghuim**										
	Ton	73.27	42.65	47.47	60.30	75.33	102.97	112.70	131.05	137.96	146.00
	ha	40.32	33.47	30.67	47.6	57.12	67.30	80.50	84.93	87.32	96.26
	yield (tons/ha)	1.70	1.27	1.42	1.27	1.32	1.53	1.4	1.54	1.58	1.52
3.	**Rice**										
	Ron	22.72	18.71	47.47	71.90	118.31	234.21	345.69	440.43	480.80	384.44
	ha	8.19	8.20	20.85	31.3	50.01	97.18	135.04	142.81	147.13	128.75
	yield (tons/ha)	2.77	2.28	2.30	2.36	2.37	2.41	2.56	3.08	3.27	2.986
4.	**Millet**										
	Ton	12.20	13.00	8.74	11.30	14.66	25.39	28.44	19.54	20.50	26.01
	ha	11.87	12.00	5.02	6.5	8.06	13.43	15.05	16.64	17.09	19.26
	yield (tons/ha)	1.03	1.04	2.30	.75	1.82	1.89	1.89	1.17	1.20	1.35
5.	**Cowpea**										
	Ton	4.95	5.56	0.67	0.721	0.70	0.968	1.08	3.12	3.27	3.58
	ha	7.04	7.74	1.47	1.5	1.39	4.34	5.12	5.42	5.54	5.91
	yield (tons/ha)	0.69	0.72	0.46	0.47	0.50	0.22	0.21	0.57	0.59	0.60

Source: KWADP, 2012

Table 3: Descriptive Statistics of Grain Yield Data (2002– 2011)

Crop	Mean	Std. Deviation	Median	Variance
Maize	143.33	48.60	150.135	2.362E3
Sorghum	92.97	38.22	89.15	1.461E3
Rice	216.47	182.88	176.26	3.344E4
33Millet	17.98	6.97	17.1	48.535
Cowpea	2.46	1.874	2.1	3.512

Multiple Regression Analysisand Analysis of Variance

The result obtained from the multiple regression analysis and the analysis of variance is shown in Table 4. The result shows that 97.9%, 96%, 95.2%, and 80% of total variability in yield of maize, sorghum, rice and millet respectively can be explained to be as a result of the effect of the climatic parameters.

The analysis of variance tests were significant at 5% level. This is because the F statistics values obtained for all the crops from the analysis of variance (ANOVA) are all greater than the F critical. Therefore, the null hypothesis of no functional relationship between grain crops yield and climate is rejected. This implies that there exist a functional relationship between crop yield and the climate in the years under consideration. Olanrewaju (2012) reported same to be true for yam.

Table 4: Regression Analysis

Crops	R	R2	Adjusted R
Maize	0.998	0.995	0.979
Sorghum	0.996	0.991	0.960
Rice	0.995	0.989	0.952
Millet	0.978	0.956	0.800
Cowpea	0.851	0.725	-0.237

Table 5: Summary of ANOVA

Crops	F	F_{crit}
Maize	0.23	2.02
Sorghum	0.26	2.02
Rice	0.61	2.02
Millet	0.13	2.02
Cowpea	0.09	2.02

From Table 6, the model of the multiple regression analysis predicts that an increase in rainfall, evaporation and soil temperature will cause a decrease in yield of all the grain crops. However, an increase in maximum temperature, minimum temperature, relative humidity and sunshine hours will result in an increase in yield of all crops except for maize, where an increase in maximum temperature will cause a decrease in yield.

Table 6: Prediction Model

	Maize	Sorghum	Rice	Millet	Cowpea
Parameters	B	B	B	B	B
(Constant)	-2515.47	-2771.38	-9678.39	-342.48	-28.90
Rainfall	-0.369	-.663	-0.798	-.191	-0.04
Maximum Temperature	26.967	23.447	51.12	3.479	0.99
Mininimum Temperature	-4.310	4.413	22.94	.572	0.58
Evaporation	61.277	49.704	197.34	12.726	0.98
Relative Humidity	-8.710	-12.796	-27.65	-4.554	-0.66
Sunshine Hours	-47.897	-48.828	-204.33	-7.619	-2.51
Soil Temp.	78.419	93.968	319.32	15.867	1.214

Correlation Analysis

The Pearson's correlation coefficient (r) between the climatic parameters and the selected grain crop yields were computed and result is as presented in Table 7. This result shows that the correlation values of rainfall, maximum temperature and evaporation against maize, sorghum and rice yields are greater than 0.5 and this shows a positive correlation relationship exist these particular grain and the climate parameters. That is an increase in these climate parameters will result in an increase in yield. However, a weak correlation relationship exist between maize, sorghum and rice yields and minimum temperature, relative humidity, sunshine hours and soil temperature except for rice which has a value greater than 0.5 for soil temperature. For millet and cowpea, a strong relation exits for rainfall and minimum temperature respectively. While a weak and negative relationship exists for the other climatic parameter under consideration.

Table 7: Correlation (r) Analysis

Crop	Rainfall	Maximum Temperature	Minimum Temperature	Evaporation	Relative Humidity	Sunshine Hours	Soil Temperature
Maize	0.544	0.546	0.268	0.841**	0.386	0.295	0.372
Sorghuim	0.539	0.613	0.443	0.610	0.266	0.195	0.509
Rice	0.668*	0.612	0.491	0.715*	0.290	0.120	0.399
Millet	0.545	0.324	0.199	0.613	-0.133	0.296	0.278
Cowpea	-0.120	0.360	0.564	-0.159	-0.064	-0.516	-0.375

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

4. CONCLUSION

From the result of the analysis, it was concluded that the null hypothesis held for millet, sorghum and cowpea, while the opposite held for rice and maize. In other words, the analytical results showed that the variations in climatic parameters within the decade under consideration had little and no impact on millet, sorghum and cowpea, but had significant impact on rice and maize..

Recommendations

Based on the above findings, it is recommended that: the current climate change effect can be minimized if policies towards climate change mitigation are put in place; agricultural productivity can also be increased and sustained by developing agricultural technologies that are environmentally sensitive, and agricultural innovations that aid soil nutrient conservation and do not contribute to change in climate.

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