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Analysis of Rainfall Variations in the Niger Delta Region of Nigeria

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Abstract: *Exploration and production of oil in the Niger delta are associated with high environmental impact. This may have its own contribution to the climate change recorded over the years in the region. Rainfall data from 1981 to 2008 was used for the study. Analysis of Variance and descriptive statistics were used to analyze the rainfall pattern and variation over the study period. An analysis of rainfall variations in the Niger Delta region shows that Akure in Ondo state recorded the least average rainfall across the study area and over the years while the highest average rainfall was recorded in Calabar in Cross Rivers State. Although Benin recorded the second least average rainfall after Akure, it has the highest rainfall variation of 17.88% over the study period. Similarly Ikom had the minimum rainfall variability of 10.27 over the study period. Furthermore, there was no visible pattern of rainfall as there were rainfall fluctuations with no particular trends in the selected towns over the years. Non availability of rainfall data for recent years was a major limitation to this study; hence an updated record may reveal better trends. It was recommended that environmental agencies in Nigeria, like the Nigerian Meteorological Agency in collaboration with the Nigerian National Bureau of Statistics should work assiduously toward keeping an up to date records of climate and weather indicators and also making it available and accessible to researchers and general public free of charge.*
Keyword: *Rainfall, Niger delta, Rainfall pattern Rainfall variation, Coefficient of Rainfall Variation*

I. Introduction

The Niger Delta region is situated at the apex of the Gulf of Guinea on the west coast of Africa and on the Nigeria's South–South geopolitical zone. The Niger Delta region consists of 9 oil–producing states (Abia, Akwa Ibom, Bayelsa, Cross River, Delta, Edo, Ondo, Imo and Rivers) and 185 local government areas. This region cuts across over 800 oil–producing communities with an extensive network of over 900 producing oil wells and several petroleum production–related facilities. The ecological zones in the Niger Delta region can be broadly group into tropical rainforest in the northern part of the Delta and mangrove forest in the warm coastlines of Nigeria. Mangrove forests and swamps, which are characterized by regular salt–water inundation, lie at the centre of a complex and sensitive ecosystem which is vital to the local economy and accommodates important flora and fauna. The Niger Delta, which is the largest mangrove forests in Africa and the third largest in the world, is the richest part of Nigeria in terms of petroleum resources and diverse natural ecosystems supportive of numerous species of terrestrial and aquatic fauna [1]

Onyenechere[2] argues that climate change has been one of the major environmental issues of discuss in recent times, noting that serious environmental problems are likely to arise in Nigeria in association with the probable global warming which may result from emissions of greenhouse gases into the atmosphere, as Ogbo, Ndubuisi & Ukpere[3] noted Climate change is a global problem that requires global solutions and that it is also one of the most important issues on the global political agenda, with a series of efforts to find solutions through international negotiations

NRC [4] defines Climate change as a significant and lasting change in the statistical distribution of weather patterns over periods ranging from decades to millions of years; noting that it may be a change in average weather conditions, or in the distribution of weather around the average conditions. Change in climatic conditions of any geographic area may be caused by factors such as biotic processes, variations in solar radiation received by Earth, plate tectonics, and volcanic eruptions[4]. Similarly Onyenechere[2] defined Climate change as a change in collective patterns of expression in various elements of weather, arguing that climate change is a permanent departure of climatic patterns from mean values of observed climate indices

Nzeadibe & Egbule et al[5] noted that that concentrations of biodiversity on the Niger Delta region may experience a loss of about 40% of its inhabitable terrain in the next thirty years. The authors argued that the perceived situation can be attributed to: natural gas flaring, oil spillage, extensive dam construction, concentration of greenhouse gases in the atmosphere, unfavourable farm practices , and over exploitation of natural resources found in the area. As majority of the people living in the Niger Delta are farmers, the environmental and social consequences of climate change is putting livelihoods at serious risks.

Odjugo[6] argues that climate change has caused a shift in the normal timing and length of wet and dry seasons, shift in the seasonal variability of weather and climate; and increase in the seasonal fluctuation of the water bodies. Rainfall variability refers to variations in the mean state and other rainfall statistics on all spatial and temporal scales beyond that of individual precipitation events

Azuwike & Enwereuzor[7] noted that rain is a renewable resource, highly variable in space and time and subject to depletion or enhancement due to both natural and anthropogenic causes. According to the authors, rainfall (pattern) as a climatic factor is known to be changing worldwide and there has been growing concern as to the direction and effects of the changes on settlement and infrastructures

Ekpoh, & Nsa[8] noted there is sufficient evidence of rising global temperatures due to increased emission of greenhouse gases: Carbon dioxide, Nitrous oxide, Methane and Chlorofluorocarbons into the atmosphere, arguing that the increased global warming has the capacity to trigger large-scale climatic disturbances, which ultimately may have significant impact on the rainfall. These green house gases are mostly encountered during oil exploration process, chief among these is gas flaring. Ologunorisa & Tersoo[9] argues in the same line that increasing flood risk is being recognized as the most imperative threat of climate change in most parts of the world.

OBJECTIVE OF THE STUDY

The main purpose of this study is to analyze the rainfall patterns and variation in some selected oil producing areas of the Niger Delta region. This will determine seasonal variability of rainfall across the selected towns as well as variation over the years

RESEARCH HYPOTHESIS

The null hypotheses of interest are:

1. H_0: Mean rainfall is the same over the years
2. H_0: mean rainfall is the same across the towns

Decision: accept H_0 if P-value is greater than 0.05 and conclude that there is no significant difference in the mean rainfall.

II. Literature Review

Several literatures on climate change and its attendant effect are abound, as climate change and weather fluctuations have greatly taken top in the priorities of global environmental discuss. Dikko, David, & Bakari[10] argues that the effect of rainfall to man is diverse ranging from designs of agricultural systems to erosion control. The authors used the Gamma distribution to model the distribution of the quarterly rainfall amount. They also employed the Kolmogorov – Smirnov, One Sample test to evaluate the model fit. The Gamma distribution according to the authors adequately fitted the quarterly rainfall data producing a suitable model base on the Kolmogorov – Smirnov One Sample test.

Okonkwo & Mbajiorgu[11] analyzed rainfall data and characteristics for locations in seven states of Southeastern Nigeria. Intensity-Duration-Frequency (IDF) curves were developed for the locations using two Graphical and Statistical methods. According to the authors, the locations were Onitsha in Anambra State, Enugu in Enugu State, Abakiliki in Ebonyi State, Umuahia in Abia State, Owerri in Imo State, Port Harcourt in Rivers State and Uyo in Akwa Ibom State. They employed the generalized accumulated rainfall patterns developed by USDA Soil Conservation Service and matched it with rainfall data for the locations of study. Their results show that the advanced pattern had the best fit with the observed characteristics and was used to break down recorded daily totals into shorter duration rainfall data.

Obasi & Ikubuwaje[12] conducted an analytical study of rainfall and temperature trends in some catchment States of Nigeria using the Benin- Owena River Basin as case study. The study covers Climatic data for rainfall and temperature for 35years. Their study employed the Cumulative Summation (CU-SUM) and the rank-sum tests. Their trend analysis shows that as temperature increases there is a corresponding increase in rainfall. The trend also indicates that no significant departure of these climatic parameters occurred. Their least square regression (r2) and the trend show that the temperature variation ranges from 0.4% in Delta to 3.5% in Edo, an indication that the temperature conditions in states understudy are not uniform even though the trend shows an increase. The rainfall least square regression variation ranges between 0.2% in Zaria and 2.7% in Plateau states, implying that the rainfall is varying in an upward trend.

Odoemene[13] interrogated issues of interest in the concrete experiences of Niger Delta communities in Nigeria in relation to environmental change. The paper highlights the transition of the delta to its present state and explores the social consequences of this downturn in delta communities. The author argues that while the destruction of traditional means of livelihood has forced Niger Delta peoples into an environment-related poverty, deteriorating living conditions, and massive underdevelopment, environmental change in the area has led to new patterns of adaptation and survival.

Ekpoh, & Nsa[8] examined Some aspects of the climate of north-western Nigeria, focusing more on rainfall, its inter- and intra-annual variability and patterns of distribution. The authors adopted some statistical tools commonly used to describe climatic conditions. These tools include: the mean, the standard deviation and the coefficient of variability, the climate of north-western Nigeria was analyzed for possible shifts in mean conditions and patterns. Their study found that climatic conditions in north-western Nigeria have altered substantially as four drought episodes took place within the last three decades of the 20th Century and, the 1984 drought-year rainfall was 58.8 percent lower than the long-term mean rainfall. The study further showed that the 1968 to 2008 mean rainfall shifted downwards by 8.8 percent from the long-term mean, although it cannot be said if the shift is permanent or temporary since recent rainfall trends tend to suggest a recovery. Possible options for stabilizing the regional climate are suggested.

Ologunorisa & Tersoo [9]conducted analysis of recent changes in the characteristics of extreme rainfall and their implication on flood frequency in Makurdi. They employed data on extreme daily rainfall, evapotranspiration and flood occurrences. They analyzed the annual rainfall for trends using spearman rank correlation coefficient and annual rainfall variability using standardized rainfall anomaly index while recurrence intervals were analyzed using Gumbell Extreme probability theory. Their results show among other things that there was a remarkable continuous downward trend in annual rainfall amounts; that the period between 1996 and 2001 witnessed the highest frequencies of extreme rainfall events and flood frequencies; that major floods were associated with high recurrence intervals, and that the seasonality of flooding in Makurdi occurs between May and October.

Azuwike & Enwereuzor [7]examined the effect of rainfall variability on water supply in Ikeduru L.G.A of Imo State. Data collected were analyzed using regression analysis and analysis of variance. Their result shows that there is a strong relationship between rural water supply in the study area and the rainfall; and that there is a significant difference in the sourcing of water supply among communities. they further stated that at the onset of the rainy season, most of the water sources in Ikeduru L.G.A. are not reliable. Rainfall change points were detected to be 1991 and 1997. Reduction in rainfall amount as revealed by trends and variability patterns, adversely affects rural water supply.

Adejuwon[14] examined rainfall seasonality in the Niger Delta region of Nigeria, using both monthly and annual rainfall data from 1931 to 1997. The data was collected on 9 synoptic stations in the region. The cumulative index analysis and the percentage of mean were employed for in study. The result indicated a wet season with over 95% of the total annual rainfall in the area. It also showed a long wet season from February/March to November and a short dry season from December to January/February. Their study also observed a northward increase in rainfall in part of the eastern side of the Niger Delta. They noted that variation of rainfall in the locality could probably be as a result of rainfall determinant factors different from the inter tropical discontinuity.

Abaje, Ati & Iguisi[15] examined fluctuations and trends in the rainfall regime of the Sudano-Sahelian Ecological Zone of Nigeria so as to discuss the risks and opportunities involve. They employed Rainfall data for eight meteorological stations were used for this analysis. They sub-divided the rainfall series into 30-year overlapping sub-periods (1949-1978, 1959-1988, 1969-1998 and 1979-2008) and used the Cramer's (tk) test to compare the means of the sub-periods with that of the whole record period. Their results revealed that there was a change towards wetter conditions in the last 30-year period. According to the authors, the result of the linear trend lines shows an increase in rainfall supply over the period of study.

Ogbo, Ndubuisi & Ukpere [3] studied risk management and challenges of climate change in Nigeria, they reviewed the incidence and consequences of climatic change and the vulnerability of Nigeria to climate change. they adopted the survey research technique. Their findings show that deforestation, industrial releases, improper disposal of sewage are human activities responsible for climate change. Furthermore the authors found out that drought, erosion and flooding constitute the challenges resulting from climate change, and finally that government agencies in charge of environmental issues do not really help to reduce the risk of climate change in Nigeria. Ogbo, Ndubuisi & Ukpere[3] concluded that gas flaring, over grazing, bush burning, CO_2 are factors responsible for climate change in Nigeria. The authors recommended that, Nigerian Government should provide solutions to manage development of biotechnology, afforestation programme, integrated climate risk management and technology that can capture at least 80% of carbon emitted by industries.

III. Research Method

The study made use the rainfall data from selected towns in the Niger delta region. The selected areas are: Warri in Delta State, Port Harcourt in Rivers State, Benin in Edo state, Ikom and Calabar in Cross River State, Uyo in Akwa Ibom State and Owerri in Imo state. The rainfall data was collected from the Central Bank of Nigeria Data Bank. The study covers a period from 1981 to 2008 as that was the period with records of rainfall. The study employed the two factor Analysis of Variance model. Interest was to ascertain if there is any significant difference in the volume of rainfall over the years and across the study areas. Here the years and

town were the two factor studied. Again descriptive statistics such as the mean, variance and coefficient of variation were computed from the data the Excel Analysis tool pak was used to conduct the analysis (see Igweze & Etaga, [16] for procedure). The formulae are given Oyeka[17] as follows

- **Mean** = $\frac{\sum_{i=1}^{n} X_i}{n}$ ..... (1)
- Variance = $\frac{\sum(x-\bar{X})^2}{n-1}$ ..... (2)
- Coefficient of Variation = $\frac{SD}{\bar{X}}$ X 100 ..... (3)

Where: SD is standard Deviation = $\sqrt{\frac{\sum(x-\bar{X})^2}{n-1}}$

IV. Discussion Of Findings

Table 1: ANOVA result

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Rows(Years)	6606086	27	244669.83	3.433859647	3.52E-07	1.544925
Columns(Towns)	40714788	7	5816398.3	81.63121264	9.92E-54	2.0583
Error	13466654	189	71252.136			
Total	60787527	223				

The two way analysis of variance result shows that there is a significant difference between the mean rainfalls across the studied areas as the observed p-value is (approximately equal to zero) is less than 0.05. This means that at least one studied town is significantly different from others. Again, there is a significant difference between the mean rainfalls across the years revealing that at least mean rainfall in a particular year is significantly different from others.

Table 2: Descriptive statistics for rainfall Records

	Count	Sum(ml)	Average(ml)	Std dev	CV	CV(100%)
Akure	28	40232.1	1436.861	180.5838	0.125679	12.56794
Warri	28	79370.34	2834.655	321.5025	0.113419	11.34186
Benin	28	58655.51	2094.84	374.4811	0.178764	17.87636
Calabar	28	81380.8	2906.457	377.8163	0.129992	12.99921
Ikom	28	62261.9	2223.639	228.374	0.102703	10.27028
P/Harcourt	28	64541.5	2305.054	286.8296	0.124435	12.44351
Uyo	28	63185.3	2256.618	317.3403	0.140626	14.06265
Owerri	28	66524.9	2375.889	298.912	0.125811	12.58106
minimum		Akure	Akure	Akure	Ikom	Ikom
Maximum		Calabar	Calabar	Calabar	Benin	Benin

Akure recorded the least mean rainfall of 1436.861 in the study area. The rainfall in Akure exceeded the observed mean in 1984; 1985, 1988, 1989, 1990, 1991, 1992, 2002, 2004, 2005 and 2008. The highest rainfall was observed in 1991 and 1995 respectively. The least rainfall in Akure was recorded in 2001 followed by 2003. The rainfall variability in Akure was calculated at 12.57%. This shows 12.57% rainfall variation occurred within the period of study. Warri has a mean rainfall of 2834.655 within the studied period, recorded rainfall above the mean rainfall in 1985, 1990, 1991, 1992, 1995, 1997, 1999, 2002, 2004 and 2008. The highest rainfall recorded in Warri within the study period was in 1999 and 1995 respectively, while the least rainfall was observed in 2003 and in 1981 respectively. The rainfall variation was to the tune of 11.34%. Benin recorded the second least rainfall in the study period with an average rainfall of 2094.84. Rainfall above the average of the study period was observed in 1987, 1988, 1990, 1991, 1994, 1995, 1996, 1997, 1999, 2000, 2002, 2004, 2006 and 2007 while the rest of the years were below average. The coefficient of variation shows that 17.88% variation occurred in Benin within the study period. This makes Benin the town with the highest rainfall variability within the study area.

Average rainfall of 2906.457 was observed in Calabar. This makes Calabar the town with the highest average rainfall over the study period. The rainfall in calabar was above average in 1995, 1996, 1997, 1999 and 2007. Furthermore approximately 13% variation in rainfall occurred in Calabar between study periods. Ikom

recorded an average rainfall of 2223.64 with the least rainfall in 1998 and the highest in 1997. Ikom has the least variability when compared over other selected towns. 10.27% variability was recorded in Ikom over the period. Port-Harcourt has an average rainfall of 2305.05. The least rainfall in Porthacourt was recorded in 1983 with an average rainfall of 1816.4 and a maximum of 2868.6. A rainfall variability of 12.44% was recorded in porthacourt over the studied period. An average rainfall of 2556.618 was recorded in Uyo within the period of study. The highest rainfall was observed in 2005 while the least record was recorded in 1983. Uyo recorded a rainfall variation of 14.063% within the study period. Finally Owerri has a mean rainfall of 2375.90, with the highest rainfall recorded in 1997 and the least rainfall observed in 1998. A rainfall variation of 12.58 was observed in owerri over the study period.

V. Conclusion

The study shows various degrees of rainfall as well as variability over the study area. Akure in Ondo state recorded the least average rainfall across the study area and over the years. The highest average rainfall was recorded in Calabar in Cross Rivers State. Although Benin recorded the second least average rainfall after akure, it has the highest rainfall variation of 17.88% over the study period. Similarly Ikom had the minimum rainfall variability of 10.27 over the study period. Furthermore, there was no visible pattern of rainfall as there were rainfall fluctuations with no particular trends in the selected towns over the years. Owing to absence of recent data for rainfall, it is therefore recommended that environmental agencies in Nigeria, like the Nigerian Meteorological Agency in collaboration with the Nigerian National Bureau of Statistics should work assiduously toward keeping an up to date records of climate and weather indicators and also making it available and accessible to researchers and general public free of charge. For this will help sieve out climatic trends and improve on extreme weather prediction and forecasting in Nigeria.

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APPENDIX: DATA

Quarterly Rainfall Statistics in Selected Towns (Millimetres)

Year	Ondo		Edo	Cross River		Rivers	Akwa Ibom	Imo
	Akure	Warri	Benin	Calabar	Ikom	P/Harcourt	Uyo	Owerri
1981	1424.2	2349.9	1785.8	2736.9	2702.7	2530.7	2382.2	2433
1982	1379.1	3056.9	1969	2809	2472.6	2173.7	2105.3	2407.2
1983	1345	2521.6	1647.2	2346.7	1960.7	1816.4	1366.7	1756.7
1984	1507.4	2697.5	1249.4	2499.1	2160.9	2362.5	1733.8	2153.2
1985	1644.2	2976.8	1545.3	2963.8	2032.1	2206.6	2471.4	2396.1
1986	1159.8	2915.8	1228.2	2609.7	2311.7	2133.6	1759.8	2482
1987	1401.4	2775.6	2336.31	2861.4	2279.5	2723.9	2165.1	2075.5
1988	1555.8	2708.8	2149.1	2812.6	1716.6	2420.9	2238.8	2562.8
1989	1449.9	2571.5	1971.3	2766	2021.9	1864.9	2502	2581.7
1990	1577.9	3098.8	2436.7	2732.1	2262.5	2482.7	2254.2	2731.9
1991	1853.4	2920.7	2597.6	2661.9	2437	2094.4	2383.9	2567.4
1992	1482.9	3060.3	2016.5	2896.4	2039.7	1971.0	2255.9	2424.8
1993	1249.2	3010.6	1860.8	2511.3	2072.4	2581.7	2175.3	2182.8
1994	1265.5	2807.0	2531.5	2904.2	2305.5	2374.2	2668.3	2617.1
1995	1725.3	3337.8	2668.4	3687.4	2337.9	2528.5	2539.9	2622.7
1996	1365.9	2705.7	2286.4	3215.5	2399.4	2339.7	2681.8	2705.5
1997	1507.6	3227.3	2200.8	3493.0	2717.9	2329.8	1932.1	2891.4
1998	1453.6	2448.5	2018.7	2691.2	2369.0	2569.1	2010.4	1641.5
1999	1480.3	3396.6	2222.8	2984.4	2390.0	2499.6	2506.4	2515.4
2000	1530.8	2722.2	2239.8	2875.6	2356.9	1994.3	1994.9	2337.2
2001	976.4	2390.2	2042.5	3202.0	1981.6	2153.5	2307.1	2304.3
2002	1549.4	3312.2	2559.2	2797.7	2225.6	2185.7	2315.7	2333.2
2003	1080.6	2329.4	1937.7	2557.7	2178.9	2446.4	2298.3	2528.0
2004	1454.5	3064.0	2328.3	2324.5	1986.8	1877.5	2162.0	1777.8
2005	1533.2	2368.6	2014.0	3862.1	2228.8	2055.2	2821.5	2247.2
2006	1407.0	3031.1	2358.5	2896.8	2246.2	2868.6	2558.7	2350.2
2007	1405.7	2452.1	2527.3	3427.9	2181.1	2855.5	2487.6	2200.8
2008	1466.1	3112.8	1926.4	3253.9	1886.0	2100.9	2106.2	2697.5

Source: Nigeria Meterological Agency (NMA): http://www.cenbank.org/OUT/2011/PUBLICATIONS/STATISTICS/2010/PartD/PartD.html