



Characterization and Implication of Drought Conditions on Agricultural Production in Yola South LGA, Adamawa State Nigeria

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ABSTRACT

This study aimed in characterization and implication of drought conditions on agricultural production in Yola South LGA, Adamawa Stat. Fifty years (50) rainfall data obtained from Upper Benue River Development Authority, Yola were analysed using RDI as drought indicator for characterization and description. The results revealed that in the year 2002, 1987, 1973, 1974 and 2006 were classified with an exceptional drought condition rated much below normal of the lowest first decile with annual rainfall amount of 656.7 mm-800 mm. Extreme drought was occurred in 2008, 2011, 1990, 2013 and 1970 classified as below normal with annual rainfall values ranges 808.9 mm-903.4 mm. Similarly, in 2001, 2017, 1994, 1981 and 1977 slightly drought events were hit the area rated with an annual rainfall 915.8 mm-969.3 mm. Moderate drought condition was classified to had occurred up mostly in seven decile in the year 1985, 1984, 1997, 2015 and 1989 having an annual rainfall of 970.5 mm-1015.3 mm. Lastly, the tenth decile classified abnormally dry had occurred in 1998, 1980, 2009, 2010 and 1995 with rainfall much above normal ranged from 1022.8 mm-1260.1 mm respectively. Reduction of crop yield, drying and cracking of soils, desertification, drying of dams, lakes and streams, loss of pasture, grazing land, vegetation and reduction in soil quality were recognized as drought implication affecting agriculture in the area. It is therefore, recommends that farmers should adopt the use of early matured crop varieties with low water use potentials, effective water harvesting techniques and completion of Chochi irrigation project by the federal government it is highly recommendable and timely.

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INTRODUCTION

Drought is a question of water demand and supply, where inadequate supply of water to meet the demand creates drought. Climate change constitutes a very serious threat to sustainable agricultural production and food security in

many parts of the world (Adebayo *et al.* 2012a). Climate change is increasing production risks in many farming systems and reducing the ability of farmers and rural communities to manage these risks on their own (Muhammad *et al.*, 2013). In Nigeria, analysis of long- term meteorological data



show discernable evidence of climate change which leads to warmer seasons; increased frequency and intensity of weather extreme events such as drought, decline in rainfall amount by about 15-20%, increased incidence of dry spell (Adebayo, 1998; Anuforom, 2010; Muhammad *et al.*, 2013). Similarly, Nigeria has been recognized as country in Sub Saharan Africa which is very vulnerable to climate change (IPCC, 2007; BNRCC, 2008). This is due to the fact that majority of the countries' population engage in agriculture as their primary occupation and agriculture in the country is mainly rain fed (Muhammad *et al.*, 2013). Likewise, Yola South LGA, is among the area with considerable arable lands for agricultural production in the state which produces a large proportion of grains and staple diet of the growing population. Yet the area is frequently under drought attack and this negatively affects food production in the area and is continuously reoccurring most especially in the recent decades. Thus, there is need for comprehensive analysis of drought severity characterization in both temporal and spatial variability in the area with the aim of providing essential and valuable information for the farmers, decision makers and other related agro-climatic agencies for strategic planning and decision making processes respectively. Therefore, this study aimed in characterization and

implication drought conditions on agricultural production in Yola South LGA, Adamawa State Nigeria.

For the purpose of this research work Rainfall Decile Index (RDI) has been chosen as drought indicator because it is simple to compute, requires less data and fewer assumptions than the Palmer Drought Severity Index and unlike the SPI, the RDI computation has no assumption about the precipitation distribute on. Conversely, the RDI has limitation of requiring a long climatological record to calculate the deciles accurately (Hayes 2000 and Keyantash and Dracup 2002). RDI is defined by dividing the distribution of occurrences over a long-term precipitation record into sections for each ten percent of the distribution. (Hayes, 2000). Each of these categories is called a "decile." The first decile is the rainfall amount not exceeded by the lowest 10% of the precipitation occurrences. The second decile is the precipitation amount not exceeded by the lowest 20% of occurrences. The fifth decile is considered the median and is the precipitation amount not exceeded by 50% of the occurrences over the period of record. The deciles are grouped into five classifications according to a decile's departure from the normal condition describe by Gibbs and Maher, (1967) is depicted on table 1 below.

Table 1: Classification of rainfall deciles

Deciles	Deciles Percentage	Class Rating
D=1-2	Lowest 20%	Much below normal
D=3-4	Next lowest 20%	Below normal
D=5-6	Middle 20%	Near normal
D=7-8	Next highest 20%	Above normal
D=9-10	Highest 20 %	Much above normal

Source:(Gibbs and Maher, 1967).

A region is considered to be "drought affected" if the total precipitation of the preceding three months falls within

the lowest decile of the historical distribution(Kinninmonth *et al.*, 2000). The conditions end when either of the following



happens: (1)The precipitation of the past month places the following three-month total in or above the fourth decile or, (2)The total precipitation for the past three months is in or above the eighth decile. In addition, drought category is also used to describe the drought condition of an area

for a particular year. The drought classification adopted is the Drought Severity Classification, currently in use by the US Drought Monitor, administered by the National Climatic Data Center. The drought classification consists of numerical ratings of 0 to 4 (Samuel *et al.*, 2003).

Table 2: Drought classification and description

S/N	Drought category	Description
1	D4	Exceptional Drought
2	D3	Extreme Drought
3	D2	Severe Drought
4	D1	Moderate Drought
5	D0	Abnormally dry

Source: (Samuel *et al.*, 2003).

STUDY AREA

The study was conducted in Yola South LGA and Environs of Adamawa State, Nigeria which lies on latitude 090 14'N and 090 20'N of the equator and longitude 120 25'E and 120 28'E of the Greenwich meridian with an average annual rainfall of 850 mm-1000 mm with over 41% of rain falling in August and September. Temperature also has a significant temporal variation in the study area; with an average maximum temperature of 42 °C with an average relative humidity of about 29% (Adebayo, 1999; Upper Benue River Basin Authority, Yola, Nigeria. 2018).

METHODOLOGY

The rainfall data for the period of fifty (50) years (1969-2018) obtained from Upper Benue River Basin Development Authority, Yola were analysed using Rainfall Decile Index (RDI) as drought indicator developed by (Gibbs and Maher, 1967) and the analysed data were also classified and described using Drought Severity Classification (DSC) based on the rainfall amount in relation to decile percent (10%) over a period of study. Table 3 below depicted the methodological parameters.

Table 3: Complementary drought classification and description using deciles percentage and rating method

Deciles	Deciles Percentage	Class Rating	Drought Category	Description
D=1-2	Lowest 20%	Much below normal	D4	Exceptional Drought
D=3-4	Next lowest 20%	Below normal	D3	Extreme Drought
D=5-6	Middle 20%	Near normal	D2	Severe Drought
D=7-8	Next highest 20%	Above normal	D1	Moderate Drought
D=9-10	Highest 20 %	Much above normal	D0	Abnormally dry

Source: (Gibbs and Maher, 1967; Samuel *et al.*, 2003)



RESULTS

Table 1: Deciles 1-2 (lowest 20%)

S/N	Years	Annual rainfall (mm)	Average Annual rainfall (mm)	Ratings
First decile is the rainfall amount not exceeded by the lowest 10%				
1	2002	656.7	82.08	Much below normal
2	1987	678.7	84.83	Much below normal
3	1973	694.6	115.76	Much below normal
4	1974	759.3	108.47	Much below normal
5	2006	764.9	109.27	Much below normal
Second decile is the rainfall amount not exceeded by the lowest 20%				
6.	1971	770.6	96.32	Much below normal
7	2003	784.7	112.10	Much below normal
8	2005	799.1	114.15	Much below normal
9	1979	799.3	99.91	Much below normal
10	2004	800	114.28	Much below normal

Table 2 Deciles 3-4 (next lowest 20%)

S/N	Years	Annual rainfall (mm)	Average Annual rainfall (mm)	Ratings
Third decile is the rainfall amount not exceeded by the lowest 30%				
1	2008	808.9	115.55	below normal
2	2011	823.2	117.60	below normal
3	1990	823.8	102.975	below normal
4	2013	827.7	103.46	below normal
5	1970	851.6	121.65	below normal
Fourth decile is the rainfall amount not exceeded by the lowest 40%				
6	1991	861.8	123.11	below normal
7	1972	880.7	125.81	below normal
8	1983	884.1	126.3	below normal
9	1986	900.6	112.57	below normal
10	2007	903.4	129.05	below normal

Table 3: Deciles 5-6 (middle 20%)

S/N	Years	Annual rainfall (mm)	Average Annual rainfall (mm)	Ratings
Fifth decile is the rainfall amount not exceeded by 50%				
1	2001	915.8	130.82	Near normal
2	2017	920.6	131.51	Near normal
3	1994	924.5	132.07	Near normal
4	1981	936.1	133.728	Near normal
5	1977	936.3	156.05	Near normal
Sixth decile is the rainfall amount not exceeded by 60%				



S/N	Years	Annual rainfall (mm)	Average Annual rainfall (mm)	Ratings
6	2000	947.6	135.37	Near normal
7	1975	949.4	118.67	Near normal
8	1982	957.3	119.66	Near normal
9	2018	961.2	137.31	Near normal
10	1992	969.3	107.7	Near normal

Table 4: Deciles 7-8 (next highest 20%)

S/N	Years	Annual rainfall (mm)	Average Annual rainfall (mm)	Ratings
Seventh decile is the rainfall amount not exceeded by 70%				
1	1985	970.5	121.31	Above normal
2	1984	970.9	121.36	Above normal
3	1997	977.6	139.65	Above normal
4	2015	979.0	122.37	Above normal
5	1989	982.2	140.31	Above normal
Eight decile is the rainfall amount not exceeded by 80%				
6	1993	983.4	122.92	Above normal
7	1976	990.0	141.42	Above normal
8	1978	993.4	141.91	Above normal
9	1996	1009.5	126.18	Above normal
10	2014	1015.3	126.91	Above normal

Table 5: Deciles 9-10 (highest 20%)

S/N	Years	Annual rainfall (mm)	Average Annual rainfall (mm)	Ratings
Ninth decile is the rainfall amount not exceeded by 90%				
1.	1998	1022.8	146.11	Much Above normal
2	1980	1044.1	130.51	Much Above normal
3	2009	1063.4	151.94	Much Above normal
4	2010	1063.6	151.94	Much Above normal
5	1995	1080.8	135.10	Much Above normal
Tenth decile is the rainfall amount not exceeded by 100%				
6	1969	1081.4	154.48	Much Above normal
7	1988	1083.5	154.78	Much Above normal
8	2012	1085.2	135.62	Much Above normal
9	1999	113.3	159.04	Much Above normal
10	2016	1260.1	180.01	Much Above normal

DISCUSSION

Results on table 1 shows that RDI for the lowest rainfall amount not exceeded 10% of the precipitation occurrences rated as much below normal and characterized as

exceptional drought (D4) which caused an exceptional damage to crops, pastures and drying of water reservoirs, dams, and low agricultural production were found in the year 2002, 1987, 1973, 1974 and 2006



respectively. Similarly, the second deciles of RDI with precipitation amount not exceeded 20% of the occurrences characterized drought as exceptional (D4) but not severe as in first decile occurred in the year 1971, 2003, 2005, 1979 and 2004 which imposed an acute damaged to crop productivity, pasture availability and reduction in ground water potential for irrigation farming. From table 2 results shows that 2008, 2011, 1990, 2013 and 1970 were rated RDI below normal as for the third decile with precipitation amount not exceeded 30% of the occurrences and characterized as Extreme Drought (D3) having an extreme damaged to crops and widespread of water shortages for both irrigation and livestock management. The trends remained the same for the fourth decile where rainfall amount not exceeded 40% of the occurrences in the area characterized with an Extreme Drought (D3) condition in the year 1991, 1972, 1983, 1986 and 2007 correspondingly.

RDI with precipitation amount not exceeded 50% considered as median of the occurrences over the period of study in the area is rated as "Near normal" and characterized as Severe Drought (D2) condition estimated to had occurred in the year 2001, 2017, 1994, 1981 and 1977 imposing losses possibilities of crops, water shortage and water restrictions for agricultural purposes in the area. Likewise for the sixth decile of RDI having rainfall amount not exceeded 60 % was also classified as severe condition occurred in the year 2000, 1975, 1982, 2018 and 1992 respectively. Moreover, 1985, 1984, 1997, 2015 and 1989 were categorized under seventh RDI with amount of rainfall not exceeded 70 % of the occurrences over the recorded period were rated "Above normal" and characterized as Moderate Drought (D1) described by some damage to

crops and pastures, with low water in the streams, reservoirs, and wells with some water shortages impended. Also, the eighth decile of RDI with amount of rainfall not exceeded 80 % of the occurrences was rated "Above normal" and characterized as Moderate Drought (D1) with low damaged when considered with the seventh decile respectively. In addition, the ninth decile of RDI with amount of rainfall not exceeded 90 % of the occurrences over the recorded period in the study area were rated "Much above normal" and characterized with "Abnormally dry condition (D0) for a period of year; 1998, 1980, 2009, 2010 and 1995 occurred in the study area described to had going into drought or coming out of drought. Thus, Going into drought is characterized by short-term dryness, slowing planting and growth of crops or pastures while coming out of drought is characterized by lingering water deficits and pastures/crops not fully recovered. For the remaining years of RDI study; 1996, 1988, 2012, 1999 and 2016 were falls under the tenth decile with amount of rainfall not exceeded 100 % of the occurrences over a period of study were also rated as "Much above normal" with an abnormal dry condition but having less or no adverse effects on crop performance or soil water deficit. Conversely, researches have shown that in the years 1996, 1988, 2012, 1999 and 2016 as tenth decile of RDI with highest 10% of rainfall occurrences imposed flood scenarios in the area with negative impacts on farmlands, crops, animals, buildings and distraction of socio-economic activities in the area. Most specifically, the 1999, 2012 and 2016 floods were the major and exacerbated to have hit the study area and particularly the 2012 considered as unprecedented over the past four decades accordingly.

IMPLICATION OF DROUGHT CONDITION ON AGRICULTURAL PRODUCTION

The effects of drought may be direct or indirect, singular or cumulative, immediate or delayed. Droughts lead directly to poor crop yield, famine, deterioration of pasture, dead of livestock etc. The direct caused by drought may include changes of land use practices, abandonment of fertile lands, migration of rural population, heavy pressure on urban areas and so on. These put severe strain on the economic development of a nation, either immediately or with a time lag (Appa, 1978; Redsteer *et al.*, 2010). The implications of decreasing rainfall include reduction in surface water availability, drought, crop failure and scarcity of animal fodders (Adebayo, *et al.*, 2012b). Similarly, Muhammad *et al.*, (2013) explained climate change impacts on agriculture include biological effect on crop yield, the resulting impact on prices, production, consumption

and the impact on per capital calorie consumption and malnutrition. Benhin (2006); Mano and Nhemachena (2006); Seo and Mendelsohn (2006) observed that climate attributes (temperature and precipitation) affect net farm revenue and such impacts can be significantly reduced through adaptation. Similarly, In Yola South LGA, food production was adversely affected due to apparent variability in timing and decreased in rainfall amount coupled with an increased in temperature and heat stress led to complementary reduction in food production per unit area, starvation of livestock due loss of pasture and vegetation cover, drying of streams and lakes, desert encroachment, and subsequently caused farmers lost their sources of livelihood. Plates below depicted some implications of water scarcity on agricultural production in the study area.



Plates 1. Wilting and dying of crops due to drought conditions in the study area



Plates 2. Starvation of livestock due to loss of fodder and vegetation in the study area



Plates 3. Drying of Njuwa Lake where irrigation and fishing activities are carried out as a result of water scarcity in the study area.



CONCLUSION

It is obvious and evident that Yola South LGA, of Adamawa State had experienced a significant and glaring reoccurrences of drought events with a varying magnitude at both temporal and spatial scales due to seasonal and annual variability of rainfall amount, intensity and duration over long periods. This climatic changes of decreased in rainfall amount super imposed the area into drought severity conditions having an adverse effects on agricultural production in the area through poor growth of crop, reduction of yield, loss of pastures, shortage of surface and sub-surface water for irrigation farming, untimely drying of dams, lakes and reservoirs and inadequate of water for livestock production. The emerged information from this research paper may be valuable and essential in taking drastic workable measures and decision making process in planning of water management and crop improvement towards ameliorating drought consequences on farming operation for sustainable food production in the study area.

RECOMMENDATION

Based on the findings from this research work, it is therefore recommends the following;

1. Farmers should adopt the cultivation of drought resistant crop varieties that will withstand drought severity emanating in the area.
2. Drought information to the farmers and decision makers should be made available for effective water use efficiency, irrigation scheduling and management towards ensuring optimum and sustainable food production for the growing population in the study area.
3. Additional of agro-meteorological stations with modern equipment should be installed at various required places in the area and the state at large (in all the agro-ecological zones) for obtaining adequate hydro-climatic data across the geospatial locations for appropriate analysis and recommendation of hydro-climatic conditions for sustainable development.

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