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Some Aspects of Rainfall Trends and Their Implications on Soil and Crop Management Practices in Makurdi, Nigeria, Southern Guinea Savanna

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Abstract: ***Some Aspects of Rainfall trends and their Implications on Soil and Crop Management practices in Makurdi were studied. The objective of the study was to evaluate the effects of some aspects of rainfall trends in Makurdi, enumerate the implications of these trends on soil and crop management practices and identify majors that will ameliorate negative implications of rainfall trends on soil and crop through management practices. Daily rainfall data for the period of 32 years (1980 – 2011) were collected from the Meteorological Department, Nigeria Tactical Air Command Headquarters, Makurdi. The data were aggregated to provide monthly and annual totals. In order to evaluate some aspects of rainfall trends, some definitions were considered. Results of the study showed that: Rainfall trends in Makurdi are characterized by seasonality and variability in rainy days and monthly rainy days. It was observed that rainfall intensities of more than 80mm per 30 minutes of rainfall are available between the months of April – October. The risk of soil erosion and degradation during the rainy seasons observed could be reduced through proper soil management practices to give soil the maximum physical resilience through a stable heterogeneous pore system by maintaining a close ground cover as much as possible. Makurdi experiences a hot tropical climate with distinct wet and dry seasons; therefore, timing of cropping seasons is necessary for proper soil and crop management and production***

Keywords: Rainfall Trends, Rainfall anomalies, Rainfall intensity, Rainfall distribution, Crop management practices, Soil Management**.**

1. Introduction

The dependence of farmers on rainfall for agricultural production in Africa cannot be overemphasized, Nigeria is not an exemption. The longevity of growing plants over the years depends solely on the duration of rainfall, amount of moisture and water availability to the soil and crop areas. Rainfall trends in Nigeria, is characterized by seasonality and variability in rainy days (Oluwasemire, 1999). Climatic report based on rainfall data over 32 years have shown anomalies identified by various implications on soil and crop management practices. The continue crop growth over the years depend purely on the amount of rainfall and water availability to the soil.

Drought is a factor that impedes continuous crop growth even with the invention of irrigation farming technologies. Such facilities cannot be easily afforded and maintained by peasant farmers that are the bedrock of crop production in Nigeria. Whereas, where the acquisition would be made possible, the location of plots of land is also another factor of concern since nearness to water source achieves the objective of irrigation better. The situation adduced that, with even rainfall distribution, occurrence of anomalies will eventually leads to reduced crop production Climate is one of the most vital components of our physical environment and is a comprehensive description of how weather changes both in time and space. Elements of climate include temperature, sunlight, humidity, precipitation, cloudiness, winds, transpiration, hail, rainfall, mist and evaporation. The biological and other processes which contribute towards crop and soil management practices are greatly influenced by climatic elements (Kassam and Kowal, 1978). Climate is a great economic asset in soil and crop management practices and therefore, special attention and consideration must be given to it to ensure a huge success in agricultural practices.

Rainfall is undoubtedly the most crucial variable in agronomy, and has far reaching influences on agricultural practices and production. Rainfall supplies moisture naturally to the soil to activate plant growth and development, replenish or top up underground and surface water and modifies other atmospheric elements. Consequently, one of the most serious constraints pose by rainfall to crop production in the sub-tropic is its variability. Both the amount and distribution are variable within a year, among years and among locations. Poor distribution and early ceasation of rainfall in the guinea savanna support agricultural practices for only three to five months a year and rendered crop production impossible for the rest of the months except with the aid of irrigation (Agboola 1979).

Farmers cope with the high rainfall variability in zone through a series of decisions designed to best utilize their climatic and soil environment. Choice of soil and crop management is based on amount of rainfall, its duration and intensity. Planting opportunities are limited by the amount and time of rainfall. Therefore, the frequency and timing of planting opportunities as determined by rainfall trends are of prime important to agriculture production.

The work was set up to examine some aspects of rainfall trends and their implications on soil and crop management practices in Makurdi, Nigeria.

The specific objectives are to:

- Evaluate some aspects of rainfall trends in Makurdi
- Enumerate the implications of the rainfall trends on soil and crop management practices in Makurdi.
- Identify measures that would ameliorate negative implications of rainfall on soil and crop through management practices

2. MATERIALS AND METHODS

Study Area

The study area Makurdi, is located at latitude 07^{0}41'N, Longitude 08.37'E and altitude, 106.4 m above sea level. Makurdi is situated in the North Central Zone (Middle Belt) of Nigeria. It is the east of River Benue/Niger confluence and covers an area of 46300 Km^2. The state is 3000 Km inland from Atlantic Ocean. Makurdi experiences a hot tropical climate with distinct wet and dry seasons It is in the southern guinea savanna ecological zone and has a bimodal rainy season starting in April and ending in late October, (Agboola, 1979). In the past, Makurdi experiences a bimodal rainfall distribution pattern with one peak in July and another in September. However, recent meteorological data (1980-2011) pointed out to unimodal pattern with peak in August. The annual average rainfall is about 1400 mm per year and the region is made up of ferruginous tropical soil.

Benue State shares boundaries with Nasarawa State to the North, Kogi State to the West, Taraba State to the East while Enugu and Cross-River States to the south. The annual mean day temperature varies from 32.2 – 32.9^{0}C with higher night temperature. (Kassam & Kowal, 1978; FAO, 1984).

Two principal air masses influence the climate of the area. The south west maritime wind which originate from the Atlantic Ocean blows across Makurdi between March and October and is associated with the wet season while the dry season is brought about by the north eastern wind generally called Harmattan. The relative humidity of the area ranges between 23 and 44%.

The vegetation of the study area falls within southern guinea savannah which is characterized by small portions of woodland. The common tress found around the study area include; *Daniella Oliveri, Piliostigma Thonnigii (Nyihaa), Prosopis Africana* (Gbaaye), *Vitellaria Paradoxa* (shea butter, *chamegh*) among others. The dominant grasses include; *Andropogon gayanus (gambagrass), Imperata cylindrica* (spear grass), *mitracarpus villosus* (*antiokpouroor*) among others. The major crops grown in the area are: Yam, cassava, maize, millet, rice and varieties of vegetable such as okra, *amaranthus*, pepper among others.

The slope of Makurdi is about 0 – 5% and the elevation above mean sea level is about 93 m.

Data Collection

Daily rainfall data for the period of 32 years (1980-2011) was collected from the Meteorological Department, Nigeria Tactical Air Command Headquarters, Makurdi. The data was aggregated to provide monthly and annual totals.

Assessment of Rainfall Trends:

In order to evaluate some aspect of rainfall trends, the following definitions were considered;

*A rainy day: defined as any day with 0.2 mm rainfall or more.

*The mean daily intensities were obtained by dividing monthly averages by the average number of rainy days (Jackson, 1986).

*Annual rainfall and rainy days anomalies were computed and express as percentage deviation from mean.

*Anomaly was computed as annual rainfall subtracted by average rainfall divide by average rainfall.

*Percentage (%) deviation from mean was calculated as anomaly X 100.

*Rain storms per rainy day/event at the early part of the rainy season were compared over years to investigate for changes in rainfall intensity with a view of assessing the implications of soil wash resulting in increasing energy of rainfall, when soil vegetative covers is low on soil texture and bulk density, infiltration capacity and chemical properties.

Rainfall Distribution

The amount of rainfall received at periodic intervals like weeks, months, seasons was used in assessing the distribution of rainfall through the determination of:

- Dry spell
- Wet spell and
- Rainy days.

Rainfall distribution analysis was based on;

* Weekly or monthly rainfall
* Wet and dry spell: number of continuous days of rainfall, whereas a dry spell is a number of continuous rainless days.
* Rainy days: When the rainfall received is equal or more than 0.2 mm on any day.

Rainfall Pattern in Makurdi was analyzed base on index below;

(i) Annual rainfall (mm)
(ii) Seasonal rainfall (mm)
(iv) Cropping season.

3. RESULTS AND DISCUSSION

Total annual monthly rainfall

Total annual monthly rainfall and seasonally distribution data on annual rainfall in Makurdi is presented in Table 1.The annual rainfall at Makurdi is 1618 $\pm$ 761.5. The rainfall is unimodal in distribution, with peaks in July – August; while the months of November to February are virtually rainless in most of the years recorded (Table 1).The monthly rainfall across all the years increased steadily from March to July/August and thereafter starts decreasing. A comparism of the total annual rainfall for the years for the period covered by this report shows greater annual reductions and variations from one year to another. However, the reductions and variation patterns were not steady. Similar patterns of reductions/increased and variation of rainfall amount was observed during the months of July, August and September. It was further observed that the declining annual rainfall was dominated by a reduction in the mid-season rainfall. Higher variation in term of rainfall amount was observed during the mid-season than at the beginning and end of the rainy seasons.

In line with the fact that lesser variations in rainfall amount is observed during the beginning of the raining seasons, crops should be planted early for rain fed agriculture for higher productivity.

DEVASTATING EFFECT OF PROLONG RAINFALL INTENSITY ON CROP AND SOIL IN MAKURDI, NIGERIA

Table 1: Annual/monthly rainfall (mm) in Makurdi

Month/ Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual total
1980	-	-	59.8	155.9	183.3	162.5	227.1	351.1	227.7	63.1	-	-	1425.5
1981	17.6	-	TR	80.1	161.5	119.3	316.3	287.6	195.7	45.8	3.2	-	1227.5
1982	-	TR	18.5	31.5	57.6	196.9	313.2	85.9	163.7	84.2	-	-	951.5
1983	-	-	1.2	2.6	193.2	213.8	232.4	158.2	128.1	0.8	-	-	930.5
1984	-	-	52.8	116.3	222.4	126.0	314.4	453.2	175.2	111.4	TR	1.3	1572.0
1985	18.6	-	60.5	14.1	119.2	148.3	289.6	134.8	185.6	34.8	-	TR	1005.4
1986	-	3.7	32.2	60.7	169.5	172.2	183.6	174.9	266.3	113.2	31.4	-	1207.7
1987	-	3.3	23.9	12.4	161.8	81.0	198.1	449.7	179.2	98.3	TR	-	1207.6
1988	9.4	TR	1.0	61.0	101.6	68.8	158.2	197.5	144.9	91.5	TR	7.2	841.1
1989	-	-	1.6	58.9	191.8	203.2	237.3	170.6	249.0	131.9	-	-	1244.3
1990	-	-	-	109.9	79.7	142.3	158.5	219.5	310.8	81.2	1.6	17.4	1120.9
1991	-	-	45.8	103.8	183.2	82.7	96.4	264.3	185.0	161.2	-	-	1122.4
1992	4.4	3.1	5.2	65.3	75.0	84.2	154.8	154.5	312.6	80.9	32.7	-	972.7
1993	-	-	9.2	46.9	52.9	268.1	341.3	177.6	137.2	186.9	TR	-	1220.1
1994	27.1	-	-	58.7	150.5	108.4	82.0	213.4	184.1	149.0	-	-	973.2
1995	-	4.4	15.4	35.1	85.0	353.9	108.4	284.4	119.3	154.1	4.1	-	1172.1
1996	-	0.1	TR	109.2	135.4	241.7	204.8	287.7	247.0	98.7	-	-	1323.9
1997	-	-	1.5	212.5	99.1	161.5	87.4	156.2	377.2	213.3	27.2	-	1335.9
1998	-	-	-	134.8	156.2	338.8	241.7	273.8	318.0	93.6	-	-	1556.9
1999	1.0	-	42.2	112.3	154.6	304.6	132.3	348.6	367.3	155.1	-	-	1618.0
2000	-	-	TR	96.4	114.2	227.0	172.7	334.6	149.2	79.0	-	-	1173.1
2001	-	-	-	98.5	136.7	240.5	96.1	251.0	216.3	36.9	-	-	1076.0
2002	-	-	42.4	73.0	109.9	171.1	187.9	215.6	353.0	108.5	20.1	-	1281.5
2003	-	-	-	56.4	80.7	200.0	119.2	145.3	136.4	39.8	33.7	-	761.5
2004	-	-	7.8	61.0	23.3	164.5	169.8	185.1	162.9	149.5	0.7	-	974.6
2005	-	-	22.0	42.9	90.5	209.8	142.4	112.7	159.4	91.6	-	-	871.6
2006	46.9	-	13.3	26.1	276.1	109.9	322.7	215.1	229.3	103.6	-	-	1343.0
2007	-	-	8.7	124.8	170.5	210.0	114.5	272.7	217.9	219.2	1.6	-	1339.9
2008	3.0	-	TR	186.1	147.4	186.1	81.6	780.2	83.0	81.5	-	1.6	1550.5
2009	2.3	-	3.0	180.1	190.3	239.6	86.1	275.3	140.5	284.1	1.2	-	1402.5
2010	-	-	12.6	31.4	134.7	119.4	192.7	178.1	305.6	116.8	24.0	-	1115.3
2011	-	68.8	-	78.0	142.8	60.4	87.0	217.4	272.0	293.4	-	-	1219.8

Number of Rainy Days

The number of rainy days over the observed periods is presented in Table 2. The results show that, 1999 and 2009 recorded more number of rainy days (95) than all the other years considered. The least year with the number of rainy days was 1983; the mean number of rainy days was 56 days. It was observed that 50% of the total number of rainy days in the years considered were above the total mean. Similarly, 50% of the total numbers of rainy days were below the total mean.

Generally, there was a decrease in the number of rainy days in the years considered. This is an indication of higher rainfall intensity per rainfall event. The higher frequency of thunderstorm and squalls early in the rainy seasons between Aprils to June is also an indication of the occurrence of higher rainfall intensities early in the season (Table 3).

Table 2: Monthly Rainy Days

Month/ Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	No. of Rainy days (mean))
1980	-	-	1	7	10	10	14	18	14	7	-	-	81
1981	1	-	-	4	11	11	16	14	15	5	1	-	78
1982	-	-	2	6	8	10	17	9	13	8	-	-	73
1983	-	-	1	2	10	11	10	10	11	1	-	-	56
1984	-	-	3	6	13	10	16	13	10	7	-	1	79
1985	1	-	6	4	8	10	15	9	16	4	-	-	65
1986	-	2	4	5	10	5	14	10	13	8	2	-	73
1987	-	1	1	3	9	9	14	20	16	6	-	-	79
1988	2	-	1	4	11	5	16	18	13	6	-	1	77
1989	-	-	1	4	12	9	13	14	11	10	-	-	74
1990	-	-	-	6	10	12	13	16	14	7	1	2	81
1991	-	-	1	7	11	8	10	17	12	9	-	-	75
1992	2	1	1	5	10	14	15	16	20	5	2	-	80
1993	-	-	2	4	9	10	14	12	13	10	-	-	74
1994	1	-	-	6	9	10	9	13	16	18	-	-	82
1995	-	1	2	5	9	13	10	4	13	2	-	-	59
1996	-	-	-	4	8	11	11	16	17	9	-	-	76
1997	-	-	1	6	11	9	9	12	15	16	4	-	83
1998	-	-	-	6	9	12	12	13	15	8	-	-	75
1999	1	-	1	6	9	11	17	17	19	14	-	-	95
2000	-	-	-	5	8	13	13	14	14	5	-	-	72
2001	-	-	-	6	7	11	11	15	16	7	-	-	73
2002	-	-	2	5	7	12	14	15	18	4	1	-	78
2003	-	-	-	5	5	14	10	14	13	5	2	-	68
2004	-	-	1	5	10	9	13	9	13	10	1	-	71
2005	-	-	1	3	10	11	13	12	15	9	-	-	74
2006	2	-	3	1	13	11	15	13	18	2	-	-	80
2007	-	-	1	6	12	9	10	19	17	13	1	-	88
2008	1	-	-	8	10	11	6	19	19	7	-	1	72
2009	1	-	1	7	9	12	15	16	15	18	1	-	95
2010	-	-	1	5	7	11	11	13	14	11	1	-	74
2011	-	3	-	7	7	6	12	14	10	18	-	-	77
						TOTAL							**2439**

Rainfall Intensity

Table 3 has been analyzed using monthly rainfall data and number of rainy days. The intensity of rainfall is a measure of the amount of rain that falls over time. The intensity of rain is a measured of the height of the water layer covering the ground in a period of time. It means that if the rain stays where it falls, it would form a layer of a certain heights, we say things like; 30 mm of rainfall today or it rained 20 mm in two hours. Generally speaking, a relatively low intensity is for instance 2 mm of rain a day and relatively high may be 30 mm an hour. High intensity of rainfall on steep slopes, may lead to flash floods. On flat areas, it may lead to pounding or urban floods when the drainage capacity is insufficient for the intensity of the falling rain.

Though, the total number of rainy days have decreased dramatically after the drought of 1973 to date, there had been years of higher annual rainfall than the long term average, but with records of lower than average number of rainy days. Hence, the results show that the seasonal rainfall is not totally controlled by the number of rainy days.

In line with the fact that rainfall intensities have increased, especially early during rainy season and the decline in annual rainfall has also been dominated by a reduction in the number of rainy days, the risk of soil degradation during the season can be reduced through appropriate management practices which may include mulching, intercropping cereal and fast growing legumes, aforestation of marginal lands and sloping lands, short duration, but drought tolerant and high yielding crop varieties need to be developed for successful agriculture in Makurdi area.

The use of water harvesting techniques through appropriate drainage systems would help conserve water for use during periods of dry spells preceding the early rainstorms and provide adequate drainage, hence reducing soil wash.

Table 3: Monthly Rainfall Intensity

Month/ Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1980	-	-	**59.8**	22.3	18.3	16.3	16.2	19.5	15.9	9.0	-	-	22.2
1981	17.6	-	-	20.0	14.7	10.8	19.8	20.5	13.0	9.2	3.2	-	14.3
1982	-	-	9.3	5.3	7.2	19.7	18.4	9.5	12.6	10.5	-	-	11.6
1983	-	-	1.2	1.3	19.3	19.4	23.2	15.8	11.6	0.8	-	-	11.6
1984	-	-	17.3	19.4	17.1	12.6	19.7	**34.9**	17.5	15.9	-	1.3	17.3
1985	18.6	-	10.0	3.5	14.9	14.8	19.3	14.9	11.5	8.7	-	-	12.9
1986	-	1.9	8.1	12.1	16.9	**34.4**	13.1	17.5	20.5	14.2	15.7	-	15.4
1987	-	3.3	23.9	4.1	17.9	9.0	14.2	22.5	11.2	16.4	-	-	17.6
1988	4.7	TR	1.0	15.3	9.2	13.8	9.9	10.9	11.1	15.3	-	7.3	9.9
1989	-	-	1.6	14.0	15.9	22.6	18.3	12.2	22.6	13.2	1.6	-	15.1
1990	-	-	-	18.3	7.9	11.9	12.2	18.7	22.2	11.6	-	8.7	12.0
1991	-	-	**45.8**	14.8	16.7	10.3	9.6	15.5	15.4	17.9	16.4	-	18.3
1992	4.4	3.1	5.2	13.1	7.5	6.0	10.3	9.7	15.6	16.2	-	-	9.8
1993	-	-	4.6	11.7	5.9	26.8	24.4	14.8	10.6	18.7	-	-	14.7
1994	27.1*	-	-	9.8	16.7	10.8	9.1	11.9	11.5	11.5	6.1	-	18.6
1995	-	4.4	7.7	7.0	9.4	27.2*	10.8	15.6	9.2	19.3	-	-	11.7
1996	-	-	-	27.3	16.9	21.9	18.6	17.9	14.5	10.9	6.8	-	18.3
1997	-	-	1.5	**35.4**	9.0	17.9	9.7	13.0	25.1	13.3	-	-	14.6
1998	-	-	-	22.5	17.4	28.2*	20.1	21.1	21.2	11.7	-	-	20.3
1999	1.0	-	42.2	18.7	17.2	27.7*	7.8	20.5	19.3	11.1	-	-	18.4
2000	-	-	-	19.3	14.3	17.5	13.3	23.9	10.7	15.8	-	-	16.4
2001	-	-	-	16.4	19.5	21.9	8.7	16.7	13.5	5.3	-	-	14.6
2002	-	-	21.2	14.6	15.7	14.3	13.4	14.4	19.6	27.1*	20.1	-	17.8
2003	-	-	-	11.3	6.1	14.3	11.9	10.4	10.5	7.9	16.9	-	11.2
2004	-	-	7.8	12.2	7.3	18.3	18.1	20.6	12.5	14.8	0.7	-	11.9
2005	-	-	22.0	14.3	9.1	19.1	10.1	9.4	10.6	10.2	-	-	13.2
2006	23.5	-	4.4	26.1	21.2	9.9	21.5	14.3	12.7	9.4	-	-	15.9
2007	-	-	8.7	20.8	14.2	23.3	11.5	14.4	12.8	16.9	1.6	-	13.8
2008	3.0	-	-	23.3	14.7	16.9	13.6	14.7	9.2	11.6	-	1.6	12.1
2009	2.3	-	3.0	25.7	21.1	19.9	7.2	17.2	10.8	15.8	1.2	-	12.4
2010	-	-	12.6	6.3	19.2	10.9	17.5	13.7	21.8	9.7	24.0	-	15.1
2011	-	22.9	-	11.1	20.4	10.1	7.3	15.5	27.2*	16.3	-	-	16.4

NB. TR = Trace Amount

Rainfall Anomalies

Total rainfall anomalies for Makurdi area is presented in figure 1. The results show erratic order of yearly rainfall and its distribution. It has been established that even rainfall distribution best enhances crop utilization, but where high rainfall is experienced everyday more than soil infiltration capacity calls for adequate soil management practices. In Makurdi, the rainy days over the years recorded higher amount of rainfall percentage anomalies. There was a drastic drift in performance every year as shown in figure 1. Rainy days anomalies follow the same pattern as annual rainfall. In Makurdi area, agricultural activities are highly dependent on rainfall, however with the drift from records (anomalies) agricultural productivity cannot be predicted with certainty. These observed anomalies could be supported by the introduction and use of proper irrigation practices and through supplemental irrigation schemes.

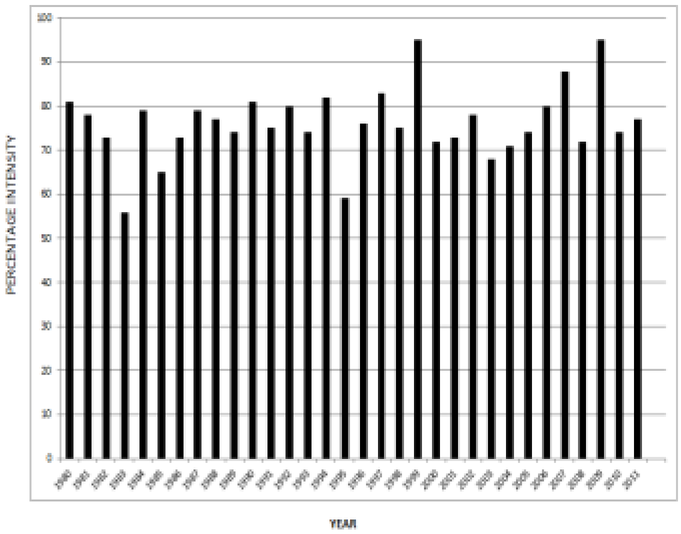

FIG. 1: ANNUAL TOTAL RAINFALL PERCENTAGE ANOMALIES IN MAKURDI FOR 32 YEAR

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