

Assessment of the Linkage between Rainfall variability and Arable Crop production in Enugu State Nigeria

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Abstract

The Enugu state of Nigeria has not over the years achieved sustainability of productivity for food security because food production has not kept pace with the growing in the area. The decline in food production in the area is attributed to some factors including rainfall variability due to climate change. This paper assessed rainfall variability and relationships with maize and cassava production in Enugu state. Questionnaire survey techniques were employed to find out perceptions of farmers on the effects of the climate system on their crops. 30 years mean monthly rainfall data and 20 years annual crop yields were collected from Nigeria Meteorological Agency (NIMET) and Agricultural Development Programme (ADP) respectively. The rainfall figures were analyzed using time-series line graph models and both rainfall and crop yield data were further analyzed using statistical techniques to determine their association. Results show high variations in rainfall within the period under investigation with upwards trends, which conforms to the farmer's response. Also, rainfall variability contributed about 2.87% in cassava yield but contributed little or nothing to maize yield in the last 20 years, as it shows a high negative correlation coefficient with maize yield. Though, the study established that rainfall variation is highly insignificant in determining maize production and highly significant in determining cassava production in the state, there is need for adjustment strategies like early planting, crop diversification, and adhering to early warning climate system in order to minimize the risk of crop failure and then boost productivity in the area.

Key word: Climate variation, influence, crop production, Enugu Nigeria

Introduction

In sub-Saharan Africa, climate change is manifesting essentially as rainfall variability (Nnaji, 2009), and in the region, annual decadal and inter decadal variations in rainfall have been reported by Anydike (1992) and Odjugo (2007). In Nigeria, changing rainfall patterns have been observed by researchers such as Anydike (2006), Ojo *et al.*, (2001), Nnaji (2001) and Okorie *et al.* (2011). Similarly, many studies also, have indicated that climate change is a reality in Nigeria, for example studies by (Zakari *et al.*, 2014); (Adewuyi, *et al.*, 2014); (Okorie, 2015); (Duru and Chibo, 2014); (Landan, 2014); (Emeruvbe and Yusuf, 2012).

Variability in rainfall as a consequence of climate change has a notable effect on agriculture and it's a limiting factor in food production. Food shortage and food insecurity in sub-Saharan Africa are linked to poor agricultural performance, accounted for by climate change and other factors (Ramirez, 2010); (Tazhibayeva and Townsend, 2012) and (Walthal, *e al.*, 2012).

In a study on crop yield variability as influenced by climate, Chi-chung *et al.* (2004) submitted that precipitation and temperature are found to have opposite effects on yield levels and variability of crops. Nwaobiala and Nottidge (2015), noted that effect of climate variability and change on cassava farmers' output in Abia State, Nigeria from 1980 – 2011, was the result of coefficients for farm size, the quantity of fertilizer, labour cost and rain. According to an inter-governmental panel on climate changes (IPCC) (2001), impacts of these changes on agriculture include the increase and redistribution of plants, crop yield losses, increase in plant and animal diseases etc. Salinger *et al.*, (2005) pointed out that agriculture is highly dependent on climate variability which is why the threat of climate change is particularly urgent.

There is evidence of global food security crises in the Enugu state of Nigeria because food production has not kept pace with the growing population over time in the state. Consequently, the state has not achieved sustainability of productivity for food security in the last few decades and this has prompted this research. Related studies by (Okoroh, et al, 2016) and (Chikezie, et al 2016) show that majority of farmers in some parts of southeast Nigeria are aware of climate change and its manifestations on their crop yields. Meanwhile, the decline in food production in the area is attributed to some factors including rainfall variability due to climate change. The study therefore, assessed rainfall variability and its relationships with the production of two major stable crops, 'maize and cassava' in the Enugu state of Nigeria.

Description of the Study Area

Enugu state is in the Southeast Geopolitical region of Nigeria. Its capital city is Enugu from which the state derives its name. It was carved out of the old Anambra State on 27th August, 1991. The state is located on latitude 6°26'33.29"N, and longitude 7°30'7.92"E, and in a tropical rain forest zone with a derived savannah. The climate is humid and this humidity is at its highest between March and November. For the whole of Enugu State the mean daily temperature is 26.7 °C (80.1 °F). As in the rest of West Africa, the rainy season and dry season are the only weather periods that recurs in Enugu. The average annual rainfall in Enugu is around 2,000 millimetres (79 in), which arrives intermittently and becomes very heavy during the rainy season. Other weather conditions affecting the city include Harmattan, a dusty trade wind lasting a few weeks of December and January. The state is prone to vulnerability factors such as floods, drought, degradation and desertification. Though some of this climate-related hazards used to have a positive impact on the farmers of the area, but of recent times, the frequency of these events has become alarming (Ekpo and Asuqwo, 2012). The livelihoods of the inhabitants are at high risk due to the extreme climatic induced events. The majority of people in Enugu State are peasant farmers. There have been reports of changes in the early onset or late onset of rainfall and early cessation or late cessation of rainfall in the area. Also high temperatures are noted to have increased over the years (Ibe, 2006). The changes in the pattern and quantity of rainfall as well as other climate parameters such as temperature, wind storms and relative humidity have a negative impact on the lives of farmers and other vulnerable group's mostly rural people who depend on natural resources for their livelihoods. The environmental degradation of the area as a result of sand mining, deforestation, agricultural activities, population explosion and industrialization has been known to increase the vulnerability level of the farmers in the zones. The state is noted for its coal deposit, the largest in Africa. Other mineral resources found in the state include limestone, iron-ore and bauxite. The state is the headquarters of the former Eastern Region of Nigeria. This is the **Coal City State** of Nigeria. During the last National Population and Housing Census in 2006, Enugu state was made up of 1,596,042 males and 1,671,795 females. The state is made up of 17 local government areas (figure 1).

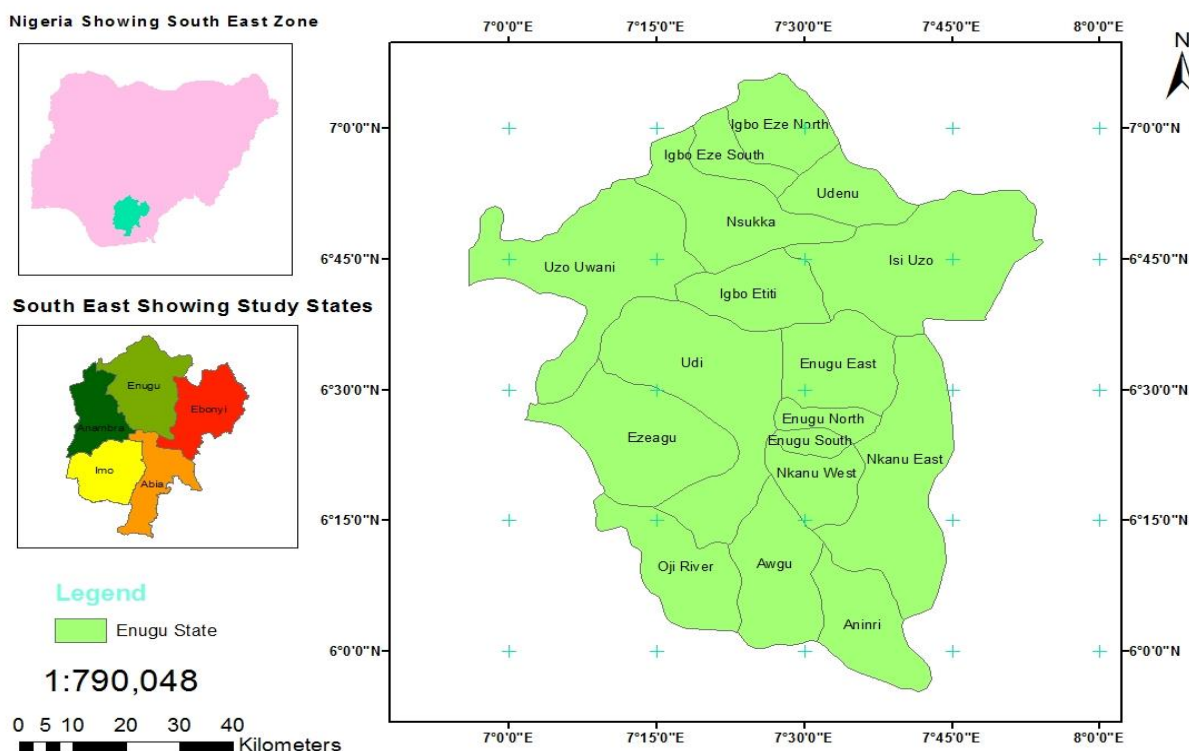


Figure 1: Location map of the study area showing the LGAs

Materials and Methods:

Primary data for the study were collected through a questionnaire survey to ascertain the perception of farmers on the effects of climate change on their crops using rainfall as an indicator. Five (5) Local government areas were selected in the state by stratified random sampling method, which are Aninri LGA, Isi-uzo LGA, Nkanu East LGA, Nsukka LGA and Awgu LGA.

Fifty (50) copies of the questionnaire were distributed and administered, giving ten (10) copies each to selected farmers in the five (5) LGAs that can read and write. Also, secondary data on mean monthly rainfall for the state over 30 years (from 1988 to 2017), and 20 years (from 1998 to 2017) available annual crop yield data for maize and cassava were acquired from Nigeria Meteorological Agency (NIMET), Enugu and Agricultural Development Project (ADP), Enugu office respectively. Rainfall data as shown in Table 1 were analyzed using the time-series line graphs model to determine ‘mean monthly’ and ‘mean annual’ rainfall variability in the state within the 30 year climatic period. Also the rainfall and crop yield data (in Table 2) were further analyzed statistically for two decades (from 1988 to 2017) using Pearson’s Moment of Correlation Coefficient in order to determine their association.

Table 1: Enugu Monthly Rainfall 1988-2017

S/N	Year	Jan	Feb	Mar	Apr	May	Jun	JUL	Aug	Sep	Oct	Nov	Dec	Total	Mean
1	1988	7.1	0	46.4	95.3	154.9	220.3	219.3	226.4	285.2	206.1	0	0	1416	121.75
2	1989	0	0	4.4	167.9	278.7	182.6	162.2	413.4	217.4	217.1	0	0	1643.7	136.98
3	1990	0.5	0.5	0	181.5	89.7	279.4	508.3	359.1	317.5	318.8	2.3	25.8	2083.4	173.62
4	1991	0	37.6	63.4	197.1	346.4	244.8	320.2	264.5	230.5	253.5	2.5	0.7	1961.2	163.43
5	1992	Trace	0	111.5	200.9	194	354	313	149.3	249.7	105.3	28.8	Trace	1706.5	170.65
6	1993	0	5.1	62.8	148.9	109.9	263.7	186.7	389.8	243.5	72.9	82.9	11.6	1577.8	131.48
7	1994	33.8	0	9.7	144.5	211.2	140	216	187.2	331.9	181.6	Trace	0	1455.9	132.35
8	1995	1.6	Trace	90.2	194.1	263.9	356.7	340.2	432.1	192.4	261.7	35	0	2167.9	197.08
9	1996	Trace	26.7	48.6	160.9	277.2	289.6	368.3	268.4	176.3	303.4	0	0	1919.4	174.49
10	1997	Trace	0	111.6	261.3	376.1	344.9	226.8	235	392.3	242.2	68.1	4.1	2262.4	205.67

11	1998	0	6.1	25.8	161.1	188.7	285.9	259.2	96.2	256.6	217.4	0	0	1497	124.75
12	1999	0	15.7	30	103.6	223.5	316.8	206.4	101.2	195.1	291.6	24.3	0	1508.2	125.68
13	2000	32.4	0	32.3	202	357.5	206.1	289.5	331.8	339.7	226.5	Trace	0	2017.8	183.44
14	2001	0	28	72.5	305.5	273.8	188.8	152	130.6	407.9	118.1	Trace	0	1677.2	152.47
15	2002	0	46.5	10.4	159.1	219.7	296.4	263.3	121.9	270.9	332.5	1.5	0	1722.2	143.52
16	2003	Trace	0	2.9	74.6	234.3	286.9	400.4	290.2	334.4	227.4	39.8	0	1890.9	171.9
17	2004	6.4	4.8	186.8	305.5	222.3	284.7	174.1	272.3	258	22.1	33.1	0	1770.1	147.51
18	2005	Trace	26.9	20.8	115.6	170	258.3	277.6	292	283.6	228.5	24.1	19.1	1716.5	156.05
19	2006	43.9	4.6	78.9	138.4	375	369.2	402.5	188.3	261.8	233.7	0	0	2096.3	174.69
20	2007	0	9.4	70	93.9	288.4	306.4	329	261.9	286.1	265.8	Trace	0	1910.9	173.72
21	2008	31.8	3	18.8	118.4	292.9	100.6	42.9	172.2	238.8	278.9	13.7	0	1312	109.33
22	2009	2.8	0.8	69.3	193.7	184.3	253.7	172.2	135.9	191	237.5	32.8	0	1474	122.83
23	2010	0	0	2.2	162.8	199.3	401.3	128.8	153.2	394.9	226	1	0	1669.5	139.13
24	2011	0	44.6	118.4	118.1	220.2	194	189.9	238.2	439	164.9	2	0	1729.3	139.13
25	2012	39	35.7	13	86.9	288.7	282.5	388	309.1	393.2	227.7	73.9	0	2137.7	178.14
26	2013	35.1	0	31.7	146	296.7	279.4	173.9	336.4	430.1	113.5	0	98.3	1941	161.76
27	2014	24.7	26.77	54.37	117	268.53	251.97	250.6	294.57	420.77	168.7	25.3	3.6	1906.9	158.91
28	2015	0	0	16.1	137.9	130.6	350.5	305.6	385.8	309.5	122.5	20.9	0	1779.1	148.28
29	2016	16.6	0	206.1	127.8	291.7	202.8	193.5	462.6	259.4	157.8	12.6	Trace	1930.9	175.54
30	2017	0	0	33	148.7	173.6	200.5	245.1	292.3	222.7	135.7	0	0	1451.6	120.97

Source of Data: NIMET Enugu, Nigeria (2019)

CROP YIELD/ HA, (000) Metric ton FOR ENUGU STATE (MAIZE AND CASSAVA) 1998-2017

S/N	Year	Maize yield	Cassava yield
1	1998	1.9	10.3
2	1999	1.9	10.3
3	2000	1.7	11.2
4	2001	1.7	11.1
5	2002	1.7	11.3
6	2003	1.8	11.3
7	2004	1.7	10.7
8	2005	1.8	12.1
9	2006	1.9	12.4
10	2007	1.8	12.4
11	2008	1.9	13.1
12	2009	1.9	13.1
13	2010	1.9	13.1
14	2011	1.9	12.8
15	2012	1.8	12.8
16	2013	1.6	19.4
17	2014	1.7	18.8
18	2015	1.4	16.0
19	2016	2.3	13.4
20	2017	0.7	9.4

Source: ADP Enugu, Enugu State Nigeria

Results and Discussion

Questionnaire survey: Response from Respondents

Years of farming experience of Respondents in the study area

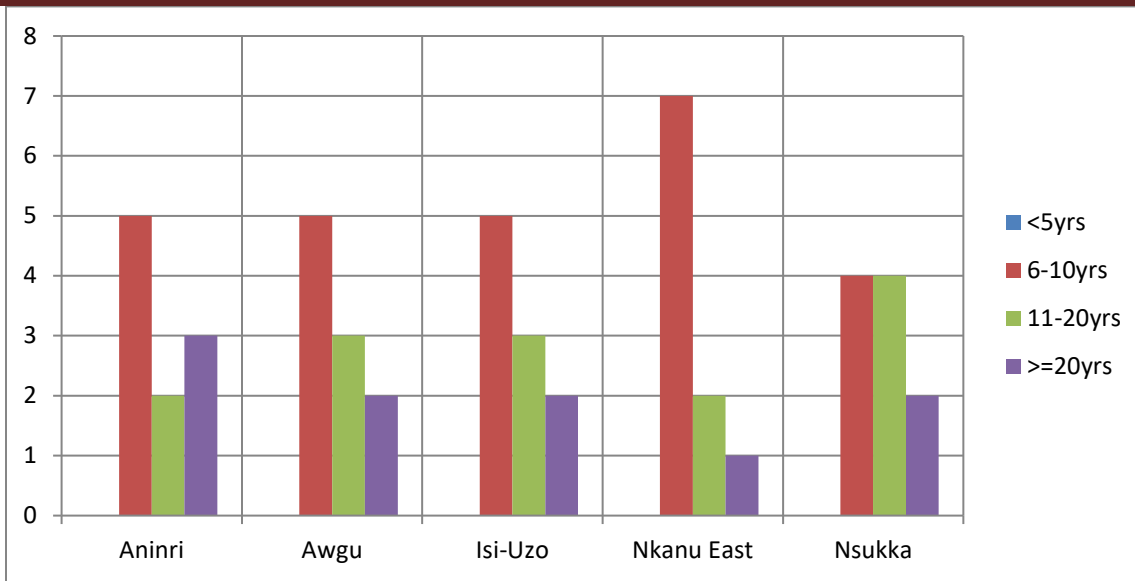


Figure 2: Years of farming experience of the respondents

Source: Author’s field work, 2019

Figure 2 shows that five respondents have 6-10 years of farming experience, two have 11-20 years experience and three respondents as well have above 20 years of farming experience in Aninri LGA. In Awgu LGA, five respondents also indicated 6-10 years experience, three indicated 11-20 years experience and two indicated above 20 years experience. In Isi-Uzo LGA, it was five respondents for 6-10 years experience, three for 11-20 years experience and two for above 20 years experience. In Nkanu East, seven respondents indicated 6-20 years of experience, two indicated 11-20 years of experience while only one respondent indicated above 20 years experience. Finally in Nsukka LGA, it was four respondents for 6-10 years experience, four respondents also for 11-20 years experience and two respondents for above 20 years of farming experience.

Identified observed changes in rainfall in the study area

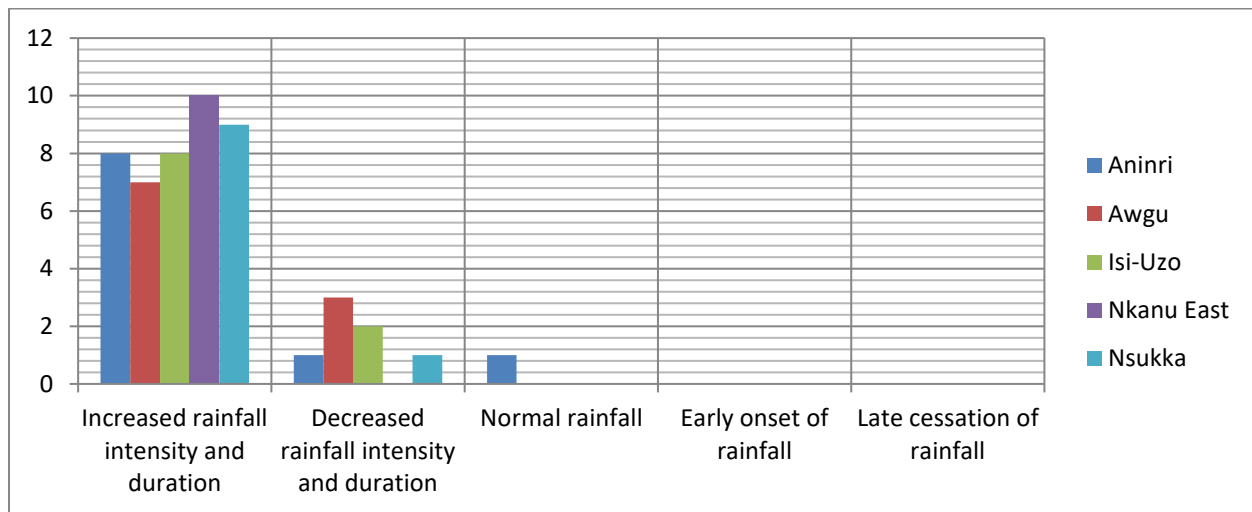


Figure 3: Identified observed changes in rainfall

Figure 3 shows that eight respondents from Aninri LGA indicated increased rainfall intensity and duration, one respondent indicated decreased rainfall intensity and duration and one respondent as well indicated normal rainfall. In Awgu LGA, seven out of ten respondents indicated increased rainfall intensity and duration while

three respondents indicated decreased rainfall intensity and duration. In Isi-Uzo LGA, it was eight respondents for increased rainfall and two respondents for decreased rainfall respectively. In Nkanu East, all ten respondents indicated increased rainfall intensity and duration. Finally in Nsukka LGA, nine out of ten respondents indicated increased rainfall while only one respondent indicated decreased rainfall.

Rainfall Variability as causes of crop failure in the study area

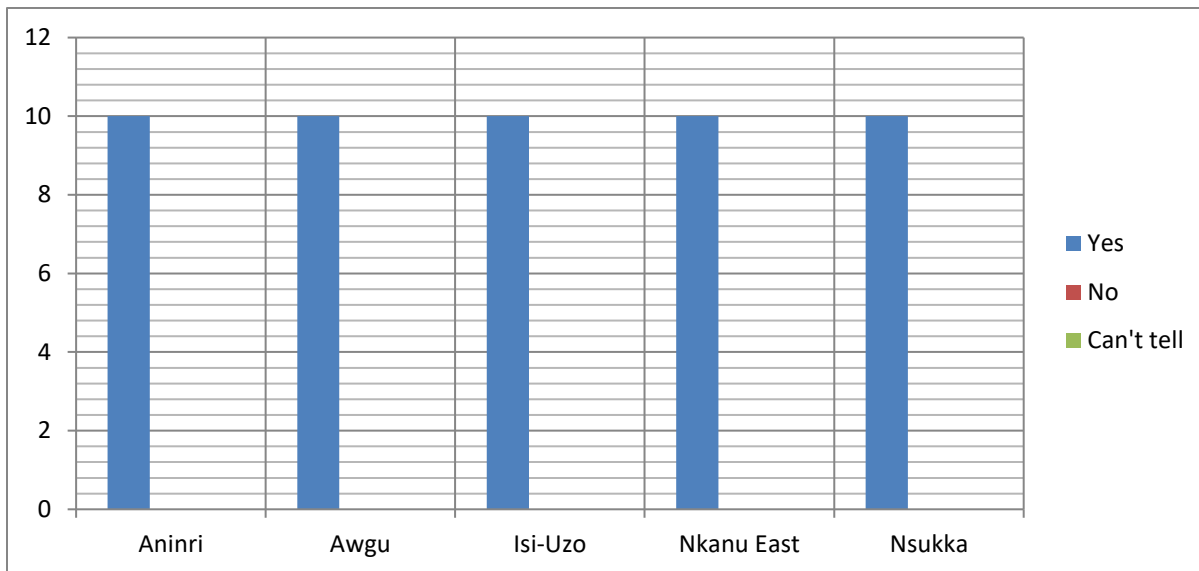


Figure 4: Rainfall Variability as causes of crop failure

Figure 4 shows that all ten respondents throughout the five local government areas indicated that rainfall variability had caused the failure of crops in the areas. This means yield for the two chosen staple crops in the state has been seriously affected by the shifts in rainfall over time.

Effect of crop failure on the socio-economic wellbeing of the people

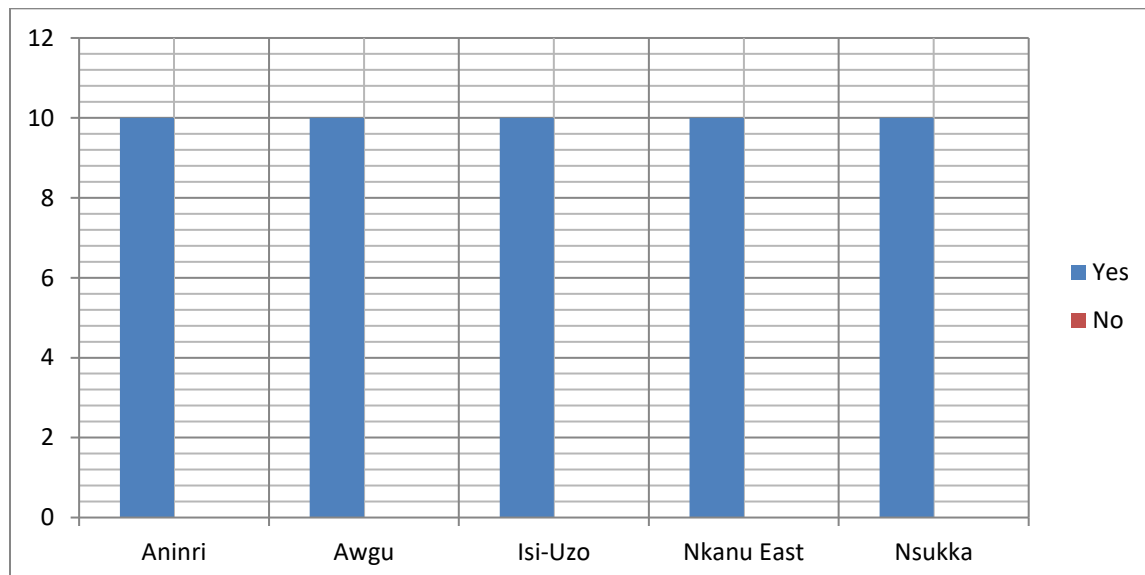


Figure 5: Effects of crop failure on the socio-economic wellbeing of people

Figure 5 shows that in all the selected local government areas for this study, the fifty respondents that participated in the questionnaire survey indicated that the so called crop failure due to rainfall variability is really affecting their socioeconomic wellbeing.

Time-Series Rainfall Analysis

Mean Monthly Rainfall Line Graph for Enugu State: Here, the mean rainfall values for each of the twelve months throughout the thirty years period were plotted in one line graph for the state. This graph revealed seasonality shifts in its bimodal regime and the little dry season.

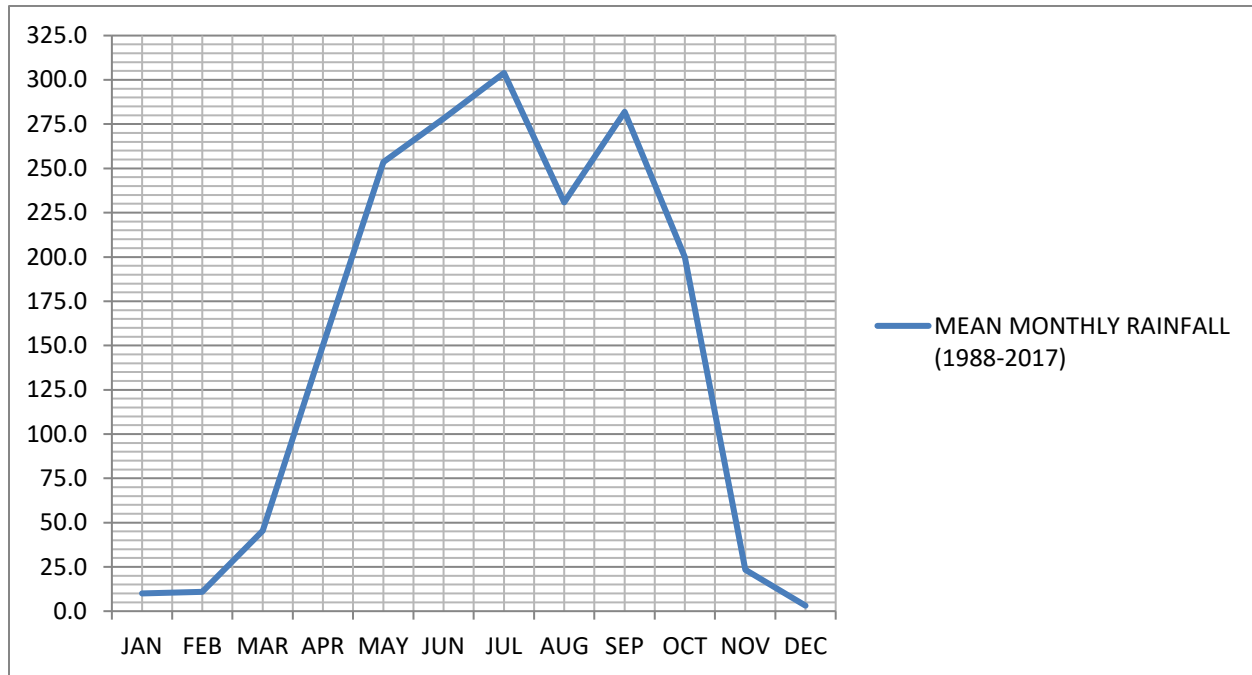


Figure 6: Mean monthly rainfall for (1988-2017) for Enugu

The time series line graph shows a normal rainfall pattern in Enugu state. There was rainfall variability in the series increasing from the onset of the rainfall. January mean was 10.1mm, February was 10.9mm, March 45.4mm, April 150.1mm, May 253.5mm, June 278.1mm and the highest (first peak) in July with 303.9mm. Then little decrease (August break) in August with 230.8mm and increased again in September (second peak) with a mean of 282.0mm, and decreased sharply to 200.0mm, in October and cessation occurred in November with 23.4mm, and December mean 3.1mm. The graph shows a bimodal rainfall pattern in July (303.0mm) and in September (282.mm (figure 5).

Mean Annual Rainfall Line Graph: The mean rainfall values for each of the thirty years were plotted in one line graph for the state. This graph shows the rainfall trend in the average annual rainfall for thirty years.

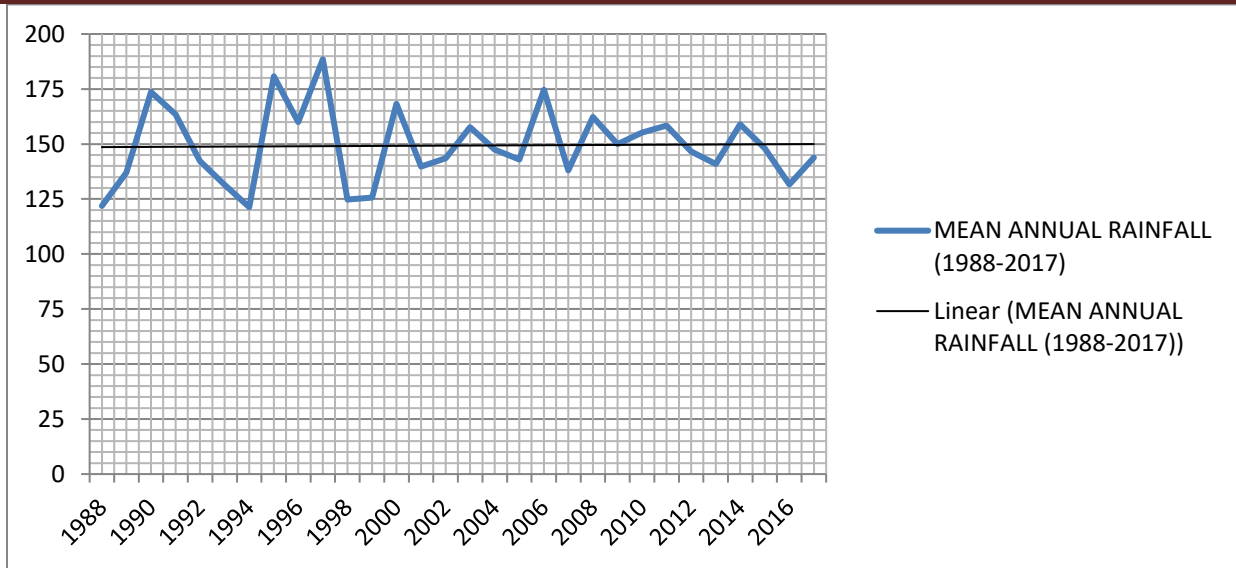


Figure 7: Mean annual rainfall for (1988-2017) for Enugu

Figure 7 shows high variability in mean annual rainfall in Enugu within the study period (1988-2017). The minimum value was 121.mmm recorded in 1995 followed by 122mm in 1988, then 125mm in 1998, 126mm in 1999, and 132mm in 1993 and 2016 respectively. Also 137mm in 1989, 130mm in 2007, 140mm in 2001, 141mm in 2013 and 142mm in 1992, then 143mm in 2005, 144mm in 2002 and 2017 respectively. The maximum mean annual was 189 mm in 1997, followed by 181mm in 1995, 175 mm in 2006, 174 mm in 1990, and 168mm in 2000. Then 163 mm in 1991, 160mm in 1996, 159 mm in 2014 and 158.4 mm in 2011. Also, 158mm in 2003, 155 mm in 2010, 150 mm in 2009, 148 mm in 2015 and 2004 respectively. The variability here was not smooth but very rough, fluctuating up and down dramatically.

Correlation of Rainfall Variability with Crop Yields in Enugu: To achieve a correlation, rainfall values, maize and cassava are integrally shown in Table 3.

Table 3. Mean values for correlation of rainfall (R) with maize (M) and cassava (C) yields

R	M	C	R ²	M ²	C ²	RM	RC
2958.6	34.8	254.9	440960.4	62.3	3377.4	5147.8	37817.7

a. Correlation of Rainfall (R) with Cassava (C).

This is given as:

$$r_{RC} = \frac{n\sum RC - \sum R\sum C}{\sqrt{(n\sum R^2 - (\sum R)^2)(n\sum C^2 - (\sum C)^2)}}$$

where n = 20 (number of years)
 R = Rainfall (mm)
 C = Cassava yield (in metric tonnes)

Therefore $r_{RC} = \frac{(20 \times 37817.7) - (2958.6 \times 254.9)}{\sqrt{(20 \times 440960.4 - 2958.6^2)(20 \times 3377.4 - 254.9^2)}}$

$$= \frac{2206.8600}{\sqrt{169610600.0000}}$$

$$= \frac{2206.8600}{13023.4634}$$

$$rRC = 0.1695$$

The correlation coefficient of 0.1695 shows a weak association between rainfall variation and cassava yield in Enugu state. To ascertain the percentage contribution of rainfall variation to the cassava yields, we calculate both the coefficient determination and Residual. This is given as

$$\text{Determinant} = 100r^2$$

$$100 (0.1695)^2 = 2.87\%$$

$$\text{Residual} = 100 (1-r^2)$$

$$= 100 \times (1 - (0.1695)^2) = 97.13\%$$

The Determination of the correlation coefficient shows that only rainfall variation in Enugu state contributes 2.87% variations recorded in cassava. Other factors, edaphic, climatic, biological and socio-economic in nature, account for 97.13%. The shift in rainfall therefore, contributes significantly to cassava yield in Enugu state.

b. Correlation of rainfall with maize

$$rRM = \frac{n\sum RM - \sum R \sum M}{\sqrt{(n\sum R^2 - (\sum R)^2)(n\sum M^2 - (\sum M)^2)}}$$

$$= \frac{(20 \times 5147.8) - (2958.6 \times 34.8)}{\sqrt{(20 \times 440960.4 - 2958.6^2)(20 \times 62.3 - 34.8^2)}}$$

$$= \frac{-3.2800}{\sqrt{2427762.240}}$$

$$= \frac{-3.2800}{1558.1278}$$

$$rRM = -0.0021$$

The correlation coefficient of rainfall with maize yield is -0.0021 . This is a high negative coefficient indicating a very weak relationship between rainfall variation and maize yield in Enugu state.

We calculated the determinant and residual of our correlation coefficient of -0.0021 to ascertain the percentage contribution of rainfall to maize production.

$$\text{Determinant} = 100r^2$$

$$= 100 \times (-0.0021)^2 = 0.00044\%$$

$$= 0\%$$

$$\text{Residual} = 100 (1-r^2)$$

$$= 100 \times (1 - (-0.0021)^2) = 99.9996$$

$$= 100\% \text{ (approx).}$$

The coefficient determinant shows that rainfall variation contributes nothing to maize yields in the state. Therefore, rainfall variation is highly insignificant in determining maize production in the Enugu state of Nigeria.

Discussion of findings:

The study confirms the manifestations of climate change in the Enugu state of Nigeria through rainfall variability. Changes observed in rainfall over 30 year period of the study is evidence of climate change in the area. This result supports the report by (Nnaji 2009), which stated that climate change has manifested as rainfall variability in sub-Saharan Africa. Also, the manifestations of climate change in the area through rainfall variability as observed in this research was in line with results of previous studies by (Zakari, et al, 2014); (Adewuyi, et al, 2014); (Okorie, 2015)]; (Duru and Chibo, 2014) and (Landan, 2014), which indicated that climate change is a reality in Nigeria. Similarly, the indications of respondents, that crop failure in the area are totally due to rainfall variability, support studies by (Okoroh, et al 2016), and (Chikezie, et al, 2016), which stated that majority of farmers in southeast Nigeria especially in Imo aware of climate change and its impacts on their crops.

In identifying the observed significant shift (changes) in rainfall, about forty two (42) respondents (farmers) in the state indicated that they have been experiencing increased rainfall intensity and duration while only eight (8) respondents indicated decreased rainfall intensity and duration. Similarly, time series line graphs show both increases and decrease in the mean monthly and mean annual rainfall for the state, but rainfall shows a general decline in mean annual within the study period (figure 7). This is impressively contrary to the perceptions of the farmers in the state as indicated in their responses.

However, the results ascertained that rainfall varies in amount spatially and temporarily with both downward and upward trends over the study period, and this conforms to Ward *et al*, (1999) study, which indicated the existence of clear inter-annual decadal rainfall variability over sub-Saharan West Africa. Furthermore, the results agree with Anyadike's (1992) reports which concluded that there is a tendency towards decreasing seasonal rainfall totals in all the regions in Nigeria. Finally the study agrees with (Odjugo, 2005 & 2007) which stated that rainfall trends in Nigeria between 1901 and 2005 showed a general decline with an indication that within the 105 years rainfall dropped by 81mm.

On the other hand, the study shows that rainfall affected cassava yield in the state but did not affect maize yield. However, this result actually, agrees with Nwaobiala and Nottidge (2015) which stated that rainfall among other factors were determinants of cassava production in Abia state of southeast Nigeria.

Conclusion

In this study, the time series analysis shows high rainfall variability in the state. This affirms that there is a significant shift in rainfall occurrence in the area, and to support the result, Odjugo (2010) informed that weather patterns had been twisted, which alters onset and cessation of rainfalls and also affects the months of the occurrence of the “short dry season” commonly called August break, which seems to be fluctuating in the south-south tropical continental climatic zone of Nigeria.

From the result of this study, rainfall generally shows a downward trend within the 30 year climatic period considering the trend line in the mean annual rainfall graph. This indicates that the general decrease in rainfall was observed in the state during the year under review. Interestingly, this does not conform to the farmer's perception, as about sixteen percent (16 %) of the respondents only indicated that decreased rainfall had been observed in the area over time to compare with eighty four percent (84%) of the respondents that indicated increased rainfall.

On statistical analysis, the determination of the correlation coefficient shows that only rainfall variation in Enugu state contributes 2.87% variations recorded in cassava during the period, and coefficient determinant shows that rainfall variation contributes nothing to maize yields in the state. Therefore, rainfall variation is highly insignificant in determining maize production in the Enugu state of Nigeria but highly significant in determining cassava production in the state. However, other factors and combined factors affecting both maize and cassava production in the state may include wind, temperature, humidity, and access to inorganic fertilizer, access to farm machines, extension services, and pest effects, edaphic, biological and socio-economic factors.

Recommendation:

1. Awareness and education needed. The farmers, stakeholders in agric sectors and the general public need more and regular education about climate change and the management strategies. This can be achieved with regular use of radio, television, newspaper, seminars and workshops.
2. Production of food crops like maize, rice and cassava that are directly affected by climate change should be intensified. Adaptive measures should be embraced by farmers. The best way to achieve this is through the effort of agricultural extension officers.
3. Adjustment strategies like early planting, crop diversification, late planting and adhering to early warning climate system to minimize the risk of crop failure as should seriously be adopted in the area and across all agricultural zones.
4. Concrete efforts should be placed on grounds by the government to ensure that the local farmers are carried along in the design and formulation of policies on climate change in relation to agriculture and production systems.

References

- i. Adamgbe, E. M & Ujoh, F. (2013): *Effect of Variability in Rainfall Characteristics on Maize Yield in Gboko, Nigeria*, *Journal of Environmental Protection*.
- ii. Adewuyi, S.A, et al (2014): "Effects of climate change on food crop production vulnerability assessment in Oyo State" in *Journal of economics and international Financial*, Vol. 7, pp. 18-24. Retrieved from <http://www.academicjournals.org/JEF>; 02/03/2017
- iii. Aina, P.O. (2012): "Climate change and food security: The challenge of transforming agriculture in Nigeria". Being text of the lecture delivered at Ikorodu Division Resource Development Group (IDRG), Lecture series on 10 November, 2012. Retrieved from [hap://dipoainyJc1_ress.com](http://dipoainyJc1_ress.com); 10/01/2017
- iv. Anyadike R. N. C. (2009). *Climate Change: Causes and Consequences*, paper presented at CEMAC, UNEC, public lecture.
- v. Anyadike, R. N. C. (1992). *Regional Variations in Fluctuations of Seasonal Rainfall over Nigeria*, *Theoretical and Applied Climatology*. Vol.37: No.4, pg 205-219
- vi. Chi-Chung C., McCarl, B.A and Schimmelpfennig, D (2004). *Yield variability as Influenced by Climate: Statistical Investigation*. *Climate Change*, 66: 239-261,204.
- vii. Chikezie, C., et al (2016): "Climate change and perceived climate hazards: a trend analysis in Southeast Nigeria" in *International Journal of 1 Weather, Climate Change and conservation Research* Vol.2, No.1, PP- 1-10. March 2016. Retrieved from www.eajournals.org; 01/03/2017
- viii. Duru, P.N, and Chibo, C.N (2014): "Flooding in Imo State Nigeria: The Socio-Economic Implication for Sustainable Development" in *Humanities and Social Sciences Letters* Retrieved from <http://pakinsight.com/?ic=journal&journal=73>; 10/01/2017
- ix. Emeruvbe, G.O., and Yusuf, G.U. (2012); "Spatial Analysis of flood Disaster in Delta State, Nigeria" in *Research Publications in Geography*, Vol.11. No.1, 2012, pp.52-58
- x. Ethan, S. (2015): "Impact of climate change on agriculture and food security in Nigeria: challenges and adaptation" in *Global Advanced Research Journal of Medical Plant (GARJMP)*. Vol. 3(1) pp. 001-009, February 2015. Retrieved from <http://garj.org/garjmp/index.htm>; 02/03/2017

- xi. *International Panel on Climate Change (2001a) Climate change 2001: the scientific basis. Contribution of Working Group I to Third Assessment Report of the Intergovernmental Panel on Climate Change. Houghton, JT, Ding Y, Griggs DJ, Noguer M, van der Linden PJ, Dai X, Maskell K, Johnson CA (eds) Cambridge University Press, Cambridge, UK and New York, NY, USA*
- xii. *Ladan, S.I. (2014): "An appraisal of climate change and agriculture in Nigeria" in Journal of Geography and Regional Planning. Vol.7 (9), pp.176-184*
- xiii. *Nnaji, A. O (2001). Forecasting Seasonal rainfall for agricultural decision-making in Northern Nigeria" Agricultural and Forest Meteorological: 107: 193-205.*
- xiv. *Nnaji, A.O (2009). Implications of Current Climate Variation on Weather Conditions over Imo State, Journal of Biological and Environmental Sciences 2: 22-23.*
- xv. *Nwaobiala, C.U and Nottidge, D.O (2015): Effect of Climate variability on output of Cassava in Abia State, Nigeria, Nigeria agricultural journal Vol 46, No1 (2015)*
- xvi. *Obasi, G. O.P., (2003): Keynote address at Regional conference on Climate Change and Food Sustainability in the 21st Century. Lagos, Nigeria, 11 November 2003.*
- xvii. *Odjugo, A. O., (2010a). Regional evidence of climate change in Nigeria, Journal of Geography and Regional Planning Vol. 3(6): pp 142-150.*
- xviii. *Odjugo, P.A.O (2007). Evidence of Climate Change in Nigeria, Paper presented at the International Conference on Climate Change, Nnamdi Azikiwe University Awka. Pp 12-14.*
- xix. *Odjugo, P.A.O. (2005) 'An analysis of rainfall pattern in Nigeria', Global Journal of Environmental Sciences, Vol. 4, No. 2, pp. 139-145*
- xx. *Ojo, S.O, Ojo, K and Oni, F. (2001) Fundamentals of Physical and Dynamic Climatology, SEDEC Publishers Lagos (2001)*
- xxi. *Okorie, F.C., Okeke, I.C., Nnaji, A.O., Duru, P.N. and Chibo, (2011). "Rainfall Variability as Evidence of Climate Variation in Imo State of Southeastern Nigeria", International Journal of Sustainable Development, Volume 4, Number 9, 2011*
- xxii. *Okorie, F. C. (2015). Analysis of 30 years rainfall variability in Imo State of southeastern Nigeria; in Hydrological Sciences and Water Security: Past, Present and Future. Edited by Christophe Cudennec et al.,(2015).Proceedings of the 11th Kovasc Colloquium. Paris, France, June, 2014 IAHS Publ. 366, 2015, pp 131-132.*
- xxiii. *Ramirez, A (2010): The Impact of climate change on rice production. Retrieved from http://www.academicjournals.org/JGRP_06/03/2017 Retrieved from www.proc-iah.net 10/01/2017*
- xxiv. *Salinger, J., Sivakumar, M. V. K and Motha, R. P (2005) Increasing climate variability and change, Reducing the Vulnerability of Agriculture and Forestry Reprinted from Climate change vol 70 nos 1-2, 2005 vi p 362.*
- xxv. *Tazhibayeva, K and Townsend, R. (2012): The impact of climate change on rice yields; Heterogeneity and uncertainty. Paper presented at the IIES conference on Climate Change in 2012. Retrieved from www.robertmtownsend.net 01/03/2017 Volume.3, No.2, pp. 458-472, retrieved from www.ijswt.net on 05/03/2017S*
- xxvi. *Ward, M. N, Lamb, P.J, Portis, D. H, el Hamly, M and Sebbari, R (1999). Climate Variability in Northern Africa Understanding Droughts in the Sahel and the Maghreb, Beyond el Nino: Decadal and Interdecadal Climate Variability, A. Navarro, Ed., Springer-Verlag, Pg 119-140 Washington D.C., Resources for the Future. Weikersheim, Germany West Africa and Equatorial Africa, Journal of Climate, vol. 16, No. 5, Pg. 1015- 1030*
- xxvii. *Zakari, S.S, et al (2014): Impacts of climate change on yam production in Abuja, Nigeria in Int'l Journal of Science, Environment and Technology*
- xxviii. *Ibe (2006)*
- xxix. *Ekpo and Asiquo (2012)*