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Analysis of Rainfall Trends in Akwa Ibom State, Nigeria

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Abstract

Rainfall availability sets the ceiling to crop yield in Nigeria. Rainfall trend is among the important characteristics of rainfall that varies both in time and space. This study has shown a gradual decline in rainfall trend as we move from the coastal south to the northern part of the state. Even though the northern part of the state tends to indicate abysmal increase in annual rainfall trend, a decline in annual rainfall of 58% and 65% of the total period was observed for the coastal south (Eket) and the central part (Uyo) of the state respectively. This decline was more pronounced in the months of March, July and September.

Keywords: climate, trend, variability, draught, rainfall, crop yield

1. Introduction

One of the most significant climatic variations in the African Sahel since the late 1960s has been the persistent decline in rainfall. The Sahel is characterized by strong climatic variations and an irregular rainfall that ranges between 200mm and 600 mm with coefficients of variation ranging from 15 to 30% (Fox and Rockström, 2003; Kandji *et al*., 2006). A rainfall decrease of 29-49% has been observed in the 1968-1997 period compared to the 1931-1960 baseline period within the Sahel region (McCarthy *et al*., 2001). The West Africa region has experienced a marked decline in rainfall from 15 to 30% depending on the area (Niasse, 2005). The trend was abruptly interrupted by a return of adequate rainfall conditions in 1994. This was considered to be the wettest year of the past 30 years and was thought to perhaps indicate the end of the drought. Unfortunately, dry conditions returned after 1994 (McCarthy *et al*., 2001).

The rainfall variability in Africa has been studied by numerous authors since the beginning of the recent drought period in the 1970s. Many studies focused on the Sahelian areas (Farmer, 1988; Lamb & Peppier, 1992; Hulme, 1992). Others also compared Sahelian rainfall with rainfall over other West African and Central Afrcan rregions (Thompson et al. 1985; Buishand, 1984).

Gil *et al.* (2001) analysed the standardized regional mean annual rainfall departure series over the period 1951-1989 for West and Central Africa. Their results were consistent with results of Moron (1994), Nicholson & Kim (1997) and Paturel *et al.* (1997) for the same regions and confirmed the difference of mean annual rainfall between West and Central Africa, according to the severity of drought. They concluded that the long-term trend of rainfall series of West and Central African showed major climatic discontinuity.

Rainfall characteristics in Nigeria have been examined for dominant trend notably by Olaniran (1990, 1992) and by Olaniran and Summer (1989, 1990). They showed that there has been a progressive early retreat of rainfall over the whole country, and consistent with this pattern, they reported a significant decline of rainfall frequency in September and October which, respectively coincide with the end of the rainy season in the northern and central parts of the country.

The pattern of rainfall in northern Nigeria is highly variable in spatial and temporal dimensions with inter-annual variability of between 15 and 20% (Oladipo, 1993a). As a result of the large inter-annual variability of rainfall, it often results in climate hazards, especially floods and severe and droughts with their devastating effects on food production and associated calamities and sufferings (Oladipo, 1993b; Okorie, 2003; Adejuwon, 2004). Rainfall is one of the key climatic resources of Akwa Ibom State. Crops and animals derived their water resources largely from rainfall. It is considered as the main determinant of the types of crops that can be grown in the area and also the period of cultivation of such crops and the farming systems that can be practiced.

2. Materials and methods

***2.1Study area*:**

Akwa Ibom State is strategically located within the oil rich Niger Delta, South-South of Nigeria and bounded to the south by Atlantic Ocean (Fig. 1a). It has coordinates of latitudes 4^0 32' and 5^0 31' North, and longitudes 7^0 25' and 8^0 25' East. Akwa Ibom State is characterized by two seasons- the wet rainy season and the dry season. In the south and central parts of the State, the wet or rainy season last for about ten to eleven months but towards the far north, it reduces to about nine months. The rainy season starts from February to March and last until mid November.   About 85-90% of the total annual rainfall is received during this period of the rainy season. The period marked by the "little dry season" and occurring for about 2-4 weeks in August is sometimes referred to as August break. This gives rise to two rainfall maxima- June/July for the first maximum, and September for the second maximum. To the extreme south of the State, particularly along the coastal areas, the "little dry season" is usually absent or shorter.

Monthly and yearly rainfall totals from the Meteorological office, Eket (1992-2008), University of Uyo weather station, Uyo (1977-2008), and Obotakara (1977-2008) were collated and analyzed. Obotakara data were gotten from the nearby University of Agriculture, Umudike. Umudike is about 10km distance from Obotakara. These three locations are representative of the agricultural zones of Akwa Ibom State.

To test for normality of the time series data, Microsoft Excel software was used to calculate both the standard coefficient of skewness (Z_1) and the standard coefficient of kurtosis (Z_2) as follows:

The equation for skewness (Z_1) is defined as:

$$\frac{n}{(n-1)(n-2)}\sum\left(\frac{x_j-\bar{x}}{s}\right)^3$$

Kurtosis is (Z_2) defined as:

$$\left\{\frac{n(n+1)}{(n-1)(n-2)(n-3)}\sum\left(\frac{x_j-\bar{x}}{s}\right)^4\right\} - \frac{3(n-1)^2}{(n-2)(n-3)}$$

Where, $\sum$ = summation of variate
x is the long term mean of xj samples and n is the total number of samples.

These statistics were used to test the null hypothesis that the samples came from a population with a normal distribution. If Z_1or Z_2 is greater than 1.96, a significant deviation from the normal curve is indicated at 95% confidence level. If this happens, transformation would be used to normalize the data. In order to identify trends, the entire rainfall time series were divided into a 5-year interval. The means of the 5-year interval were then compared with that of the whole periods.
To analyze annual rainfall variability, the standardize rainfall anomaly index was used.

It was calculated as: SAI= $\frac{x-\bar{x}}{S}$

where,
x is annual rainfall totals and
$\bar{x}$ is the mean of the entire series
S is the standard deviation from the mean of the series.
To further examine the nature of the trends in the rainfall series, linear trend lines were also plotted using Microsoft Excel statistical tool, and estimation of changes in the rainfall series was determined. Comparisons were then made with the long term mean totals.

3. Results and discussion

The mean (x), standard deviation (SD), coefficient of variation (CV), standard coefficient of skewness (Z_1), kurtosis (Z_2), normality index and the long term annual rainfall for Eket, Uyo and Obotakara are presented in Table 1. The results for Z_1 and Z_2 show that all the months were accepted as indicative of normality at 95% confident level with the exception of Z_1 for the months of August and September for Eket; Z_1 for the months of February, March, April, November and December for Uyo and Z_2 for the months of February and December also for Uyo. For Obotakara, all months were accepted as indicative of normality at 95% confident level exception of Z_1 for the months of September and November which show significant deviation from the normal. It was therefore not necessary to transform the data.
Table 2 shows the results of the variation in rainfall trends for the three locations from the Duncan Multiple Range Test (DRMT). It reveals that at 95% confident level, the three locations differ significantly, showing a gradual decrease in recent rainfall trend. For instance in Eket, the recent period of 2002-2006 was significantly lower by 400mm relative to that of the period 1992-1996. The same decreasing trend was observed for Uyo and Obotakara where recent rainfall period (2002-2006) was significantly lower by 556.15mm relative to that of 1977-1981, and also by 241.84 when compared to that of 1992-1996 respectively. This agrees with the studies of Ati et al. (2007) and Abaje et al. (2010); they observed that rainfall trend in Nigeria is decreasing on annual basis.

Figures 1b, c and d smoothened with a 5-year moving average show the graphical presentation of the annual rainfall anomalies for the three locations of Eket, Uyo, and Obotakara respectively. They show declining rainfall across the three locations as many of the years have their annual rainfall values below their long term mean. Whereas the wettest years (years with the highest rainfall) for Eket, Uyo and Obotakara were recorded in 1994 (Fig. 2a), 1977 (Fig. 3a) and 1996 (Fig. 4a) respectively, the driest years (years with the lowest rainfall) were recorded in 1998 (Fig. 2b), 1983 (Fig. 3b) and 1983 (Fig. 4b) for the same respective locations. The 5-year moving average shows that the recent decline in annual rainfall started from 1999 to 2008 for Eket (58% of the period), and from 1984 to 2004 for Uyo (65% of the period). However, for Obotakara, the rainfall pattern showed a fluctuating trend. Also, the 5- year moving average for the driest months show that rainfall was lowest from the months of March to October (Figs. 2b, 3b and 4b) ; these are critical crop growing months for rain-fed agriculture in the study area. The same conclusion was reached by Adejuwon (2004) for Western Nigeria; Ati *et al*. (2007) for Guinea, Sudan and Sahel Savanna of Nigeria; and Abaji *et al*. (2010) for Guinea Savanna of Nigeria. They found out that because of the decline in July to September rain, relative dryness was observed across the zones.

Linear annual trend lines for the period of study show a general decrease across the three locations. Estimate of annual rainfall changes for Eket shows a significant decrease of approximately 1525mm at the rate of 89.71mmyr^{-1} (Fig. 5a). A significant decrease in rainfall of approximately 2266.20mm and at the rate of 73.10mmyr^{-1} was also observed for Uyo (Fig. 5b). However for Obotakara, a rainfall increase of approximately 1238mm at the rate of 39.94mmyr^{-1} was observed as depicted in Fig. 5c. When compared with the long-term mean, it means that Eket and Uyo rainfall decreased at the rate of 2.12 and 2.97% per year respectively. Conversely, Obotakara rainfall increased at the rate of 1.86% per year when compared with the long-term mean. The results gotten from the linear trend lines are in tandem with that earlier gotten from analyses of the rainfall anomalies. It confirms that the decline in the annual rainfall was due to diminishing rainfall yields in the months of March to October. Exactly the same result was observed by Abaje et al. (2010). He noted that for Kafanchan, North Central Nigeria, the decline in annual rainfall was predominantly due to the substantial decline in July, September and August rainfall.

4. Conclusions

Rainfall availability sets the ceiling to crop yield in Nigeria. Rainfall trend is among the important characteristics of rainfall that varies both in time and space.
This study has shown a gradual decline in rainfall trend as we move from the coastal south to the northern part of the state. Even though the northern part of the state tends to indicate abysmal increase in annual rainfall trend, a decline in annual rainfall of 58% and 65% of the total period was observed for the coastal south (Eket) and the central part (Uyo) of the state respectively. This decline was more pronounced in the months of March, July and September. Generally, the observed decline in rainfall trend may be due to the migration pattern of the region of Inter-Tropical Discontinuity (ITD) – a region of convergence of the trade wind and the monsoonal air flow. Accordingly, droughts in Nigeria, and indeed over West Africa, are associated with a restricted northward advance of the ITD. On the other hand, wet years result from a considerable northward advance of the ITD. Different from this simplistic picture, the ITD itself is erratic in its south-north advance and north-south retreat. It moves in a series of surges. A decline in rainfall could also be attributed to a phenomenon known as biogeophysical feedback mechanism (BFM). Reduced rainfall, combined with human and animal activities (such as

overgrazing) could reduce the vegetation cover and increase the reflectivity, or albedo, of the land surface. Higher albedo changes the heat balance of the surface-atmosphere system and ultimately this leads to increased divergence in the lower atmosphere and reduced uplift over the higher albedo region.

These changes, in turn, lead to less rainfall and hence initiation of drought condition.
Undoubtedly BFM, as described above, has served to reinforce drought conditions over the northern part of Nigeria. This is due to large scale depletion of the vegetation for fuel wood and as well as due to overgrazing by animals in this part of the country.
The decline in rainfall in the month of March/April has serious implications on the timing and commencement of planting as here, planting is usually done between March and April. A delay in the commencement of planting may therefore cause uncertainty in the season. This will undoubtedly affect crop yield vis-à-vis farm income. Also, the "little dry season" (August break) that was usually shorter or absent in the coastal South is gradually becoming a permanent feature with increasing dryness. This obviously is due to the attendant decline in rainfall trend as shown in this study. The implication is that the culture of "2nd season planting" is at the risk of extinction. If this declining rainfall trend continues, it may not be economically feasible for farmers to plant a crop like maize two times during one rainy season.

It is recommended that pre-season and on-season climatic information should be disseminated to farmers to guide them particularly during seasons of uncertain rainfall. Also, drought resistant and early maturing crop species should be planted. Deforestation (cutting of woods for cooking fuel) should be discouraged as this depletes the vegetative cover of the soil.

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References

Abaje, I.B., S. Ishaya, and S.U. Usman. 2010. An Analysis of Rainfall Trends in Kafanchan, Kaduna State, Nigeria. Res. J. Environ. Earth Sci. 2(2): 89-96.
Adejuwon, S. A., 2004. Impact of Climate Variability and Climate Change on Crop Yield in Nigeria. Being the lead paper presented at the stakeholders' workshop on Assessment of Impacts and Adaptation to Climate Change (AIACC),Obafemi Awolowo University, Ile-Ife, Sept.20-21.
Ati, O.F. and E.O. Iguisi. 2007. Recent Trends in the Duration of the Rainy Season in Some North Latitude 9^0N of Nigeria. J. Appl. Sci. Res. 3(12): 1737-1745.
Fox, P. and Rockstrm, 2003. Suplemental irrigation of dry-spell mitigation of rainfed agriculture in the Sahel. Agric. Water Manage., 61: 29-50.
Kandji, S.T., L. Verchot and J. Mackenson, 2006. Climate Change and Variability in the Sahel Region: Impacts and Adaptation Strategies in the Agricultural Sector. World Agroforestry Centre/United Nations Environment Programme.
McCarthy, J.J., O.F. Canziani, N.A. Leary, D.J. Dokken and K.S. White, 2001. Climate Change 2001: Impacts, Adaptation, and Vulnerability. Contribution of Working Group 11 to the Third Assessment Report to the InterGovernmental Panel on Climate Change, pp: 487-532. Cambridge. Cambridge University Press.
Niasse, M., 2005. Climate Induced Water Conflict Risks in West Africa: Recognizing and coping with increased climate impacts on shared watercourses. An International Workshop organized by Centre for the Study of Civil War, International Peace Research Institute, Oslo (PRIO) and Centre for International Environmental and Climate Research at University of Oslo (CICERO) for the global environmental change and human security program (GECHS). Retrived from: http:www.gechs.org/downloads/holmen/Niasse.pdf.
Okorie, F.C. 2003. Studies on Drought in the Sub-Saharan Region of Nigeria Using Satelite Remote Sensing and Precipitation Data.Retrieved from: http://www.mathaba.net/gci/docs/research/nigeria-drought.html.
Oladipo, E. O., 1993a. A comprehensive approach to drought and desertification in Northern Nigeria. Nat. Hazards, 8: 235-261.
Oladipo, E. O., 1993b. Some aspects of the spatial characteristics of drought I Northern Nigeria. Nat. Hazards, 8: 171-188.
Olaniran, O.J. (1990). Changing patterns of rain-days in Nigeria. GeoJournal. 22(1): 99: 107-137.
Olaniran, O. J. (1992). An analysis of rainfall trends in Nigeria on the inter annual and multi-year time scales, Staff/PG

seminar, Dept. of Geography, Uni. Of Ilorin, 14pp.

Olaniran, O. J., and G.N. Summer. 1989. Climate change in Nigeria:change in the rainfall receipt per rain day. Weather: 43(6): 242-248pp.

Olaniran, O. J., and G.N. Summer. 1990. Long-term variations of annual and growing season rainfalls in Nigeria. Theor. Appl. Climatol.(41): 41-53.

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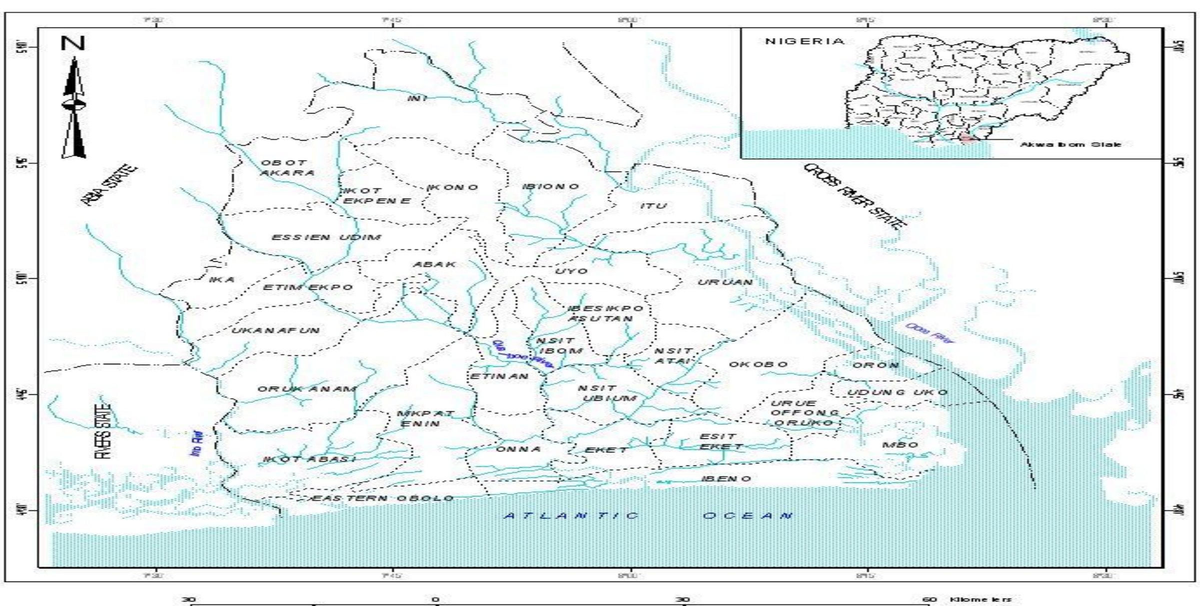

Fig. 1a: Map of Nigeria showing the study area

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Table 1. Summary of Monthly Rainfall Statistics for Uyo, Eket And Obotakara of Akwa Ibom State (1977-2009)

	JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEPT	OCT.	NOV.	DEC.	ANNUAL (1977-2008)
					a (Uyo)								
AVERAGE	19.72	44.00	141.36	217.61	278.46	293.53	360.99	350.96	342.37	275.99	108.85	26.34	6755.55
SD	24.51	59.42	93.30	127.46	86.28	113.71	141.10	144.04	143.75	90.66	72.92	58.21	5135.34
CV	124.30	135.05	66.00	58.57	30.99	38.74	39.09	41.04	41.99	32.85	66.99	221.00	2529.03
Z_1	0.13	4.53	6.70	2.73	-0.02	0.83	-0.03	1.59	1.05	0.02	2.90	19.91	-29.52
Z_2	1.17	2.06	1.89	1.46	0.55	0.28	0.58	1.03	0.73	0.70	1.44	4.12	-674.77
Z	26.55	23.70	48.48	52.93	100.04	82.61	81.87	77.97	76.21	97.42	47.77	14.48	476.68
					(b) Eket								
	JAN.	**FEB.**	**MAR.**	**APRIL**	**MAY**	**JUNE**	**JULY**	**AUG.**	**SEPT**	**OCT.**	**NOV.**	**DEC.**	
AVERAGE	62.68	63.81	219.94	295.44	418.58	621.52	617.79	670.41	556.05	423.20	216.95	66.67	5996.79
SD	69.97	77.25	80.51	108.82	124.78	191.38	194.47	189.17	145.05	151.64	114.44	74.36	4422.23
CV	111.64	121.08	36.61	36.83	29.81	30.79	31.48	28.22	26.09	35.83	52.75	111.53	1259.28
Z_1	1.66	0.22	-1.03	0.64	-1.19	1.29	0.00	2.50	-0.18	2.82	-0.77	-0.21	-9.81
Z_2	11.72	11.42	11.12	10.82	10.53	10.26	10.07	9.85	9.64	9.34	8.94	8.46	6.09
Z	14.33	13.21	43.71	43.44	53.67	51.96	50.83	56.70	61.34	44.65	30,33	14,35	234.62
				(c) ObotAkara									
AVERAGE	15.70	29.75	112.91	169.47	272.80	285.78	303.24	308.53	343.20	253.95	54.16	7.11	5750.92
SD	23.93	34.62	72.48	58.33	83.78	100.24	84.11	103.67	95.35	103.08	47.82	10.23	4692.72
CV	152.42	116.37	64.19	34.42	30.71	35.08	27.74	33.60	27.78	40.59	88.29	144.02	2624.65
Z_1	1.59	1.16	-0.69	1.05	-0.12	0.22	-0.40	-0.24	3.12	0.38	2.38	0.79	-30.88
Z_2	1.64	1.35	0.45	0.63	-0.02	0.62	0.34	0.13	1.50	0.53	1.21	1.40	8.77
Z	20.34	26.64	48.29	90.07	100.94	88.38	111.77	92.26	111.59	76.37	35.11	21.52	435.58

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Table 2: Result of sub-period analysis using Duncan multiple test.

Period	Eket	Uyo	Obotakara
1977-1981	-	3250.98±273.25a	1941.04±139.96g
1982-1986	-	2020.12±136.86g	2134.14±212.04b
1987-1991	-	2246.90±94.89d	2115.54±91.66c
1992-1996	4478.92±185.19a	2221.32±128.14e	2293.34±148.25a
1997-2001	4078.36±225.63d	2085.98±143.22f	2070.14±172.65e
2002-2006	4177.52±127.02c	2694.83±271.86b	2051.50±129.65f

Values are given as means ± standard error of means (n=5). Values followed by different letters within a column are significantly different (p<0.05). No authentic recorded values from 1977-1991 for Eket.

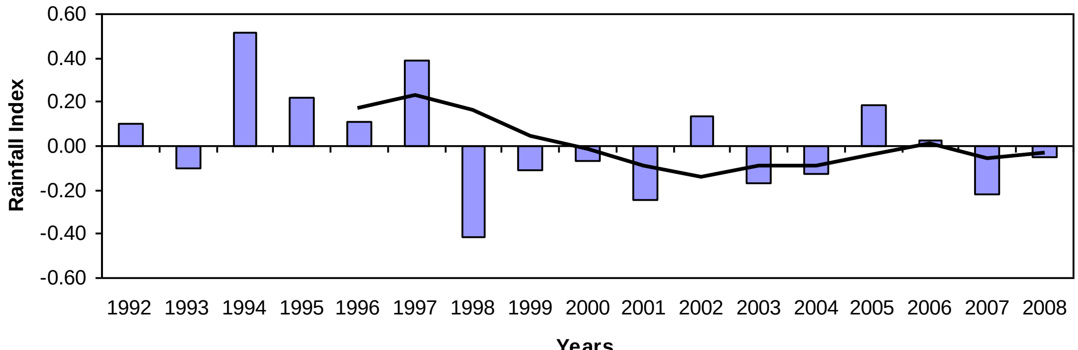

Fig.1 (b): Eket Annual Rainfall Anomaly (1992-2008)

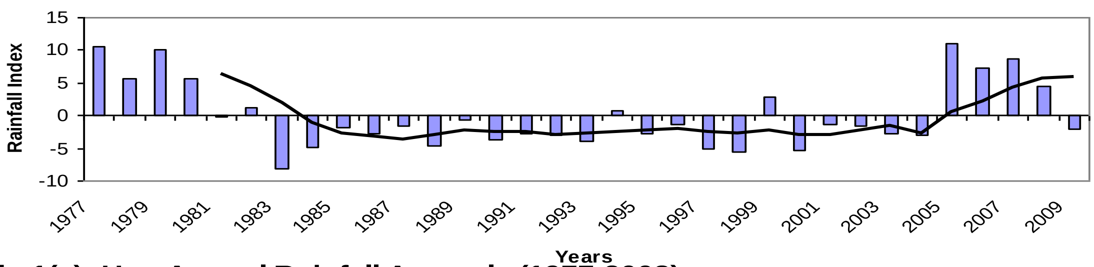

Fig.1(c) :Uyo Annual Rainfall Anomaly (1977-2008)

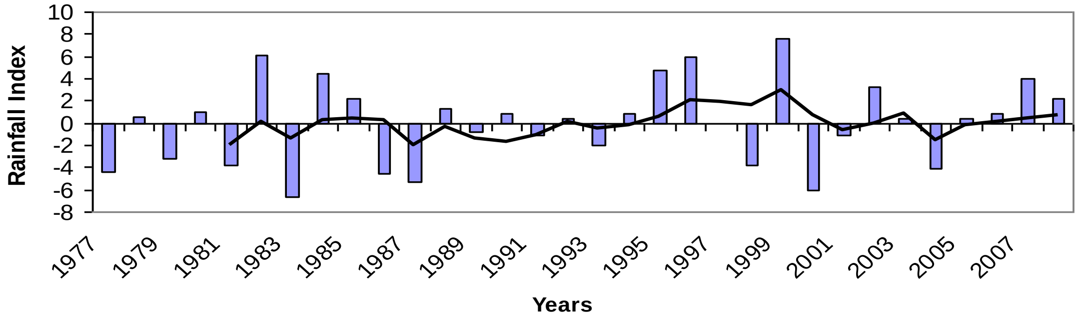

Fig.1(d): Obotakara Annual Rainfall Anomaly (1977-2008)

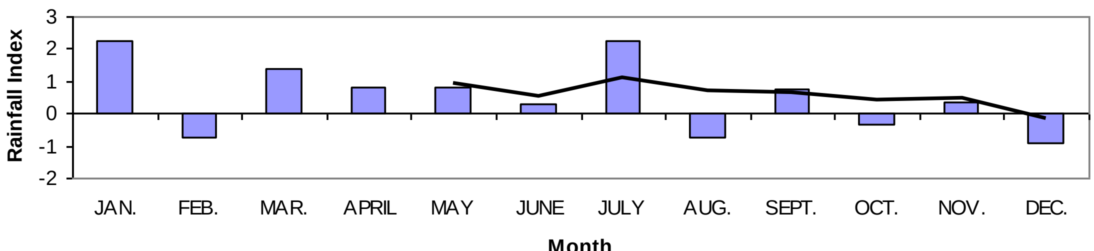

Fig . 2a: Rainfall anomaly for the year with the highest rainfall amount for Eket (1994)

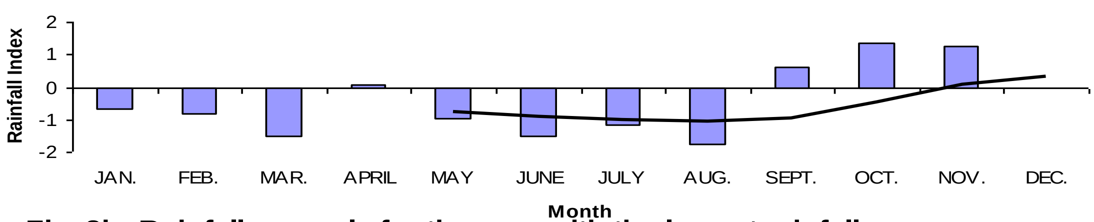

Fig. 2b: Rainfall anomaly for the year with the lowest rainfall amount for Eket (1998)

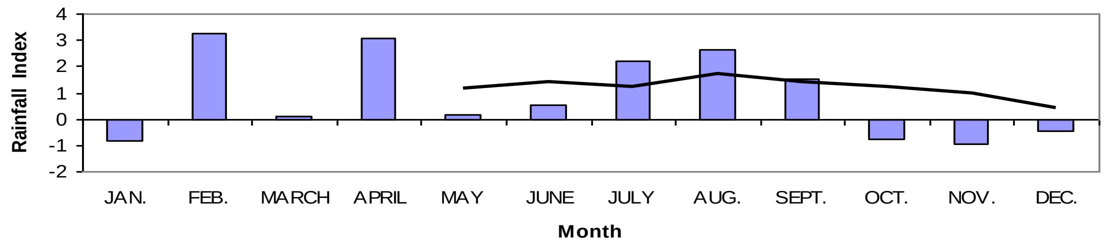

Fig. 3a: Rainfall anomaly for the year with the highest rainfall amount for Uyo (1977)

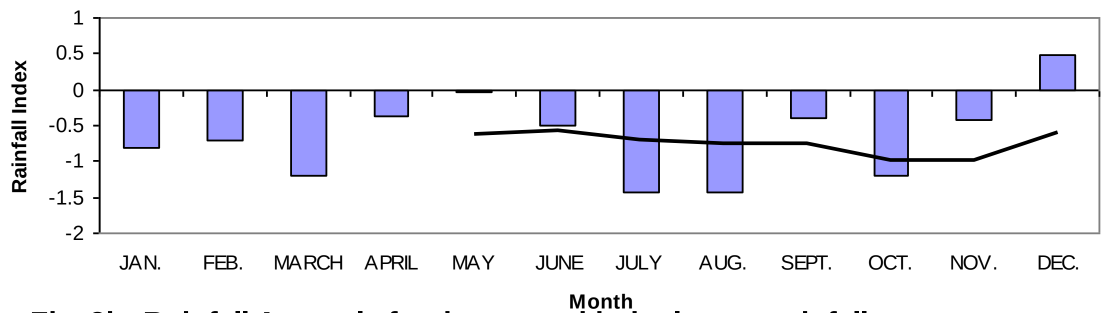

Fig. 3b: Rainfall Anomaly for the year with the lowest rainfall amunt for Uyo (1983)

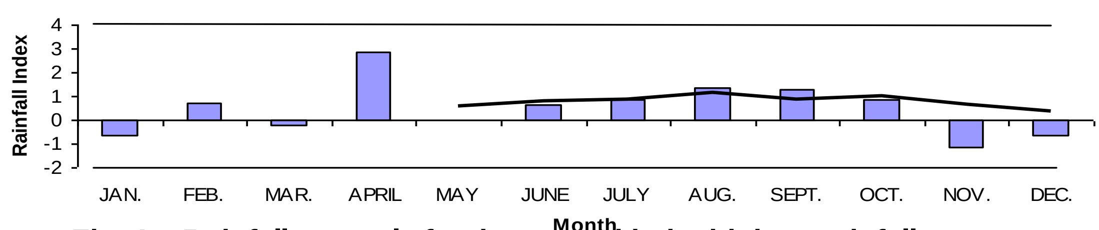

Fig. 4a: Rainfall anomaly for the year with the highest rainfall amount for Obotakara (1996)

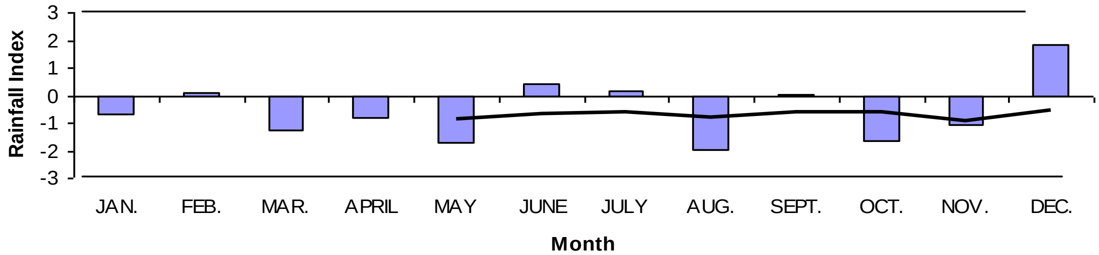

Fig. 4b: Rainfall anomality for the year with the lowest rainfall amount for Obotakara (1983)

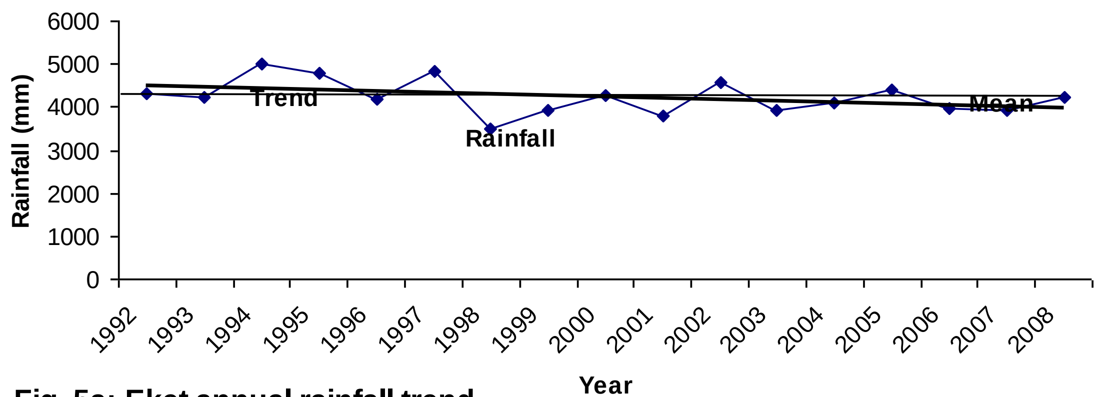

Fig. 5a: Eket annual rainfall trend

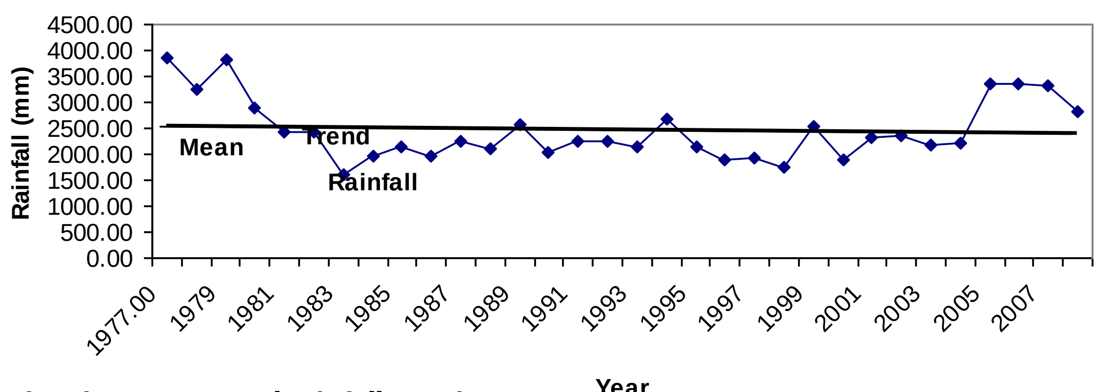

Fig. 5b: Uyo annual rainfall trend

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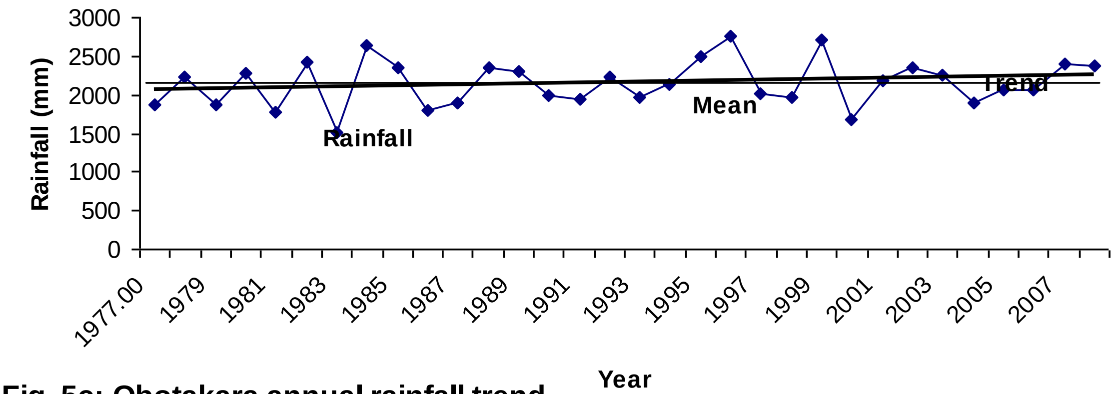

Fig. 5c: Obotakara annual rainfall trend