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The Influences of Temperature and Rainfall on the Yields of Maize, Yam and Cassava among Rural Households in Delta State, Nigeria

EMAZIYE, P.O.
Department of Agricultural Economics and Extension Delta State University, Asaba Campus, Asaba, Nigeria
Email: pemaziye@yahoo.com

Abstract
This study examined the influence of temperature and rainfall on the yields of maize, yam and cassava among rural households in Delta state, Nigeria. The specific objective is to determine the relationship between maize, yam and cassava yields and climatic factors (temperature and rainfall) in the state. Multistage sampling procedure was used in the random selection of local government, communities and rural households for the research study. Annual mean time series data of temperature and rainfall were collected from Nigerian Meteorological Agency (NIMET) and also annual mean time series data of yield of maize, yam and cassava were collected from Agricultural Development Programmes (ADP). Data were analyzed using descriptive statistics, trend analysis, correlation matrix and growth model. The households mean age in the state is 47 years and mostly headed by males. Most rural farming households were married (65.2%). Education level of rural households is dominated by primary school with a mean large household size of 10 persons. The state witnessed a low mean annual income of N50,803 ($338.69). There was an increasing trend in the annual mean temperature and a decreasing trend in annual mean rainfall while their projected future values are increasing in the state. Rainfall is negatively related to the yields of maize, yam and cassava respectively which is not good for optimal performance of the yields of maize, yam and cassava respectively. There was a decreasing trend in the yield of maize in the state which points to hunger. Thus, this study recommends that climate change mitigation and adaptive measures should be adopted to forestall hunger and food insecurity situation in the state. Also rural households' educational programmes should be a priority to the state for both climate change awareness and ability to understand Government policies and programmes towards achieving food security in the state.
Keywords: Temperature, Rainfall, Yields, Rural Households, Delta State.

INTRODUCTION

Climate change has become more threatening to the sustainable development globally. The " mean global temperatures have been increasing in line with precipitation increases since 1850, mainly due to the accumulation of greenhouse gases in the atmosphere" (FAO, 2007). Extreme climate conditions such as high wind, heavy rainfall, heat and cold can result in wide-ranging scenarios such as tropical storms, flood, landslide, droughts and sea-level rise. Pest and diseases are implicated in climate change. Significant climate conditions such as temperature, precipitation, sunshine and wind can affect and accelerate their dispersion and their increase (Okoh *et al* 2011). Nigerian Agriculture depend highly on climate because temperature, sunlight, water, relative humidity are the main drivers of crop growth and yield (Adejuwon, 2004). Crops generally require certain amount of rainfall during growth periods for maximum yield and when this becomes excessive it leads to poor harvest if at all. Also when this is added to high temperature the soil environment will become unconducive to micro-organism which decomposes biomass into organic matters. This phenomenon will result into soil infertility which leads to very poor yield. This places climate change as an important parameter in agricultural production for rural household food security. Climate change has significant effects on the environment and indeed soil, which significantly effect on agriculture otherwise food production. (Unanonwi, 2010). It was estimated that by 2015, Nigeria and other West Africa countries are likely to have agricultural losses of up to 4% of GDP due to climate change (Mendelsohn, 2000). This is in line with the findings of Oyerinde and Osantande (2010) who reported "that rural farmers are becoming poorer because their faming system is characterized by low and declining productivity due to climate change". Agricultural productions are important in securing food security. Increase in agricultural productivity increases rural incomes and lower food prices, making food more accessible to the poor. But effect of climate change will lead to low agricultural productivity resulting in rural households' food insecurity as already been experienced in Nigeria especially in Delta state were agricultural lands are render useless and crops are been destroyed as result of flooding mostly due to sea level rise coupled with the existing oil spillage in the state. In Africa, food demand is expected to reach $100 billion by 2015, double its level of 2000 (Diao *et al*, 2003). If food demands increases and agricultural production decreases as been witness in Delta state, Nigeria, there is bound to be food insecurity situation and hunger in the state, if special measures are not taking to expose the danger of climate variability and change that causes flooding which pose a substantial risk to food production. Rural households in Nigeria are vulnerable to chronic food shortages,

erratic supply, poor quality food and fluctuating food prices (Akinyele, 2010). Despite the increased rate of urbanization, the majority of those suffering from food insecurity remain in the rural areas (Fresco, 2000). Most households in Delta state live in the rural areas and mostly engaged in Agriculture for the production of food to feed the state. Growing consensus in the scientific literature on the future years or decades reveals that higher temperatures and changing precipitation levels caused by climate change will be unfavourable for crop growth in many regions and countries (Yesuf *et al*, 2008). To what extent will be the case in Nigeria particularly in the Delta state where climate change awareness is minimal? This prompted this study titled 'The influence of temperature and rainfall on the yields of maize, yam and cassava in rural households in Delta state, Nigeria. The following research questions were addressed in the study:

1) What is the relationship between temperature and yield of maize, yam and cassava?
2) What is the relationship between rainfall and yield of maize, yam and cassava?
3) What are the influence of temperature and rainfall on the yield of maize, yam and cassava?
4) What are the trend of temperature, rainfall and the yield of maize, yam and cassava in Delta state?

LITERATURE REVIEW

Concept of Climate Change

Climate change can be refers to long-term changes in average weather conditions (WMO, 1992). A minimum period of thirty years average is required for its occurrence.

Climate change according to IPCC (2007) refers to changes in modern climate which are 90-95 percent likely to have been in part caused by human action.

Climate Change and Agriculture

With increasing global warming and higher temperatures, a number of phenomena associated with water bodies in different ecological zones of Nigeria as it apply particularly to the coastal zone where Delta state belongs are as follows:

(i) Beach erosion and coastal flooding are widespread due to higher waves generated by onshore storm winds.
(ii) Mangroves adjoining estuaries are receding due to wave incursion and beach breaching
(iii) The receding shoreline compiled with the 30 to 60km tidal excursion length around Delta state in Niger Delta region suggests increasing Stalinization of upland ground water.

Sea-beds reworked by storm waves threaten the integrity of offshore buried oil pipelines leading to rupture and oil spillage (Climate change in Nigeria www.nestinteractive.org). All these lead to the end-product of low or poor agricultural yield as most of the available land for agriculture has been destroyed.

METHODOLOGY

The Study Area

Delta state, located in the south south geopolitical region of Nigeria was created on the 27th of August 1991 out of the former Bendel state. At inception, Delta state was made up of twelve political divisions called Local Government areas (LGA's), later increased to 19 in 1996. Presently there are 25 local government areas in Delta State.(Delta state gov., N.D). The state occupy a land mass of about 17,163 square kilometer with a population of about 4,098,398 persons (NPC, 2006).

Geographically located within Longitudes 5° and 6.4°E and 5°00 and 6.30', the state is bounded Northwards by Edo state, on the East by Anambra State, on the South East by Bayelsa state and on the South west by the Bight of Benin which covers approximately 160km of the states coastline, (Delta state gov., N.D). Southern parts of the state which is transverse by numerous flat floored rivers that drain into the Atlantic ocean is generally low lying without remarkable hills, consisting of unconsolidated sediments of quaternary age. Some hills can be found northwards within the LGA's of Ika and Aniocha. The major rivers include the Niger River, Ethiope, Warri, kiagbodo **(**Aweto, 2002). Drainage is done in the eastern flank by the Niger River via its several distributaries such as the forcados, escravos, and the Warri rivers and creeks such as the Bomadi creek. Rivers Jamieson and Ethiope rise from the north and northeast respectively subsequently join and form the Benin River which eventually drains into the sea in the west. (online Nigeria,2003.)

Delta state shares similar climatic features with other states in the Niger-delta. The general climate is characterized by a long rainy season from March/April through October. The climate in Delta state shows latitudinal fluctuation in humidity ranging from the humid tropical in the south to the sub- humid in the north east. Lessening humidity towards the north is accompanied by an increasingly marked dry season (online Nigeria, 2003)

Method of Sampling / Sampling Size

Multistage sampling procedure was used in the random selection of local government, communities and rural households for the research study. Firstly, one local government areas were selected from the each of the three agricultural zones in the state. Secondly, two communities from each of the local government areas were

selected, making it up to 6 communities. Finally, fifty (50) rural farming households were randomly selected from each of the sampled communities making it up to 300 households. Data for this study were obtained using personal interview and structured questionnaire survey and out of the 300 respondents 274 was utilized for this study.

Method of Data Collection

Annual mean time series data from Nigerian Meteorological Agency (NIMET) that include the following; temperature, and rainfall were collected and also annual mean time series data collected from Agricultural Development Programmes (ADP) were collected for the study.

Method of Data Analysis

Trend Analysis

Temperature, rainfall and the yield of maize, yam and cassava trend in Delta state was determined using line graph.

Growth Model

Temperature, rainfall and yield of maize, yam and cassava future values were predicted using the Growth model. This model was specified as linear, quadratic and cubic equations. The equations are as follows:

$CH_f = a(1+i)^t + e$ (Linear) ……. i

$CH_f = a(1+i)^t + b(1+i)^{2t} + e$ (Quadratic)…….ii

$CH_f = a(1+i)^t + b(1+i)^{2t} + c(1+i)^{3t} + e$ (Cubic)……iii

Where CH_f = Temperature and Rainfall.

i = Rate of growth

t = Time horizon (integer values starting from 1 to 38 Years)

e = Error term

a,b,c, and d = Coefficients of the model.

The cubic functional form that fits the data best fitted was selected.

Correlation matrix:

Correlation matrix was used to determine the relationship between temperature, rainfall and the yield of maize, yam, and cassava in the state.

It helped to show the relationship between temperature, rainfall and the yield of maize, yam, and cassava in the state.

$Y = A_0 + A_1X_1 + A_2X_2 + E$ …… iv

Where

Y = yield of maize, yam and cassava (Kg/Ha)

X_1 = temperature (^{0}C)

X_2 = rainfall (mm)

E = error term.

A_0, A_2 and A_2 = model parameters

RESULTS AND DISCUSSION

Respondents Socio-economic Characteristics in Delta State

The households mean age in the state is 47 years and mostly headed by males (Table 1). Most rural farming households were married (65.15%) confirming that they were responsible and conscious on the consequences of temperature and rainfall on the yield of maize, yam and cassava in rural households in Delta state, Nigeria. Education level of rural households is dominant by primary school with a mean household size of 10 persons showing relatively large household size in the state. The state witnessed a low mean annual income of N50,803 ($338.69) in the state.

Trend Analysis of Temperature (Delta State)

Temperature data from Delta State in Niger Delta region, Nigeria between 1971 and 2009 shows an increasing trend with a trend coefficient of 0.57^{0}C per year (Table 2) and is statistically significant. The minimum value of temperature (30.09^{0}C) was recorded in 1976 while the maximum value of temperature (32.60^{0}C) was recorded in the year 1976. The standard deviation and mean values of temperature over the period (1971 – 2009) are 0.53^{0}C and 31.49^{0}C respectively. This implies that there is variability between temperature and time. The trend line had a positive slope of 0.56 indicating that over the time period 1971 to 2009 annual mean temperature in Delta state rose by 0.56^{0}C per unit change in time.

Trend Analysis of Rainfall (Delta State)

Rainfall record from the Delta State in Niger Delta region, Nigeria between 1971 – 2009 shows a decreasing trend with the minimum value for the period (189.02mm) recorded in 1977 and maximum value for the period (283.05mm) recorded in 1999 (Table 3). The mean and standard deviation values of rainfall from 1971 – 2009 are 231.41mm and 27.31mm respectively (Table 3). This implies that rainfall has a large variability (11.80) with time. The rainfall trend coefficient is – 0.38mm per year and significant. This reveals a decreasing trend with the

negative value of the trend coefficient of rainfall in Delta state in Nigeria delta region, Nigeria. The trend line had a negatives slope of – 0.38 indicating that over the time period 1971 to 2009 annual mean rainfall in Delta state fell by - 0.38mm per unit change in time.

Predicted Future Values of Temperature and Rainfall in Delta State.

The temperature and rainfall in Delta State projected future values were made in accordance with the study analytical framework. The future project values of temperature are; 32.25^0C, 32.40^0C, 32.56^0C, 32.71^0C, 32.87^0C, 33.03^0C, 33.18^0C and 33.34^0C for the year 2015, 2020, 2025, 2030, 2035, 2040, 2045 and 2050 respectively. There was an increasing trend in the projected future values of temperature and rainfall in the State. The values of the projected future values of rainfall in the Delta State are: 234.38mm, 246.19mm, 249.02mm, 251.89mm, 254.79mm, 257.72mm, 260.69mm and 263.69mm for the year 2015, 2020, 2025, 2030, 2035, 2040, 2045 and 2050 respectively (Table 4). There was a great variability of climatic variables in the study area (Delta State).

Trend Analysis of Yield (Delta State)

Statistical yield data recorded from 1999 – 2009 in Delta State in Niger Delta region, Nigeria recorded an increasing trend in the yield of yam, cassava and a decreasing trend in maize yield. The maximum mean annual yield of maize, yam and cassava was 2215 Kg/Ha, 12720 Kg/Ha and 14010 Kg/Ha respectively. While the minimum mean yield of maize, yam and cassava for the period (1999 – 2009) was 1604 kg, 10619 kg and 11090 kg respectively. The mean and standard deviation of the yield of maize was 1889.50 kg and 223.241 kg respectively while the mean yield of cassava and yam was 12467.40 kg and 11432.30 kg respectively with the standard deviation of cassava and yam yield was 1225.48 kg and 1015.09 kg respectively in Delta State (Table 5).

The Relationship between Temperature, Rainfall and the Yield of maize, yam and cassava in Delta State

Table 6 shows the relationship between temperature, rainfall and the yield of maize, yam and cassava in the state. Temperature is positively related to maize, yam and cassava yield respectively implying that as temperature increases yam, maize and cassava yield respectively increases. But yam and cassava yield are both positively related and significant at 5% level showing that temperature play a vital role in their growth and yield.

Rainfall is negatively related to maize, yam and cassava yield respectively implying that as rainfall increases yam, maize and cassava yield decreases, which is not good for optimal performance of the yield of maize, yam and cassava respectively. This will in turn affect household food productions that will likely lead to hunger and food security in the state.

CONCLUSION AND RECOMMENDATION

Most rural farming households were married (65.15%) confirming that they were responsible and conscious on the consequences of temperature and rainfall on the yield of maize, yam and cassava in rural households in Delta state, Nigeria. Education level of rural households is dominant by primary school with a mean household size of 10 persons showing relatively large household size in the state. The households mean age in the state is 47 years and mostly headed by males. The state witnessed a low mean annual income of N50,803 ($338.69) in the state. The trend line had a positive slope of 0.56 indicating that over the time period 1971 to 2009 annual mean temperature in Delta state rose by 0.56^0C per unit change in time. The trend line had a negatives slope of – 0.38 indicating that over the time period 1971 to 2009 annual mean rainfall in Delta state fell by - 0.38mm per unit change in time. There was an increasing trend in the projected future values of temperature and rainfall in the State. There was an increasing trend in the yield of yam, cassava and a decreasing trend in maize yield. Temperature is positively related to maize, yam and cassava yield respectively implying that as temperature increases yam, maize and cassava yield respectively increases. Rainfall is negatively related to maize, yam and cassava yield respectively implying that as rainfall increases yam, maize and cassava yield decreases, which is not good for optimal performance of the yield of maize, yam and cassava respectively. This will in turn affect household food productions that will likely lead to hunger and possible food insecurity in the state. Thus, this study recommends that climate change mitigation and adaptive measures should be adopted to forestall hunger and food insecurity situation in the state. Also rural households' educational programmes should be a priority to the state for both climate change awareness and ability to understand Government policies and programmes towards achieving food security in the state.

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Table 1: Socio-economic Characteristics of Respondents

Variables	Respondents (n=198)	Percentages (%)
Age (Years)		
30 – 39	44	22.22
40 – 49	79	39.90
50 – 59	64	32.32
60 – 69	11	5.56
Mean	47 years	
Gender		
Female	94	47.47
Male	104	52.53
Marital Status		
Single	14	7.07
Married	129	65.15
Widow	29	14.64
Widower	3	1.52
Divorced	23	11.62
Educational Status		
Informal	61	30.81
Primary	76	38.38
Secondary	42	21.21
Tertiary	19	9.60
Mode	Primary school	
Household Size		
2 – 4	8	4.04
5 – 7	41	20.70
8 – 10	75	37.88
11 – 13	47	23.74
14 – 16	27	13.64
Mean (persons)	10	
Annual Income (N)		
21,000-60,000	148	74.75
61,000-100,000	49	24.75
101,000-140,000	1	0.50
Mean (₦)	50,803	

Author computed result, 2013.

Table 2: Analysis of Temperature data from 1971 – 2009 in Delta State

Temperature	
	Delta
Mean (^{0}C)	31.49
Standard Deviation (^{0}C)	0.53
Max. Temperature (^{0}C)	32.60
Min Temperature (^{0}C)	30.09
Trend of Coefficient (^{0}C/yr)	0.57
Coefficient of Variation (CV) (%)	1.68

Source: NIMET and Author computed result, 2013.

Table 3: Analysis of rainfall data from 1971 – 2009 in Delta State

Rainfall	**Delta**
Mean (mm)	231.41
Standard Deviation (mm)	27.31
Max. Rainfall (mm)	283.05
Min rainfall (mm)	189.02
Trend of Coefficient (mm /yr)	-0.32
Coefficient of Variability (CV) (%)	11.80

Source: NIMET and Author computed result, 2013.

Table 4: Predicted future values of Temperature and Rainfall in Delta State.

Year	2015	2020	2025	2030	2035	2040	2045	2050
Temperature (^{0}C)	32.25	32.40	32.56	32.71	32.87	32.03	33.18	33.34
Rainfall (mm)	243.38	246.19	249.02	257.89	254.79	257.72	260.69	263.69

Source: Author computed projected values, 2013

Table 5: Analysis of Yield record from 1999 – 2009 in Delta State.

Yield	Cassava	Maize	Yam
Mean (Kg/Ha)	12467.40	1889.50	11432.30
Standard deviation (Kg/Ha)	1225.48	223.24	1015.09
Maximum yield (Kg/Ha)	14010	2215	12720.00
Minimum yield (Kg/Ha)	11090	1604	10619.00
Coefficient of Variation (%)	9.83	11.81	8.88

ADP and computed result, 2013

Table 6: The Relationship between Temperature, Rainfall and Yield in Delta State.

Correlations

		Delta Maize	Delta Yam	Delta Cassava	Delta Temp	Delta Rain
Delta Maize	Pearson Correlation	1				
	Sig. (2-tailed)					
	N	10				
Delta Yam	Pearson Correlation	-.745	1			
	Sig. (2-tailed)	.013				
	N	10	10			
Delta Cassava	Pearson Correlation	.752	.989	1		
	Sig. (2-tailed)	.012	.000			
	N	10	10	10		
Delta Temp	Pearson Correlation	.243	-.728	.715	1	
	Sig. (2-tailed)	.499	.017	.020		
	N	10	10	10	10	
Delta Rain	Pearson Correlation	.009	.114	.092	.287	1
	Sig. (2-tailed)	.981	.754	.800	.421	
	N	10	10	10	10	10

* Correlation is significant at the 0.05 level (2-tailed)
** Correlation is significant at the 0.01 level (2-tailed)
Source: Author computed result, 2013

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