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An Overview of Spatio-Temporal Variability of Drought Intensity and its Implications on Agricultural Production in Yola and Environs of Adamawa State, Nigeria

A.A. Sadiq[1*] and Maryam Abdullahi[2*]

[1 &2] Department of Agricultural Technology, Adamawa State Polytechnic, Yola, P.M.B 2147,

Abstract – The study aimed to overview the spatio-temporal variability of drought intensity and its implications on agricultural production in Yola and environs of Adamawa State, Nigeria. The data overviewed, synthesized and overviewed in this work were secondary based obtained from the relevant work conducted in the area. The results from the different outcome of the previous work revealed that out of the forty to fifty years (1969-1978-2017) 21 years were assessed to have falls under drought conditions with a variable intensity. Similarly, among the 21 years of drought conditions fourteen years (14) were identified with high drought intensity (1979, 1983, 1986, 1987, 1990, 1991, 2002, 2003, 2004, 2005, 2006, 2007, 2008 and 2013). Furthermore, 1990, 2002, 2006, 2008 and 2013 (five years) were quantified as very high drought intensity. The unprecedented seasonal drought with an extreme condition was found in the year 1987, 2002 and 2006 having a minimum amount of rainfall (678.7mm, 656.4mm and 764.9 mm) which imposed serious implications on agricultural production such as poor yield, loss of vegetation, starvation of livestock, drying of lakes and dams and subsequently affecting socio-economic activities in the area. It is obvious that the study area is adversely facing drought with a variable intensity due to gradual reduction of precipitation caused by climatic changes most especially in the recent decades. The insufficient rainfall is enough substantial to support the growth and development of the major crops grown in the area. Farmers should therefore adopt early planting of improved drought resistant crop varieties in an attempt to curtail the spatial and temporal variability of droughts hazards in the area for optimum food production of the growing population in the area.

Keywords – Agricultural, Drought, Implications, Overview, Spatio-Temporal, Variability, Yola.

I. INTRODUCTION

Drought is a question of water demand and supply, where inadequate supply of water to meet the demand creates drought [1]. Droughts are one of the more costly natural hazards affecting many economic sectors and adversely affecting agriculture and food security [2]. Drought is an insidious natural hazard that results from lower levels of precipitations than what is considered normal [3]. When this phenomenon extends over a season or a more extended period of time, precipitation is insufficient to meet the demands of human activities and the environment [4]. Climatic changes in a geographical area may be detected by examining long time series of precipitation variability [5].

Climate change constitutes a very serious threat to sustainable agricultural production and food security in many parts of the world [6]. Decrease of precipitation is considered as the origin of drought which is leads to a reduction of storage volumes and fluxes involved in the hydrological cycle [7]. There is practically no climatic area in which droughts of various intensities have not occurred in past decades, mostly as a result of the most significant threat facing the world in the 21st century: climate changes and timing [2]. For example in Yola South LGA of Adamawa State, Nigeria drought conditions have been assesses through various research using different methods and indices of drought quantification and its risk imposed on agricultural production. However, each method revealed more or less different results of drought conditions over a long period of time with an adverse impact on food production. Generally, food production will be adversely affected by the variability in timing and amount of rainfall and heat stress and the consequence is an increase in

Corresponding Author: A.A. Sadiq

food shortages and many farmers could lose their sources of livelihood due to climate change [(8); (9)]. It is a known fact that the complexity of drought lies in the fact that it cannot easily be predicted because it develops slowly, and it is usually noticed when it has already been present for weeks or months [4]. Therefore, understanding the spatial and temporal variability of drought conditions and its effects on agricultural within a geographical area is highly imperative. Thus, current study aimed to overview of spatio-temporal variability of drought intensity and its effects on agricultural production in Yola and environs of Adamawa State, Nigeria.

II. Materials And Method

2.1 Study Area

The study was conducted in Yola South LGA and Environs of Adamawa State, Nigeria which lies on latitude 09° 14'N and 09° 20'N of the equator and longitude 12° 25'E and 12° 28'E of the Greenwich meridian (figure 1) 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 ^{0}C with an average relative humidity of about 29% [(10); (11)].

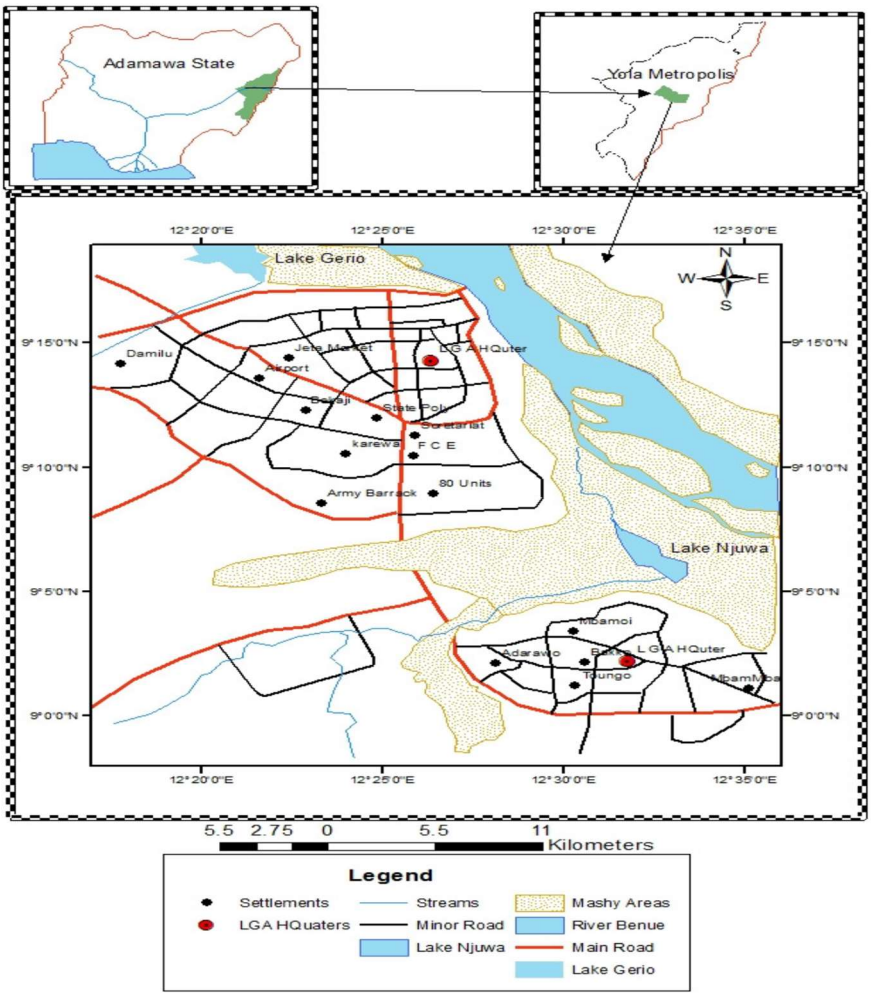

Figure 1. The Study Area

2.2 Data collection

Secondary data sources forms the main document used for this research. The data were obtained from scientific research work conducted in the area and other related literatures such as Journals, textbooks, internet, and maps were also obtained from libraries and institutions. The data collected were statistically compared using graphs, tables etc.

III. RESULTS

Table 1. Variability of Drought intensity using Percent of Normal Precipitation of Yola South LGA from 1978-2017 (40 Years) period

S/N	Pn Classification [18]	Years of Occurrences	Frequency	Percent (%)
1	Moderately Dry	1987 and 2002	2	5
2	Very Dry	Nil	0	0
3	Extremely Dry	Nil	0	0

Source: Ref [4].

Table 2. Variability of Drought Intensity using Rainfall Deciles Index of Yola South LGA from 1969-2018 (50 Years) period

Rainfall ratings (mm)	Decile percentage	Years	Frequencies	Drought Category	Drought Description
Much below normal (800-656.7)	Lowest 20%	2002, 1987, 1973, 1974, 2006, 1971, 2003, 2005,1979, 2004	10	D4	Exceptional Drought
below normal – (903.4-808.9)	Next lowest 20%	2008, 2001, 1990, 2013 1970, 1991, 1972,1983, 1986, 2007	10	D3	Extreme Drought
Near normal (915.8-936.3)	Middle 20%	2001, 2017, 1994, 1981, 1977	5	D2	Severe Drought

Source:[1].

Table 3: Variability of Drought intensity using Rainfall Anomaly Index in Yola South LGA from 1978-2017 (40 Years) period

Dry conditions	Years	Frequencies
Slightly dry	1983,1986 and 2007	3
Moderately dry	1991	1
Very dry	1979, 1990, 2003, 2004, 2005, 2008, 2011 and 2013	8
Extremely dry	1987, 2002 and 2006	3

Source: [5].

Table 4. Identified spatio-temporal variability of drought intensity occurred in the study area between 1968-2017 using different drought index.

S/N	Years	Total (mm)	No. Of Rainy Days	Drought Intensity
1	1970	851.6	NA	High
2	1972	880.5	NA	High
3	1977	936.3	NA	High
4	1979	799.3	55	High
5	1981	936.1	66	High
6	1983	884.1	65	High
7	1986	900.6	57	High
8	1987	678.7	62	Extreme
9	1990	823.8	58	Very High
10	1991	861.8	69	High
11	1994	924.5	74	High

12	2001	915.8	77	High
13	2002	656.4	72	Extreme
14	2003	784.7	62	High
15	2004	800	71	High
16	2005	799.1	68	High
17	2006	764.9	64	Extreme
18	2007	903.4	72	High
19	2008	808.9	72	Very High
20	2013	827.7	67	Very High
21	2017	920.6	65	High

Source: Authors' analysis. NA: Not Available

Table 4. Impact of drought intensity on agricultural production

Impact on agricultural production	Frequency (n= 50)	Percentage (p=100%)
Reduction in crop yield	9	18
Physiological stress and low crops growth	6	12
Drying of dams, reservoirs and lakes	6	12
Loss of profit and capital	3	6
Desertification and loss of some wild animals	2	4
Loss of employment opportunities	3	6
Loss of aquatic animals and fishing activities	2	4
Dead of livestock and starvation	3	6
Abandoning of rain fed farming activities	2	4
Drop in water table and drying of soils	3	6
Loss of pastures, forages and grasses	2	4
Soil degradation	3	6
Outbreak of crops' pest and diseases	6	12

Source: Ref. [4]

IV. Discussions

4.1 Overviewed of Drought Conditions obtained from Different Methods in the Area

For the use of PNP method of drought analysis from 1978-2017, moderately dry condition was occurred in two years only (5%) in the year 1987 and 2002 having the percent normal values of 72.61 % and 70.23 % as depicted in table 1 respectively [4]. While the use of RDI for the lowest rainfall amount not exceeded 10-20% of the precipitation occurrences rated as much below normal and characterized as exceptional drought (D4) were found in the year 2002, 1987, 1973, 1974, 2006, 1971, 2003, 2005, 1979 and 2004 [1]. From table 2 results show that 2008, 2011, 1990, 2013, 1970 1991, 1972, 1983, 1986 and 2007 correspondingly. were rated RDI below normal as for the third decile with precipitation amount not exceeded 30-40 % of the occurrences and characterized as Extreme Drought (D3) RDI with precipitation amount not exceeded 50% considered as median of the occurrences over the period of study in the area was rated as "Near normal" and characterized as Severe Drought (D2) condition estimated to had occurred in the year 2001, 2017, 1994, 1981 and 1977. From the result obtained using the rainfall anomaly, it was revealed that in forty (40) years from 1978- 2017 fifteen (15) years were assessed to falls between slightly dry to extremely dry conditions as depicted on table 3 respectively. In fifteen (15) years of dryness, highest frequencies of years were observed to be very dry condition with the period of 8 years. The changing trend from wetness conditions to dryness conditions was mostly occurred in the recent two decades where most of years were considered as dry in the year 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2011 and 2013 [5].

4.2 Spatio-Temporal Variability of Drought Intensity in Yola and Environs

Droughts are regional in extent and each region has specific climatic characteristics. The amount, seasonality and

form of precipitation differ widely between each of these locations [3]. 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 [(12), (13), (14)] Similarly, Ref. [15] who revealed that in Adamawa State about 69.2 % of the farmers were aware of the climatic hazards affecting their crop yield and they do little to reduce the impacts of these hazards on their crops. In Yola South LGA which is the study of this work there are quite number of research works on drought analysis and its characterization using different indices such as rainfall seasonality index (RSI) by [16]. Rainfall Anomaly Index (RAI) by [5], Rainfall Decile Index (RDI) by [1] and Percent of Normal precipitation (PNP) by [4] respectively. For the drought durations most farmers (55%) agreed that to have experienced drought intensity for a period of 1-2 weeks. For example, last year 2019 drought had occurred from 4th August-29th August, 2019 while this year the area experienced drought for two weeks from Sunday,3rd August- 17th August, 2020 respectively. The variability of drought scenarios in both spatial and temporal scales of different methods in the area were overviewed and presented on table 1, 2 and 3 respectively.

4.3 Identified Seasonal and Temporal Variability of Drought Intensity in the Study Area

The overviewed results from the different outcome of the previous work revealed that out of the (1969-1978-2017) 21 years were assessed to have falls under drought conditions with a variable intensity as shown on table 4. The years affected with seasonal drought scenarios were 1970, 1972, 1977, 1979, 1981, 1983, 1986, 1987, 1994, 1990, 1991, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2013 and 2017 respectively. Similarly, among the 21 years of drought conditions fourteen years were identified with high drought intensity (1979, 1983,1986, 1987, 1990, 1991, 2002, 2003, 2004, 2005, 2006, 2007, 2008 and 2013.) which imposed serious hazards on agricultural production and economic activities in the area. Furthermore, 1990, 2002, 2006, 2008 and 2013 were quantified as very high drought intensity. The unprecedented seasonal drought with an extreme condition was found in the year 1987, 2002 and 2006 having a minimum amount of rainfall (678.7mm, 656.4mm and 764.9 mm) as presented on table 4. The result further explained that an extreme event of drought occurred when the rainfall amount is less than 770 mm annually while the very high drought scenarios might occurred when the rainfall ranges between 770 mm – 830 mm per annum and highly drought condition is expected to occur when the annual rainfall ranges between 830 mm-950 mm per annum respectively. This is to say that variability of drought scenarios in the study is directly dependent on the amount and timing of rainfall experienced. It could be ascertained that rainfall amount that falls between 600 mm- 950 mm per annum would be characterized as drought season with less or more effects on agricultural production. This is because most of the crops cultivated in the area are cereal crops especially rice and maize crops which required about 750 mm-1500 mm of rainfall amount per annum respectively. Therefore, identified drought with rainfall amount of 600 mm-950 mm per annum is insufficient for the effective growth and development of most of the crops in the area consequently to poor yield and economic lost. Thus, Reference [5] further explained that the seasonal years estimated with dry condition over the recorded period of study in the area especially in the recent two decades might be attributed to significant decreased in the amount of rainfall compared with other decades which imposed the area in to drought severity in the region damaging crop and pasture production thereby reducing the ground water recharge, reducing soil water content, lowering water table and drying off soils affecting irrigation farming and livestock management in the area. The results revealed that about 55% of the farmers in the area conceived that drought occurs every year most especially in the recent decades affecting agriculture and the ecosystem. This explains the reason why the area is considered under natural drought hazards seasonally.

4.3 Implication of Drought Conditions on Agricultural Production in Yola and Environs

Of all the extreme meteorological events affecting agriculture and forestry, drought is perhaps the most important hazard with serious implications for the economic well being of the farming community [17]. The implications of decreasing rainfall include reduction in surface water availability, drought, crop failure and scarcity of animal fodders [18]. Droughts can adversely affect agriculture and food security [2]. A drought impact is an observable loss or change at a specific time [2]. Continuous droughts stretching over several years in different parts of the world in the past significantly affected productivity and national economies [16]. As droughts evolve, the impacts can vary by region and by season. [2]. Yola South LGA, is located in the savannah region of Nigeria with a significant fertile landmass which produces a large proportion of the grains that provide the staple diet to 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 [5]. In the area the level of the drought impact on agricultural production most farmer (55%) agreed to a have high impact on their productivity [4]. The use of RDI for the lowest rainfall amount not exceeded 10-20% of the precipitation occurrences characterized as exceptional drought (D4) caused an exceptional damage to crops, pastures and drying of water reservoirs, dams, reduction in ground water potential for irrigation farming and low agricultural production [1]. Hence, the effects of drought may be direct or indirect, singular or cumulative, immediate or delayed [19]. Droughts lead directly to poor crop yield, deterioration of pasture, dead of live stock etc. [1]. 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.

Results on the impact of drought intensity on agricultural production were presented in table 4. Reduction of crop yield was revealed as the major effects imposed by the drought intensity in the area by 18 % of the farmers. Droughts lead directly to poor crop yield, [19]. Physiological stress and low crops growth were caused due to drought condition conceived by 12 % of the farmers in the area. Physiological stress and low crops growth also attributed to 10 % of the respondents to had caused negative effects due to insufficient water in the area [20]. Similarly, about 12 % of the respondents perceived that drying of dams, reservoirs and lakes were affected by the drought hazards. The outbreak of crops' pest and diseases also received 12% out of the respondent as among the second major negative impact of drought intensity in the area. Water scarcity in the area had led crop failure, the decline in fishing activities and livestock starvation which are the primary occupation of the dwellers in the area which directly affects their income and led to poverty growth in the area [22]. Similarly, drought effects had also manifested in the area in terms of vegetation loss subjecting the area into desertification process thereby forcing an indiscriminate movement of cattle by the herdsmen to Cameroon border threatens permanent soil degradation, cracking and drying of soils and disrupts crop growth [(21), (22), (16)]. 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 that 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. Njuwa Lake is rapid before the onset of rainfall coupled with the low quality of the water, most of the livestock grazing in the area are seriously affected which imposed them moving to river Benue scavenging drinking water [23]. The reduced changed in wetness conditions with a gross increased in dryness conditions is an apparent indication of climatic change in the study area which has an adverse impact on agricultural production. Moreover, drought in Yola South LGA, drought disrupts crop growth, reduces grazing land, and threatens permanent soil degradation [5]. According to [22] revealed that Njuwa lake is subjected to seasonal drying which sometimes led to reduction of crop yield due to insufficient of water at flowering stage. Plates 1, 2, 3, 4 and 5 were portrayed of some of the exacerbated effects of drought on agricultural production in the study area.

Plate 1: Gradual Encroachment of Desert, Loss of Pastures for Cattle and Drying of Farmlands due to Drought Events in Yola South LGA **Source**: Adopted from [21;22]

Plate 2: Drying of Njuwa lake, farmlands and River Chochi due to drought hazards in the area. **Source**:(Adopted [22]).

Plate 3: Uncompleted irrigation dam project in the study area meant to curtail drought conditions for effective farming. **Source**:(Adopted [22]).

Plates 4. Starvation of livestock due to loss of fodder and vegetation in the study area. **Source**:[1].

Plates 5. Drying of Njuwa Lake where irrigation and fishing activities are carried out as a result of water scarcity in the study area. **Source**: [1].

V. CONCLUSION

Climate change constitutes a very serious threat to sustainable agricultural production and food security in many parts of the world most especially in the north-eastern part of Nigeria where rainfall variability and gradual decrease of precipitation in the region considered as the origin of drought manifestation on agricultural production. This study attempts to overview the spatio-temporal variability of droughts conditions in the area through the comparative analysis of the related previous work for about forty years. It was revealed that 21 years were found with variable intensity of drought conditions. The years affected with seasonal drought scenarios were 1970, 1972, 1977, 1979, 1981, 1983, 1986, 1987, 1994, 1990, 1991, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008.2013 and 2017 respectively. In addition, 1990, 2002, 2006, 2008 and 2013 were quantified as very high drought conditions while an extreme drought condition was found in the year 1987, 2002 and 2006 with a less amount of rainfall which are 678.7mm, 656.4mm and 764.9 mm respectively. Therefore, it is apparent that the study area is adversely affected with drought conditions as a consequence of reduction in annual rainfall amount most especially in the two recent decades having adversed effects of agriculture. Among the implications of drought scenarios identified in the area includes poor growth and yield of crops, loss of vegetation and pasture for livestock, pest and diseases infestation, drying of lakes and dams among others. Farmers in the area have saddled strategically in adopting different ways in order to cope with the situation which include early planting of improved drought resistant crop varieties, early planting and water harvesting in an attempt to curtail the spatial and temporal variability of droughts hazards in the area for optimum food production of the growing population in the area.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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