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RAINFALL CHARACTERISTICS IN THE HUMID AND TRANSITION ZONES OF SOUTHWEST, NIGERIA

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Abstract: *Rainfall characteristics are important for agriculture since they are the variable constant in rain-fed agriculture. Three important characteristics of rainfall are its amount, frequency and intensity, the values of which vary from place to place, day to day, month to month and also year to year. Precise knowledge of these characteristics is essential for planning the full utilization of rainfall. This study compared rainfall characteristics in the humid zone (Lagos) and transition zones (Abeokuta and Ibadan) in South-Western Nigeria. Daily rainfall data for 26 years (1985-2010) were used to determine the rate of evapotranspiration using the FAO56 Penman-Monteith method for evapotranspiration while dry spells and rain days were subjected to inferential and descriptive statistics. During the 26years period, the mean rainfall in Abeokuta, Ibadan and Lagos was 1236.77mm, 1418.8mm and 1507mm respectively. Results found that there was no statistically significant difference in amount and incidence of rainfall in Lagos and Ibadan only. On average, dry spell varies from 6-35days with Lagos>Abeokuta>Ibadan while Abeokuta had the mean highest evapotranspiration rate followed by Ibadan and Lagos, during the study period.*

Keywords: *Mean amount, humid period, climate change, moisture, crop growth*

INTRODUCTION

Precipitation or rainfall, is the most dynamic hydrometeorological variable which controls the existence of ecosystems and also the agricultural, industrial, and economic development of a country and may show high variability in its distribution. Understanding the spatial and temporal distribution of rainfall is critical for framing and implementing better agricultural and industrial development projects (Arvor et al, 2014).

Individuals have devoted more effort at collecting climatic data than to their subsequent analysis. The major way to improve data quality is to analyze the existing data to demonstrate their importance and shortcomings. Rainfall is a climatic parameter that affects the way and manner man lives. It affects every facet of the ecological system, flora and fauna inclusive. Hence, the study of rainfall is important and cannot be over emphasized (Obot and Onyeukwu, 2010). Rainfall is by far the most important element of climate change in Nigeria and water resources potential in the country and the impact could be measured in terms of effects on crop growth, availability of soil water, soil erosion, incident of pest and diseases, sea level rise and decrease in soil fertility (Adejuwon, 2004)

Agricultural productivity is strongly linked to rainfall variability, than any other element of climate in the tropics because farmers rely on rain fed agriculture. Therefore water scarcity is a major constrain to crop production. Rainfall determines not only where and when to plant crops but also whether crop will yield effectively or not. The amount of rainfall that is normally received determines which type of agriculture the can be carried out, and which crop that can be cultivated in a region. The seasonal rainfall occurrence regulates the agricultural calendar in the tropical region of Africa (Ayanlade et al, 2009).

Rainfall provides most of the needed water for agriculture in the tropics. The role of moisture in agriculture is even more spectacular in tropics where because of relative high temperature throughout the year, the rate of evaporation is constantly high. On the other hand, rainfall is highly seasonal over most part of the tropics. Because temperature is high

throughout the year, to ensure the growth of crops over most parts of the tropics with exception of few mountain areas, the growing season/harvest unlike in the temperate region is determined by availability of rainfall (Ayoade, 2003)

High or low precipitation has significant effect on agriculture. All crops need at least some water to survive; therefore rain (being the most common source of water) is important to agriculture. A regular rainfall pattern is usually vital for crop development but too much or too little rainfall can be harmful, even devastating to crops. Drought can kill crops if it's severe, while overly wet weather can cause harmful fungus to flourish and affecting crops. Different crops need varying amounts of rainfall to survive. In areas with excessive rainfall, soil nutrients diminish and erosion increase (Southern Sudan Agrometeorology Update, 2010). Whenever there is late onset, hunger, temporal unemployment and poverty loom. Dry spells and droughts which are related to rainfall and occur annually in Nigeria (Audu E.B et al 2012, Sawa B.A 2011) are injurious to crops leading to crop failure.

Living organisms (both plants and animals including man) cannot survive without optimum water supply. Although, it has been argued that rainfall (water) and temperature are the most important climatic determinants of crop survival and production especially in Nigeria. However, generally; temperature has remained favorable to crop production especially during the growing season, but rainfall is not only disappointing, but also erratic, highly unreliable and unpredictable. Meanwhile, Nigeria which still practices rain – fed agriculture rely on the "mercy of nature" to produce adequate food and the needed raw materials for the few agro allied industries. (Adebayo, 1997, Audu, 2012)

Generally, the study of the weather and climatic elements of a region is vital for sustainable development of agriculture and planning. Particularly, rainfall and temperature temporal analyses for trends, fluctuations and periodicities are deemed necessary as such can indirectly furnish the "health" status of an environment. A declining and/or rising trend etc. may be quite instructive for different segments of the human and natural systems. Impending long or short term weather – related natural disasters for instance may be predicted and better mitigated or adaptive actions initiated through the analysis of the fluctuations and return periods of the series. Extreme weather events that can lead to drought and prolonged heat spell; flooding etc. can be accessed through the statistical analysis of a region's temporal rainfall regime (Afangideh et al 2010).

Over the years, there has been considerable increase in rainfall records which are very important in planning and design of the water projects and Agro Meteorological studies. The study of weather and climatic element; rainfall of Abeokuta, Ibadan and Lagos respectively is vital for sustainable development of agriculture and planning.

Extreme and unusual weather events, resulting in loss of life and property and disruption of socio-economic activities, are part of daily experiences all over the world. The increasing frequency and intensity of these events constitute a major challenge to socio-economic development, particularly in developing countries. The main aim of this study is to compare rainfall characteristics in the Abeokuta, Ibadan and Lagos as timely continuous analysis of weather and climate information is a vital tool for planning in key sectors of the economy that are sensitive to weather. The knowledge amount of rainfall, number of rainy days and its distribution over the cropping season are important for timely preparation of seed bed, selection of crop varieties, choice of cropping pattern.

METHODOLOGY

Description of Study Area: The study areas of this discourse are Abeokuta, Ibadan and Lagos in South Western Nigeria. Abeokuta lies in the rainforest belt of the tropics between Latitude 7°10′ N and 7°15′ N and longitude 3°17′ E and 3° 26′ E. Abeokuta is 100 km North of Lagos and 80km Southwest of Ibadan with a terrain composed of granite and metamorphic rock of basement complex with an altitude ranging from 120 m to 180m above sea level. The topography is rugged with distinctly pronounced domed and boulder strewn hills

rising approximately 170m above sea level. Ibadan is located on Latitude 7˚20' and 7˚26' of the equator and 3˚48' and 3˚56' east of the Greenwich Meridian. Ibadan is located in the southern eastern part of Oyo State and about 120km east of the border with the Republic of Benin in the forest zone close to the boundary between the forest and the savanna. The city ranges in elevation from 150m in the valley area to 275m above sea level on the major north-south ridge which crosses the central part of the city. Lagos is located at latitude 6 º 27' N and Longitude 3 º 24' E. This falls just above the equator on African continent. This elongated state spans the Guinea coast of the Atlantic Ocean for over 180km., from the Republic of Benin on the west to its boundary with Ogun state in the east. The topography of Lagos is dominated by its system of islands, sandbars and lagoons. The city itself sprawls over four main islands: Lagos, Iddo, Ikoyi and Victoria which are connected to each other and to the mainland by a system of bridges. The entire territory is low lying being only 22feets above sea level.

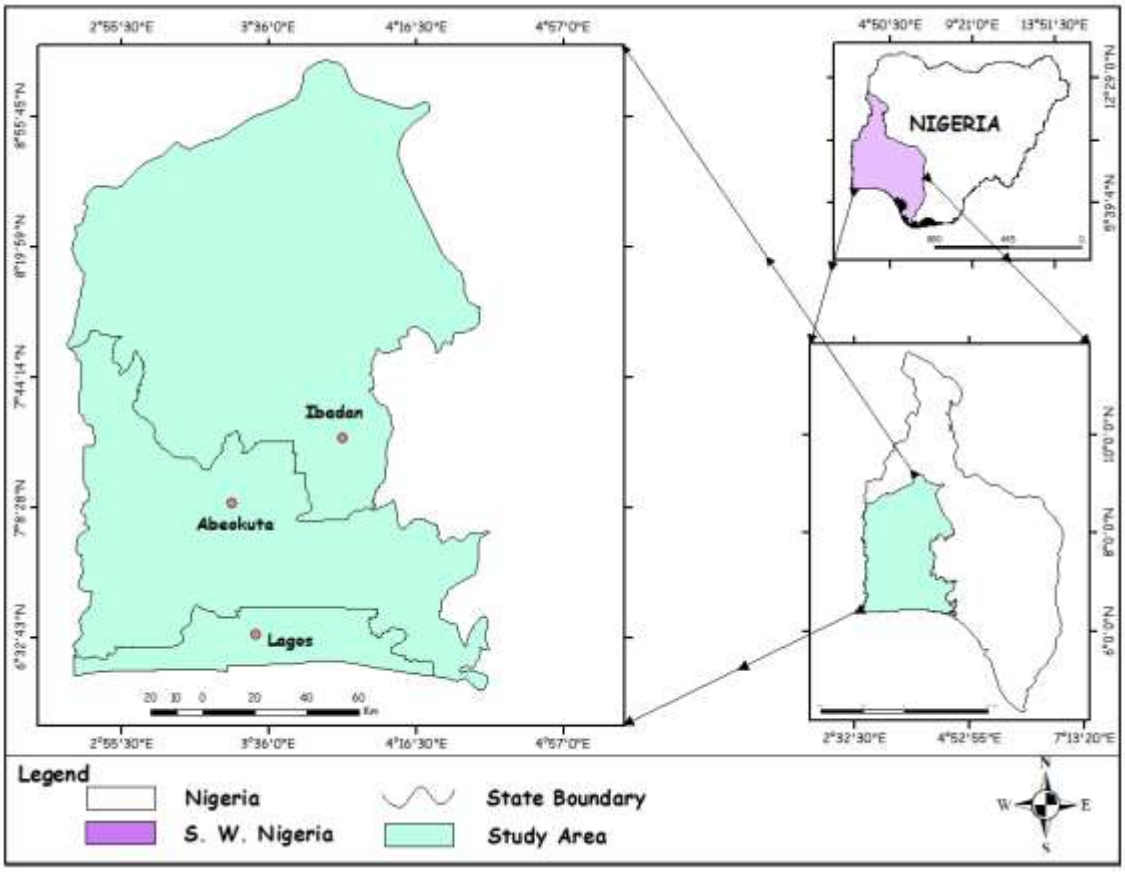

Figure 1: Map of the study areas

Data Sources: Daily rainfall data for 26 years (1985-2010) were obtained from the archives of National Horticultural Research Institute (NIHORT), Department of Water Resources Management & Agricultural Meteorology (Federal University of Agriculture Abeokuta) and Nigerian Meteorological Agency (NIMET) where rainfall data are routinely measured and recorded. Availability and reliability of the annual rainfall data was considered foremost, as each station has longstanding operational synoptic stations, standard equipment and personnel, data to be gathered are therefore high grade.

Data Analysis: Instat+ software application was used to explain and analyze the rainfall data. Rainfall data was entered into excel spread sheet and were imported into Insat plus. The study employed the FAO56 Penman-Monteith method to analyze rate of evapotranspiration. The FAO56 Penman-Monteith method estimates ET rates for a well

referenced water surface based on physical atmospheric observations of solar radiation, temperature, wind speed and relative humidity. This estimate is commonly referred to as reference ET.

$$\lambda ET = \frac{\triangle (R_n - G) + p_a c_P \frac{(e_s - e_a)}{r_a}}{\triangle + \gamma\left(1 + \frac{r_s}{r_a}\right)}$$

where R_n is the net radiation, G is the soil heat flux, $(e_s\text{-}e_a)$ represents the vapour pressure deficit of the air, r_a is the mean air density at constant pressure, C_p is the specific heat of the air, D represents the slope of the saturation vapour pressure temperature relationship, g is the psychrometic constant, and r_s and r_a are the (bulk) surface and aerodynamic resistances.

The Analysis of Variance (ANOVA) was used to test for variation among the average total and mean annual rainfall of the three weather stations by comparing their means to see if there are statistically significant differences among them.

A preliminary task, when looking at dry spells, is to define a dry day. The obvious definition is any day with zero rainfall. However, when comparing stations, one often finds that different observers are not equally conscientious in the recording of small rainfalls, or in the extent to which data are rounded. The criterion used in this study adopts Nigerian Meteorological Agency (NIMET) standard for South Western Nigeria. NIMET adopts rainfall threshold value of 0.85 mm and defines the starts of the raining season as the first 10 days period with at least 30 mm of rainfall with dry spells not exceeding 5 days in the next ten day period. It rained for 2325 days out of about 9516 days. Year 1986 had extremely low and the lowest annual amount of rainfall of 796.8 mm over the 26 years period which could have led to drought, reduction in crop yield and available water resources.

RESULTS AND DISCUSSION

Table 1 showed the total rainfall, mean rainfall and rainy days for respective years from 1985 to 2010 in the study area. In Abeokuta, total amount of rainfall was 32155.9 mm, mean amount of rainfall was 1236.77 mm and mean monthly amount of 103.64 mm while the highest amount of rainfall was 1615.7 mm in year 2007 and lowest is 796.8 mm in 1986. It showed the number of rainy days i.e. a day with rainfall amount above the threshold amount of 0.85 mm, this means that days with rainfall amount less than the threshold doesn't count as rainy days.

In Ibadan, The total amount of rainfall was 36888.4 mm, mean amount of rainfall was 1418.79 mm and mean monthly amount of 118.23 mm while the highest amount of rainfall was 2115 mm in year 2008 and the lowest is 1007.7 mm in 1998. It rained for 2346 days out of about 9516 days. Year 1992, 1994, 2001and 2004 also had very low annual amount of rainfall of 1131.2 mm, 1034.4 mm and 1204.2 mm respectively. Year 1987, 1989, 1990, 1991, 1993, 1996 and 2001 had rainfall varying slightly from the mean. In Lagos, the total amount of rainfall was 39192.4 mm, mean amount of rainfall was 1507.4 mm and mean monthly amount of 125.62 mm while the highest amount of rainfall is 1802.3 mm in year 2002 and lowest is 926.5mm in 1998. It rained for 2334 days out of about 9516 days.

Overall, the mean annual rainfall in Abeokuta was 1236.77 mm, though the number of years below the mean is more than the number of years above it. The values of those above the mean are very alarming; the abnormal rainfall in Abeokuta could be harmful to the types of crop grown in the locality. The annual rainfall in Abeokuta favors the growing of maize, pepper, tomato etc. The mean annual rainfall in Ibadan is 1418.8 mm, with the number of years below the mean equal to the number of years above it; the values of those above the mean are very alarming as well. The mean annual rainfall in Lagos was 1507.4 mm; the number of years below the mean is less than those above it. It is worthy of note that despite their proximity, Abeokuta, Ibadan and Lagos have different years of maximum rainfall amounts.

Table 1: Characteristics of rainfall in the study area during the study period

Year	Abeokuta			Ibadan			Lagos		
	TR	MEAN	RD	TR	MEAN	RD	TR	MEAN	RD
1985	1092.3	91	85	1492.3	124.4	95	1052.9	87.7	91
1986	796.8	66.4	69	1475	122.9	71	1015.2	84.6	73
1987	1277.1	106.4	103	1345.3	112.1	93	1688.7	140.7	87
1988	1608.5	134	96	1455.5	121.3	93	1927	160.6	93
1989	1370.8	114.2	110	1265	105.4	92	1368.9	114	85
1990	1105.2	92.1	90	1287.3	107.3	94	1610.1	134.2	87
1991	1173.1	97.6	101	1321.9	110.2	93	1671.8	139.3	96
1992	1076.5	89.7	87	1131.2	94.3	83	1188.4	99	81
1993	1193.6	99.5	81	1344.6	112.1	93	1671.5	139.3	92
1994	878.8	73.2	77	1034.4	86.2	79	1141.3	95.1	74
1995	1177.5	98.1	102	1483.5	123.6	81	1629.8	135.9	121
1996	1471.6	122.6	101	1358.4	113.2	100	1589.5	132.5	89
1997	1354.9	113	93	1251.6	104.3	116	1749.6	145.8	78
1998	1118.5	93.2	82	1007.7	84	80	926.5	77.2	60
1999	1529.8	127.5	92	1860.8	155	115	1667.9	139	100
2000	1209.9	100.8	85	1392.8	116	76	1209.6	100.8	91
2001	849.2	70.8	68	1230.2	102.5	79	1392.1	116	88
2002	1253.1	104.4	88	1588.6	132.4	96	1802.3	150.2	96
2003	1470.2	122.5	91	1616.6	134.7	86	1692.1	141	91
2004	1167.2	97.3	87	1204.2	100.4	75	1699.2	141.6	92
2005	924.2	77	73	1487.6	124	85	1483.9	123.s7	90
2006	1149.3	95.8	82	1733.4	144.5	92	1516.9	126.4	97
2007	1615.7	134.6	91	1486.9	123.9	101	1649.1	137.4	86
2008	1398.3	116.5	92	2115	176.3	101	1779.9	148.3	104
2009	1346	112.2	90	1428.5	119	85	1384.4	115.4	85
2010	1547.8	129	109	1490.1	124.2	92	1683.8	140.3	107

***TR- Total rainfall RD-Rainy Days Mean-Mean monthly rainfall**

Annual variation of dry spell in the study areas

Lagos has the highest number of long spell in the humid period, followed by Abeokuta and Ibadan. The longest dry spell during the study period in the study area is 34days. The longest dry spell in the Abeokuta ranges between 6-25 days which could have been detrimental to crops grown. The crops may have been aided by irrigation during the period of dry spell to enhance crop growth and prevent loss of crops.

Determination of rate of evapotranspiration

Table 2 illustrated the evapotranspiration rate in the study area. In Abeokuta, the mean annual evapotranspiration rate was 3.2mm. February had the highest evapotranspiration rate of 6.6mm (peak value) with November and December with least amount of 1.9mm respectively. For Ibadan, the mean annual evapotranspiration rate is 2.7mm. February had the highest evapotranspiration rate of 3.7mm with September with least amount of 1.8mm. In Lagos, the mean annual evapotranspiration rate is 2.2mm. April has the highest evapotranspiration rate of 3mm with June and September with least amount of 1.6mm. Highest evapotranspiration rate for Ibadan and Abeokuta was recorded in February while highest evapotranspiration rate for Lagos was recorded in April. Abeokuta had the mean highest evapotranspiration rate followed by Ibadan and Lagos. The highest rate of evapotranspiration was recorded during dry season.

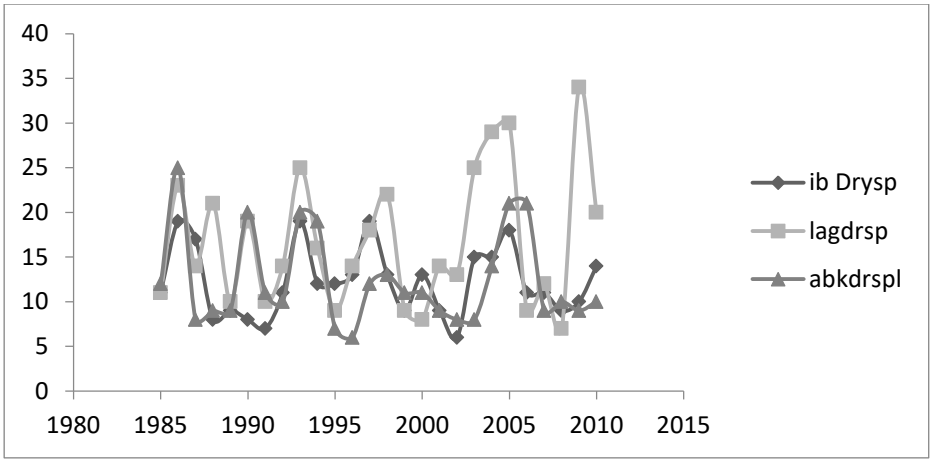

Figure 2: Annual variation of dry spell in the study areas

Table 2: Rate of evapotranspiration rate in the study areas in 2010

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MEAN ETO (mm)												
ABEOKUTA	2.7	6.6	4.5	4.8	3.4	2.4	2.6	2.2	2.3	2.0	1.9	1.9
IBADAN	3.3	3.7	3.4	3.2	2.4	2	1.9	1.9	1.8	2.3	2.5	3.3
LAGOS	2	M	2.6	3	2.4	1.6	2.1	1.8	1.6	1.8	2.1	2.2

Note: M signifies missing data.

Comparison of mean rainfall amount

On the average, Lagos had higher amount of rainfall in comparison to Abeokuta and Ibadan, this is attributed to the fact that Lagos is a coastal area having an advantage of Tropical Mari-time Air mass blowing from the Atlantic Ocean. Abeokuta had lower rainfall in comparison to the other locations due to land use pattern as a result of activities such as quarrying, deforestation etc. which affects rainfall formation and occurrence. The result also indicates the number of rain days in Ibadan is higher but not significantly different from Lagos and Abeokuta.

The result of comparison of mean rainfall amount in the study areas is presented below.

Table 3: Comparison of rainfall characteristics in the study areas

Location	Mean total rainfall	Mean Average rainfall
Abeokuta	1237[b]	103[b]
Ibadan	1419[a]	118[a]
Lagos	1507[a]	126[a]

Note: Values with same letter in column within treatment are not significantly different using Least Significant Difference (LSD) comparison (P = 0.05).

CONCLUSIONS AND RECOMMENDATION

Total annual rainfall decreased from South to the North. The alarming amount of rainfall above the mean in the study areas could lead to flooding and erosion which is detrimental to agriculture and water resources. Lagos being a Coastal city, not surprisingly among the locations under review, had the highest amount of rainfall records; it had the highest values in minimum, maximum, mean and sum columns, respectively followed by Ibadan with the least being Abeokuta. The result obtained here is somewhat in consonance with the findings of Obot et al. (2010). In their work which

assessed 30 years (1978-2007) rainfall data in Nigeria, they concluded that Nigeria is bounded at the extreme South by the Atlantic Ocean and Calabar having the highest values in maximum, mean and sum rainfall values was attributed to the fact that it is a coastal city.

This study also found that the longest dry spells in the humid period (April to October) occurs mostly during the August break which varies from three weeks to one month and the dry spell occurring in April and October indicates that rainfall is well established after the dry spell in April and the dry season starts in October i.e. the wet season in the transition zones is between April to October. Rainfall retreats truly towards the end of October and early November. Thus, the months of April and May qualify as the first two months into the rainy season while the last two months to the end of the rainy season in the sub-region are September and October.

The result also revealed that Abeokuta, Ibadan and Lagos had evapotranspiration rate of 3.2mm, 2.7mm and 2.2mm respectively. In year 2010, Abeokuta had higher rate of evapotranspiration than the other study areas. This could be due to its location in a mountainous region which is expected to generate more heat. The evapotranspiration rate of Lagos can be linked to its proximity to the Atlantic Ocean. Also, the lower rate is also due to the missing data in February hence, the result for Lagos is inconclusive.

In conclusion, there is no significant difference between the mean annual amount of rainfall in Lagos and Ibadan but there is difference between the mean annual amount between Lagos and Abeokuta, and Ibadan and Abeokuta respectively.

The study recommends that farmers should plant crops that can withstand high variability of rainfall especially in Abeokuta. Relevant authorities in the study areas should put appropriate measures in place to prevent flooding which could lead to loss of lives and properties. Ground practices such as mulching, terracing etc. should be encouraged in order to reduce rate of evapotranspiration especially in Abeokuta

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