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A Critical Analysis of Climate Change Factors and its Projected Future Values in Delta State, Nigeria

Emaziye, P. O., R. N. Okoh and **P. C. Ike** (Department of Agricultural Economics and Extension, Delta State University, Asaba Campus, Asaba, Nigeria)

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Author(s)

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

R. N. Okoh and **P. C. Ike**
Department of Agricultural Economics and Extension Delta State University, Asaba Campus, Asaba, Nigeria

Abstract

The study focused on the critical analysis of climate change factors (temperature and rainfall) and its projected future values in the state. The main objective was to determine the trends of climate change factors (temperature and rainfall). And the specific objective was to determine the projected future trends of climate change factors in the state. Multistage sampling procedure was used in the random selection of states, 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). Data were also obtained from structure questionnaire survey. The collected data were analyzed using descriptive statistics, trend analysis and growth model. The study reveals that there were increasing trends of temperature values and decreasing rainfall values in the state. But their projected future values witnessed an increasing trend. The increasing trends in temperature values may lead to a situation were crops will be smothered by excessive heat thereby reducing food production in the state. The study therefore recommends that meteorological station units should be established in the rural farming households in the state where accessibility is extremely difficult. This will make available meteorological data (information) to the reach of the poor rural farming household for the attainment of food production.

Keywords: Climate Change, Trend, Climatic Change Factors, Delta State, Nigeria

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). Exposure to climate change, most particularly flooding poses substantial risks to food production in the rural household resulting in food insecurity. Greater rainfall variability and more severe droughts in semi-arid Africa will hinder efforts to enhance food security and combat malnourishment (Schmidhuber and Tubiello, 2007). Given the pronouncement of climatologist on the evidence of global warming, there is concern that climatic impacts on food crop production will be exacerbated in developing countries (Molua and Lambi, 2007). This is in line with the report of Adejuwon, (2004) that Nigerian Agriculture depend highly on climate because temperature, sunlight, water, relative humidity are the main drivers of crop growth and yield. A variety of crops such as maize, yam and cassava produced in Delta state depend on rainfall for their optimum performance. But in line with IPCC (2007a) reported that precipitation levels are on the downward trend. The decrease and irregular rainfall pattern pose a problem that need to be addressed to avoid food shortage in the state.

Hence this study will provide an insight to the trends of climate change factors (temperature and rainfall) in the state. The study also addressed the following research questions:

1)   What is the trend of temperature values in the state?
2)   What is the trend of rainfall values in the state?
3)   What are the projected future values of climate change factors in the state?

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 govt., 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 govt. 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 random selection of local government areas, communities and rural households for the research study. Firstly, three local government areas each were selected from each of the three agricultural zones in the state making up to nine (9) local government areas from the twenty-five (25) local government areas. Secondly, two communities from each of the local government areas were selected, making it up to 18 communities. Finally, twenty five rural households were randomly selected from each of the sampled communities making it up to four hundred and fifty (450) rural households. Only four hundred and ten (410) respondents were utilized for this research study.

Method of Data Collection
Annual mean time series data from Nigerian Meteorological Agency that include the following; temperature, and rainfall from January, 1971 to December, 2009 were collected for the study. Data for this study were also obtained using personal interview and structured questionnaire survey

Method of Data Analysis

Descriptive Statistics
Descriptive statistic was used to summarize the respondents' socio-economic characteristics of rural farming households in the state.

Trend Analysis
Line graph was used to determine the trend of the climatic change factors (temperature, and rainfall) in Delta state.

Growth Model
Growth model was used to predict the future values of climate change factors (temperature, and rainfall). This model was specified as linear, quadratic and cubic equations. The equations are as follows:

$$CH_f = a(1+i)^t + e \qquad \text{(Linear) ………. i}$$
$$CH_f = a(1+i)^t + b\,(1+i)^{2t} + e \qquad \text{(Quadratic)……..ii}$$
$$CH_f = a(1+i)^t + b\,(1+i)^{2t} + c(1+i)^{3t} + e \qquad \text{(Cubic)…………iii}$$

Where
CH_f = climate change factors (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.

Results and Discussion

Socio-economic Characteristics of Respondents in Delta State, Nigeria
Primary school level of education dominated the state with large household size of 9 persons. The mean age of respondents in the state is 48 years engaging in farming activities and dominated by male headed households. Most rural farming households were married confirming that they were matured and conscious on the level of climate change factors (temperature and rainfall) in the state. The mean annual income of the rural farming households in the state was N54,702 ($353) revealing a low annual income level due to impacts of climate change in the state. Socio-economics characteristics is shown in Table 1

Trend Analysis of Temperature in Delta State, Nigeria
Temperature data from Delta State, Nigeria between 1971 and 2009 shows an increasing trend with a trend coefficient of 0.57^0C per year (Table 2) and is statistically significant. The minimum value of temperature (30.09^0C) was recorded in 1976 while the maximum value of temperature (32.60^0C) was recorded in the year 1976. The standard deviation and mean values of temperature over the period (1971 – 2009) are 0.53^0C and 31.49^0C respectively. 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 (figure 1). The trend analysis results revealed an increasing trend in mean annual temperature in the state. The increasing trend may lead to a situation were crops will be smothered by excessive heat thereby reducing food production in the state.

Trend Analysis of Rainfall in Delta State, Nigeria

Rainfall record from the Delta State, 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. 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 (figure 2). This reveals a decreasing trend with the negative value of the trend coefficient of rainfall in the state. Crops needs water for optimum development but with the decreasing nature of rainfall in the state will lead to crop failure thereby resulting in hunger and food insecurity situation in the state if prompt action is not taking.

Predicted Future Values of Climate Change Factors in Delta State, Nigeria

The future projected 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 (Table 4). There was an increasing trend in temperature in the state. Rainfall projected future values also witnessed an increasing trend. The values of the projected future values of rainfall in the 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. Figure 3and 4 shows the projected future upward trend.

Conclusion and Recommendation

Primary school level of education dominated the state with large household size of 9 persons and a mean age of 48 years. Most respondents were married with a low annual income of N54,702 ($353). 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. The trend analysis results revealed an increasing trend in mean annual temperature and a decreasing trend in mean annual rainfall in the state. There were increasing trend in projected future values of temperature and rainfall in the state. The increasing trend may lead to a situation were crops will be smothered by excessive heat thereby reducing food production in the state.

The study therefore recommends that meteorological station units should be established in the rural farming households in the state where accessibility is extremely difficult. This will make available meteorological data (information) to the reach of the poor rural farming household for the attainment of food production.

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Table 1: Socio-economic characteristics of Respondents

Variables	Delta (n=410)	Percentages (%)
Age (Years)		
30 – 39	91	22.2
40 – 49	163	39.8
50 – 59	132	32.2
60 – 69	24	5.8
70 – 79	0	
Mean	48 years	
Gender		
Female	195	47.6
Male	215	52.4
Mode	Male	
Marital Status		
Single	29	7.1
Married	267	65.1
Widow	60	14.6
Widower	6	13.2
Divorced	48	
Educational Level		
Informal	126	30.7
Primary	157	38.3
Secondary	87	21.2
Tertiary	40	9.8
Mode	Primary	
Household size		
2 – 4	17	4.1
5 – 7	85	20.7
8 – 10	155	37.8
11 – 13	97	23.6
14 – 16	56	13.8
Mean (persons)	9	
Annual Income(₦)		
21,000-60,000	304	74.1
61,000-100,000	100	24.4
101,000-140,000	6	1.5
141,000-180,000	0	
181,000-220,000	0	
221,000-260,000	0	
Mean (₦)	54,702 ($353)	

Source: Field survey data, 2011

Table 2: Analysis of temperature record from 1971 – 2009 in Delta State

Variable	Coefficient	Std. error	t-statistic	Prob.
C	13.72317	4.721015	2.906826	0.0062
DT (-1)	0.564891	0.150065	3.764305	0.0006
Temperature		**Value**		
Mean (^{0}C)		31.49		
Standard deviation (^{0}C)		0.53		
Maximum temperature (^{0}C)		32.60		
Minimum temperature (^{0}C)		30.09		
Trend coefficient (^{0}C/year)		0.57		
Coefficient of Variability (CV)		1.68		

Source: NIMET and Author computed result, 2011

Table 3: Analysis of Rainfall Data from 1971 – 2009 in Delta State

Variable	Coefficient	Std. error	t-statistic	Prob.
C		37.41685	8.522643	0.0000
DR (-1)	- 0.376412	0.159985	- 2.352793	0.0242
Rainfall			**Value**	
Mean (mm)			231.41	
Standard deviation (mm)			27.31	
Maximum rainfall (mm)			283.05	
Minimum rainfall (mm)			189.02	
Trend coefficient (mm/ year)			- 0.38	
Coefficient of Variability (CV)			11.80	

Sources: NIMET and Author computed result, 2011

Table 4: Predicted future values of climate Change Factors 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, 2011
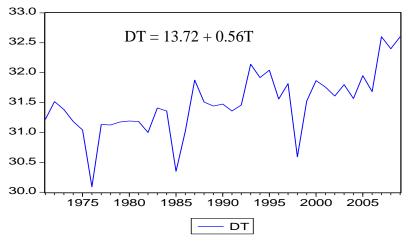

$$DT = 13.72 + 0.56T$$

Figure 1: Trend of Temperature Data for Delta State (1971 – 2009)

Figure 1 reveals an increasing trend of temperature in Delta State

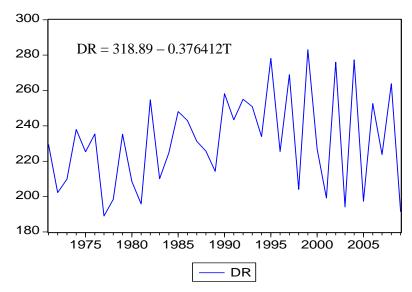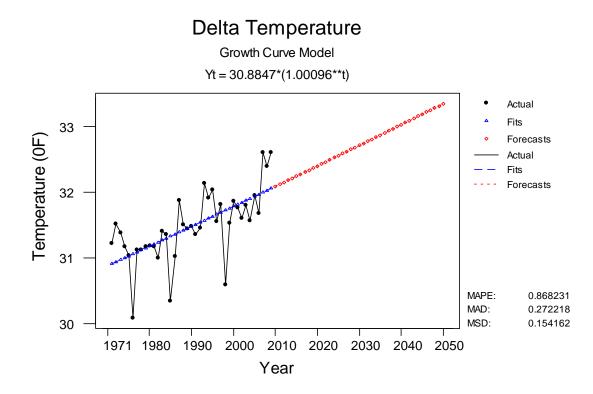**Figure 2: Trend of Rainfall Data for Delta State (1971 – 2009)**

Figure 3: Predicted Future Values of Temperature (Delta State)

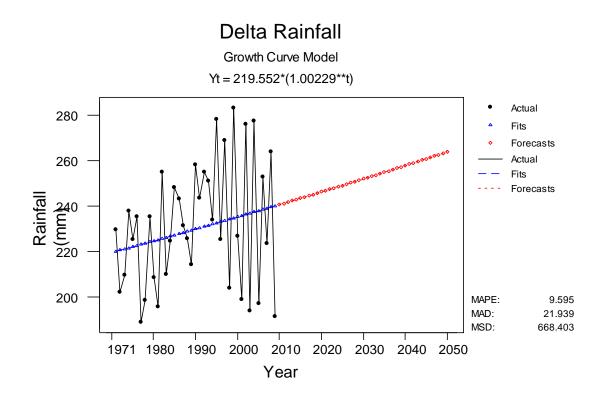# Delta Rainfall

Growth Curve Model

Yt = 219.552*(1.00229**t)

Figure 4: Predicted Future Values of Rainfall in Delta State