



Meteorological Drought Characterization and Crop Planning For Sustainable Production

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ABSTRACT

The research work identified meteorological drought characterization and crop planning for sustainable production in Yola South North-eastern Nigeria. Thirty (30) years rainfall data were used in analyzing and characterizing the meteorological drought in the area. The results revealed that the year 2002, 2003, 2005 and 2006 were characterized with severe drought which consequently posed serious damage on crop production in the area while 1990, 1992, 1993, 1996, 1997, 2004, 2007, 2008 and 2011 were rated with moderate drought episode. Similarly, for mitigation planning of crop practices, suitable time for sowing of maize crop in the area is early July while middle June for rice crop which requires supplemented irrigation of about 59.97 mm to attained optimum production. Farmers are therefore recommended to use early maturing crop varieties with low water requirement for sustainable production.

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INTRODUCTION

Agriculture is an economic activity that produces food necessary for human livelihood and it is highly dependent upon weather and climate; however, agriculture is also likely to be very vulnerable to climate variability and change. (FAO, 2019) The main important source of water in any area is rain and it has a dramatic effect on agriculture. (Arvind, ET AL., 2017). Over 90 percent of agriculture depends on rainfall without the aid of artificial irrigation and only 5 percent of the cultivated land in Africa is irrigated and the majority of the farmers depend on rainfall (FAO, 2019). However, there is apparent changes in climatic condition in the tropics through gradual decline in rainfall and increase in temperature which adversely affects cropping activities. It is known that plants

get their water supply from natural sources and through irrigation (Arvind, *et al.*, 2017). Thus, the insufficient or deficient of rainfall below the normal is considered as drought in consequence reduces crop growth and development. According to Yellamanda and Sankara (2010), drought is a condition under which crops fail to grow and mature because of insufficient soil moisture. Drought is a serious hazard to agriculture in both temperate and tropical regions of the world. Drought is a normal feature of climate and its recurrence is inevitable (Wilhite, 2000). However, there remains much confusion within the scientific and policy community about its characteristics. It is precisely this confusion that explains, to some extent, the lack of progress in drought management in most parts of the world. (Wilhite, 2000).



Drought can be of different types either hydrological, agricultural or meteorological. Meteorological drought is expressed solely on the basis of the degree of dryness (often in comparison to some normal or average amount) and the duration of the dry period. (Wilhite, 2000). Thus, intensity and duration are the key characteristics of these definitions. Meteorological drought definitions must be considered as region specific since the atmospheric conditions that result in deficiencies of precipitation are climate regime dependent. Climate variability and climate change are the main causes of stress on food production and availability. Depending on the level of development, roughly 20 to 80 percent of the inter-annual variability of yields is caused by the changes in weather and 5 to 10 percent of national agricultural production is lost annually due to weather variability. (FAO, 2019). The economic, social, and environmental costs and losses associated with drought are also increasing dramatically, although it is difficult to quantify this trend precisely because of the lack of reliable historical estimates of losses (Wilhite, 2000). It is a known theory that frequency or probability of rainfall distribution helps to relate the magnitude of the extreme events like floods, droughts and severe storms with their number of occurrences such that their chance of occurrence with time can be predicted easily (Arvind, *et al.*, 2017).

Yola is characterized by marked rainfall variability both seasonally and annually, this makes the area highly susceptible to drought (Binbol and Edicha, 2012). The yield of crops particularly in rain-fed areas depends on the rainfall pattern, which makes it important to predict the probability of occurrence of rainfall (and drought) from the past records of hydrological data using statistical analysis (Arvind, *et al.*, 2017). In Yola South LGA, of Adamawa State Nigeria, different methods

and indices have been adopted by researchers towards characterization of drought and its implication on agriculture and environment. For example Binbol and Edicha (2012) assess drought characteristics in Yola, using Standardized Precipitation Index (SPI) techniques, Sadiq, *et al.*, (2020a) studied the rainfall anomaly variation, Sadiq, (2020a) studied the seasonal variability of rainfall using Rainfall Seasonality Index (RSI), Sadiq, (2020b) also characterized drought using Rainfall Decile Index (RDI), Sadiq, *et al.* (2020b) studied the Percent of Normal Precipitation (PNP). But yet little or no efforts have so far been made by scholars to assess drought characterization with the aim of providing crop planning strategies to mitigate the adverse effects caused by the incidences in the area. Thus, agricultural planning can often reduce the risk of drought impact on crops by altering the crop, genotype, planting date, and cultivation practices. (Wilhite, 2000). One strategy that farmers can adopt to sustain or increase crop yields in the face of a highly variable climate is to manipulate the crop environment through improved management strategies for adaptation. (Rao, *et al.*, 2015). However, in the area most of the farmers have no enough strategic planning techniques and required information towards improving the drought edipsodes. Thus, Umar and Musa, (2005) 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 a related findings majority of the farmers (60 %) in Yola South LGA, revealed that the level of the drought impact on agricultural production was high affecting crop yield, drying of dams, reservoirs and lakes and outbreak of crops' pest and diseases (Sadiq *et al.*, 2020b). The information on drought management can be effectively obtained from the analysis of rainfall distribution and

variability over a long period of time for future planning and mitigation. Therefore, present study aim to characterize meteorological drought and provide effective crop planning strategies for sustainable food production in the area.

STUDY AREA

Yola is located on latitude 9° 14'N and longitude 12° 38'E of the Greenwich meridian. It has an average altitude of about 185 meters above sea level. Yola lies within the Benue trough consisting of undulating flood plains. It has an area of 8,068 sq/km and a population of 3,166,101 inhabitants for the entire state (NPC, 2006) provisional census figure. Yola lies within the Sudan savannah vegetation classification characterized by tall grasses and sparsely distributed trees mostly of economic value such as shear butter, locust bean, baobab, gum Arabic, *balanite* etc. In terms of climate classification, Yola falls

under the Koppen's Aw class. That is, tropical savannah climate with distinct dry season in the low sun period. The dry season is strongly developed for about five months, beginning from October ending to late March. Rainfall is about 958.99 mm per annum with highest down pour occurring between August/September (Binbol and Zemba, 2007). Yola has an average minimum temperature of 15.2 °C and an average maximum of 39.7 °C. The hottest months are March/April with maximum temperature of 42.7 °C while the coldest months are November/December with minimum temperature of 11.11 °C (Binbol and Henry, 2009). Agriculture and cattle rearing are among the major economic activities of the people in the study area. Crops grown include Cotton, Groundnuts, Rice, Millet, Maize, Beans and Guinea corn. Cows, Sheep and Goats are reared while the river Benue is exploited for fishing and dry season cultivation.

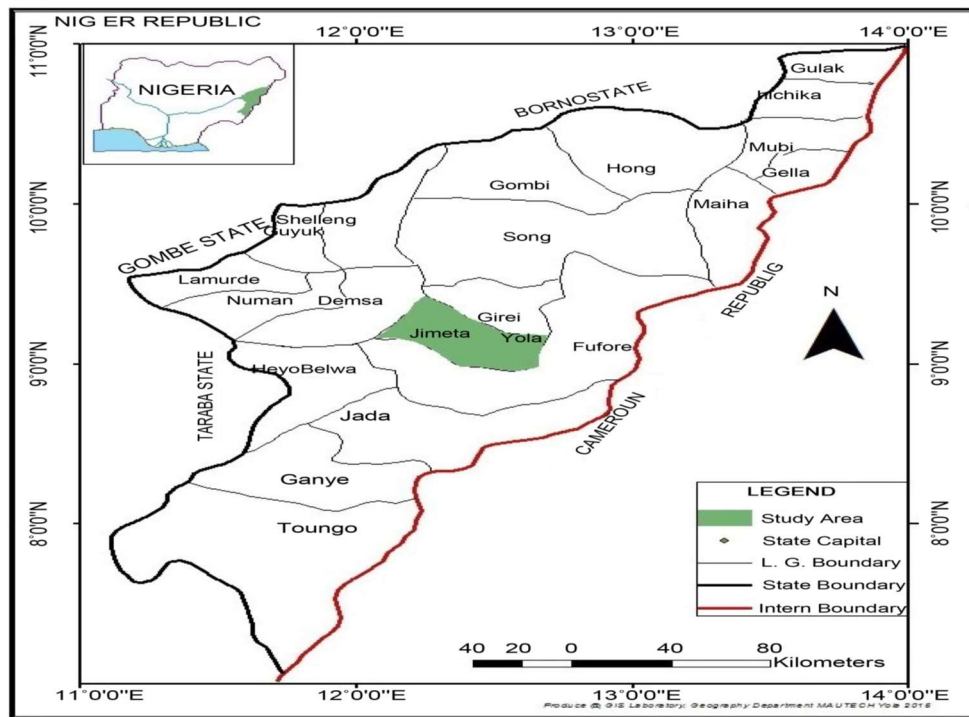


Figure 1: The Study Area.



MATERIALS AND METHOD

The rainfall data used in the research work were obtained from the Agro-meteorological Station of the Upper Benue River Basin Development Authority, (UBRBDA) Yola for the period of thirty (30) years (1988-2017). The data were subjected

to analysis of meteorological drought as follows;

Meteorological Drought

Meteorological drought is estimated as percent of rainfall deficit in relation to normal rainfall over a long period of time. It is express as;

$$\text{Meteorological Drought} = \frac{\text{Rainfall Deficiency}}{\text{Normal Rainfall}} \times 100 \dots \dots \dots \text{equation 1}$$

A drought is said to be a meteorological drought if the rainfall deficiency is more than 25% of the normal rainfall over an area. It becomes moderate

drought if the deficiency is between 26 and 50% of normal. If the deficiency of rainfall is more than 50%, it is known as severe drought (Yellamanda and Sankara, 2010).

Table 1. Rainfall Deficiency Levels and Drought Characterization

Rainfall Deficiency Level	Drought Characterization
< 25 %	Normal Rainfall
26-50 %	Moderate Drought
> 50 %	Severe Drought

Source: (Yellamanda and Sankara, 2010).

Rainfall Deficiency

Rainfall Deficiency was obtained using Rainfall Effectiveness (**R_e**) formular as defined by Monkhouse and Wilkinson, (1967) and Singh and Dhillon, (1994) respectively. It is usually expressed as the actual total rainfall minus the total possible evaporation.

R_T = is the actual total rainfall, **R_E** = is the total possible evaporation

The positive values is considered and rated as effective (if rainfall amount > evaporation rate) while the negative value is considered and rated as not effective (if rainfall amount < evaporation rate). The rainfall effectiveness may explain how much the quantity and concentration of rain of a particular area that is suitable for a particular crop (Singh and Dhillon, 1994).

$$\text{Rainfall Effectiveness } R_e = R_T - R_E \dots \dots \dots \text{equation 2}$$

Where;



RESULTS

Table 2: Estimated Rainfall Effectiveness (mm)

Years	Apr	May	Jun	Jul	Aug	Spt	Oct	Total	Average	Ratings
1988	-241.47	-80.24	21.52	72.64	72.04	210.82	-107.52	-52.21	-7.45	Not Effective
1989	-240.95	-20.20	-61.24	13.28	328.74	-46.01	-154.58	180.96	-25.85	Not Effective
1990	-227.61	-115.75	-48.02	114.42	68.10	-11.96	-132.15	-352.97	50.42	Effective
1991**	-----	-----	-----	-----	-----	-----	-----	-----	-----	Not Available
1992	-170.78	-102.43	-62.41	-34.28	30.58	93.07	-160.46	-406.71	-58.10	Not Effective
1993	-199.54	-47.33	-38.71	68.94	-20.42	31.96	-79.91	-285.01	-40.71	Not Effective
1994	-163.51	-116.13	26.72	-56.00	158.35	-28.05	-56.77	-235.39	-33.62	Not Effective
1995	-240.23	-116.62	11.03	20.76	47.26	-77.61	-92.03	-166.40	-23.77	Not Effective
1996	-212.65	-4.06	11.03	20.76	47.26	-77.61	-92.00	-307.30	-43.90	Not Effective
1997	-129.40	-104.30	-115.69	59.50	14.00	43.20	-44.40	-276.90	-39.55	Not Effective
1998	-215.40	-163.30	-74.30	121.50	20.20	177.80	-88.00	-221.50	-31.64	Not Effective
1999	-243.90	-69.60	-35.10	10.16	132.29	147.60	53.20	-5.35	-0.76	Not Effective
2000**	-----	-----	-----	-----	-----	-----	-----	-----	-----	Not Available
2001**	-----	-----	-----	-----	-----	-----	-----	-----	-----	Not Available
2002	-268.37	-219.14	-34.38	-30.18	-13.77	158.00	-37.7	-445.54	-63.64	Not Effective
2003	-277.72	-214.83	-130.38	29.62	115.79	80.84	-35.84	-432.52	-61.78	Not Effective
2004	-263.26	-85.42	8.08	-12.60	97.60	49.02	-86.82	-293.40	-41.91	Not Effective
2005	-275.48	-148.35	-82.48	74.08	125.12	3.93	-132.55	-435.73	-62.24	Not Effective
2006	-307.00	-118.00	-12.71	0.32	65.26	92.36	-162.23	-442.00	-63.14	Not Effective
2007	-217.26	-135.92	-43.02	1.83	85.88	61.11	-121.54	-345.49	49.35	Effective
2008	-260.51	-95.94	-43.02	1.83	85.88	61.11	-121.54	-372.19	-53.17	Not Effective
2009	-166.82	-17.53	78.13	86.86	154.13	137.82	-67.84	204.75	29.25	Effective
2010	-194.83	-82.62	103.66	127.06	119.88	101.99	22.90	198.04	28.29	Effective
2011	-178.88	-71.74	-112.63	-49.56	18.94	138.22	17.66	-237.99	-33.99	Not Effective
2012	-175.70	28.87	119.12	67.06	101.5	110.62	-6.89	244.58	34.94	Effective
2013	-190.09	-22.29	-8.80	54.52	57.11	105.16	-63.78	-68.17	-9.73	Not Effective
2014	-97.82	20.05	63.29	19.86	74.37	93.55	-72.73	100.57	14.36	Effective
2015	-218.74	-163.07	37.10	89.78	163.52	137.80	-50.07	-3.67	-0.52	Not Effective
2016	-187.45	64.35	208.45	33.94	173.64	107.10	-28.65	371.38	53.05	Effective
2017	-109.80	-35.98	42.93	46.51	84.00	103.02	-94.16	36.52	5.21	Effective

** *Missing Data; Not Available*

Table 3. Rainfall effectiveness for 30 years period

Months	Rainfall effectiveness (mm)
January	0
February	0
March	0
April	0
May	37.75
June	60.89
July	50.65
August	97.65
September	99.59

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Months	Rainfall effectiveness (mm)
October	31.25
November	0
December	0

Table 4: Characterization of drought using Rainfall Effectiveness method

YEAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	*CMV %	RATING
1988	Severe	Severe	Normal	Moderate	Moderate	Severe	Severe	04.81	Normal
1989	Severe	Normal	Severe	Normal	Severe	Severe	Severe	18.42	Normal
1990	Severe	Severe	Severe	Severe	Moderate	Severe	Severe	42.85	Moderate
1991	-	-	-	-	-	-	-	-	**NA
1992	Severe	Severe	Severe	Moderate	Normal	Normal	Moderate	41.59	Moderate
1993	Severe	Moderate	Moderate	Moderate	Normal	Normal	Severe	28.98	Moderate
1994	Severe	Severe	Normal	Severe	Severe	Moderate	Severe	25.46	Normal
1995	Severe	Severe	Normal	Normal	Normal	Severe	Moderate	15.39	Normal
1996	Severe	Normal	Normal	Moderate	Normal	Moderate	Severe	30.43	Moderate
1997	Severe	Severe	Severe	Moderate	Normal	Normal	Moderate	31.43	Moderate
1998	Severe	Severe	Severe	Moderate	Normal	Severe	Severe	21.65	Normal
1999	Severe	Moderate	Normal	Normal	Severe	Severe	Moderate	00.48	Normal
2000	Severe	-	-	-	-	-	-	-	**NA
2001	Severe	-	-	-	-	-	-	-	**NA
2002	Severe	Severe	Moderate	Moderate	Normal	Severe	Severe	67.84	Severe
2003	Severe	Severe	Severe	Normal	Severe	Moderate	Moderate	55.11	Severe
2004	Severe	Severe	Normal	Normal	Moderate	Moderate	Severe	36.67	Moderate
2005	Severe	Severe	Severe	Moderate	Severe	Severe	Severe	54.52	Severe
2006	Severe	Severe	Normal	Normal	Moderate	Normal	Normal	57.78	Severe
2007	Severe	Severe	Moderate	Normal	Moderate	Moderate	Severe	38.24	Moderate
2008	Severe	Severe	Moderate	Normal	Moderate	Moderate	Moderate	46.00	Moderate
2009	Severe	Normal	Moderate	Moderate	Severe	Severe	Severe	19.25	Normal
2010	Severe	Severe	Moderate	Severe	Severe	Severe	Moderate	18.61	Normal
2011	Severe	Severe	Severe	Moderate	Normal	Severe	Normal	28.91	Moderate
2012	Severe	Normal	Moderate	Moderate	Severe	Severe	Moderate	22.53	Normal
2013	Severe	Normal	Normal	Moderate	Moderate	Severe	Severe	08.23	Normal
2014	Severe	Normal	Moderate	Normal	Moderate	Moderate	Severe	09.90	Normal
2015	Severe	Severe	Normal	Moderate	Severe	Severe	Severe	00.30	Normal
2016	Severe	Moderate	Severe	Moderate	Severe	Severe	Moderate	04.20	Normal
2017	Severe	Moderate	Moderate	Moderate	Severe	Moderate	Severe	03.96	Normal

*Cumulative Value ** Not Available

Table 5: Summary of the seasonal variability of drought occurrences for the years of study

Drought Category	April	May	June	July	August	September	October
Severe	27 ^a	17 ^a	9 ^a	3 ^c	11 ^a	15 ^a	16 ^a
Moderate	0 ^c	4 ^c	9 ^a	15 ^a	8 ^b	8 ^b	9 ^b
Normal	0 ^c	6 ^b	9 ^a	9 ^b	8 ^b	4 ^c	2 ^c
Total (Years)	27	27	27	27	27	27	27



Table 6: Summary of the seasonal variability of drought for monthly occurrences

Drought Category	Months of Reoccurrences	Cumulative Days
Normal	June	60
Moderate	June and July	60
Severe	April, May, August, September and October	150 days

Table 7: Seasonal variability of cropping suitability and irrigation requirement as influenced by drought scenarios

Year	*CMV %	Drought Rating	Cropping System	Irrigation requirement
1988	04.81	Normal	Highly Suitable	Not required
1989	18.42	Normal	Highly Suitable	Not required
1990	42.85	Moderate	Moderately Suitable	Required
1991	**NA	**NA	**NA	**NA
1992	41.59	Moderate	Moderately Suitable	Required
1993	28.98	Moderate	Moderately Suitable	Required
1994	25.46	Normal	Highly Suitable	Not required
1995	15.39	Normal	Highly Suitable	Not required
1996	30.43	Moderate	Moderately Suitable	Required
1997	31.43	Moderate	Moderately Suitable	Required
1998	21.65	Normal	Highly Suitable	Not required
1999	00.48	Normal	Highly Suitable	Not required
2000	**NA	**NA	**NA	**NA
2001	**NA	**NA	**NA	**NA
2002	67.84	Severe	Not suitable	Highly Required
2003	55.11	Severe	Not suitable	Highly Required
2004	36.67	Moderate	Moderately Suitable	Required
2005	54.52	Severe	Not suitable	Required
2006	57.78	Severe	Not suitable	Required
2007	38.24	Moderate	Moderately Suitable	Required
2008	46.00	Moderate	Moderately Suitable	Required
2009	19.25	Normal	Highly Suitable	Not required
2010	18.61	Normal	Highly Suitable	Not required
2011	28.91	Moderate	Moderately Suitable	Required
2012	22.53	Normal	Highly Suitable	Not required
2013	08.23	Normal	Highly Suitable	Not required
2014	09.90	Normal	Highly Suitable	Not required



2015	00.30	Normal	Highly Suitable	Not required
2016	04.20	Normal	Highly Suitable	Not required
2017	03.96	Normal	Highly Suitable	Not required

***Cumulative Value ** Not Available**

Table 8. Cropping farming in Yola South LGA, Adamawa State

Crop type	Temp (°C)	Rainfall (mm)	Early planting	Middle planting	Late planting	Maturity days
Maize	20-30	750-1500	April-May	May-June	July-August	90-120
Rice	20-30	750-1200	May	May-June	June-July	120-210
Cowpea	27-30	600-1250	June	June-July	July-August	90-120
G/nut	25-30	700-1000	May	May-June	June-July	120-150
Cassava	21-35	1500-2000	June	July-August	September	240-450
S Potato	21-30	1300-2000	June	June-July	August	90-150
Tomato	20-25	500-1250	July	September	October	56-84
Okra	18-30	1000-1500	April-may	June-July	August-Sept	90-210

Table 9: Crop Planning for Drought Mitigations in Yola South LGA, Adamawa State

Crops	Best suited		TCRR (mm)	ACRR (mm)	TCWR (mm)	Effective Rain-fed (mm)	Irrigation (mm)
	month Sowing	Harvesting					
Maize	Early July	Late October	1500	1125	450	279.14	170.86
Rice	Middle June	Middle October	1200	975	400	340.03	59.97
Cowpea	Late July	November	1250	925	350	228.49	121.51
Groundnut	Middle June	Middle October	1000	850	380	340.03	39.97
Cassava	Middle June	March-April	2000	1750	700	340.03	360
Sweet potato	Late June	October-November	2000	1650	500	320.03	179.97
Tomato	Late August	October	1250	875	300	163.34	136.66
Okro	June	Late August – Sept	1500	1250	500	308.01	191.99

TCRR: Total Crop Rainfall Requirement

ACRR: Average Crop Rainfall Requirement

TCWR: Total Crop Water Requirement

DISCUSSIONS

Characterization of Rainfall Effectiveness

The estimated values for rainfall effectiveness were depicted on table 2 and 3, where the month of September was estimated with the highest effective value of 99.59 mm followed by 97.65 mm in August respectively. Thus, it is known that

the two months were the rainiest months in the area where the rate of precipitation is higher than evapotranspiration. However, in recent decade reoccurrence of dry-spells was experienced in the months of August and September most especially in September due to sudden climatic change in the area. Conversely, conclusion was



drawn by Sadiq, *et al.*, (2020b) explained that the months of July-August were assessed to have more reoccurrences of drought scenario in the area by about 55% of the farmers while 45 % perceived to have occurred mostly in the months of May-June respectively. Findings of Umar, (2001) and Umar and Musa, (2005) revealed that the month of May and June in the Northern part of the state is more characterized by drought conditions. In contrast, however in the 2019 drought had occurred from 4th August-29th August, 2019 while the year 2020 the area experienced drought for two weeks from Sunday, 3rd August- 17th August, 2020 respectively. 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 which eventually affects crop growth and yield production.

Meteorological Characterization

Results on drought characterization were shown in table 4. It was revealed that 2002, 2003, 2005 and 2006 were characterized with drought severity having corresponding values of 67.84 %, 55.11 %, 54.52 % and 57.78 % respectively. These years posed a serious damage on agricultural production which leads to scarcity of food among the growing population. This finding correlated with the result of Sadiq, (2020b) who studied drought characteristics in the area using RDI where he found out that 2002, 1987, 1973, 1974 and 2006 falls under 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 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. Moderate drought episode was characterized in 1990, 1992, 1993, 1996, 1997, 2004, 2007, 2008 and 2011 while the remaining years were rated with normal rainfall respectively.

Moreover, the summary of the seasonal variability of drought occurrences on monthly basis was presented and rated on table 5. From the table severe drought episode was reoccurred seasonally in every April in all the periods (30 years) of study while 17 years of drought severity was occurred in May and 16 years in October, 15 years in September, 11 years in August and 9 years reoccurred in June respectively. Furthermore, moderate drought episode was estimated to have reoccurred 15 years in July, 9 years in June while normal rainfall was occurred in 9 years in the month of June correspondingly.

Generally, severe drought was reoccurred in the months of April, May, August, September and October (150 days) while June and July (60 days) were categorized as moderate drought condition and normal rainfall was occurred in June (30 days) as shown in table 6 respectively.

Cropping Suitability and Irrigation Requirement

Characterization of cropping suitability and irrigation requirement as influenced by seasonal variability of drought scenarios was presented on table 7. Cropping system was not suitable and required high supplemented irrigation for maximum growth and production in the year 2002, 2003, 2005 and 2006 accordingly. The season that moderately support cropping system with supplemental



irrigation was found in the year 1990, 1992, 1993, 1996, 1997, 2004, 2007, 2008 and 2011. In these years if irrigation is not adopted there will be tendency of low crop performance and productivity. Thus, the water deficit is leading to crops growth reduction as well as biomass accumulation (Sretenka, *et al.*, 2012). Conversely, the remaining years under the study cropping activities have rated highly suitable with normal rainfall amount that support effective crop growth and development which required no irrigation.

Crop Planning for Drought Mitigations

The crops grown in the area are maize and rice as the major cereals, cowpea and groundnut as the major leguminous crops, for the root tubers are cassava and sweet potato, while tomato and okra are considered as vegetables. The range of temperature and rainfall requirement, date of plantings as well as their maturity days were presented on table 8. This information coupled with local traditional experiences is used for planning of crop-drought mitigation strategies in the area for optimum and sustainable food production in the area. Table 9 described the planned mitigations for droughts episode in the area. Thus, the adverse effect of drought can be ameliorated to an extent by in situ conservation of rain water harvesting, wind breeze and agronomic practices to overcome moisture stress (yellamanda and sankara (2010). The best suitable month for sowing of maize crop is early July which takes 90-120 days for its maturity and required about 170.86 mm of irrigation for effective yield while rice crops can be sown around middle June and harvested middle October but still with the addition of 59.97 mm as supplemented irrigation to attained optimum yield production. For the major leguminous crop cowpea can best be sown in late July under a required 121.51 mm of irrigation while

groundnut can be sown middle June and harvested middle October by the addition of about 39.97 mm to met up the total crop water requirement of 340.03 mm respectively. Cassava crops require 360.00 mm of water supplement on the effective rain-fed which can best be planted middle June while sweet potato late June requiring about 179.97 mm respectively. Tomato as vegetable requires addition of 136.66 mm of water for effective output and Okra crops require highest irrigation of about 191.99 mm to supplement the effective rain-fed of 308.01 mm. Okro is sown in June while tomato around late August with supplemented. It has been estimated that drought leads to yield reduction for about 20% in regard to plant genetic potential and the main measure that could be used to prevent drought consequences is irrigation (Sretenka *et al.*, 2012). Thus, it is a known fact that the impacts of drought are crop specific because the most weather-sensitive phenological stages vary between crops, planting dates and maturation periods also vary between crops and locations (Wilhite, 2000).

CONCLUSION

Crop production is directly dependent sustainable food production can be attained through maximizing and improving the level of crop production which is directly depending on climatic variables plays a vital role in predicting and determining the quantity and quality of crop yield to be produced. Rainfall deficiency below the crop requirement can be considered as drought.

However, drought can be characterized in to different levels depending on the level of effective, duration and intensity. In Yola South LGA result shows that severe drought meteorological drought was found in four (4) years under the period of study while moderate drought episode was occurred in



eight (8) years respectively. To realize sustainable production of food in the area effective agronomic planning through the use of early maturing varieties, suitable time for planting coupled with supplemented irrigation method.

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