Effect of Climate Change on Selected Tuber Crops (Sweet Potato and Yam) in Nigeria

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Abstract: **- Climate change is emerging as the most important environmental problem facing the country due to increases in atmospheric stocks of greenhouse gases (GHG), including carbon dioxide (CO_2) methane (CH_4) and nitrous oxide (N_2O), which occur by human activities have been linked to global climate change.The study hence, examined the effect of climate changes on the selected tuber crops in Nigeria. The study was to investigate the effect of climate change on tuber crop yield in Nigeria, define clearly the ranges of possible climatic effect, identify critical threshold and economic implication and explore adaptation.**

The data used were sourced for from various issues of Central Bank of Nigeria (CBN), Statistical Bulletin and FAOSTAT Database of Food and Agricultural Organization (FAO) of the United Nation Agrostat Database. The data covered a range of 1961 – 2015 (55years). The data collected for this study was analyzed using, simple descriptive statistics, inferential statistics which involves the use of multiple regression. The average percentage land area yam yield is 63.91% while that of sweet potato cultivation is 11.82%.

The regression analysis estimated the impact of climate change on tuber crops yield.

Keywords: **Climate change, sweet potatoes, yam, Nigeria.**

I. INTRODUCTION

Climate change is emerging as the most important environmental problem facing modern society. Increases in atmospheric stocks of greenhouse gases (GHG), including carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), due to human activities have been linked to global climate change (Intergovernmental Panel on Climate Change (IPCC), 1990, 2007). The Fourth Assessment Report of the IPCC (2007) emphasizes that there will be changes in the frequency and intensity of some weather events and extreme climate events which will likely challenge human and natural systems much more than gradual change in mean conditions. According to this report it is virtually certain (more than 99% probability of occurrence) that most land areas will have warmer and fewer cold days and nights. It is also very likely that most areas (between 90 to 99% probability of occurrence) will have warmer temperature, more frequent heat waves and heavy precipitation events. More drought, tropical cyclone, and incidence of extreme high sea level are also likely.

Agricultural may be particularly vulnerable to climate change due to its dependence on natural weather patterns and climate cycles for its productivity. There is a growing literature focused on predicting and quantifying the impact of climate change on agricultural systems in many areas around the world. A few degrees of warming will generally increase temperate crop yields while in the tropics, yields of crops near to their maximum temperature tolerance and dry land crops will decrease. A large decrease in rainfall would have even greater adverse effect on yields. In addition, degradation of soil and a decrease in water resources resulting from climate change are likely to have negative impact on global agriculture (IPCC, 2007). However, climate changes will not only have an effect on the productivity of agricultural products but will also have economic consequences on farm profitability, agricultural supply and demand, trade price, and so on (Kalser and Drennen, 2993). Since there is great uncertainty in the understanding of the timing, magnitude and rate of climate change (CBO, 2003).

Sweet potato (*Ipomoea batatas L*) is among the world's most important, versatile, and under exploited food crops, with more than 133 million tone (FAOSTAT, 1997), in annual production. Sweet potato currently ranks as the most important food crop on a fresh-weight basis in developing countries after rice, wheat, maize and cassava. Among the root and tuber crops, it is the only one that has a positive per capita annual rate of increase in production in sub-Saharan Africa (Bashaasha and Mwanga, 1992). According to Agric News series (1981), yield in farmers' farm varies from 6 – 8 tonnes /ha while under improved management practices yield ranges from 30 – 37 tonnes/ha. National Root Crops Research Institute (NRCRI), (Umudike, 1981) estimated that 250,000ha of land are under *Ipomoea batatas* production in Nigeria. Food and Agriculture Organization (FAO) estimates of average sweet potato yield of 5 to 8t/ha similar with estimate from surveys conducted by state Agricultural Development Project (ADPs) in Nigeria, which reported yields of popular local varieties from 7t/ha in the south eastern zones, 3.5t/ha in the northern zone, and 7 to 8t/ha in Plateau and Bauchi states (Tewe, *et al.*, 2003).

Yam is an important food crop for people in the tropical and subtropical countries although it is not an export crop in Nigeria, it severs as a raw material for some production industries as a source of pharmaceutical compound, dysgenic the primary precursor of corticosteroids and anabolic drug and a better source of protein, fat and vitamins than cassava although it has income potential and tuber is on high demand, the production is declining. (Fasari, 2006).

Yam production in Nigeria, Nigeria is the world' largest producer consumer of food yams global production of food yams is now estimated at 32.9 million metric tonesper annum with about 96% of this coming from the west African zone and Nigeria alone accounts for about 70% of the total world. (Orkwor, 1997). The root and tuber crops cassava, yam sweet potato and cocoyam are important source of energy in our daily diets and constitute a major part of the rural Nigerian staple diet.

Some change in agricultural practices might also be taking place across the agro-ecologies of the zone, in order to ensure food security in Southwestern Nigeria, a region that feeds about 45 percent of the nation's population (Awotoye& Mathew, 2010). Climate change is another challenge to the initial inability of food production to meet up with the demand which is already identified in Nigeria. Impacts of climate change on the socio-economic sector are projected to include; decline in yield and production, reduced marginal GDP from agriculture, fluctuation in world market price, change in geographical distribution to trade regimes, increased number of people at risk of hunger and food security and migration and civil unrest (Khanal, 2009). Increase in temperature, at the same time, might affect both the physical and chemical properties in the soil. Increased temperature may accelerate the rate of releasing CO_2 resulting in less than optimal conditions for plant growth. When temperatures exceed the optimal level of biological processes, crop often respond negatively with a step drop in net growth and yield. Heat stress 5 might affect the whole physiological development, maturation and finally yield of cultivated crops (Khanal, 2009; Rosegrant*et al*., 2008). Steps must be taken to reduce the negative effects of climate change on Nigeria agriculture, especially food crop production in Southwestern Nigeria.

The inter-annual variability of rainfall, particularly in the northern parts is large, often results in climate hazards, especially floods and droughts with their devastating effects on food production and associated calamities and human sufferings. More often than not certain parts of Nigeria receive less than 75 percent of their annual rainfall and this is particularly worrisome in the north. By virtue of Nigeria's location primarily within the lowland humid tropics, the country is generally characterized by a high temperature regime almost through the year. In the far south, mean maximum temperature is between 30^{o}C and 32^{o}C while in the north it is between 36^{o}C and 38^{o}C. However, the mean minimum temperature is between 20^{o}C and 22^{o}C in the south and under 13^{o}C in the north which has a much higher annual range. The mean temperature for the country is between 27^{o}C and 29^{o}C (Ajetomobi, 2001).

II. METHODOLOGY

Nigeria is located on the 5" degrees north of the equator and it is within the region of West Africa. The data was sourced from various issues of Central Bank of Nigeria (CBN) statistical bulletin and FAOSTAT database of the Food and Agricultural Organization (FAO) of the United Nation Agrostat Database. The data covered a range of 1961 – 2015 (55years).The data collected for this study was analyzed using simple descriptive statistics, inferential statistics which involves the use of multiple regression analysis.The linear regression model that relatesyield per hectare to meteorological data (Torvanger, 1994). The study assumed a quadratic relationship between yield per hectare, Y and temperature, T, precipitation, P, and a time trend, Annual mean temperature was measured in degree centigrade while precipitation was measured in millimeters. The equation is:

$$Y_{it} = a_i + b_j T_{ji} + C_j + d_j T_2 j_1 + e_j p_j t^2 + \theta t + w_j$$

Where *j* is the state index, *t* is the time index, denoting annual observations from 1961 to 2006. w_{jt} is the error term. The estimated parameters are *a*, *b*, *c*, *d*, *e*and *f*. A time trend has been include in the model. This served as a proxy, for the non-inclusion of some on climate variables which are important in agricultural productivity. Such factors include technological change and innovation (improvement in agricultural inputs /and or practices and/or changes in production patterns), increased productivity due to other climate variable and a fertilizer effect from increased CO_2 concentration in the atmosphere. Although sunlight is another important weather variable necessary for crop growth it was not possible to include it in the analysis because the meteorological stations did not have the data or its proxy for the period of the study (Ajetomobi, 2010).

III. RESULT AND DISCUSSIONS

The basic summary for descriptive statistic of the data set for the relevant variables used in the estimation of the statistical model of this study are presented over the entire analysis period (1995 – 2006) in the table 1 below:

Table 1:Estimate of climatic variables

Description	Mean	Standard deviation	Minimum	Maximum	Total
Yam	1636873	915997.9	471000	3123000	19642476
Sweet potato area	302824.8	413308	11000	1131000	3633898
Yam yield	95744.25	20677.63	56284	122718	1148931
Sweet potato yield	59079.05	23594.71	21503	94167	708948.6
Minimum rainfall	679.7087	58.39243	511.5619	778.673	8156.504
Maximum rainfall	465323.9	77890.21	261695.6	606331.6	5583887
Minimum temperature	25.02079	2.66989	19.26366	27.29319	300.2495
Maximum temperature	632.9808	127.0768	371.0884	744.9182	7595.77
Trend	19.5	11.11306	1	38	234
					30734427

Source: Computed result 2017.

The table 1 shows that the minimum aloud misaimed area for yam cultivation varied from 471000 hectares to 3123000 hectares. It was shows that the average percentage land area yam yield is 63.91 percent while that of sweet potato land area cultivation is 11.82% the minimum and maximum annual sweet potato land area varied from 1131000 hectares to 3633898 hectares respectively. It also presented the percentage average yield per hectare of yam yield. It was recorded that the average percentage of yam yield is 3.74 percent, the case of sweet potato production, the annual average yield per hectare is 2.31%. It was recorded that the minimum and maximum yield per hectare was 94164 and 708948.6 respectively.

In the case of average annual precipitation, the table shows that the minimum precipitation for the whole state way 511.5619mm while maximum annual precipitation was recorded to be 606331.6mm respectively. This shows that the average percentage volume of annual precipitation for the total period covered was 18.17 percent.

Temperature has a minimum value of 19.26 (in degree centigrade) and the maximum mean value was recorded to be 744.91 degree centigrade:

Table 2: Report of yam yield and sweet potato yield to climate change

Crop	Constant	Rainfall	Temperature	Square of Rainfall	Square of Temperature	Trend	R^2
Yam	– 295302	495.27*	20705 – 16	– 0.32**	– 528.37	1429.78*	0.22
	(– 0.64)	(0.59)	(0.63)	(– 0.54)	(– 0.77)	(3.02)	
Sweet potato	103477.6	– 463.30	11412.38	0.40	– 225.85	2200.76**	0.95
	(0.81)	(– 2.01)	(1.27)	(2.14)	(– 1.19)	(– 16.90)	

Source: Computed result 2017

The Regression Results

The regression analysis that was employed to estimate the impact of climate change on cereal crop yield for this study was a linear-quadrate model for ease of interpretation.

$$T = \beta_0 + \beta_1 + T_{1i} + \beta_2 + T_{2i} + \beta_3 + T_{3i}^2 + + \beta_4 + T_{4i}^4 + t + \varepsilon$$

Where; T = Yield per hectare

T = Temperature

P = Precipitation

t = Trend

ε = Random error

1 and 2 are the state index

i is the time index, representing annual observations from 1995 to 2006.

The estimated parameters are β_0, β_1, β_2, β_3, + β_4, and E. the values in each parenthesis of table 1 represent the t-ratios of the corresponding explanatory variables

* ⇒ represent the significance level at 10% while

** ⇒ represent the significance level at 5%

The regression result is explained on the strength of the independent value of coefficient of the parameters estimate.The result reveals a positive correlation of yam yield to precipitation at a significant level of 10%. This implies that rainfall is a significant determinant of yam production. It suggests that an increase in the amount of rainfall will increase the yield of yam production and cultivation by 495.27%.

On the other hand, there exist a positive and insignificant relationship between the yield of yam and temperature. This might be due to the variation in the intensity of temperature. It therefore implies that at optimum temperature, yam yield will be determined significantly by temperature. It was also discovered that time trend has a positive and significant relationship with yam yield at 5% level.

The table 2 also shows that precipitation has a negative and insignificant relationship with sweet potatoes yield whereas, in the case of temperature it has a positive and insignificant relationship with sweet potatoes yield, only time trend is moving in negative direction with sweet potato yield which was significant at 5% level.

IV. CONCLUSION

The purpose of this is to clearly analyze the effect of climate change of selected tuber crops in Nigeria. According to the result analysis carried out, it is obvious that we have different element of climate with different impact or effect on root tuber crop production under this study. Some were found to have positive effect and others negatives. Some wee had negative effect but their readjusted make them to become positive and hence favour average production of selected crops.

Based on the empirical evidence from the study, the importance of root tuber crops cannot be over looked as it provide food for man and the entire populace, a source of foreign exchange, and increase in food security, diversification in the type and amount of food intake by man and other benefit derived from its production in Nigeria.

The result of this study bring focus to increase root tuber crop production in Nigeria as a mean to increase food security in Nigeria and provision of root tuber crop under a weather condition that is conducive and convenient.

It also brings to our notice that some climatic element can be adjusted and hence a necessary calculation is needed to know the time that will favour maximum production of root tuber crops. It also shows that tuber crops yield is likely to respond to climate change in Nigeria. The response of tube crops yield to climate change varies from one geographical location to the other. These results also showed that as the years went by and climate factors ran contrary to agricultural productivities, farmers were also adopting new measures to cope with the negative effect of climate change. Through adaptation the negative effects of climate change on tuber crops yield could be reduced and the positive influences enhanced. Examples of potential adaptive measures include the introduction of drought or heat resistant varieties, early sowing, mixed cropping, alteration of the tillage system and utilization of land that has been considered too marginal for agricultural cultivation.

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