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Statistical Analyses of Rainfall Distribution: A Check on Climatic Shift

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Abstract

The study Statistical Analyse of Rainfall Distribution: A check on Climate Shift is concerned with using table values and graph to visually compare rainfall distribution over different climatic cycles. To achieve this, rainfall data from Nigeria Meteorological Agency archive was extracted for analysis. The study observed that only two months had mean rainfall less than 51mm. It was also observed that rainfall occurrence decreases over the years, as indicated by the negative trend line. The study among other things discovered that the double maxima as a result of August dry spell has reduced significantly, thereby increasing run-off. This paper observed that the time of the years is significantly related to rainfall occurrence. The month of August had more improved rainfall throughout the period of study. The rate of dispersion of mean annual rainfall from the station mean is an indication of the reliability of rainfall or otherwise. This work opined that change in climate will lead to a complete shift in RF distributions; therefore, the activities that were influenced by RF will be affected positively or in a negative way in the future. This work recommends that agriculture calendar of the study area need to be changed therefore farmers need to adopt new farming techniques as RF distribution change. There agricultural calendar needs to also change.

Keywords: climate, climatic cycle, rainfall distribution, rainfall fluctuation, dry spell rainfall dispersion

1. Introduction

Graphs, pictures and diagrams are visual methods of transmitting, impacting and easier way of explaining an idea or presenting a problem. Geographers and Environmental scientist have been using same in explaining and addressing environmental challenges over the years. Statistical geography is concerned with using tables, graphs, maps, charts, etc. to present results of a problem.

Understanding what climate is, and what it is not is not as easy as it seems, especially when the term climate change is involve. Scholars have defined climate in various term, in technical terms and plain word. For instance, climate is defined as the average atmospheric weather condition of a place over a long period of time, say 35–40 years (Ajayi, 2003; Iwena, 2021; Hardy, 2004). Chinago, (2020) defined climate as the mean state of the atmosphere of a location over a defined period of 25 to 30 years or more.

Climate is the expected weather (Allen, 2003). It is the mean physical state of the climatic system, which is constituted by atmosphere, hydrosphere, cryosphere, lithosphere and biosphere, which are intimately interconnected (Lucarini, 2002). The opinion of this paper is that climate is the generally expected seasonal atmospheric/environmental condition of an area, whose fluctuation over a long period of time is minimal.

The study of climate is in front burner as a result of the unexpected weather which seem abnormal to man. This abnormal condition is what is termed climate change. Definition of climate change varies as school of thought. Most often the immediate problem of a scholar determines what influences his definition of climate change and what he believes is vital on the subject.

Lot of scholars within and outside Nigeria has worked on climate change, its consequences and mitigations. For instance, Kandji, et al, (2006) stated that there is significant scientific evidence that the global climate is changing. Similarly, Abaje, et al, (2010) pointed out that observations show that as climate changes, it is evident in amount, intensity, frequency and timing. This implies a clear shift from the normal situation. The global climate has changed rapidly, with the global mean temperature increasing by 0.7^0C., within the last century (Ayoade, 2014; Akinsanola & Ogunjobi, 2014; Abaje et al, 2012).

The change in climate has many contributory factors. It could be natural, man-made (Anthropogenic) or both factors (NOAA, 2007; Odjugo, 2010; Bates, et al, 2008; DeWeeedt, 2007; Buba, 2004; Agbola & Ojeleye, 2007; Pobeni, 2004 & Alexander, 2012). Change in the orbital elements (eccentricity, obliquity of the ecliptic precession of equinoxes, effects of El Nino, Volcanic eruption, thunderstorm set of bush fire, etc., are some of the natural factors responsible for climate change (Alexander, 2015).

This work is not concern with extensive definition of climate or climate change, which is available in many literatures on line and in hardcopies. The present work is an attempt to use graphs and statistical evidence to prove if climate is actually changing or not in the study area Port Harcourt. Most of the previous works actually defines and explain what climate change is, but in an attempt to explain the terms sometimes the common people get more confused than convince with their explanation. The comparison of the graphs that would be used in this work and statistical comparison of data would be an easy way of understanding what a shift in climate is (climate change). This work will also enable scholar to fashion out a generally accepted definition of climate change.

2. The Study Area

The study area is the tropical climate which lies between latitude 5^0N and 5^0S of the equator. The Amazon Basin of South America, the coast of West Africa and Zaire Basin of Central Africa falls within the zone.

Temperatures are high and almost uniform throughout the year. Mean monthly temperatures are 27^0C; the diurnal range in temperature is between 6^0C to 8^0C. There are no months without rainfall throughout the year; however, two months of dry season can be recognized, which in most cases are December and January. The commonest rainfall regime is double maxima, with annual rainfall of over 1500mm. One of such Station is Port Harcourt.

Port Harcourt is the capital of Rivers State and the only pronounce city in Rivers State. The State capital is located on longitude 06° 50′E to 08° 0′E and latitude 04° 45′N to 04° 60′N. It is generally a low land area with the highest altitude of about 15m above sea level (Alexander, 2012; Salau, 1985). Port Harcourt has an estimated population of about 2.1million. From the 2005 population census, the population of Port Harcourt was 1.4 million and in 2016 the population has reached about 1.9 million. The general population density of Rivers State as at 2005 was 190 persons per square Km. The population density of Port Harcourt were over 198 persons per km^2 (NPC, 2010).

Port Harcourt has equatorial climate, with 8 to 9 months of rainfall. In a true sense of it, only December and January can be termed a dry month since all the other months has more than 51mm of RF. The RF pattern shows double maxima with the peaks in July and September. The dry spell of August is gradually but steadily decreasing over the years.

The seasons in Port Harcourt is determined by the position of the inter-tropical discontinuity (ITD). Areas south of the ITD have wet condition, while areas north of the line will have dry condition. The proximity of Port Harcourt to Atlantic Ocean modifies its atmospheric condition despite been very close to the equator. Rainy season starts around the 45th day of the year (14th February), while on average RF ends around the 326th day of the year (22nd November). In all the duration of RF in and around Port Harcourt is about 281 days (> 9 months). The mean annual RF is about 2400mm, while the monthly mean RF is 197mm (Aloni & Alexander, 2022).

The city of Port Harcourt has a mean moderate temperature of about 28ºC, with a temperature range of about 3-5ºC. Generally, the relative humidity is high. The highest relative humidity is recorded in July and September with over 95%. Sunshine is very much abundant in the study area. The cumulus and cumulonimbus cloud dominate the sky during the rainy season.

Port Harcourt soil is fragile infant soil mostly of alluvial deposit. The indigene of Port Harcourt is the Ikwerre (Iwhnerowhna) people. Port Harcourt is home for multinational companies and higher institutions, with an international airport and two domestic airports. Seaports are also located in the study area.

Port Harcourt has a good connection of roads within and outside the city. The Port Harcourt – Enugu rail line, that is the main route for coal export is no longer functioning. A mono rail project started by the state government was also abandoned after the government that started it. Port Harcourt is key, both in economic and political development in Nigeria.

Port Harcourt is used as a case study in this work as it satisfied the requirements of tropical climate.

Figure 1. Map showing Port Harcourt

Source: Google Earth.com

3. Methodology

The data for this work is secondary data retrieved from Nigerian Bureau of Statistics and Nigeria Meteorological Agency. The retrieved data include rainfall data from 1931-2014 (84) years data. The data is arranged in four (3) climatic periods of 28 years per climatic cycle. The years are not repeated in the climatic cycle, since in real live no two years will appear twice in two years.

The results were represented in graphs, which include lines, bars, and dispersion or divergent graphs. The essence is to show graphic relationship between rainfalls under different time period or climatic period. Inferential statistics like Friedman test of several treatments will be applied to test the relationship between climatic periods over time. Other descriptive statistics like mean, standard variation and coefficient of variation were also employed in this work. Simple percentage will be employed for an easier comparison between the four climatic period designed for this paper. Tables were also used. The interpretation of the graphs and result of the statistics will form the result of this work.

$$\text{Freidman test } (\chi^2) = 12/cr(r+1)\,[R^2_1+R^2_2+R^2_3+R^2_4 \ldots\ldots R2r] - 3c(r+i) \quad (1)$$

Where R_1, R_2, R_3,…….. R_r = Individual rows sum, while c is the number of columns

$$\text{Coefficient of variation (CV)} = \text{Stdev/Mean} *100 = \sigma/\quad * 100 \quad (2)$$

4. Result and Discussions

Table 1. Mean Seasonal Rainfall Distribution of Port Harcourt (1931-2014)

	Jan	Feb	March	April	May	Jun	Jul
Total	2887.8	5734.5	10968.5	15483.4	19602.9	24477.5	29419.7

Mean	34.38	68.27	130.58	184.33	233.37	291.40	350.24
STDEV	28.00	50.78	67.27	77.68	77.02	90.42	112.24
CV	81.46	74.39	51.52	42.14	33.00	31.03	32.05

Aug	Sept	Oct	Nov	Dec	Total	Mean	STDEV	C.V
25082.3	31453.0	22474.6	8767.6	3167.8	199520	16626.6	12178.8	6167
298.60	374.44	267.56	104.38	37.71	2375.23	197.936	144.986	73.4167
129.24	121.00	84.20	68.80	50.68	328.754	27.3962	25.7996	9.46525
43.28	32.31	31.47	65.91	134.38	13.8409	13.8409	17.7946	12.8925

Source: Nigeria Meteorological Agency, Lagos. (2021).

Table 1 shows the seasonal rainfall (RF) distribution of Port Harcourt from 1931 to 2014 (84 years). From Table 1 only two months January (34.38mm) and December (37.71mm) recorded mean RF below 51mm which is the ideal characteristics of onset of rainy season. The only other month with two digits mean RF is February, with a record of 68.27mm RF during the study period.

The mean seasonal rainfall over Port Harcourt during the period of study shows that the highest rainfall occurred in the month of September (374mm), it was followed by July (350..24mm). Rainfall increases from January to July before an unexpected decrease in rainfall in August. The August dry spell is locally called "August break".

The driest month in Port Harcourt is January (34.4mm), it is closely followed by December (37.71mm). Only these two months of actually qualifies as dry season months in Port Harcourt. This is because according to Walter, (1979) the onset of rainy season starts when rainfall occurrence reaches 51mm. The only two months, with rainfall below 51mm are January and December. From figure 2, July rainfall occurrence was 350.24mm, August 298.6mm and September 374.4mm. Note the difference between July rainfall occurrence and August rainfall occurrence is 51.64mm, while the difference between September rainfall and August rainfall is 75.84mm.

A very long weather data may distort the actual characteristics and pattern of climate, as heavy rainfall from one or two months from a climatic cycle can skew the pattern of rainfall. To actually see if there is a shift in climate or not 28 to 30 years data is reasonable. The annual distribution of rainfall does not actually describe the spread of rainfall in an area. Similarly, the mean rainfall does not also state the rainfall condition of a place; it is a generalization that all things been equal, that certain amount of rainfall could be recorded in a month or year.

Figure 2 is the distribution of Port Harcourt from 1931-2014. It is a guide to the climatic pattern, however lot of changes are buried within it. Figure 2 show that September had the highest rainfall in the study area, it is followed by July. The gap between the two prominent rainy months was 24.20mm

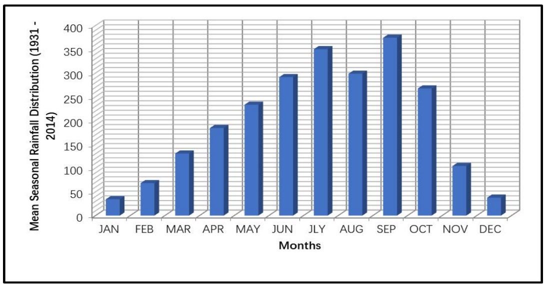

Figure 2. Mean Seasonal Rainfall Distribution in Port Harcourt (1931-2014).

Source: Compiled from Nigeria Meteorological Agency Data (2021).

A close comparison of the three climatic cycles (1931-1958, 1959-1986, 1987-2014) shown in figure 3 – figure 5. Each of the climatic periods can also be compared with figure 2 which covers 84 years data.

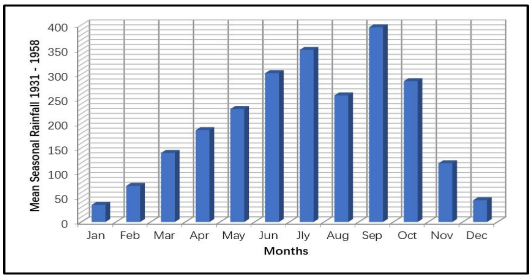

Figure 3. Mean Monthly Rainfall of Port

Harcourt from 1931-1958

Source: Nigeria Meteorology Agency, Lagos. (2021).

There is a clear difference between figures 3 with figure 2. July RF is 349.64mmmm, August had 257.15mm and September had 395.59mm of RF. The difference in RF occurrence between August and July 92.47mm, and the difference between August and September RF was 138.44mm. August dry spell was very clear. The months of June and October had more rainfall than August.

Comparing figure 2 and figure 4, it was observed that the difference between the July and August RF distribution 38.88mm and the September and August difference is 51.37mm. August RF exceeded June and October RF. It was also observed that June RF was greater than October RF. April and May rainfall exceeded the Previous cycle RF.

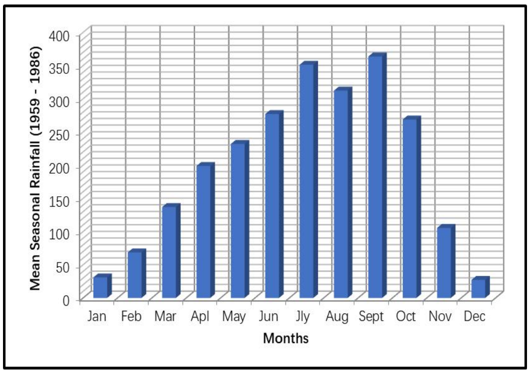

Figure 4. Mean Seasonal Rainfall of Port Harcourt (1959–1986).

Source: Nigeria Meteorology Agency, Lagos. (2021).

In figure 5, the difference between July RF occurrence and August was just 23.54mm, while the difference between September RF occurrence and August was 37.71mm. The difference in RF distribution of July and September was 14.71mm. It was also observed that May RF occurrence for figure 2 was 233.4mm. But from figure 3 to figure 5 it has been increasing from 229.5mm, 231.97mm to 238.6mm respectively. In addition, the month of August is getting wetter than pervious.

The wettest climatic cycle was 1931-1958; it was followed by the 1957-1986 cycles, and lastly the 1987-2014 cycles. The RF characteristics have not changed significantly. The first peak still occurs in July, followed by a brief dry spell in August, before the major peak in September.

It was also observed that the first half of the years (first 6 months) recorded lesser rainfall than the last 6 months of the years. The first half of the years accounted for 39.67% of the total rainfall during the study period, while 60.33% of the rainfall occurs during the second half of the years.

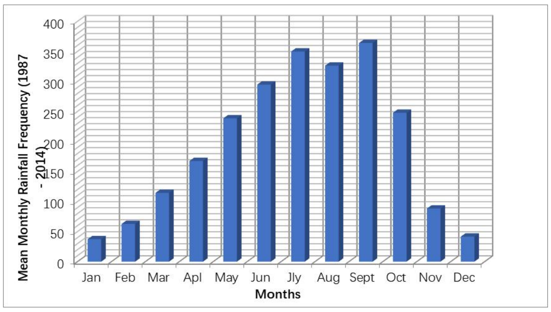

Figure 5. Mean Seasonal Rainfall of Port Harcourt (1987–2014).

Source: Nigeria Meteorology Agency, Lagos. (2021).

A clear observation of the figures shows that January and December have not gone beyond 50mm. The gap between July, August and September RF is reducing; this will create a mono peak pattern of RF, which if it happened is a clear climatic shift.

There is no clear shift in climate, but there is a progressive shift in mean RF distribution over the years. For instance, the August dry spell for figure 2 and 3 were more pronounced than for figure 4 and 5. This is a clear evidence of a change in pattern of RF over the study Area. Other things observed were that the amount of RF is gradually reducing. However, it is not seasonal rainfall that can explain the trend of RF.

Figure 6 is a comparative chat of the three climatic cycles under review. A close study shows that from the month of May to September the 1987-2014 climatic cycle had very high RF, with a wet August and very wet September the stage is set for heavy flash flood that can trigger urban flood in Port Harcourt.

Table 2. Comparative climatic cycles in Port Harcourt

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Mean
9311958	34.8	73.4	140.2	186.6	229.5	302.4	341.2	252.1	395.6	281.1	119.2	44.3	2400.3	200.0
19591986	31	68.6	137	198.8	232	277.0	351.2	312.3	363.7	268.7	105.5	27.2	2372.9	197.7
19872014	37.4	62.8	114.6	167.6	238.6	294.8	349.9	326.3	364.1	247.9	88.4	41.7	2334.0	194.5
Total	103.1	204.8	391.7	553	700.1	874.2	1042.3	890.7	1123.3	797.7	313.1	113.1	7107.2	592.3
Mean	34.4	68.3	130.6	184.3	233.4	291.4	347.4	296.9	374.4	265.9	104.4	37.7	2369.1	197.4
STDEV	3.2	5.3	14	15.7	4.7	13.0	5.4	39.5	18.3	16.76	15.5	9.2	160.6	13.4
CV	9.4	7.8	10.7	8.5	2.0	4.5	1.6	13.3	4.9	6.3	14.8	24.5	108.2	9.0

Table 2 show that July and May had the least variability in RF distribution over the study period. This agreed with figure 6, where the months of July and May were closed to each other. That explains that RF distribution is more reliable in the months of May and July.

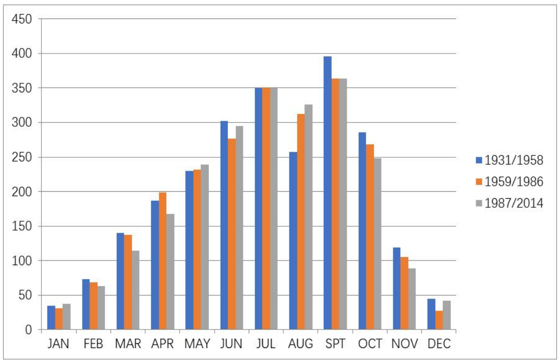

Figure 6. Comparative Men Seasonal Rainfall over Port Harcourt

The trend in RF over Port Harcourt is expressed using the annual RF occurrence or distribution. Figure 6 represents the RF distribution of Rivers State from 1931-2014.

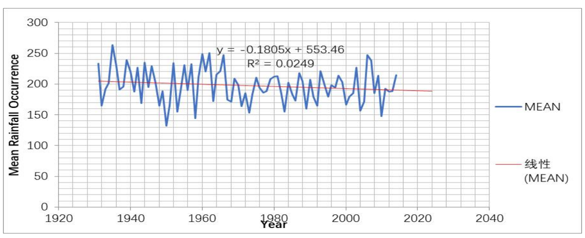

Figure 7. The annual RF fluctuation and trend over Port Harcourt from 1931-2014

Source: Nigeria Meteorological Agency

From Figure 7 the trend line (red line) shows a downward slope, indicating decrease in RF distribution over time. The least RF was recorded in 1950 with annual mean of 131.88mm; it is closely followed by 2010 with annual mean RF of 147.98mm. 1973 also had a low RF with a mean of 153.12mm. The highest RF was recorded in 1935 with a mean RF of 263.57mm. Other high RF years includes 1962 (250.4mm), 1960 (249.2mm), 2006 (247.2mm).

To further examine the trends in RF distribution in the study area over time, specific climatic cycles were considered as shown in figures 8–10.

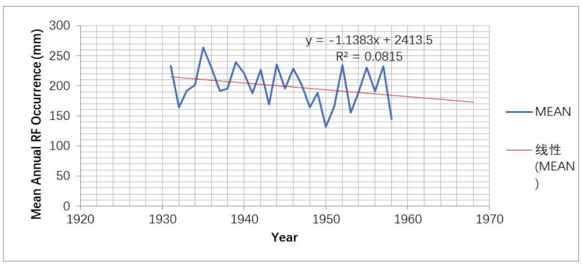

Figure 8. Mean Annual RF Fluctuation and Trend over Port Harcourt 1931-1958

Source: Nigeria Meteorological Agency

Figure 8 negative RF trend was more obvious than the slight downward trend in figure 6. During the 1931-1958 period of study only a year recorded mean RF above and below 250mm and 150mm respectively. 15 years recorded mean RF below 200mm, while 13 years had RF above 200mm. Majority of RF occurrence during the study period were within 160mm to 240mm. The mean monthly RF for the period is 201.57mm.

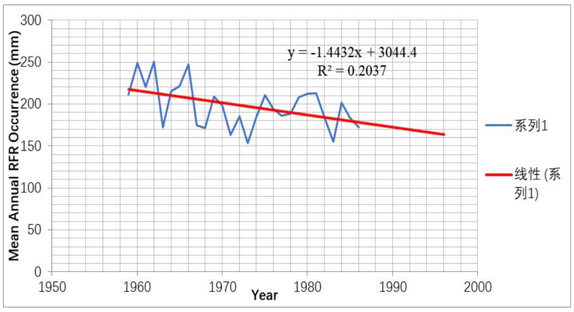

Figure 9. Mean Annual RF Fluctuation and Trend over Port Harcourt 1959-1986

Source: Nigeria Meteorological Agency

Figure 9 show that the period recorded moderate RF. The higher RFs were recorded in 1962, 1960 and 1966 with annual mean RF of 250.4mm, 249.2mm and 247.2 respectively. While the low RF was recorded in 1972, 1983 and 1970 with mean annual RF of 153.1mm, 154.9mm and 163.7mm respectively. The trend line decreased over time, showing a decrease in RF. Most of RF recorded during the period was between 170mm to 220mm. The annual mean RF during the period is 237.9mm and the mean of mean (monthly RF) is 197.7mm.

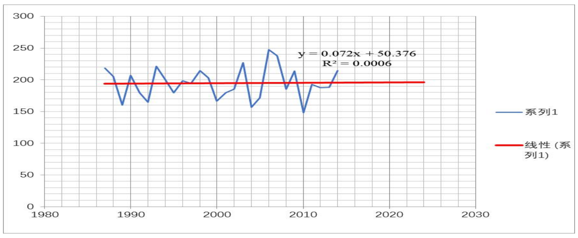

Figure 10. Mean Annual RF Fluctuation and Trend over Port Harcourt 1987-2014

Source: Nigeria Meteorological Agency

Figure 10 is different with the other climatic periods depicted with figures 7–9. The RF trend and fluctuations in Port Harcourt from 1987 to 2014 are shown in figure 10. The trend line equation y = 0.072x+50.38 implies that RF is increasing gradually over time during the climatic period under review. The mean annual RF from 1987-2014 is 2334mm and the monthly mean is 194.5mm. From figure 10 the highest RF was recorded in 2006 and 2007 with a mean annual RF of 247.4mm and 238mm respectively. The lowest RF occurred in 2010 and 2004 with a mean annual RF of 148mm and 156.5mm respectively.

The effect of extreme RFs that occurred in specific periods affected the trend in figure 6 The specific periods review shows the climatic cycles or periods trend at the particular point in time. From figure 10, which is the most recent; it was observed that RF is gradually increasing over time just as we observed the decreasing dry spell in August.

Table 3. Ranked climatic cycles Rainfall

1931-1958	1959-1986	1987-2014
3	1	2
1	3	2
2	3	1
1	3	2
3	1	2
3	2	1
1	2	3
1	3	2
3	1	2
3	1	2
1	3	2
3	1	2
2	1	3
3	2	1
3	1	2
3	1	2
1	2	3
2	3	1
3	2	1
1	2	3
1	2	3
3	2	1
1	2	3

3	2	1
3	1	2
3	2	1
3	1	2
2	1	3
62	**51**	**55**
3844	2601	3025

Source: Field Work Report, (2021).

Using Freidman Test to examine the relationship between climate and RF distribution over Port Harcourt

$$\chi^2 = 12/cr(r+1)\ (R^2_1 + R^2_2 + R^2_3 + \ldots\ldots R^2_r) - 3c(r+1)$$

H_O: There is no relationship between climatic cycles and RF distribution

$$\chi^2 = 12/3*28*29(62^2+51^2+55^2) - 3*3*29 = 12/2436(9470) - 261$$

χ^2 = -213.65, since χ^2critical (40.11) > χ^2calculated at 5% level of confidence. At a 5% significance level and with v – r – 1 = 27, the χ^2 table value is 40.11, since the χ^2 value obtained from the data is less than 40.11it is concluded that climate period does not affect RF distribution. H_O is accepted. This implies that climatic cycles do not determine RF distribution in the study area. Table 4 also shows that RF occurrence does not depend on the climatic period. Rather daily RF accounts for the climatic cycles RF.

Table 4. Ranked Mean climatic Annual Rainfall

24	20	24	68	4624
3	27	19	49	2401
12	24	3	39	1521
15	28	20	63	3969
28	5	7	40	1600
21	23	4	48	2304
11	25	25	61	3721
14	26	17	57	3249
27	7	9	43	1849
18	4	16	38	1444
8	18	15	41	1681
19	15	22	56	3136
6	3	18	27	729
26	11	5	42	1764
13	1	8	22	484
20	8	11	39	1521
17	19	26	62	3844
4	14	2	20	400
9	12	6	27	729
1	13	28	42	1764
5	17	27	49	2401
25	21	10	56	3136
2	22	21	45	2025
10	10	1	21	441
22	2	14	38	1444
16	16	12	44	1936
23	9	13	45	2025
7	6	23	36	1296
406	**406**	**406**	1218	57438

Source: Field Work Report, (2021).

Freidman Test was also used to examine the relationship between Time (years) and RF occurrence over Port Harcourt. The column which represents the yearly distribution of RF was used instead of the rows.

$$\chi^2 = 12/rc(c+1)\ (C^2_1 + C^2_2 + C^2_3 + \ldots\ldots C^2_c) - 3r(c+1)$$

H_O: There is no significant relationship between time (season and RF occurrence).

$$\chi^2 = 12/rc(c+1)\ (C^2_1 + C^2_2 + C^2_3 + \ldots\ldots C^2_c) - 3r(c+1) = 12/28*3*4(57438) - 336$$

$$\chi^2 = 0.0357 * 57438 - 336 = 1714.54$$

At 5% significance level and with v = c – 1 = 2, the table value is 5.99. Since the χ^2 value obtained from the data is greater than 5.99 it is concluded that time is significantly related to RF occurrence in the study area over the period of study. Since χ^2calculated > χ^2critical at 5% level of significance, then H_O is rejected and the alternative accepted. This implies that time is significantly related to RF occurrence over Port Harcourt during the study period. For instance, it has been observed that RF decreases over time. RF occurrence between 1931 –1958 was greater than RF between 1954 –1986. Similarly, the RF occurrence between 1959 –1986 was greater than RF occurrence between 1987–2014. Besides the time of the year is a decider on yearly RF. For instance, the amounts of RF recorded during the wet season are greater than the RF during the dry season. Base on the above it is obvious that the pattern of rainfall is steadily but gradually changing over the years.

To what extent has RF move from the stations mean RF over the years in Port Harcourt. The divergent from the mean shows the amount of fluctuation in RF. This will be considered using the entire 84 years data and looking at each climatic period on its merit.

The mean monthly RF of the station for the 84 years data is 197.4mm, while the mean annual RF is 2369.1mm

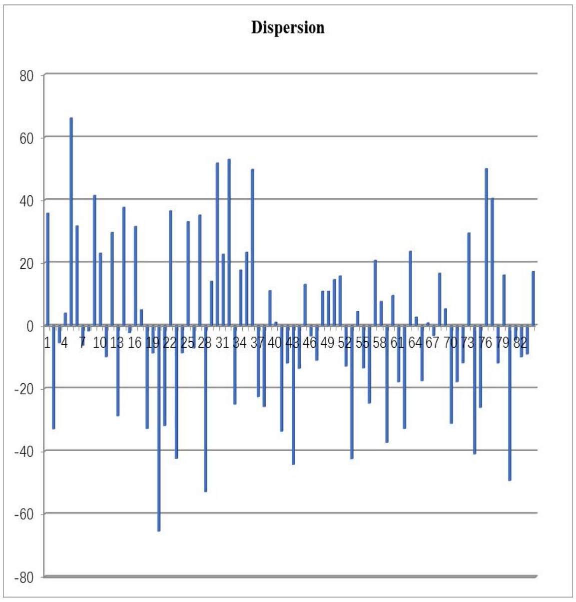

Figure 11. Rainfall dispersion from the annual mean, 1931-2014.

From figure 11, 41 years mean monthly RF was over the station mean RF, while 43 years mean RF was lower than the station mean RF. The overall mean RF dispersion from the station mean seems balanced, as only one year was greater and lower than the 60 and -60 mark, and 7 years was able to reach or pass the 40 and -40 mark. Further investigation shows that more variability took place before the 1987-2014 climate cycle.

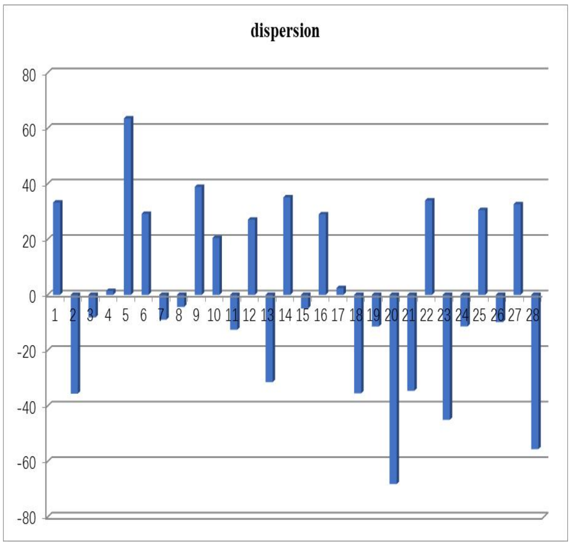

Figure 12. Rainfall dispersion from the annual mean, 1931-1958.

Figure 12 shows how annual rainfall distributions fluctuate from the climatic cycle mean rainfall. For the last 14 years of the climatic 28years, only 5 years had rainfall greater than the climatic mean rainfall, while 9 years had negative fluctuation, which mean rainfall lower than the climatic cycle mean rainfall. Figure 12 shows that only on great dispersion took place in each direction that is in 1935 and 1950, where the positive and negative fluctuations exceeded the +60 and -60 lines respectively. Additional two years crosses the -60 line, while no other exceeded the +40 mark.

A total of 10 years rainfall distribution exceeded the +20 mark of rainfall occurrence, while only 7 years rainfall distribution went below the -20 rainfall occurrence mark. The other variations were close to the mean climatic rainfall.

This dispersion shows that rainfall was reducing over the years within this climatic period.

Figure 13 shows rainfall dispersion from the climatic cycle of 1959-1986. It was observed from figure 13 that only 4 years rainfall variability exceeded the +20 rainfall occurrence mark, 3 of such year rainfall distribution were over +40 rainfall occurrence mark and 2 of the years equal or exceeds the +50 mark. The figure 13 shows that none of the negative rainfall fluctuation got to the -50 mark. 2 years rainfall distribution was lower than the -40mark, however about 8 years rainfall varies up to -20 mark of the rainfall occurrence mark.

Taken from the last 14 years from the climatic cycle, 9 years had a negative dispersion from the mean, while 5 of the years had positive dispersion or fluctuation from the climate period mean rainfall. It is important to note that the positive fluctuation is close to the mean than the negative fluctuations. This also point to the fact that rainfall is greatly decreasing over the years. The decrease continues from the previous climatic cycle decrease, which seem moderate.

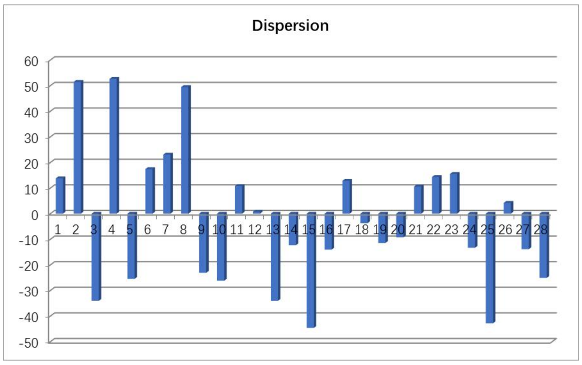

Figure 13. Rainfall dispersion from the annual mean, 1958-1986

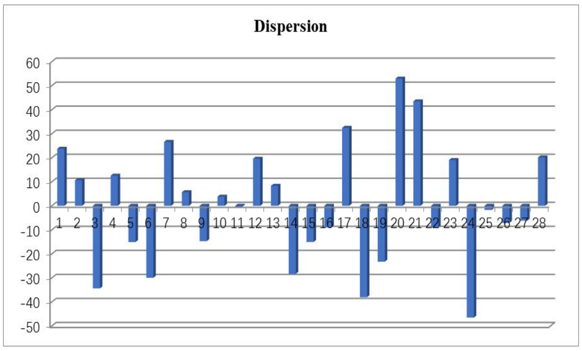

Figure 14. Rainfall dispersion from the annual mean, 1987-2014

In figure 14, it was observed that 15 years had positive dispersion from the climatic period mean, while 13 years had negative dispersion from the mean climatic period rainfall. One year dispersion was greater than +50 rainfall variation marks while only a year goes beyond the -40 mark. Generally, about 14 years fluctuations were below ± 20 rainfall variation mark. Counting from the last 14 years of the climatic cycle, 8 of the years had negative fluctuations and 6 years had positive dispersion. However, the dispersion rate for the last 14 years is such that the negative dispersion had only 3 years exceeding the -20 rainfall variation mark, in fact 4 of the 9 negative dispersion years had less than -10. In the other hand 3 of the 6 positive dispersion years had dispersion greater than +30 and only a year lower than +10. This implies that rainfall distribution is gradually increasing during the climatic period.

5. Summary of Findings

From the study "A Graphic Analysis of Rainfall: An Indicator to Climatic Shift" it was discovered that rainfall over the years has reduced. For instance, from the climatic period of 1931-1958 the annual mean rainfall for the 28 years under study was 200mm, it dropped 197.7mm in 1959-1986 climatic period and further to 194.5mm in the 1987-2014 climate cycle. These show an approximate drop of 2mm to 3mm in every 28 years.

A further analysis of the rainfall condition shows that a new trend in rainfall distribution has started from the 1987-2014 climate cycle as shown in figure 6.3, which displayed a positive trend as against the previous negative trends.

The study observed that the August dry spell (August break) is diminishing over years. For instance, in the 1931-1958 cycle August mean rainfall was 252.1mm, as against July and September mean rainfall of 341.2mm and 395.6mm respectively. This shows that the difference in rainfall occurrence between August, July and September are 89.1mm and 143.5mm respectively. But in the 1959-1986 period August rainfall occurrence as increased to 312.3mm, July rainfall also increased to 351.2mm, a 10mm increase in rainfall from the previous climatic period. However, September rainfall dropped to 363.7, a decrease of 31.9mm in rainfall amount. The study shows that the difference in rainfall between July and September with August was 38.9mm and 50.4mm respectively. This shows an improvement of 50.2mm and 98.1mm respectively of August rainfall to the compared months. The 1987-2014 climate period shows that August mean rainfall (RF) was 326.3mm, July was 349.9mm and September was 364.1mm. August RF increased by 14mm from the previous climatic period. While July dropped 1.3mm and September added 0.4mm. August and July difference was 23.6mm and August September difference was 37.8mm. This study shows that August RF is increasing over the years, this imply that in the near future the rainfall of the location will be a mono peak instead of double maxima.

The study discovered that the highest RF dispersion occurred during the 1931-1958 climate period, where variation of over +60 and

-60 was recorded. This simply means that RF variation was high during the period. The most reliable climate period was the 1987-2014. Only one year had positive dispersion over +50 and the highest negative dispersion was a year with -46.5.

Statistically, it was discovered that climatic period does not affect the amount of RF occurrence. However, time of the year and seasons significantly affect RF distribution.

6. Conclusions

Rainfall distribution varies diurnally, weekly, monthly and annually. The factor responsible for RF is the time of the year. The rainy season accounted for more RF than the dry season.

It is important to note that RF characteristic is gradually changing without change in pattern of RF. The August dry spell which is a major characteristics of RF in equatorial climate is fading out, which will lead to mono peak RF. The pattern of RF is the same, we still expect more RF during certain period of the year and some certain months RF not exceeding 50mm.

The fluctuation of RF reduces as the year goes. This implies that RF is becoming more reliable than before. RF trend line show that RF is decreasing over the years. However from 1987-2014 the trend line was positive, an indication that RF is increasing recently over years.

The similarity between 1931-1958 and 1959-1986 shows that climate change is a gradual Process. The 1987-2014 has developed a slight change in climate both in trend line and in August mean monthly RF occurrence.

Graphic representation of RF distribution clearly shows RF variation over the years.

7. Recommendation

- The gradual change in climate will lead to a complete shift in RF distributions; therefore, the activities that were influenced by RF will be affected positively or in a negative way in the nearest future.
- Mono peak RF will likely trigger flooding or drought, therefore farmers need improved crops to limit the effect of excessive or scanty RF.
- The greatest amount of RF are recorded during the months of June, July, August, September and October, so there is need for the people to be at alert, especially during late September for flooding. Drainages. Canal and channels should be kept neat to avoid flash flood.
- Farmers need to adopt new farming techniques as RF distribution change. There agricultural calendar needs to also change.

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Competing Interests

No competing interest.

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