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Predicting the impact of climate variability on cassava yield in ibiono ibom local government area of Akwa ibom state, Nigeria

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Abstract
This study examined the linkages between climate variation and cassava yield in Ibiono Ibom LGA of Akwa Ibom State. Through the use of secondary data obtained on annual cassava yield and climate variation drivers, such as average annual temperature, rainfall, solar radiation and relative humidity in Ibiono Ibom LGA, the relationship between cassava yield and climate variation was established using step-wise regression inter-correlation model. The results revealed that average annual rainfall and relative humidity are not strong determinants of variation in annual cassava yield in the study area, compared to variation in annual solar radiation and temperature. The result of the analysis revealed further that average annual temperature is more significant in explaining the variation in cassava yield than variation in annual solar radiation (R^2=.71% for temperature and 56% for solar radiation). The direction and magnitude of influence of these variables indicate that a unit increase in average temperature above normal will result in 27% decrease in cassava yield, while a unit decrease in average solar radiation above normal will also results in 44% decrease in annual cassava yield. These buttress the significant influence of both temperature and solar radiation in determining cassava yield. The study recommends the need for researches on climate-crop relationships under changing climate scenario to be carried out as climate change affects resources which are vital for human livelihood systems. The anticipation of how future climate variability will affect crop production and its bio-physical systems is an important issue to also consider.

Keywords: climate variability, step-wise regression, cassava yield, human livelihood, biophysical systems

Introduction

Cassava (manihot esculenta) is a native of South America that is extensively cultivated as an annual crop in the tropical and subtropical regions for its edible starchy tuber root. Cassava has the ability to grow on marginal lands and it is one of the most important staple food crops in Tropical Africa with its efficient production of food energy, year round availability and tolerant of extreme environmental stresses which makes it eminently suitable for farming and food system in Nigeria. Cassava production plays a key role in alleviating poverty in Nigeria, as it is virtually impossible that an average household will not consume cassava product in a day. Therefore, cassava is an important factor in food security, poverty alleviation, rural-urban drift and reducing unemployment among others (Okpukpara, 2006) [8]. Cassava production is highly sensitive to variation in climatic factors most especially rainfall, temperature and sunshine duration. Several views have been expressed about the impact of irregularity of climate on cassava production. The climatic elements that influence cassava yield include rainfall, temperature, sunshine intensity, relative humidity, atmospheric pressure, and wind among others. Climate change is one of the most serious threats to cassava production in particular and agricultural sector and food security in general due to its sensitivity and vulnerability to high ambient temperature and rainfall fluctuations. For instance, higher temperatures lower the yield of cassava while encouraging weeds and pests' proliferation and changes in precipitation patterns increase the likelihood of short-run cassava failure and long run production declines, thus its variability creates a huge challenge for food production (Parry, Rosenzweig, Iglesias, Liver and Fischer, 2004) [10].

Generally, climate change refers to a long term alterations in global weather patterns like rises in temperature over time, rainfall fluctuation and storm activity evolved from the potential consequences of the greenhouse effects and continuous deforestation. In recent usage, in the context of environmental policy, the term climate change often refers only to changes in modern climate including the rise in average surface temperature known as global warming. It is very obvious that climate is constantly changing and the signal which indicates that the alterations are occurring can be evaluated over a range of temporal and spatial scales. Climate can be considered to be an integration of complex weather conditions averaged over a significant area of the earth expressed in terms of both the mean of weather and properties such as temperature, radiation, atmospheric pressure, wind, humidity, rainfall and cloudiness amongst others and the distribution or range of variation of these properties usually calculated over a period of 30 years. As the frequency and magnitude of seemingly unremarkable events change, such as rainstorms, the mean and distribution that characterize a particular climate will start to change. Therefore, climate as defined is influenced by events occurring over periods of time through global processes taking centuries. The consequences of changes may be as important as those that arise due to variations in mean climatic variables (Hulme, *et al* 1999) [4].

Climate change drives extreme weather events such as hurricanes and floods and, the increased risks of droughts and floods due to rising temperature may results in low crop yield (Parry, Rosenzweig, Iglesias, Liver, and Fischer, 2004) [10]. Global and regional climate changes are affecting all economic sectors to some degrees but the agricultural sector is perhaps the most sensitive and vulnerable, because agricultural production remains very dependent on climatic resources. However, according to Intergovernmental Panel on Climate Change (IPCC, 2007) [5] report, the earth is likely to warm by 0.2^0C per decade for the next two decades and to rise between 0.6^0C and 4.0^0C by the end of the century depending on future emissions; as a result, climate variability will impact food production in several ways. Cassava is an annual crop that may often be left longer than 12 months and usually planted as a sole crop or in combination with other crops. Production is all year round and it does well in a warm, moist climate. Cassava is very tolerant and has the ability to grow on marginal land where other food crops cannot grow well, but for its high yield and productivity, moderate climatic condition and best soil properties like a light, sandy loam soil of medium fertility and good aerations or drainage are all crucial (Akanbi and Olabode, 2004) [1]. Hence, extreme weather conditions such as prolonged drought and excessive amount of rainfall that leads into flood may be detrimental to cassava outputs.

While several studies have focussed on the impacts of climate variation on agricultural development in Ibiono Ibom Local Government Area of Akwa Ibom State, studies that examined the possible impacts of climate variation on cassava yield is lacking, in spite of the high dependence on cassava for food, fibre, and energy sources by the inhabitants. This study was conducted to bridge this gap of knowledge. Specifically, the study was designed to:

1. Identify the annual cassava production in the study area.
2. Determine the pattern of climate variation in the study area.
3. Determine the relationship between climate variability and cassava yield in Ibiono Ibom Local Government Area of Akwa Ibom state.

Literature Review

The major direct impact of climate change is expected to have on food security is through food availability component due to changes in agricultural productivity (Wlokas, 2008) [12]. Food availability in Sub Saharan Africa is directly affected by many aspects of climate change like temperature increase, change in rainfall amount and patterns, rising atmospheric concentrations of Carbon dioxide, change in climatic variability and extreme events and sea water rise (Oyiga, Mekibib, and Christine, 2011) [9]. Study by Badolo, Kinda and Somlanare (2012) [2] indicates that moderate increase in temperature (1°C-3°C mean temperature) is expected to benefit crop yields in temperate regions but have a negative impact in tropical and seasonally dry regions particularly for cereal crops. The study, however, warns that warming of the climate more than 3°C is expected to have a negative effect in all regions. An assessment of the impact of climate change on food production of a 2020 perspective by Liliana (2005) [6] shows that about two thirds of arable land in Africa is expected to be lost by 2025 due to decreased rainfall and reduce yields with an estimations of up to 50 percent in some Sub Saharan countries where 96% of the cultivated land depends on rain feed agriculture. The most significant impacts of climate change on food production is in tropical regions between 30° North and 60° South of the equator due to less water availability and increased temperature and in temperate regions between 300 North and 600 South due to changes in precipitation (Liliana, 2005) [6]. The International Food Policy Research Institute (IFPRI) tries to compare calorie availability in 2050 with and without climate change and predicted a decline resulting in an additional 24 million undernourished children (0-5 years), 21% more relative to a world with no climate change, almost half of which would be living in sub-Saharan African countries (Nelson, 2009) [7]. The impact of climate change on food availability in Sub-Saharan Africa is generally expected to be severe. This is primarily due to the vulnerability of subsistence farmers, who are believed to have a low capacity to cope with environmental stresses (Gregory, Ingram J.S and Brklacich, 2005) [3]. According to Intergovernmental Panel on Climate Change’s (IPCC) Assessment Report (IPCC, 2007) [5] in developing countries including Sub Saharan Africa, agricultural productivity will decrease from 9-21% by 2080 due to climate change and in some Sub Saharan African countries, the effect will be felt much sooner even by 2020. This report also indicates rising in temperature and variability in precipitation are likely to reduce the production of stable foods by up to 50% (Nelson, 2009) [7]. A study in Tanzania in 2011 indicates by 2050, projected seasonal temperature increases by 2°C reduce average maize, Sorghum and rice yields by 13%, 8.8% and 7.6% respectively. Also 20% increase in intra seasonal precipitation variability reduces agricultural yields by 4.2%, 7.2% and 7.6% respectively for maize, sorghum and rice (Pedram, David and Navin, 2011) [11]. A time series study in the Northern Showa zone in Ethiopia (2012) indicates food production faces severe challenges due to climate change. The annual production losses to climate variability significantly increase from year to year [27].

Materials and Methods

1. The Study Area

The study was conducted in Ibiono Ibom Local Government Area of Akwa Ibom State in the South-South region of Nigeria. Ibiono Ibom LGA consists of 9 clans, 33 groups, and 193 villages. It covers a total land of 2761.76km^2, with a total population of 385,145 (NPC, 2006). The LGA is bounded in the north-west by Ikono LGA, north –east by Itu LGA, the south by Uyo LGA respectively. The inhabitants of LGA are predominantly farmers producing mainly food crops like cassava, yam and maize; in addition to trading, craftworks are undertaken as part time basis. The LGA is situated in the gentle rolling coastal plain sands typified by sedimentary basin formation of largely unconsolidated deposits. Rainfall is heavy and last about 10 months in the year. The LGA has two different seasons, namely: wet and dry seasons. The wet seasons last for about 10-11 months. The wet seasons start about February – March and last till mid-November and are characterized by the little dry spell, which occurs about two weeks in August. What this implies is that changing climate pattern would have considerable impacts on the livelihood activities of the inhabitants. This informed the basis for this study.

2. Methods of data collection

Data for the study was collected primarily from secondary sources. Information on the annual yield (metric yield) per hectare of cassava produced in Ibiono LGA (2002-2018) was obtained from the Akwa Ibom State Ministry of Agriculture, Uyo, while data on climate variables (average annual temperature, average annual rainfall, average annual relative humidity, and average annual solar radiation,) were obtained from the University of Uyo Meteorological station. Both descriptive and inferential statistics were employed in the data analysis. The descriptive statistics involves the use of graphs/charts, tables and figures in analysing the data generated for the study. The Stepwise Regression Model was applied to aid the prediction of the joint variation between the dependent (cassava yield) and independent variables (climatic parameters). The general form of the Stepwise Regression Model is expressed as:

$$Y = a+b_1 X_1+ b_2 X_2 + b_3 X_3 + b_4X_4.........+ bnX_n + e$$

Where
Y = dependent variable (annual cassava yield)
a = Y intercept
$b_1b_2b_3$ = the net regression co-efficient
$X_1X_2X_3X_4$…………Xn = the independent variables
(X_1 = average annual rainfall, X_2 = average annual temperature, X_3 = average annual relative humidity and X_4 = average annual solar radiation).

The justification for the application of the Stepwise Regression Model was based on its ability to select the independent variable that offers the best explanation in accounting for the variation for the dependent variable. The procedure continues in a stepwise manner, entering at each stage the "best" independent variable in terms of its ability to reduce the remaining unexplained variance. Only the independent variable that significantly contribute to the total unexplained variance were chosen while the others were dropped.Regression analysis is employed in that it helps in establishing the relationship between climate variation and cassava yield and is also useful in identifying the climatic variable(s) that offer the best explanation in accounting for the variation in cassava yield in the study area.

Results and Discussions

Table 1: Annual Quantity of Cassava Production in Ibiono Ibom Local Government Area, Akwa Ibom State.

Years	Quantity Produced (metric tons)
2004	6,553
2005	6,715
2006	6,956
2007	7,576
2008	9,156
2009	9,665
2010	10,286
2011	10,498
2012	10,566
2013	11,484
2014	14,833
2015	15,870
2016	15,721
2017	16,286
2018	16,451
2019	16,867
2020	17,095

Source: Ministry of Agriculture Uyo, Akwa Ibom state

Results of the annual quantity of cassava produced (Table 1) in Ibiono Ibom LGA shows significant variation in annual cassava yield in the LGA. While the highest cassava yield was obtained in 2020 followed by 2019, the lowest yield was obtained in 2004. This may be due to variation in climatic parameters such as increase relative humidity (79mm), and average temperature (27.3^0), and decrease in solar radiation (10.4langsley) and rainfall (195.2mm) compared to the values obtained for these parameters in 2020.

Table 2: Average Relative Humidity, Solar Radiation, Average Annual Rainfall, Temperature and Quantity of Cassava Produced in Ibiono Ibom Local Government Area, Akwa Ibom State (2002-2015)

Year	Relative Humidity(mm)	Solar Radiation (langsley)	Average Rainfall (mm)	Average Temperature (^oc)	Cassava Produced (metric tons)
2004	79	10.4	195.2	27.3	6,553
2005	80	9.9	157.9	26.9	6,715
2006	80	10.1	185.1	27.1	6,956
2007	83	10.8	254.2	26.8	7,576
2008	83	10.9	281.1	26.5	9,156
2009	81	11.0	275.7	26.1	9,665
2010	80	10.6	247.6	27.2	10,286
2011	82	10.1	162.0	27.1	10,498
2012	82	10.7	231.9	26.7	10,566
2013	80	11.0	240.0	26.7	11,484
2014	79	11.1	319.9	25.8	14,833
2015	79	10.8	243.8	25.9	15,870
2016	80	12.0	252.2	26.3	15,721
2017	77	12.8	247.3	26.4	16,286
2018	81	10.8	238.9	25.8	15,478
2019	80	11.0	246.4	27.2	15,721
2020	81	11.1	251.6	27.1	17,095

Source: University of Uyo Meteorological Station

Results of the climatic variables in Table 2 indicate that there is temporal variation in all the climatic elements in the study area. It is observed that the highest percentage of relative humidity was recorded in 2007 and 2008 with the lowest being in 2017. It is also observed that the highest solar radiation was recorded in 2017, followed by 2016 with the least being 2005. While 2014 and 2008 recorded the highest rainfall duration, the lowest was recorded in 2005 and 2006. 2004 and 2010 recorded the highest temperature, while 2014 witnessed the lowest rainfall. A regression model was employed to establish the relationship between these climatic variables (solar radiation, average temperature, average rainfall and average relative humidity) and cassava yield in Ibiono Ibom Local Government of Akwa Ibom State. Hence, the result is shown below.

Table 3: Relationship between climate variation and cassava yield in Ibiono Ibom LGA Model summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.751[a]	.563	.527	2419.88752
2	.841[b]	.708	.654	2068.65221

a. Predictors: (Constant), Solar Radiation
b. Predictors: (Constant), Solar Radiation, Average Temperature
c. Dependent Variable: Cassava Produced coefficient[a]

ANOVA[c]						
Model		Sum of Squares	D f	Mean Square	F	Sig.
1	Regression	9.071E7	1	9.071E7	15.490	.002[a]
	Residual	7.027E7	12	5855855.625		
	Total	1.610E8	13			
2	Regression	1.139E8	2	5.695E7	13.309	M0 .00`4r1[b]
	Residual	4.707E7	11	4279321.967		
	Total	1.610E8	13			

a. Predictors: (Constant), Solar Radiation
b. Predictors: (constant), Solar Radiation, Average Temperature
c. Dependent Variable: Cassava Produced

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Correlations		
		B	Std. Error	Beta			Zero-order	Partial	Part
1	(Constant)	-26817.093	9597.051		-2.794	.016			
	Solar radiation	3466.520	880.771	.751	3.936	.002	.751	.751	.751
2	(Constant)	71580.246	43050.759		1.663	.125			
	Solar radiation	2382.773	885.194	.516	2.692	.021	.751	.630	.439
	Average temperature	-3251.855	1396.677	-.446	-2.328	.040	-.718	-.575	-.380

Table 3 shows that of all the four climate variables input in the analysis, only two (solar radiation and average temperature) are significant in explaining the variation in cassava yield. Together these variables accounted for 70.8% variation in cassava yield in the study area. The magnitude and direction of influence of these independent variables are shown by their respective *B* and *Beta* values. The indication is that a unit decrease in average temperature will result in -27% decreases in cassava yield. It is clear from Table 3 that average temperature is a very significant determinant of cassava production; it is therefore a more important causal variable in explaining the variation in cassava yield in the study area. This factor alone accounted for 70.8% (R^2=0.708) variation in cassava yield, while the first determinant X_1 (solar Radiation) accounted for the remaining 0.18% (R^2 = 0.708 – 0.527) variation in cassava yield in Ibiono Ibom Local Government Area of Akwa Ibom State. This, of course is less important for accounting for the variation in cassava yield than the first variable (average temperature). Also as shown in table three, the relationship between X_1 (solar radiation) and X_2 (average temperature) in accounting for cassava yield in the study area is significant as F = 15.490 for X_1 (Solar Radiation) and F = 13.309 for X_2 (Average Temperature) are greater than the significant F (0.002 and 0.001). The relationship is also strong as R = 0.751 for X_1 (solar radiation) and 0.841 for X_2 (average temperature) are higher than average (0.5000). On the basis of the foregoing, it is significant to state that strong influence in determining cassava yield. This is because the calculated Fs for the two climatic variables are greater than the significant Fs. It is however worth saying that the third and fourth variables (X_3 = Rainfall, X_4 = Relative Humidity) included in the analysis was dropped as exclusion variables since their contribution in accounting for cassava yield in the study area is insignificant What this suggest is that rainfall and relative humidity are not significant determinants of cassava production in the study area. This is probably so because there is no month without rainfall in the study area.

Conclusion and Recommendation

The study has established the linkage between climate variation and crop yield. It is recommended that climate-crop relationships under changing climate scenario should be investigated because climate change affects resources which are vital for human livelihood systems. The anticipation of how future climate variability will affect crop production and its bio-physical systems is an important issue to consider.

References

1. Akanbi WB, Olabode OS, Olaniyi JO, Ojo AO. *Introduction to Tropical Crops*. Ibadan: Raflink Computer, 2004.
2. Badolo F, Kinda, Somlanare R. Rainfall Shocks, Food Prices Vulnerability and Food Security: Evidence for Sub-Saharan African Countries, 2012.
3. Gregory PJ, Ingram JSI, Brklacich M. Climate Change and Food Security. *Philos Trans R Soc B*,2005:360:2139-48.
4. Hulme M, Barrow EM, Arnell NW, Harrison PA, John TC, Downing TA. Relative Impacts of Human Induced Climate Change and Natural Climate Variability. *Nature*, 1999, 397-691.

5. IPCC (Inter-Government Panel on Climate Change). The Science Basic Third Assessment Report in the Intergovernmental Panel on Climate Change. Cambridge University Press, 2007, 335.
6. Liliana H. The Food Gaps: The Impacts of Climate Change on Food Production: A 2020 perspective, 2005.
7. Nelson GC. Climate Change: Impact on Agriculture and Costs of Adaptation. International Food Policy Research Institute. Washington DC, USA. 2009.
8. Okupukpara BC. Credit Constraints and Adoption of Modern Cassava Production Technologies in Rural Farming Communities of Anambra State, Nigeria, 2006 282-290
9. Oyiga B, Mekibib H, Christine W. Implications of Climate Change on Crop Yield and Food Accessibility in Sub Saharan Africa. Bonn University, Germany, 2011.
10. Parry ML, Rosenzweig C, Iglesias A, Liver M, Fischer G. Effects of climate change on global food production under SRES emissions and socio-economic scenarios. *Global Environmental Change*,2004:14:53-67.
11. Pedram R, David BL, Navin R. Climate Variability and Crop Production in Tanzania. *Agricult Forest Meteorol*,2011:151:449-60.
12. Wlokas HL. The Impacts of Climate Change on Food Security and Health in Southern Africa. *Journal of Energy*,2008:19:12-20.