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Assessment of drought occurrences and its implications on agriculture in Niger State, Nigeria

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General Note
Article is recommended to print as color version in recycled paper. *Save Trees, Save Nature*.

ABSTRACT

The study analyses the extent of drought events and its consequences on agriculture. This is to integrate drought adaptation options into government development plans. Strategies for drought adaptation options in the study area have often been made without experimental foundations placed on the extent of drought and its implications on agriculture. To achieve this, a climatic index (CI) analysis of rainfall was employed to ascertain the extent of drought occurrences using standard deviation as a tool for rationalization. The study also used crop yield to test the relationship between the yield and rainfall characteristics for thirty years (1988-2017). Rainfall data and crop yield (soybean, maize, and groundnut) were collected. The data collected were analysed using statistical and climatic index analyses. The results show that there were various degrees of drought that occurred (from mild drought to severe droughts). Moreover, the regression analysis shows that F-values > p-values. Consequently, the occurrences of drought impact negatively on agricultural output, which undermines food security. Based on the findings, recommendations were made to mainstream the adaptation options.

Keywords: Agriculture, Climatic Index, Drought occurrences, Rainfall characteristics, Rainfall Deviation

1. INTRODUCTION

Agriculture plays important roles in promoting economic growth and enhancing food security (World Bank, 2008). Agriculture can be a source of economic growth at the local and national level. It is also a provider of investment opportunities for the private sector and agriculture-related industries. The agricultural sector accounts for a large share of national income, employment, and foreign trade in Africa. Despite the role of agriculture in Africa, it has not helped significantly to reduce poverty or to alleviate hunger and malnutrition. Therefore, to achieve higher rates of agricultural growth, crop productivity needs to improve significantly (World Bank, 2008). However, scientific literature has been established empirically that in spite of recent technological advances, farmers in Africa still depend heavily on rain-fed agriculture (Ndamani and Watanabe, 2015; Tiamiyu et al., 2015; Ezihe et al., 2017; Eze et al., 2018a). Thus, environmental factors, particularly, the climate is still the most important variable in crop production. Climate affects agriculture and determines the adequacy of food supplies in two major ways. One is through climatic hazards (drought, flood) to crops and the other is through the control exercised by the environment on the type of crops feasible or viable in a given area (Jones and Thornton, 2003; Shi et al., 2013; Eze, 2018). Thus, climatic parameters (rainfall, temperature, relative, and humidity) have an influence on all stages of agricultural production chain including land preparation, sowing, crop growth and management, harvesting, storage, transport, and marketing (Ayinde et al., 2011; Popova et al., 2014). Rainfall is undoubtedly one of the most important climatic variables. It has far-reaching influences in agricultural production. The crucial role rainfall plays in crop production includes the supply of moisture to the soil to activate plant growth, the replenishment of water in rivers to make irrigation possible through seepage and percolation, and building of underground water resources which are later tapped by wells in drier areas (Tiamiyu et al., 2018). The amount, incidences, variations and reliability of each of these roles rainfall plays go a long way towards explaining the differences in cropping patterns and livestock management practices in various ecological zones of Nigeria (Ayinde et al., 2011). Jones (2000) argue that climate change has a direct effect on crop yields and farm management and that variation in climatic parameters will have subsequent effects on the implementation of new economic policies and adaptation strategies. The most direct impact of climate change in Africa stems from growing water shortages or drought, leading to an increasing dependence on imported foodstuffs (Boubacar, 2010; Shittu et al., 2017; Eze, 2018). Moreover, the changing climatic conditions are likely to impose additional pressure on water availability, reducing the length of the growing season and forcing large regions of marginal agriculture out of production (IPCC, 2007). Moreover, there will be a 50% reduction in yields by 2020 and a 90% reduction in crop net revenues by 2100 in areas that are already classified as marginal in Africa (IPCC, 20007).

Many scholars have carried out research on the impacts of drought on agriculture in various parts of the world (Gadgil et al., 2002; Popova et al., 2014; van der Pol et al., 2015; Tiamiyu, et al., 2015; Jin et al., 2016; Kazemzadeh & Malekian, 2016; Ezihe et al., 2017; Shittu et al., 2017; Eze et al., 2018b; Eze, 2018). Most of the studies concentrated on the impact of rainfall variation on agriculture, health, water resources, causes and effects on the land, households and the extent of drought occurrences. However, none of the above studies focused on the extent of deviation of rainfall from normal and its implication on agriculture. Therefore, the knowledge of the relationship between agriculture and rainfall facilitates an understanding of the various interactions and inter-relations required in areas of agricultural management and production (Shi et al., 2013; Eze et al., 2018a). This is to explain the variations in the yield and possibly formulate a predictive model for forecasting the future yield of the crop given certain environmental parameters (Shi et al., 2013; Choudhury and Jones, 2014). The decline in the yield and production of Soybean in Nigeria has been a major problem of concern in recent years. Despite huge sums of money being spent on fertilizer, tractors and imported high-yielding grain hybrids, the problem still lingers on (Idoko and Sabo, 2014). This is because the real issue of environmental constraints against sustained agricultural production has not been adequately addressed. Moreover, Oladipo (1993) argues that the degree of impact of a particular drought on the environment and the extent to which it may affect agricultural production depend on the length of the period of the drought event. Moreover, Eze (2018) state that there is a need for appropriate techniques to be used to determine drought occurrence to reduce its impact on the environment. Libanda et al. (2019) also argue that understanding the patterns of drought is essential because it informs decision-making processes for possible adaptive measures. Against this background, the study fills the gap by assessing the extent of deviation of rainfall from the normal and its implications on agriculture in Niger State, Nigeria, using climatic Index (CI). This has much to offer in terms of farm-level policy decision making on Agricultural production.

2. MATERIALS AND METHODS

Data Collection

Rainfall data were obtained from the Nigerian Meteorological Agency, Abuja for Thirty years (1988-2017). Also, data on crop production (soybean, maize and groundnut) were collected from the Niger State Agricultural Development Project (NADP) for thirty years (1988-2017). Only 3 crops (soybean, maize and groundnut) were selected due to unavailability of complete data on other crops cultivated in the study area.

Data Analysis

Data collected were analysed using descriptive analysis (mean, standard deviation), statistical analysis (regression analysis) and climatic index. The analyses were carried out using Statistical Package for Social Sciences (SPSS) version 21 and Microsoft Excel. Rainfall data were analysed using the Climatic Index (CI). This index represents a quantitative expression of rainfall characteristics (Near-normal, Mild drought, mildly wet, Moderate drought, moderately wet, Severe drought, and Severe wetness) (Table 1) using standard deviation as a tool for rationalization. The climatic index can be expressed as shown in equation 1:

$$CI = \frac{Xi - \bar{X}}{\partial} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where Xi= Total rainfall of a particular year or period

$\bar{X}$ = mean annual rainfall for the station for the period under study

∂ = standard deviation

When the value of the climatic index (CI) is in the range as shown in Table 1, it indicates near-normal, mild, moderate and severe drought or wetness of the rainfall.

Table 1 Classes of Climatic Index values

Index	Characteristics of Rainfall
0.40 to -0.40	Near-normal
-0.41 to -0.80	Mild drought
0.41 to 0.80	Mildly wet
-0.81 to -1.20	Moderate drought
0.81 to 1.20	Moderately wet
< -1.20	Severe drought
> 1.20	Severe wetness

Source: Computed by the author

The regression analysis was employed to determine the degree of relationship between rainfall characteristics and crop production. Thus, the computation was carried out using linear regression as shown below.

$$Y = a + bX \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

Where X is the independent variable (rainfall amount) and Y is the dependent variable (crop production). The slope of the line is b and a is the intercept (the value of y when x = 0). To establish a conclusion, the hypothesis is posited, thus:

H_0: There is no significant relationship between rainfall characteristics and crop yield, at 0.05 significant levels

H_1: There is a significant relationship between rainfall characteristics and crop yield at 0.05 significant levels

3. RESULTS

Rainfall Variations

The rainfall data collected for the period under study (1988-2017), indicate that the total annual rainfall in the study area varies from year to year and from place to place. The highest amount of rainfall was recorded in Badeggi (1523mm) in 2009, Kainji (1350mm) in

1998, and Minna (1532.7mm) in 1998, (Table 2). On the other hand, the lowest amount of rainfall was recorded in Badeggi (899.7mm) in 2013, Kainji (753) in 1992, and Minna (1049.5mm) in 2013 (Table 2). On the other hand, the highest amount of rainfall within the period of study (30 years) occurred in Minna, in the year 1998 with a total annual rainfall of 1532.7mm and the lowest occurred in Kainji, in the year 1992 with a total annual rainfall of 753mm.

Table 2 Total Rainfall amount and Climatic Index (CI) and its Characteristics in the Study Area

Year	Badeggi Rainfall (mm)	CI	Rainfall Character	Kainji Rainfall (mm)	CI	Rainfall Character	Minna Rainfall (mm)	CI	Rainfall Character
1988	1170.9	-0.17	N-normal	1059	-0.54	Mild-drought	1302	0.54	Mild-wet
1989	1152.9	-0.29	N-normal	1179	0.32	N-normal	1181.5	-0.53	Mild-drought
1990	1239.26	0.27	N-normal	1181	0.34	N-normal	1109.5	-1.17	Mod-drought
1991	1394.5	1.26	Severe-wet	1285	1.08	Mod-wet	1316.7	0.67	Mild-wet
1992	968.2	-1.47	Severe-drought	753	-2.72	Severe-drought	1241.9	0.00	N-normal
1993	1407.1	1.34	Severe-wet	1016	-0.84	Mod-drought	1069.4	-1.53	Severe-drought
1994	1193.7	-0.03	N-normal	1228	0.67	Mild-wet	1482.3	2.14	Severe-wet
1995	1123.8	-0.47	Mild-drought	1098	-0.26	N-normal	1279.3	0.33	N-normal
1996	1192.7	-0.03	N-normal	823	-2.22	Severe-drought	1274.3	0.29	N-normal
1997	1432.3	1.50	Mild-wet	1117	-0.12	N-normal	1245.1	0.03	N-normal
1998	1030.9	-1.07	Mod-drought	1350	1.54	Severe-wet	1532.7	2.59	Severe-wet
1999	1200.4	0.02	N-normal	1295	1.15	Mod-wet	1249.5	0.07	N-normal
2000	1238.6	0.26	N-normal	975	-1.14	Mod-drought	1274.5	0.29	N-normal
2001	1292.4	0.61	Mild-wet	1267	0.95	Mod-wet	1233	-0.08	N-normal
2002	1051.1	-0.94	Mod-drought	1286	1.09	Mod-wet	1294	0.47	Mild-wet
2003	1088.2	-0.70	Mild-drought	1288	1.10	Mod-wet	1314	0.64	Mild-wet
2004	1181.4	-0.10	N-normal	1121	-0.09	N-normal	1162.5	-0.70	Mild-drought
2005	1207.1	0.06	N-normal	1185	0.36	N-normal	1216.7	-0.22	N-normal
2006	1131.6	-0.42	Mild-drought	1053	-0.58	Mild-drought	1141.9	-0.89	Mod-drought
2007	1296.7	0.63	Mild-wet	1116	-0.13	N-normal	1169.4	-0.64	Mild-drought
2008	1340.4	0.91	Mod-wet	1248	0.81	Mod-wet	1282.3	0.36	N-normal
2009	1523	2.08	Severe-wet	1198	0.46	Mild-wet	1379.3	1.22	Severe-wet
2010	1287.5	0.57	Mild-wet	1023	-0.79	Mild-drought	1254.3	0.11	N-normal
2011	1168.1	-0.19	N-normal	1127	-0.05	N-normal	1145.1	-0.86	Mod-drought
2012	1158.6	-0.25	N-normal	1310	1.26	Severe-wet	1232.7	-0.08	N-normal
2013	899.7	-1.91	Severe-drought	995.7	-0.99	Mod-drought	1049.5	-1.71	Severe-drought
2014	953.4	-1.56	Severe-drought	1075	-0.42	Mild-drought	1074.5	-1.49	Severe-drought
2015	1032.4	-1.06	Mod-drought	1067	-0.48	Mild-drought	1133	-0.97	Mod-drought
2016	1503.1	1.95	Severe-wet	1216	0.59	Mild-wet	1394	1.35	Severe-wet

2017	1073.4	-0.80	Mod-drought	1088	-0.33	N-normal	1214	-0.25	N-normal
Mean	1197.8			1134.1			1241.6		
STD	156.2			139.9			112.5		

Source: Computed by the author:

N-normal = near-normal; mild-wet = mild wetness; mod-wet = moderately wet; mod-drought = moderate drought; severe-wet = severe wetness; severe-dry = severe drought.

Computation of Climatic Index (CI)

The results of the climatic index for the study area are shown in Table 2. The CI for Badeggi station in 1988 = (1170.9– 1197.8)/ 156.2 = -0.17. The CI calculations for the rest of the stations per year followed the same procedure.

Drought events and other rainfall characteristics in the Study Area

The results on the Climatic Index (CI) analysis in the study area were presented in Table 2 for Badeggi, Kainji and Minna stations. The results show that the study area experienced near normal to severe dryness and also from near normal to severe wetness. In Badeggi, the area experienced 9 years of mild droughts (1988, 1989, 1994, 1995, 1996, 2004, 2006, 2011 and 2012), 3 years of severe droughts (2002, 2003 and 2017), with 5 years of extreme droughts (1992, 1998, 2013, 2014 and 2015). In Kainji, the area experienced 8 years of mild droughts (1995, 1997, 2004, 2007, 2011, 2014, 2015 and 2017), 5 years of severe droughts (1988, 1993, 2006, 2010 and 2013) with 3 years of extreme droughts (1992, 1996 and 2000). Also, in Minna, the area experienced 4 years of mild drought (2001, 2005, 2012 and 2017), 6 years of severe drought (1989, 2004, 2006, 2007, 2011 and 2015), with 4 years of extreme drought (1990, 1993, 2013 and 2014).

On the other hand, in Badeggi, the area experienced 4 years of mild wetness (1990, 1999, 2000 and 2005) 4 years of severe wetness (2001, 2007, 2008 and 2010), with 5 years of extreme wetness (1991, 1993, 1997, 2009 and 2016). In Kainji, the area experienced 4 years of mild wetness (1989, 1990, 2005 and 2009), 4 years of severe wetness (1994, 2001, 2008 and 2016) with 6 years of extreme wetness (1991, 1998, 1999, 2002, 2003 and 2012). Moreover, in Minna, the area experienced 9 years of mild wetness (1992, 1995, 1996, 1997, 1999, 2000, 2002, 2008 and 2010), 3 years of severe wetness (1988, 1991 and 2003), with 4 years of extreme wetness (1994, 1998, 2009 and 2016) (Table 2). The results were also presented graphically in Figure 1.

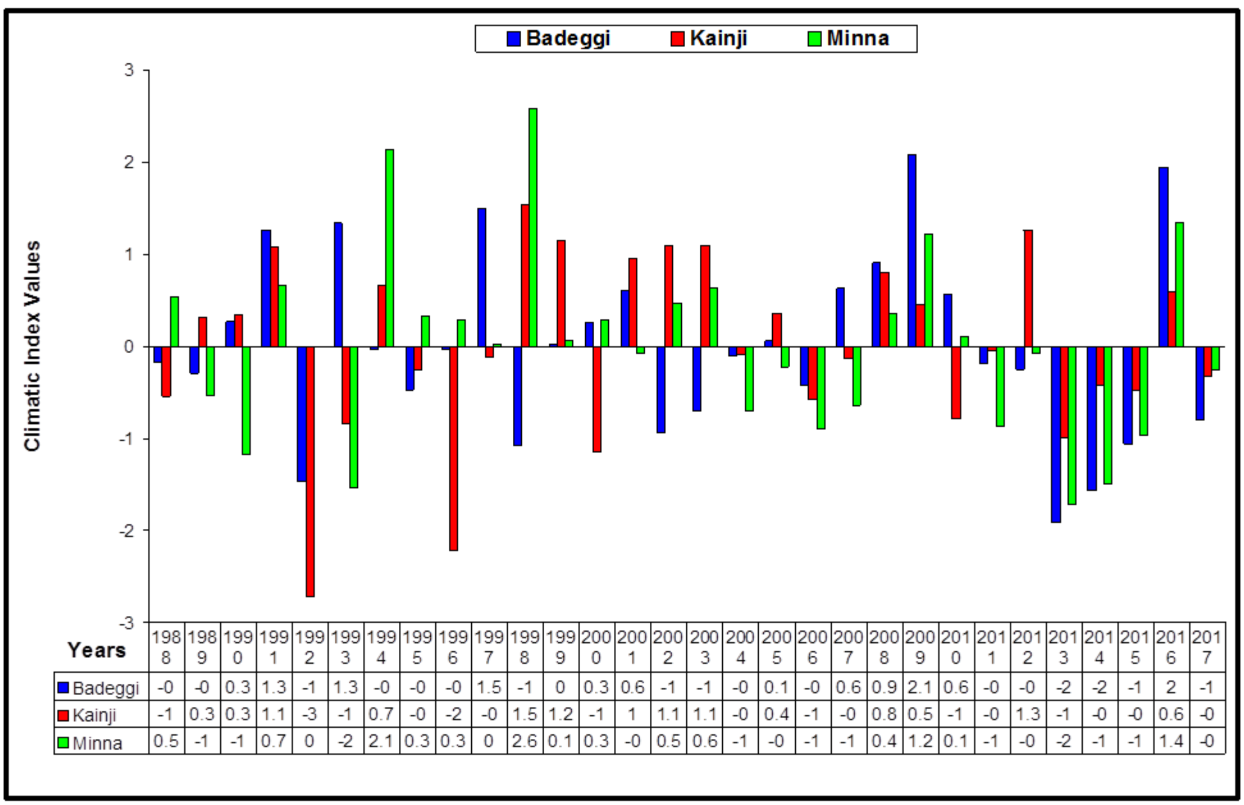

Figure 1 Climatic Index for the study area

Annual Variations in Crop Yield in the Study Area

Table 3 shows the crop yield (soybean, maize, and groundnut) for 30 years (1988-2017). The results indicate that crop yield varies from year to year and from place to place. The highest soybean yield of 43.7 (000 metric tons) was recorded in the year 2011 with the lowest yield in 2013. The highest maize yield of 42.7 was recorded in 1990, the lowest yield of 7.2 (000 metric tons) was recorded in the year 2000 (Table 3). Moreover, the highest groundnut yield of 40.2 (000 metric tons) was recorded in 2008 and the lowest yield of 10.3 (000 metric tons) was recorded in the year 2013. The result also shows that in the last 30 years, the southern part (Badeggi station) had the highest mean yield of 28.7 (000 metric tons), followed by the north-eastern part (Minna station) with 27.4 (000 metric tons). The lowest mean yield was recorded in the north-western part (Kainji station) with 25.1 (000 metric tons) (Table 3). This was calculated, since the water requirement of the three crops selected is within the same range.

Table 3 crop yield s in the Study Area from 1988-2017

Year	soybean yield in Badeggi (000 mtons)	Maize yield in Kainji (000 mtons)	Groundnut yield in Minna (000 mtons)
1988	36.6	10.1	25.3
1989	35.4	39.1	15.6
1990	29.4	42.7	12.4
1991	26.3	23.6	26.2
1992	9.7	7.2	38.1
1993	27.3	16.8	11.3
1994	37.2	31.8	39.4
1995	39.8	15.4	38.9
1996	37.1	8.9	37.1
1997	26.9	41.7	36.8
1998	12.1	27.9	24.7
1999	33.5	31.5	36.1
2000	28.3	9.8	37.6
2001	33.2	34.5	35.8
2002	15.9	27.5	39.1
2003	16.4	33.8	24.6
2004	41.1	36.7	14.8
2005	34.7	40.1	39.1
2006	39.2	9.1	14.3
2007	36.8	41.8	15.2
2008	29.8	28.3	40.2
2009	35.7	36.9	25.8
2010	33.9	27.4	39.6
2011	43.7	39.7	14.2
2012	40.6	24.1	39.6
2013	8.9	8.2	10.3
2014	9.4	8.9	10.7
2015	12.8	9.6	13.5
2016	33.4	30.2	28.6
2017	16.9	10.6	36.8
Mean	28.7	25.1	27.4

Source: Niger State Agricultural Development Programme

Relationship between rainfall characteristics and crop yield

The results of the regression analysis on the crop yield and rainfall characteristics in the study area show that in Badeggi station, the regression model yielded coefficient of determination of 0.29, an F-value of 11.45, and a p-value of 0.002. In Kainji station, the model yielded a coefficient of determination of 0.35, an F-value of 14.96, and a p-value of 0.001. Also in Minna station, the result of the regression model yielded a coefficient of determination of 0.32, an F-value of 13.20, and a p-value of 0.001. Since F-values > p-values in the 3 stations studied, H_o is rejected. Thus, there is a significant relationship between rainfall characteristics and crop yield in the study area at 0.05 significant levels. Moreover, in Badeggi, the results indicate that a unit variation in rainfall results in 1.0, 0.9, 0.9, 1.5, 0.9, 0.5, 0.1, 1.4, 0.6, 1.4, 0.5, 0.2, 1.8 and 1.5 unit increase in crop yield in 1988, 1989, 1994, 1995, 1996, 1999, 2004, 2005, 2006, 2007, 2010, 2011 and 2012, whereas, in other years, a unit variation in rainfall results in -0.1, -1.1, -1.2, -1.0, -1.2, -1.1, -0.2, -0.8, -0.9, -0.5, -0.6, -01.0, -1.1, -1.1, -0.7, and -0.8 unit decrease in crop yield in Badeggi (Table 4). Similar cases were recorded in Kainji and Minna stations (Table 4).

Table 4 Estimated values of crop yield from the regression equation

Years	Estimated Y for Badeggi	Standard Residuals	Estimated Y for Kainji	Standard Residuals	Predicted Y for Minna	Standard Residuals
1988	27.7	1.0	21.2	-1.1	30.8	-0.6
1989	27.1	0.9	27.5	1.1	24.0	-0.9
1990	30.3	-0.1	27.6	1.5	19.9	-0.8
1991	36.0	-1.1	33.1	-0.9	31.7	-0.6
1992	20.2	-1.2	16.7	-0.9	27.4	1.1
1993	36.5	-1.0	18.9	-0.2	17.6	-0.7
1994	28.6	0.9	30.1	0.2	41.1	-0.2
1995	26.0	1.5	23.2	-0.8	29.5	1.0
1996	28.5	0.9	8.7	0.0	29.2	0.8
1997	37.4	-1.2	24.2	1.7	27.6	1.0
1998	22.5	-1.1	36.5	-0.9	44.0	-2.1
1999	28.8	0.5	33.6	-0.2	27.8	0.9
2000	30.3	-0.2	5.0	0.5	29.3	0.9
2001	32.2	0.1	32.1	0.2	26.9	1.0
2002	23.3	-0.8	33.1	-0.6	30.4	0.9
2003	24.7	-0.9	33.3	0.1	31.5	-0.7
2004	28.1	1.4	24.4	1.2	22.9	-0.9
2005	29.1	0.6	27.8	1.2	26.0	1.4
2006	26.3	1.4	20.8	-1.2	21.7	-0.8
2007	32.4	0.5	24.2	1.7	23.3	-0.9
2008	34.0	-0.5	31.1	-0.3	29.7	1.1
2009	40.8	-0.6	28.5	0.8	35.2	-1.0
2010	32.1	0.2	19.3	0.8	28.1	1.2
2011	27.6	1.8	24.8	1.5	21.9	-0.8
2012	27.3	1.5	34.4	-1.0	26.9	1.4
2013	17.7	-1.0	17.8	-1.0	16.5	-0.7
2014	19.7	-1.1	22.0	-1.3	17.9	-0.8
2015	22.6	-1.1	21.6	-1.2	21.2	-0.8
2016	40.1	-0.7	29.5	0.1	36.1	-0.8
2017	24.1	-0.8	22.7	-1.2	25.8	1.2

Source: Computed by the author

4. DISCUSSION

The rainfall analysis in the study area shows that there were variations in the rainfall characteristics from year to year and from place to place. As a result of the variations in the rainfall, the study area experienced near-normal rainfall to severe droughts within the period of study. For 30 years studied, the study area was free from droughts only in 1991, 1994, 1997, 1999, 2001, 2005, 2008, 2009, 2012 and 2016. Thus, other years experienced droughts either in some parts of the study area (1988, 1989, 1990, 1992, 1993, 1995, 1996, 1998, 2000, 2002, 2003, 2004, 2007, 2010, 2011 and 2017) or in all the parts of the study area, such as the droughts of 2006, 2013, 2014 and 2015. Some of the droughts that occurred during the period of the study had serious negative consequences on crop yields and other vital agricultural support systems (such as rivers, wetlands and rangelands) that provided means of livelihood to farmers.

Moreover, the result of the regression analysis on crop yield and rainfall characteristics in the study area shows a positive correlation. The result also shows that 29%, 35%, and 32% variations in soybean, maize and groundnut yields respectively are determined by variations in rainfall. This implies that 71%, 65% and 68% of the variations in soybean, maize and groundnut yields are due to other causes or reasons, such as soil type, application of fertilizers, farming methods etc. However, the researchers observed that the crop yields were mostly at best in those years characterised with Near-Normal rainfall and mild wetness. On the other hand, the periods of drought occurrences (mild, moderate and severe drought) largely affected the crop yield. Exceptional cases were observed in Kainji station in the year 1995 and 2017 where production was very low during near-normal rainfall. This was attributed to pest and diseases attack. However, in Badeggi station (1995, 2006) and Kainji station (2010), there were records of high crop yield during mild droughts. This was attributed to the availability of irrigation facilities at the time, which supplemented the shortfall in rainfall and also farmers' access to improved crop varieties (drought resistant and early maturing varieties), particularly in the year 2010.

Eze (2018), states that the most immediate consequence of drought is a reduction in farm output, due to inadequate rainfall. Therefore, insufficient rainfall causes poor pasture growth and may also lead to a decline in fodder supplies from crop residues. Farmers in drought affected areas are usually faced with poor harvests that are too small to feed their families (Tiamiyu et al., 2018). Thus, the scarcity of water due to the occurrence of droughts affects the agricultural outputs. Abaje et al. (2013) argue that incidences of minor drought result in a decrease in farm outputand weight loss in livestock. However, total losses in farm output, particularly in crop yield usually occur, during severe drought. Severe drought also results in increased mortality rates of farm animals. Moreover, irrigation systems which would have served to mitigate the problems of droughts are always affected by water shortages. This is because most of the dams desiccate during the period of droughts, thus, increasing the impact of drought on the agricultural production (Eze et al., 2018a). Construction of wells and boreholes are affected by severe drought through lowering the water table. This is because the depth of water table increases depending on a particular place, thus reducing water availability for the crop use, particularly those crops that depend on surface and groundwater sources impacts negatively on agricultural production (Eze, 2018). During drought, the land is usually under great pressure due to increased human activities and animal grazing, which lead to desertification (Time et al., 2018). Nyong et al. (2003) argue that when plant communities that are used to the characteristically variable climate is disturbed by persistent droughts, it may be impossible to regain complete ecological recovery, when the rains return leading to desertification. The reduction in farm output affects the farmers' income and the general state's revenue (Shittu et al., 2017). Therefore, irrigation systems that are sustained by the sources of waters such as groundwater and rivers always dry up during/after severe drought (Adeleke, 2017). However, Eze, 2018 states that farmers usually sell oxen and donkeys used as draft animals for income generation during severe drought. Where crops are badly tormented by drought, pasture production additionally seems to be reduced though output from natural pastures tends to be less liable to drought than crop production (Eze, 2018).

Consequently, poor regions of the world, such as Africa, which depends on agriculture, have been described as one of the most vulnerable regions to the impacts of climatic and environmental changes (Vogel, 2008, Eze et al., 2018b), particularly droughts occurrences in Niger State, Nigeria. The extent of rainfall deviation from its normal occurrences, therefore, has great implications for the crop yield and agricultural production in general.

5. CONCLUSION

In conclusion, the rainfall in the study area is highly variable in time and space. The incidences of droughts have impacted negatively on agricultural production, particularly, crop yield in Niger State. However, the crop yield and rainfall amount in the study area shows a generally weak positive correlation. Also, the researchers observed that the crop yield was mostly at best in those years characterised with Near-Normal rainfall and mild wetness. On the other hand, the period of droughts (mild, moderate and severe droughts) and excess rainfall (severe wetness) largely affected the crop yield. The extent of rainfall deviation from its normal occurrences, therefore, has great implications for the crop yield and agricultural production in general. Finally, the study has effectively used the climatic index to determine the extent of variation of rainfall from the normal and its implication on agriculture, particularly, crop yield, which has much to offer in terms of farm-level policy decision making on Agricultural production. The results can be used for the reduction of the potential damage of climate variability and crop production, by integrating its outputs into planning on reducing the impact of climate variability on crop production in Nigeria.

Recommendations

In other to reduce the impact of droughts on farmers and achieve agricultural sustainability, farming systems have to become more robust and efficient. Additionally, climate-smart agricultural practices targeted towards mitigating drought impacts, improving the environment and increasing the food production, are needed (Eze et al., 2018b). Thus, we recommend the following methods in order to achieve agricultural sustainability and to protect the farmers against the impact of droughts:

1) Adoption of improved crop varieties: Adoption of improved crop varieties such as drought-resistant crops, early maturing crops enables farmers cope with rainfall variability, particularly drought occurrences. Therefore, adoption of improved crop varieties by the farmers enables them to cope with the impacts of droughts.
2) Provision of an irrigation system by the government or Organisation will help farmers that are dependent on rainfall to cultivate and harvest crops during shortfall in rainfall amount. This can be done by providing irrigation facilities such as tube-well for each registered farmer.
3) Land-care: Land-care approach is a unique community-based approach that has played a major role in raising awareness, influencing farming and sustainable land management practices and delivering environmental outcomes (Curtis & Cook, 2006). The Land-care approach involves the formation of three key stakeholders which include farmers/communities that are supported through partnerships with the Local Government Authority (LGA) and technical service providers. These stakeholders form the land-care group with the aim of providing appropriate technologies, institution building, and partnership building. (Cramb et al., 2007).

Authors Contributions

Jude NwaforEze is the principal investigator. His contributions were encompassing (study design, data collection, also involved in the analysis, and the general compilations). Philip Audu Ibrahim is a co-investigator. His contribution focused on the impact of rainfall variability on crop production. Saliu Akinlabi Tiamiyu, is a co-investigator. His contributions were mainly on the aspect of statistical analysis and literature review. Muhammed Alfa is a co-investigator. He is an animal scientist. His contributions focused on the impact of drought on livestock production in the study area

Conflict of Interest

We, write to attest that the article submitted to your journal for consideration has not been published previously. It is not under consideration for publication elsewhere and that its publication is approved by us (Jude Nwafor Eze, Philip Audu Ibrahim, Saliu Akinlabi Tiamiyu, Muhammed Alfa) and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder

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