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CLIMATE CHANGE AND FOOD CROP PRODUCTION IN IMO STATE NIGERIA: AN ANALYSIS OF 30 YEAR PERIOD

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ABSTRACT: The study was conducted in Imo State in South-eastern Nigeria where rain fed agriculture is widely practiced. People in the area are affected by the current global food security crisis due to their total dependence on rainfall for agricultural production. It assesses relationships existing between climate change and food crop production in the area. Rainfall variability was used as climatic indicator and 30 yrs rainfall data were analysed using time-series line graphs model. Interviews were conducted and questionnaire was also administered to farmers in the area with the intension of ascertaining their perception of effects of climate change on their crops. Pearson's Moment Coefficient of correlation was used in the Statistical analysis. The results show that (1) rainfall fluctuated moderately in the area with downward rainfall trends; (2) rainfall shift accounts for 0.03 percent variations in Cassava production and 1.19 percent variation in production of maize respectively in the last two (2) decades in the study area. That makes the correlation of rainfall with cassava and maize productions in the study area a very poor/weak one and a low one respectively. However, some other factors other than rainfall variability also, contributed to cause variations in the productive levels (decrease in production) particularly the arable crops in the state. Nonetheless, rainfall variability in Imo state is partially, responsible for the high variations recorded in the productivity and productivity efficiency for the major food crops under investigation. Recommendations were made to ensure increased productivity and sustainability for food security in the state.

Keyword: Climate Change, Rainfall Variation, Crop Yield, Food Insecurity, Imo State.

INTRODUCTION

Evidence on global climate change indicates that African countries may yet face another major emerging environmental and development challenge (Obasi, 2003). Reduced and uncertain levels of rainfall, extreme climatic events, inappropriate land tenure and land use and the uses of obsolete technologies further exacerbate the problems. These issues are even more critical when viewed in the light of the need for countries to achieve their overall food security and sustainable development goals. Agriculture is a primary activity that depends on natural conditions that include precipitation and water supply, soil, wind, altitude, angle of slope and aspect (Waugh, 1995; in Landan, 2014). Rainfall is one of the most important natural resources for many African nations (Hulme, 1992). However, in the last three decades, significant changes in temperature, precipitation and sunshine, driven by climate change have significantly affected global agriculture. But while the more developed countries have the requisite skills, technologies and political will, to mitigate or adapt to the changing climate, the less (LDCs) developed countries including Nigeria lack the strong mitigation and adaptation strategies, hence they stand the highest risk of exposure to the consequences of climate change.

In Imo state of Nigeria, issues pertaining to climate change are not new. Even in localities where most of the inhabitants have low level education, knowledge of the meaning, causes and solutions to climate change exist. Studies by Okoroh, Olaolu and Igbokwe (2016) and Chikezie et al (2016) show that majority of Imo farmers, are aware of climate change and its manifestations on their crop yields. This awareness is influenced highly by the farmers' level of education and farming experiences. The majority of the farmers (visited in the course of this review) attributed long sunshine hours, late arrival of rains, prolonged dryness, incessant flooding, and low yields to "signs of end time".

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); Ladan (2014); Emeruvbe and Yusuf (2012). Most of the researchers however, focused on the trends of rainfall and temperature variations, and perceptions of people on climate change. In spite of all the similar or related studies, including that of Zakari et al (2014), Ezekiel et al (2014) and Adewuyi *et al.* (2014) on the specific investigation of climatic impacts on yam and cassava in Abuja, Osun and Oyo states of Nigeria respectively, the implications of climate on food crops in Imo state seem not to have been investigated.

However, there is evidence of global food security crises in Imo state since food production has not over the years kept pace with growing population in the area. The decrease in food production and supply in the state is therefore, attributed to effects of climate change among other factors. This study is aimed at assessing the relationships between climate change and crop production in Imo state using rainfall as climatic indicator, hence, climate change has manifested as rainfall variability in sub-Saharan Africa (Nnaji, 2009).

Description of the Study Area

Imo State is one of the 36 states of Nigeria and it lies within latitudes $4^0 45'$N and $7^0 15'$N; and longitudes $6^0 50'$E and $7^0 25'$E with an area of 5,288km^2 against 923,769km^2 of the country's total land area (Wikipedia, 2017; and NBS, 2012). Imo state is one of the oil producing states of Nigeria and is divided into twenty seven (27) local government areas (LGAs), (Figure 1), with Owerri, Orlu and Okigwe as its geo-political zones. The administrative capital is Owerri.

The 2006 national census puts the state's population at 3,927,563 against 140,431,790 of the country's total population (NPC, 2006 in NBS, 2012). The same source puts the state and country's 2011 projected population at 4,609,038 and 164,728,579 respectively.

Currently, Imo state population is estimated at 3,934,899 (oasdom.com), while Nigeria is 199,906,931 according to United Nation's latest estimates of 20 April, 2019.

The state is bordered by Abia state on the east, River Niger and Delta State on the west, Anambara state on the north and Rivers State on the south. Imo state is criss-crossed by many rivers and streams. Chief among them are Rivers Niger which seprates the state from Delta State, Imo River and Otamiri river. Notable creek is the Onas Creek in Ohaji/Egbema.

The area lies within the tropical monsoon (AM) based on Koppen's Classification of Climate. Mean annual rainfall ranges from 2250mm to 2500mm. The mean monthly temperature of the area ranges from 28^0C to 35^0C, while the mean monthly minimum air temperature ranges between 19^0C and 24^0C (Duru and Chibo, 2014). The rainy season begins fully in April and lasts until October. The annual temperature above 20^0C (68^0F) creates an annual relative humidity of 75 percent. This reaches 90 percent in the rainy season. The dry season experiences two months of harmattan (from December – Late Febuary). The hottest days fall between January and March. Many communities, especially in the, Southern part of the state are lowland areas – hardly rising above 20m above sea level.

The state is endowed richly with natural resources including crude oil, natural gas, lead, zinc, white clay, sand and limestone. Economic tree include Iroko, Oil palm, Obeche, Mahogany, Bamboo, Rubber and Mango, Orange, Banana and Plantain. Large proportion of Imo population engages in farming and fishing. Notable food crops include cassava, yam, maize, cocoyam, melon and rice.

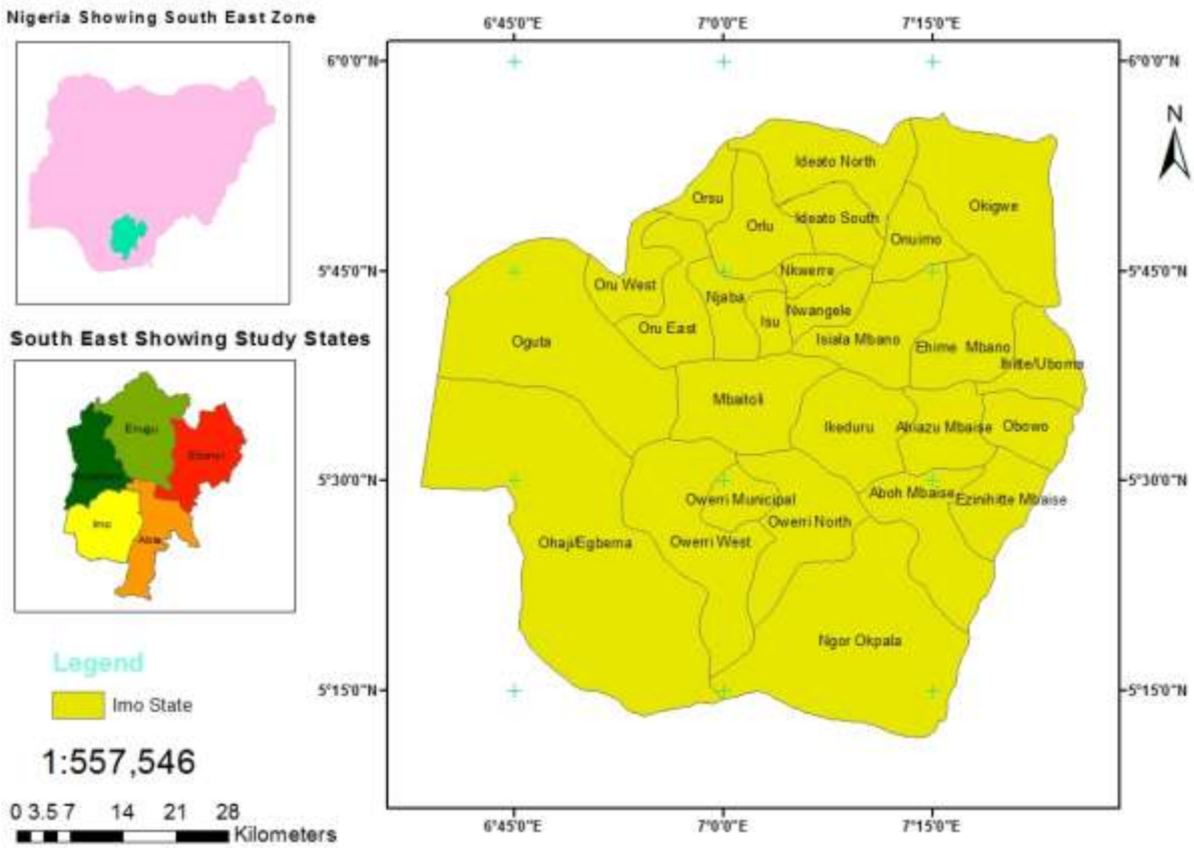

Figure 1: Map of the Study Area; Imo State, Nigeria

Materials and Methods

Primary data sources for the study include personal interview for selected farmers and 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 Ideato-South, Isiala-Mbano, Ohaji/Egbema, Okigwe and Orlu. Ten (10) farmers were interviewed in all by selecting two (2) from each of the five (5) selected Local Government Areas. Fifty (50) copies of questionnaire were distributed and administered, giving ten (10) copies each to selected farmers in the five (5) selected LGAs. Also, secondary data on mean monthly rainfall for the state over 30 years (from 1988 to 2017), and 20 years (from 1998 to 2017) and available annual crop yield data for maize and cassava were acquired from Nigeria Meteorological Agency (NIMET), Owerri and Agricultural Development Project (ADP), Owerri offices respectively. Rainfall data as shown on Table 1 were analyzed using time-series line graphs model to determine 'mean monthly', 'mean annual' and 'decadal mean' rainfall variability in the state within the 30 year climatic period. Also the rainfall and crop yield (on Tables 1and 2) were further analyzed statistically for two decades (from 1989 to 2017) using Pearson's Moment of Correlation Coefficient in order to determine their association.

Table 1: Imo State Mean Monthly Rainfall (mm) for 30 years (1988 – 2017)

S/N	Year	Jan	Feb	Mar	Apr	May	Jun	JUL	Aug	Sep	Oct	Nov	Dec
1	1988	10.9	12.2	172.2	187.6	220.6	428.6	327.1	278.9	446.1	392.7	34.4	52.4
2	1989	0	0	86.4	225.6	304.3	469.5	321.6	431.6	316.6	360.8	26	39.1
3	1990	9.8	10	7.1	213.2	185.2	256.9	650.1	641	571.1	273.3	119.7	23.9
4	1991	Trace	42.5	107.1	182.6	245.2	498.3	402.9	521.1	193.9	349.8	24	0
5	1992	0.9	2.8	157.5	216.8	248.1	373	489.9	289.4	333.7	214.9	79.5	17.6
6	1993	0.0	58.7	90.2	177.8	291.0	293.9	464.3	315.5	218.8	176.6	73.7	22.3
7	1994	37.1	34.3	45.9	99.6	298.8	185.9	468.0	438.2	622.2	284.3	111.7	0.0
8	1995	59.6	12.5	72.2	115.9	361.5	339.2	484.0	381.6	460.9	292.4	26.7	15.8
9	1996	21.1	74.6	68.7	238.4	252.7	395.3	350.0	502.0	573.2	228.0	1.5	Trace
10	1997	31.7	0.0	215.1	309.8	542.7	504.8	311.9	304.3	242.5	262.5	137.4	28.7
11	1998	14.6	0.0	48.7	130.5	253.7	289.4	288.9	168.5	254.2	179.2	12.4	0.0
12	1999	49.1	73.9	118.7	161.5	256.7	218.3	270.5	302.7	609.0	354.5	100.5	0.0
13	2000	39.1	0.0	53.2	354.2	47.3	391.8	382.7	356.4	344.0	246.5	116.5	5.5
14	2001	5.5	62.0	206.4	172.2	140.8	385.4	301.7	348.7	430.8	213.4	22.6	14.8
15	2002	27.9	90.4	241.7	265.6	198.3	391.5	131.5	293.5	372.4	40.9	0.0	0.0
16	2003	92.6	136.9	73.3	278.1	277.4	439.5	379.2	476.4	123.8	50.6	xxx	0.0
17	2004	73.5	32.4	173.3	163.1	225.2	240.4	185.4	309.1	322.9	37.0	0.0	0.0
18	2005	35.5	58.4	102.6	194.3	469.8	367.0	260.0	302.4	232.9	199.8	13.9	Trace
19	2006	89.8	1.8	167.9	81.9	358.2	454.7	625.5	286.7	479.4	360.6	302.6	0.0
20	2007	0.0	46.8	78.0	135.2	393.3	407.6	311.2	246.3	472.2	165.5	85.8	19.7
21	2008	0.0	23.2	86.6	240.3	309.6	280.9	580.4	377.2	300.7	244.9	26.4	0.0
22	2009	0.0	51.1	94.7	138.9	239.0	142.1	291.7	274.0	527.9	214.9	88.3	30.2
23	2010	33.0	36.0	36.2	125.5	382.0	207.7	86.1	318.4	382.2	398.8	108.6	0.0
24	2011	0.0	131.9	75.0	99.2	413.3	196.8	289.5	465.8	283.8	257.9	69.8	130.0
25	2012	0.0	90.9	55.3	187.4	306.1	518.5	516.0	367.7	493.9	211.8	86.2	0.0
26	2013	59.3	56.5	83.2	198.7	330.7	185.9	263.1	243.6	254.2	159.9	56.5	84.1
27	2014	2.5	0.0	157.0	102.7	308.2	142.3	288.7	173.8	432.7	236.2	163.1	17.7
28	2015	20.7	208.9	26.1	108.9	252.9	369.8	184.7	440.7	544.1	345.6	37.2	0.0
29	2016	0.0	0.0	266.6	129.3	277.8	324.9	265.1	308.3	312.8	273.4	4.5	4.1
30	2017	36.0	0.2	155.2	91.6	167.5	313.5	201.2	367.7	550.6	164.9	8.7	3.4

Source: NIMET Owerri, Imo State

Table 2: Annual yield of Maize and Cassava /HA, (000) M/Tone for 20 years (1998-2017) in Imo State

S/N	Year	Maize Yield	Cassava Yield
1	1998	3.20	7.90
2	1999	2.17	13.58
3	2000	2.14	13.24
4	2001	2.15	12.99
5	2002	2.21	13.90
6	2003	2.07	13.76
7	2004	2.21	14.02
8	2005	2.40	16.21
9	2006	2.32	14.87
10	2007	2.16	14.99
11	2008	1.31	14.94
12	2009	1.35	14.91
13	2010	1.35	15.08
14	2011	1.43	15.07
15	2012	1.80	14.47
16	2013	2.39	15.60
17	2014	2.40	15.65
18	2015	2.50	15.85
19	2016	3.05	15.90
20	2017	3.05	15.75

Source: ADP Oweeri, Imo State

RESULTS

Interview Reports

From the results of this study, the farmers were of the opinion that rainfall has a good correlation with both maize and cassava crops. Maize and cassava are water retentive crops that require sufficient rainfall to grow from early stage to maturity. Results also show that rainfall variability affects maize more than cassava because cassava can resist the trends to a larger extent. According to the farmers, maize crop is always affected by rainfall deficit, and excessive rainfall associated with severe storm can also affect maize crops before maturity and cropping stages especially the older species that normally grow taller. While cassava crops can only be affected by serious dry spell, the crop can resist rainfall anomaly to a lager extent. Therefore, it requires sufficient rainfall even excessive rainfall from early stage to maturity, and also withstand rainfall deficit.

The farmers also reported alterations in the onsets of rainfall which put them into confusion on when to begin planting of their crops as well as the cessations of the rain which also affects their harvest. Plates 1 and 2 show the researcher's interview with farmers in the fields.

Furthermore, they reported about changes in bimodal rainfall pattern with shifts in little dry season from what it used to be in the past.

The farmers emphasized that the unstable weather patterns, rainfall variability particularly, are seriously affecting their productivity, bringing about uncertainty in production and most times production decrease or crop failure, which in turn affects prices of the commodities in the markets. This invariably leads to food security crisis that in turn affects the socioeconomic well-being of the people in the area under study.

Plate1: Interviewing Mrs Akaeme of Ogboko in Ideato South LGA of Imo State during her maize cropping

Plate 2: Interview with Mr Sylvester Ebere Ngharam of Isiala Ogberuru in Orlu LGA, Imo State

Responses from Questionnaire

All the fifty (50) copies of the questionnaire distributed were retrieved from the respondents. Copies of the questionnaire was strictly administered and monitored in order to recover all since number of copies were not too many. All questions to the respondents in the questionnaire apart from personal data information were based on the farmer's perception of the relationships between rainfall and crops (especially maize and cassava) in the area, as highlighted and analyzed in the figures 2-6.

Respondent's Farming Experience: The diverse levels of experience of respondents in number of years farming are indicated in figure 2.

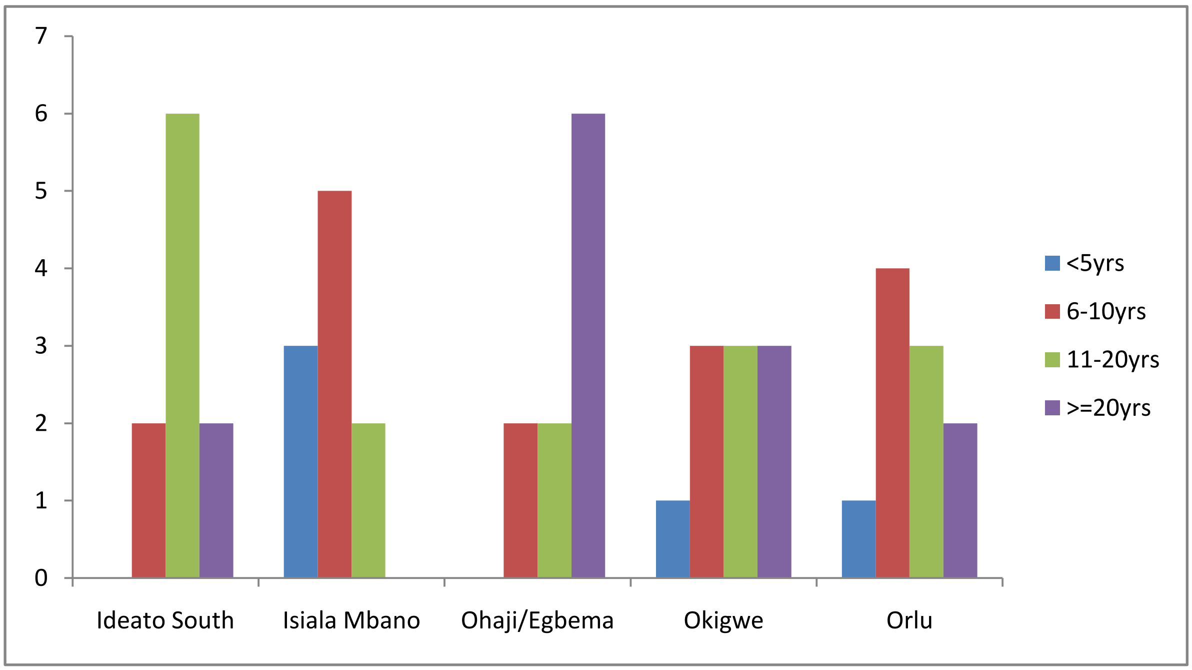

Figure 2: Years of farming experience of the respondents

Source: authors' field work (2019)

Figure 2 shows farming experiences of the respondents in Imo state. Farmers with less than five years faming experience were identified in Orlu and and Okigwe local government areas of the state, while respondents with more than twenty years of faming experience were identified in Ideato south and Ohaji/Egbema local government areas of the state.

Observed Changes in Rainfall

Changes perceived to have occurred in rainfall are shown in Figure 3.

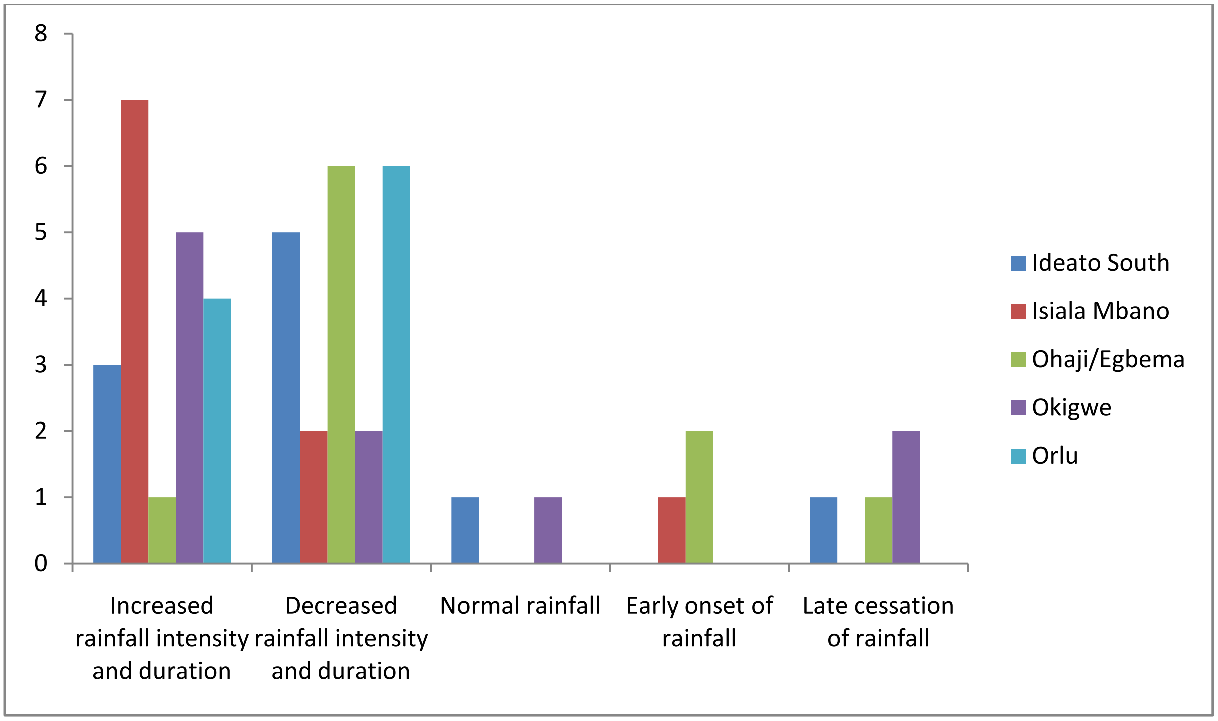

Fig 3: Identified observed changes in rainfall

Source: Authors' field work (2019)

To identify the observed changes in rainfall in the state, figure 3 above shows that many respondents indicated that they have observed increased in rainfall intensity and duration. Also, large number of respondents indicated that they observed decreased rainfall intensity and duration, and only few respondents indicated that they have observed normal rainfall condition in the state. This shows that changes in rainfall are observed mainly in the increase and decrease other than normal rainfall and early onset and late cessation.

Rainfall Variability as a Cause of Crop Failure

The farmers' perception of the role of rainfall variability in the causation of crop failure is shown in Figure 4.

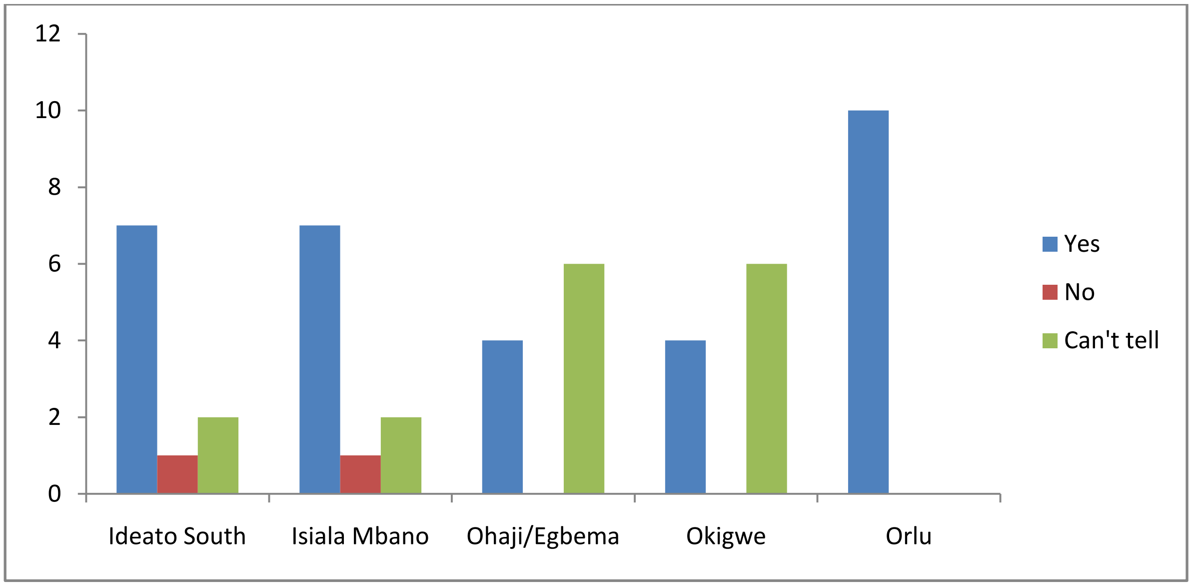

Fig 4: Has rainfall variability caused crop failure in your area?

From Figure 4 above, seven respondents in Ideato south and Isiala Mbano respectively indicated that rainfall variability has caused crop failure in their areas and, one respondent to the contrary, while two other respondents indicated they cannot tell respectively. In Ohaji/Egbema and Okigwe respectively, four respondents indicated yes and six respondents indicated they cannot tell respectively. In Orlu LGA, all ten respondents indicated yes, meaning that they agreed that rainfall variability has caused crop failure in the area.

Crop Failure Effects

Responses of the farmers on crop failure effects on socioeconomic wellbeing as figure 5.

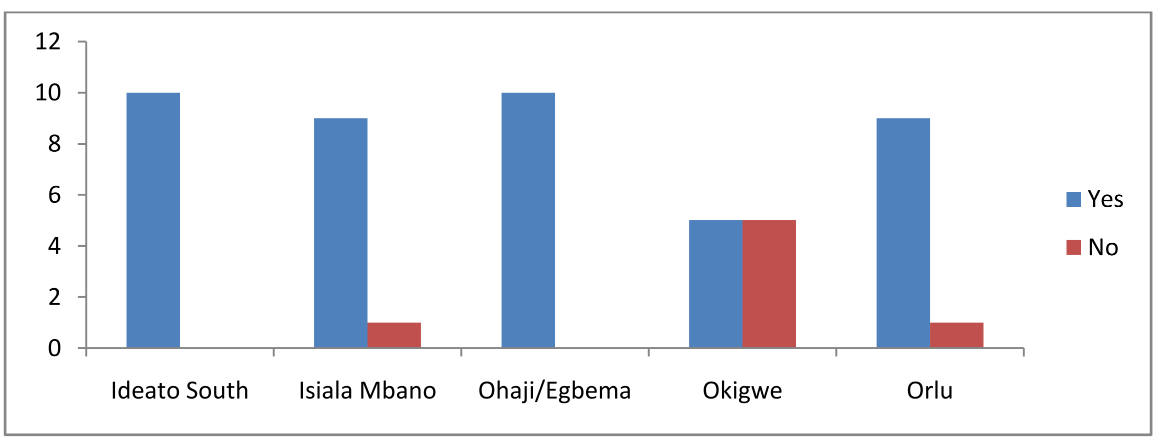

Figure 5: Crop failure effects on socioeconomic wellbeing

Figure 5 above therefore, shows that in Ideato south and Ohaji/Egbema respectively, all respondents indicated yes; that crop failure due to rainfall variability and other factors in their areas is affecting their socioeconomic wellbeing. In Isiala Mbano and Orlu respectively, nine out of ten respondents indicated yes and the other respondent indicated no respectively. In Okigwe LGA, five respondents indicated yes while the other five respondents indicated no. Generally, forty seven respondents indicated that their socioeconomic well being are affected by failure of crops in the state, while only seven respondents indicated they are not affected socioeconomically due to crop failure.

Adjustments made to minimize Risk of Crop failure:

Adjustments made to minimize risk of crop failure are varied and are shown in figure 6.

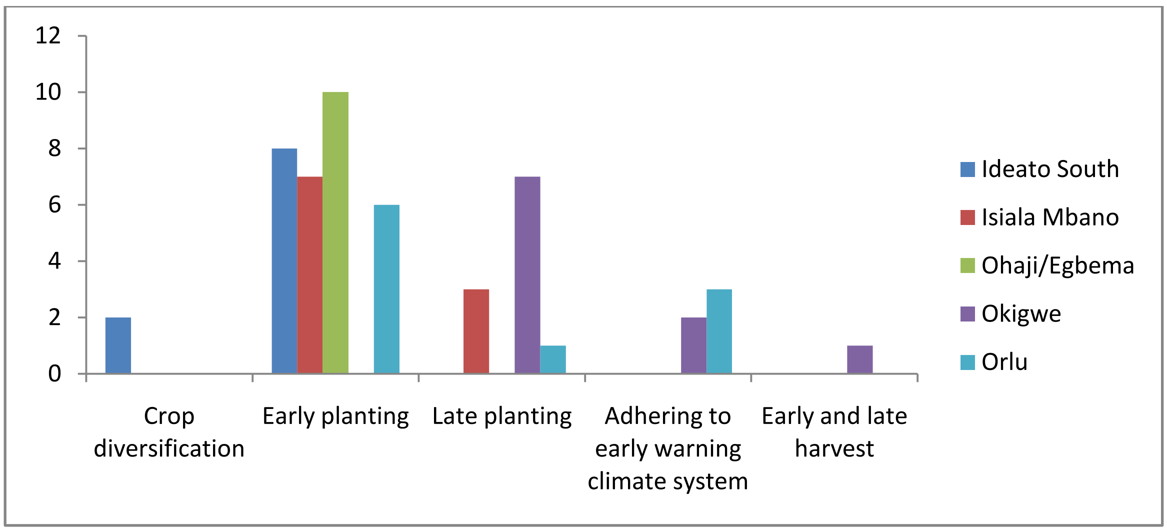

Figure 6: Adjustments made to minimize the risk of crop failure

Source: Author's field work (2019)

Concerning adjustments farmers made for minimizing the risk of crop failure, two respondents from Ideato south indicated crop diversification and eight respondents indicated early planting of crops (fig. 6). In Isiala Mbano, seven respondents indicated they prefer early planting of crops and three other respondents indicated they prefer late planting of crops. In Ohaji/Egbema, all the ten respondents indicated they prefer early planting of crops, while in Okigwe, seven respondents indicated late planting, two respondents indicated adhering to early warning climate system and one respondent indicated early and late harvest. In Orlu LGA, six respondents prefer early planting of crops, one respondent prefer late planting while three respondents prefer adhering to early warning climate system.

Time Series Rainfall Analysis using Line Graph Model

(i). Mean Monthly Rainfall: The mean monthly rainfall for the period is shown in Figure 7.

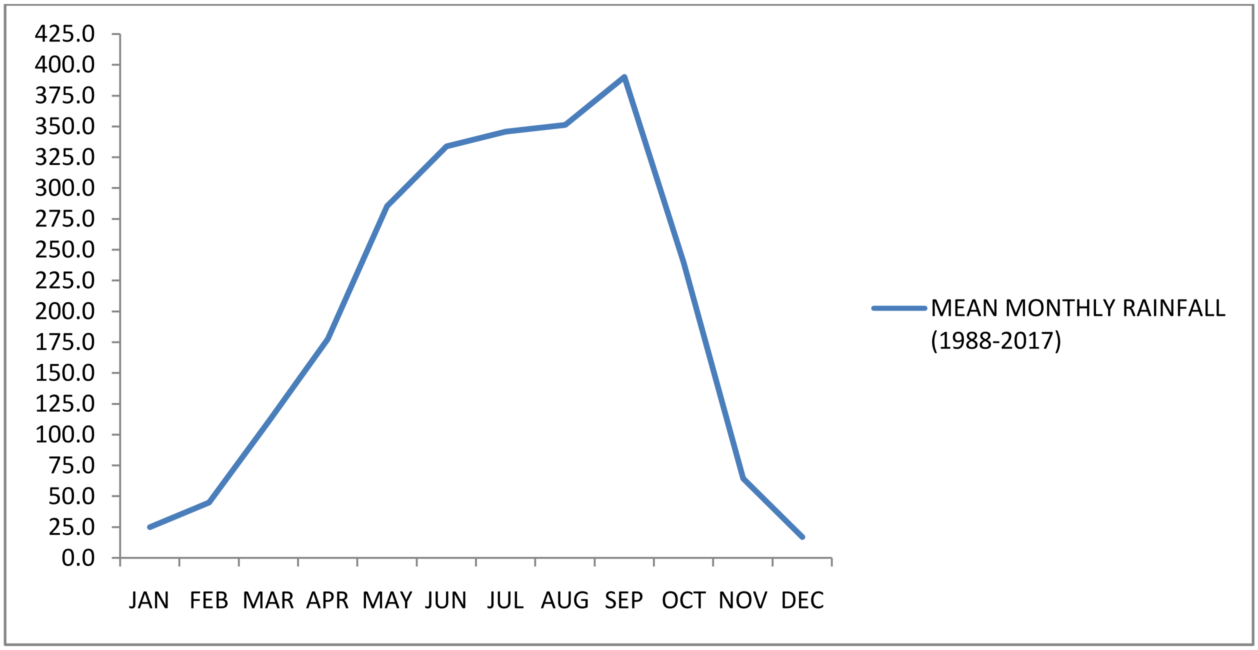

Fig. 7: Mean monthly rainfall from 1988-2017

Source: Author's field work (2019)

Imo is a high rainfall state like others within Southeast Nigeria. There was high variability in mean monthly rainfall in the state with high rainfall intensity also throughout the study period. The rainfall was steadily high and increasing from January to September and decreased in October. There was abnormal rainfall regime in the state since there was no August break and no bimodal rainfall pattern.

(ii). Mean Annual Rainfall: The mean annual rainfall is as shown in Figure 8.

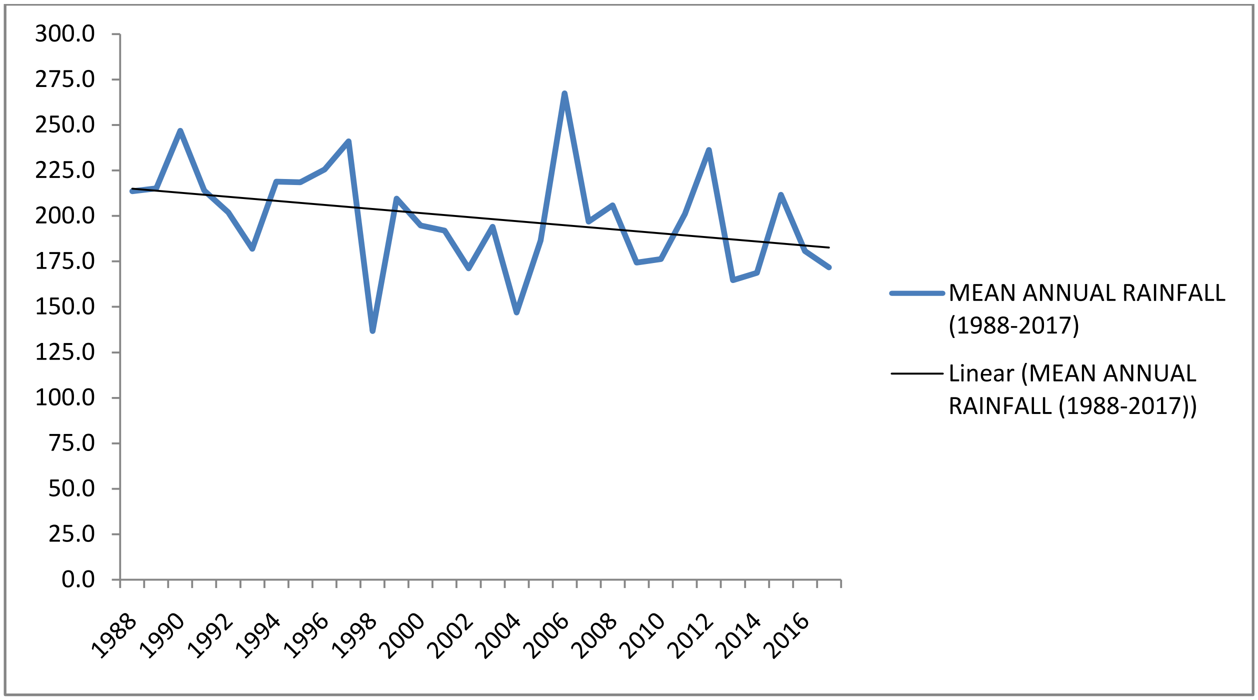

Figure 8: Mean annual rainfall from 1988-2017

The mean rainfall values for each of the thirty years were plotted in one line graph for the state, and from the graph (Fig. 8) the state shows high and dramatic variability in mean annual rainfall during the period under investigation.

Minimum mean annual was recorded in 1998 with 136.7mm value, and the maximum occurred in 2006 with mean value of 267.4mm. However, rainfall generally shows downward trend within the 30 year climatic period following the trend line (see figure 8). That means general decrease in rainfall was observed in the state during the year under review.

(iii). Decadal mean annual rainfall: The decadal mean annual rainfall covering 10 year period within the study period is shown in Figures 9, 10 and 11.

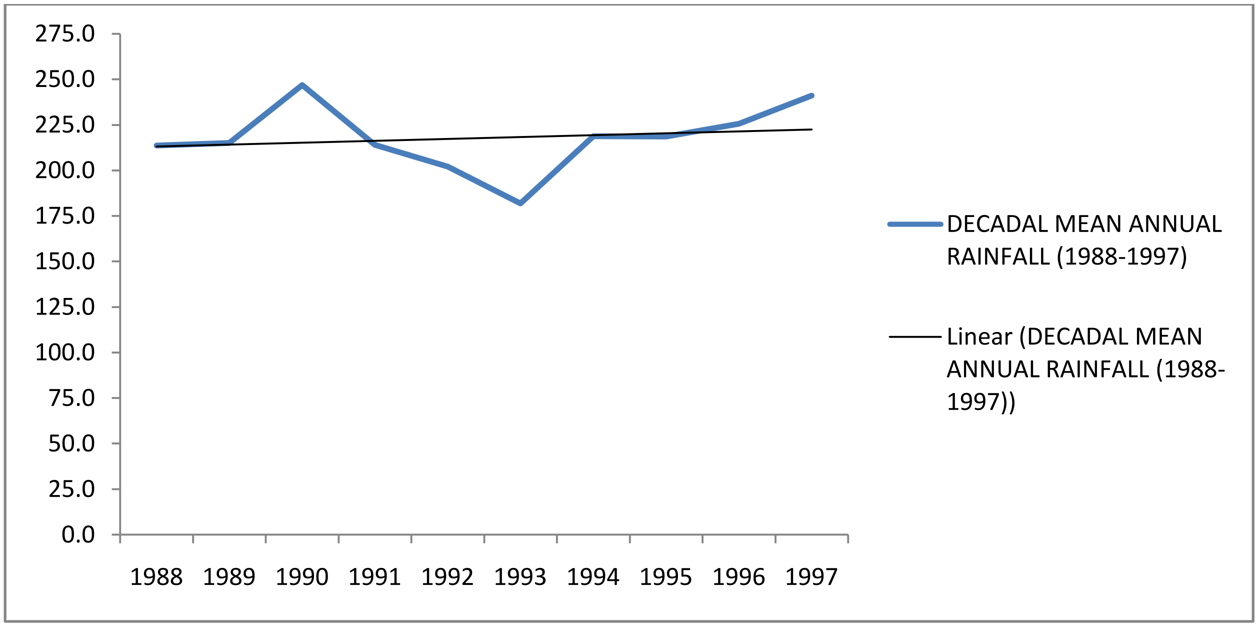

Fig.9: Decadal mean annual rainfall for D1 (1988-1997)

Source: Authors' field work (2019)

On the decadal level, the mean annual rainfall in Imo State for the first decade 1988-1997 shows high variability from the lowest mean of 181.9mm in 1993 to the highest mean of 246.8mm in 1990. Next low rainfall of 202mm occurred in 1992, followed by 213.6mm in 1988, then 214mm in 1991 and 215.1mm in 1989. Next to the highest mean rainfall was 241mm, which occurred in the last year of the decade 1997, followed by 225.5mm in 1996, and then 218.8mm and 218.5mm in 1994 and 1995 respectively. In this decade however, rainfall variability trend was slightly insignificant upward, following the trend line in the graph (Figure 9).

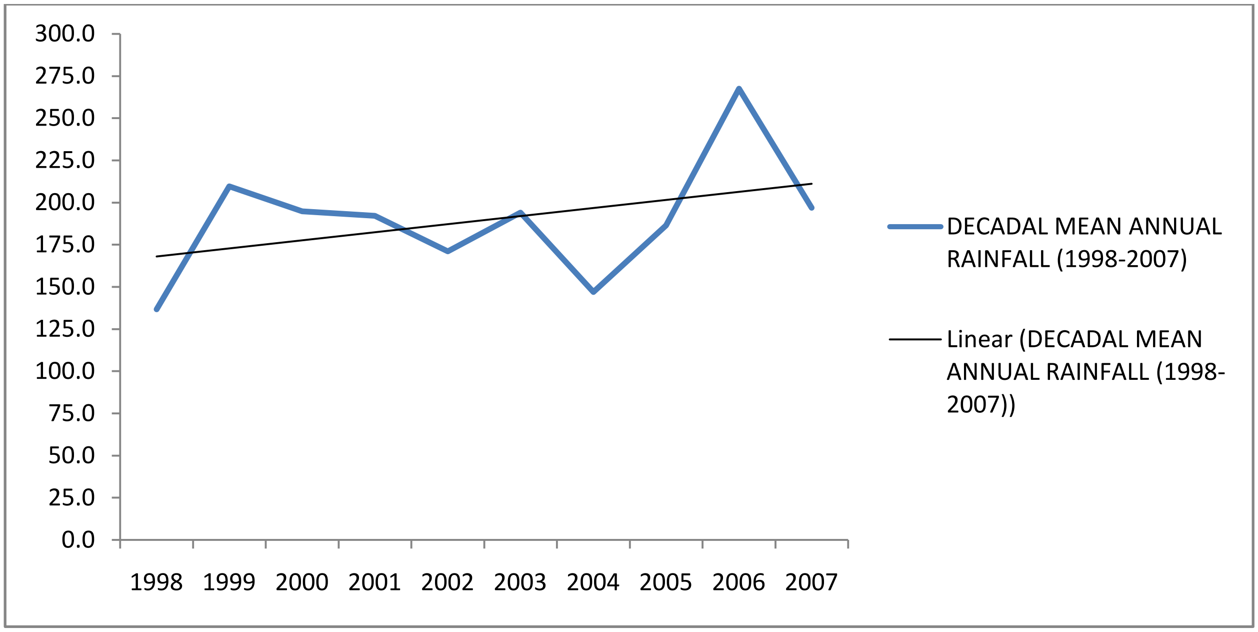

Fig. 10: Decadal mean annual rainfall for D2 (1998-2007)

Source: Author's field work (2019)

The line graph on Figure 10, also indicate continuous and high variability in mean annual rainfall for Decade II (1998-2007) in the state. The minimum mean value of 136.7mm in 1998 and the maximum mean value of 267.4mm in 2006 were the lowest and highest mean values respectively throughout the three decades. This decade therefore shows an interesting variability in the series. Second maximum mean value of 209.6mm occurred in 1999, followed by 196.8mm in 2007, and then 194.8mm and 194mm in 2000 and 2003 respectively. While the second minimum was 146.9mm in 2004 and followed by 171.1mm in 2002 and 186.4mm in 2005 and finally 192mm in 2001. However, rainfall trend was generally upward throughout the decade, following the trend line in the graph (Figure 10).

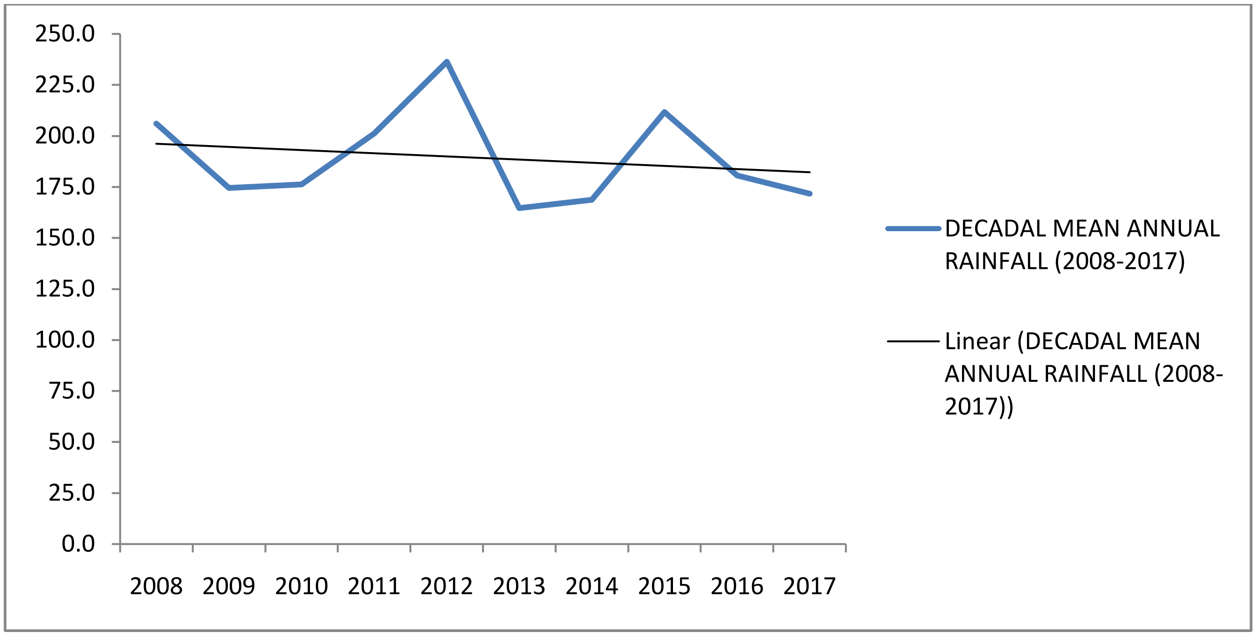

Fig.11: Decadal mean annual rainfall for D3 (2008-2017)

Source: Author's field work (2019)

In the third (last) decade, (2008-2017) the high variability in mean annual rainfall continued dramatically as evidence of climatic drama in the state in relation to entire Southeast Nigeria. The highest mean rainfall occurred in the middle of the decade (2012) with value of 236.2mm and followed by year 2015 with mean value of 211.6mm. Next in the series occurred in 2008 with mean value of 205.9mm and next 2011 with 201.1mm and finally in 2016 with mean value of 180.6mm. The lowest mean value occurred in 2013 at 164.6mm, followed by 2014 at 168.7mm, then in 2017 at 171.7mm and 2009 at 174.4mm and finally in 2010 at 176.2mm. In this decade, rainfall variability trend was significantly downward, which took care of the previous decades making the variability for the 30 year study period generally downward (see Figure 7).

Correlation of Climatic Element (rainfall) with Crop Yields in Imo State: 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
3786.7	42.6	294.4	733411.8	95.4	4350.1	8035.5	55749.6

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

This is given as:

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

where n = 20 (number of years)

R = Rainfall (mm)

C = Cassava yield (in metric tonnes)

$$\text{Therefore} \quad rRC = \frac{20 \text{ x } 55749.6 - 3786.7 \text{ x } 294.4}{\sqrt{(20 \text{ x } 733411.8 - 3786.7^2)(20 \text{ x } 4350.1 - 294.4^2)}}$$

$$= 0.0180$$

The correlation coefficient of rainfall with cassava yield is 0.0180. This shows a poor/weak positive relationship between cassava yield and rainfall variation in Imo state.

The percentage contribution of rainfall variation to cassava production in the last two (2) decades is calculated as follows;

Coefficient Determinant = 100 r^2

100 x 0.018^2 = 0.0324 = 0.03%

Coefficient Residual = 100 $(1-r^2)$

100 x $(1- 0.018^2)$ = 99.9676 = 99.97%

The result of the correlation coefficient determination shows that only about 0.03% of the variation in cassava yield can be attributed to rainfall variation.

Possible factors which account for the residual of 99.97 percent include access to inorganic fertilizer, access to farm machines, extension services, temperature variability and pest effects.

These aforementioned factors affect cassava yield/production more than rainfall variability in Imo state.

b. Correlation of Rainfall (R) with Maize (M)

This is also, given as:

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

where n = 20 (number of years)

R = Rainfall (mm)

M = Maize yield (in metric tonnes)

$$\text{Therefore } rRM = \frac{20 \text{ x } 8035.5 - 3786.7 \text{ x } 42.6}{\sqrt{(20 \text{ x } 733411.8 - 3786.7^2)(20 \text{ x } 95.4 - 42.6^2)}}$$

$$= -0.1089$$

The correlation coefficient of rainfall with maize yield is -0.1089, indicating a low negative association of rainfall variation with maize yield in Imo State. We further calculate the percentage contribution of rainfall variation to maize yield in the last 2 decades as follows;

Coefficient Determinant = 100 r^2

100 x $(-0.1089)^2$

= 1.19%

Coefficient Residual = 100 $(1-(-0.1089)^2)$

= 98.81%

The results show that rainfall variation contributes only 1.19 percent of the variation in maize yield in Imo State. Other climatic elements such as wind, temperature and humidity combine with edaphic, biological and socio-economic factors to account for 98.81 percent.

Nevertheless, rainfall variation in Imo State is partially responsible for the variations recorded in maize yields.

DISCUSSION

Changes observed in rainfall over 30 year period of the study is an evidence of climate change in the area. The study therefore, confirms that climate change exists in Imo State of Southeast Nigeria. This result supports report by Nnaji (2009), which stated that climate 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 is in line with results of previous studies by Zakari et al (2014); Adewuyi et al (2014); Okorie (2015); Duru and Chibo (2014); Landan (2014); Emeruvbe and Yusuf (2012), which indicated that climate change is a reality in Nigeria. Similarly, the indications of respondents, that crop failure in the area is partly due to rainfall variability, and the correlation results which show about 1.19 percent and 0.03 percent rainfall variation contribution on maize and cassava, respectively, support studies by Okoroh, Oluola and Igbkwe (2016), and Chikezie et al (2016) which stated that majority of Imo farmers are aware of climate change and its manifestations on their crops.

Conclusion

Food shortage and food insecurity in sub-Saharan Africa are linked to poor agricultural performance, accounted for by climate change and other factors. According to estimates, ninety percent of Africa's poor live in rural areas, and seventy percent of Africa's population depends on agriculture as a primary source of employment and livelihood (Obasi, 2003). The study confirms manifestation of climate change in Imo state of Nigeria through rainfall variability. Food crop production is important in Imo State as over 50 per cent of the state population is involved in form of agriculture or the other. With mean annual rainfall ranging from 2250mm to 2500mm and mean monthly temperature ranging from 28^0C to 35^0C, the soil is suitable for variety of crops including yam, cassava, maize and rice, but maize and cassava are the key staple crops of the state.

However, from the results of the study, rainfall generally shows downward trend within the 30 year climatic period following the trend line. This means general decrease in rainfall was observed in the state during the year under review. This conforms to the farmer's perception, as 42% of the respondents, indicated that decreased rainfall has been observed in the area over time to compare with 40% of the respondents that indicated increased rainfall. Also, 64 percent of the farmers confirmed that climate change through rainfall variability has caused failure of their crops, while about 94 percent respondents indicated that their socioeconomic well being and livelihoods are affected by failure of crops in the state. Finally, about 80 percent of the farmers prefer early planting of crops as the best adjustment option to improve their productivity.

From the statistical analysis; correlation coefficient of rainfall with maize yield is -0.1089, indicating a low association with rainfall variation, contributing 1.19 percent of the variation in maize yield in the state in the last 20 years. Also, correlation coefficient of rainfall with cassava yield is 0.0180. This shows a poor/weak relationship contributing only about 0.03 percent of the variation in cassava yield in the state in the last 2 decades. Nevertheless, rainfall variation in Imo State is partially responsible for the variations recorded in maize and cassava yields but other combined factors account for more than 98 percent such as, wind, temperature, humidity, and access to inorganic fertilizer, access to farm machines, extension services, and pest effects, edaphic, biological and socio-economic factors.

Recommendations

1. Awareness and education needed. The farmers, stakeholders in agric sectors and the general public need more and regular education about the climate change rainfall variability temperature 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 indicated by the farmers 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.

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