# Geography and Regional Planning

## Frequency and Distribution of Intense Rainfall in Uyo, South Eastern Nigeria.

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**Abstract**
*Estimates were made of the magnitude, frequency and distribution of extreme rainfall events in a humid tropical environment. Some of the parameters include the infrequent occurrence of maximum rainstorms, % of total annual rainfall >25mm, >50mm and >100mm as well as the probable maximum precipitation based on the Chow's general frequency formula.*
*The probable maximum precipitation was calculated for Uyo using the formula*
*P.M.P. =Y +sd. K*
*Where P.M.P. – probable maximum precipitation*
*Y = mean maximum daily rainfall*
*Sd.=standard deviation of maximum daily rainfall and K is frequency factor assumed to be 15*

*The computed value was 586.4mm. This value is slightly higher than those of Port Harcourt[463.5mm] Calabar[480.3mm] Benin City [453.9mm] and Enugu[322.3mm], but certainly not as high as that of Warri. The return period for the computed value for Uyo is 30 years. Since floods [particularly seasonal are primarily due to intense and prolonged rainstorms, the data for extreme rainfall in an area are needed for design purposes such as bridges, culverts, storm drains and design of flood control structures, particularly in large cities.*

### INTRODUCTION

Apart from annual precipitation totals and the seasonal or monthly distribution, engineers and hydrologists require information for many purposes on the frequency and magnitude of extreme precipitation, the distribution of rainfall in storms of different sizes as well as the characteristics of rainstorms. Analysis of the frequency of intense rainfall of various durations, especially 24 hours or below is necessary for the design of structures such as culverts, bridges, dams and erosion control structures. The design of such structures must be based on the magnitude of floods which the structures will be likely to have to withstand during the estimated economic life.

In the humid tropical environment, floods are usually due to intense and/or prolonged rainfall. There is an urgent need to analyze these storms, particularly the maximum probable precipitation, PMP, distribution of rainstorms of various sizes, isolate those storms or rain events that can initiate soil erosion, among others.

The literature is replete with studies involving the use of [i] statistical, physical and empirical methods to estimate extreme precipitation amount of various return periods. The statistical method for instance, is based on probability theory and the two distributions most often used are the normal distribution and the extreme value distribution functions developed by Gumbel[1958]. The Gumbel extreme value theory is favoured by most analysis because it provides quite reliable estimates and does not usually require data transformation, as in the case of normal or log-normal distribution. The extreme value theory has been applied to many hydrological problems with satisfactory results.

Arising from the foregoing, therefore the objective of this study is to estimate the PMP for Uyo, southeastern Nigeria based on the Chow's General Frequency formula. Also subsumed under this objective are the following;

[i] estimate the percentage of non-erosive rain events in the humid tropical environment using Uyo as a case study,

[ii] estimate the proportion of total annual rainfall that can trigger off soil erosion in an ecologically sensitive environment where the balance between incoherent sand particles and the amount of vegetation cover is precarious, among others.

**FIG. 1 LOCATION OF AKWA IBOM STATE**

## METHODOLOGY

Daily rainfall total were collected for a period of thirty years -1977-2006. This include measurement of total annual, monthly totals, mean monthly/annual, percentage of annual rainfall <25.4mm, >25.4mm >50mm and >100mm. Graphs were plotted to identify erosive months. Furthermore the PMP was calculated for Uyo using the formula ;

PMP = Y +sd.K

Where PMP = Probable maximum precipitation

Y = mean maximum daily rainfall

Sd = standard deviation of maximum daily rain fall and K is the frequency factor assumed to be 15. Hershfield [1961] has shown that reliable estimates of probable maximum precipitation[PMP] can be obtained using Chow's general frequency formula without the elaborate physical analysis by just assuming a K value of 15. using a K value of 15 Ayoade[1976] found that most of the PMP estimates made for 19 Nigeria stations were reliable.

## RESULTS AND DISCUSSION

Analysis of the results presented in tables 1 and 2 show that between 8 and 9 months constitute the rainy season in Uyo[March –October/November]. On the other hand, the dry season commences from Nov./December to March. The monthly distribution of total rainfall coincides roughly with the frequency of rainfall in the area [fig.2] it ranges from 19 days with a mean monthly value of 351.8 in July to one day/month in December with a mean value of 13.4mm. The frequency of rainfall in a year clearly shows that in every year about 130 days experience rainfall that is 35.6% of the number of days in a year.

**FIG. 2 MEAN MONTHLY RAINFALL AT UYO (1977-2006)**

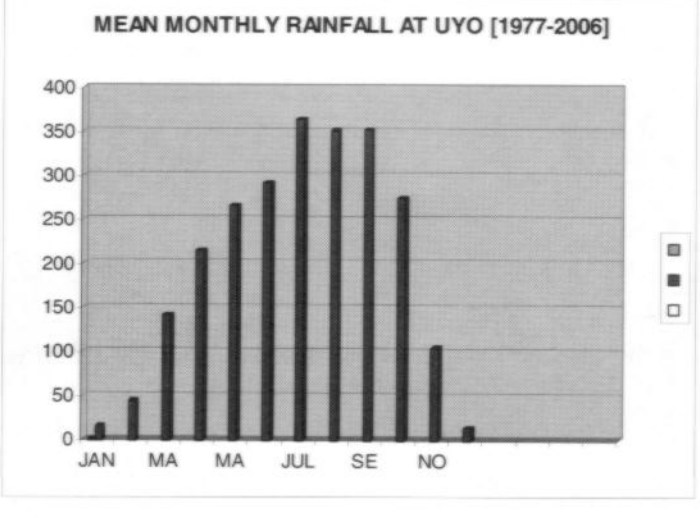


**FIG. 3 FREQUENCY OF RAINFALL AT UYO, AKWA IBOM STATE**

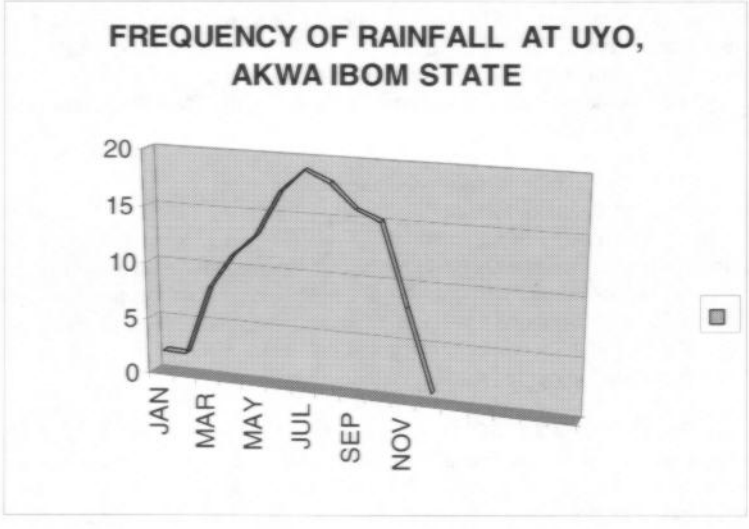



**TABLE 1: RAINFALL PARAMETERS IN UYO AREA OF THE COASTAL PLAINS SANDS**

| MONTH | TOTAL RAINFALL mm (MEAN) | RAINDAYS (MEAN) | A.P.I |
|---|---|---|---|
| January | 15.4 | 2 | 0.00 |
| February | 44.18 | 2 | 4.54 |
| March | 141.2 | 8 | 37.26 |
| April | 214.2 | 11 | 161.10 |
| May | 265.75 | 13 | 202.90 |
| June | 291.1 | 17 | 232.02 |
| July | 364 | 19 | 337.41 |
| August | 350.4 | 18 | 320.96 |
| September | 351.26 | 16 | 230.36 |
| October | 274.5 | 15 | 190.90 |
| November | 104.0 | 8 | 30.16 |
| December | 13.84 | 1.0 | 0.37 |
| Total | 2443.3 | 130 | 1743.01 |
| Mean | - | - | 145.25 |

Mean monthly rainfall and number of rain days were computed for 30 years (1977-2006). Any month with an average rainfall of at least 102mm denotes a wet month, rain day = 1.0mm or more.
Source: Extracted from Rainfall Records at Uyo.

**Table 2: Frequency of Occurrence of Intense Rainstorms**

**Table 2: Frequency of Occurrence of Intense Rainstorms**

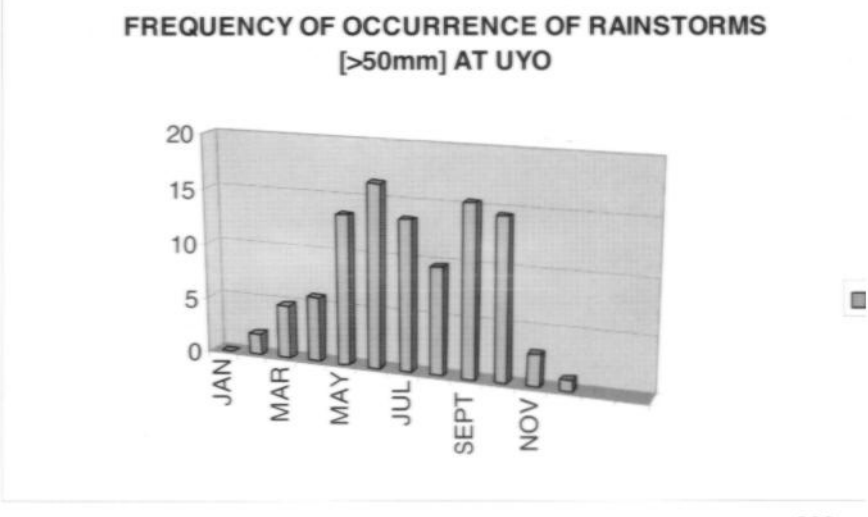
| MONTH | >50mm | PERCENTAGE | >100mm |
|---|---|---|---|
| JAN | 0 | - | 0 |
| FEB | 2 | 1.94 | 0 |
| MAR | 5 | 4.85 | 0 |
| APR | 6 | 5.83 | 1 |
| MAY | 14 | 13.6 | 1 |
| JUN | 17 | 16.5 | 6 |
| JUL | 14 | 13.6 | 2 |
| AUG | 10 | 9.7 | 1 |
| SEPT | 16 | 15.5 | 3 |
| OCT | 15 | 14.6 | 2 |
| NOV | 3 | 2.9 | 1 |
| DEC | 1 | 0.97 | 0 |

Extracted for a period of ten years[1997 – 2006]

Table 3 shows that in the study area 41.32% of the total annual rainfall of 1599.4mm to 3855.5mm, mean=2443.3mm fall in daily showers, drizzles and light rains of less than 25.4mm. The highest concentration of light rains/showers of <25.4mm was 1997[58.6%] this is in sharp contrast with the proportion recorded in 1977[15.9%] of total rainfall of 3855.5mm].

In the study area, rainfall is mainly conventional; hence rainstorms of more than 25.4mm contribute a total of 58.7% of annual rainfall. In some wet years[above mean annual] the contribution of rainstorms, particularly cloudburst rains of more than 100mm could be above 80% as in 1977[84.1%] and 1979[80.8%].

**FIGURES 4 & 5**



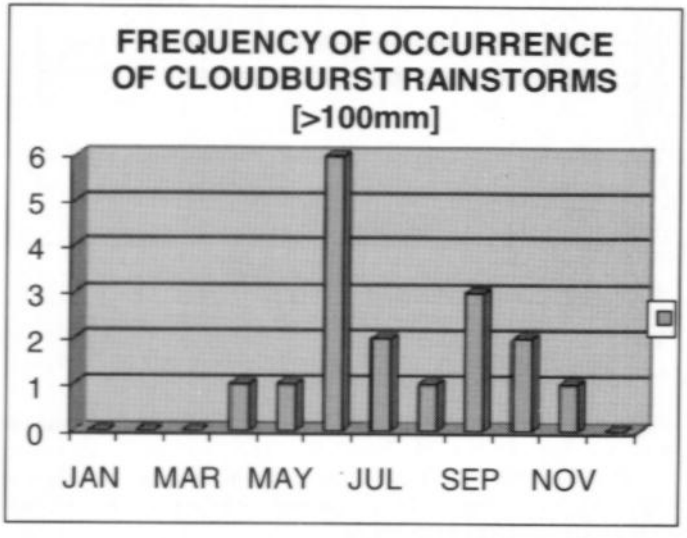

FREQUENCY OF OCCURRENCE
OF CLOUDBURST RAINSTORMS
[>100mm]
6
5
4
3
2
1
0
JAN
MAR
MAY
JUL
SEP
NOV

**TABLE 2: ANNUAL DISTRIBUTION OF RAINSTORMS IN UYO AREA.**

| Year | Total Annual Rainfall | %of total > 25.4mm | % of total 100mm | % of total less than 25mm |
|---|---|---|---|---|
| 1977 | 3855.5 | 84.1 | 50.69 | 15.9 |
| 1978 | 3270.7 | 69.4 | 35.45 | 30.6 |
| 1979 | 3825.4 | 80.8 | 29.68 | 19.2 |
| 1980 | 2860.4 | 55.8 | 3.75 | 44.2 |
| 1981 | 2426.8 | 50.1 | 8.400 | 49.2 |
| 1982 | 2442.5 | 51.1 | 9.13 | 48.9 |
| 1983 | 1599.4 | 44.9 | - | 55.1 |
| 1984 | 1878.7 | 56.3 | - | 43.7 |
| 1985 | 2132.6 | 60.9 | - | 39.1 |
| 1986 | 1904.2 | 59.6 | - | 40.4 |
| 1987 | 2251.4 | 51.5 | 5.92 | 48.5 |
| 1988 | 2115.0 | 65.8 | - | 34.2 |
| 1989 | 2588.5 | 62.8 | 9.43 | 37.2 |
| 1990 | 2032.8 | 46.7 | 5.93 | 53.3 |
| 1991 | 2246.7 | 47.6 | 9.79 | 52.4 |
| 1992 | 2256.8 | 67.4 | 17.80 | 32.6 |
| 1993 | 2229.5 | 56.2 | 5.10 | 43.8 |
| 1994 | 2668.7 | Na | NA | Na |
| 1995 | 2282.0 | NA | Na | NA |
| 1996 | 2378.4 | 44.8 | 5.05 | 55.2 |
| Mean | 2462.2 | 58.7% | 10.9% | 41.3% |
| 1997 | 2004.0 | 41.39 | 5.01 | 58.61 |
| 1998 | 2033.8 | 52.41 | 4.91 | 47.59 |
| 1999 | 2945.4 | 42.97 | - | 57.03 |
| 2000 | 1904.5 | 45.56 | 5.27 | 54.44 |
| 2001 | 2317.2 | 61.95 | - | 38.05 |
| 2002 | 2341.45 | 67.94 | 9.01 | 32.06 |
| 2003 | 2194.8 | 51.33 | - | 48.67 |
| 2004 | 2221.6 | 66.45 | 11.06 | 33.55 |
| 2005 | 3030.5 | 60.38 | 16.24 | 39.62 |
| 2006 | 3373.7 | 65.88 | 18.83 | 34.12 |
| Mean | 2443.3 | 58.68 | 9.1 | 41.32 |

Source: Extracted from Rainfall Records at Uyo.

The proportion of total annual rainfall due to rainstorms in Uyo area of Akwa Ibom State is shown in table 2. Three valid conclusions can be drawn from the table; viz. (I) more than 55% of the total annual rainfall is due to rainstorms of more that 25.4mm, (ii) there is a declining trend in the proportion of light/moderate rains[<25.4mm] and (iii) finally an increase in the proportion of total rainfall due to rainstorms of more than 100mm in recent years.

There is also seasonal variation in the distribution of rainstorms in the area. Figure 2 shows that there is no month of the year where daily rainfall of less than 25.4mm does not occur. On the other hand, cloudburst rainstorms of of more than 100mm occurs only in the months of April – November and is mostly concentrated in the months of June and October i.e. bimodal[fig.3] the sharp peak in September indicates higher frequency of occurrence of rainfall[>100mm] than in October , as the wet season is tailing off. In 2006 alone, a total of 636.01mm of rainfall was recorded from 6 high intensity rain events[>100mm] between May and October. It would be recalled that this value exceeds the average monthly rainfall in he area. In a similar fashion, more than 340mm[344.6mm] occurred in June[precisely in 3 days of torrential rainfall-between $10^{th}$ and $24^{th}$]. Thus, rainfall is concentrated in comparatively large daily falls I the area. This is typical of stations in southern Nigeria.

The frequency of occurrence of rainfall of more than 50mm was also computed for 10 years-1997-2006. the monthly distribution of rainfall of >50mm shows that January does not record heavy rainstorms in this category and that rainfall of >50mm is concentrated in the months of May-October, with two peaks in June and October respectively[fig.4]. in the last 10 years i.e. 1997-2006 the highest daily rainfall was 161.2mm recorded in July $2^{nd}$ 2005, followed by 151.1mm in September 10th 2006.

Furthermore, Chow's formula was employed to estimate the probable maximum precipitation in the area. The computed value of 586.4mm is slightly higher than those of Port Harcourt[463.5mm]; Calabar[480.3mm]; Benin City[453.9mm] and Enugu[322.3mm]. However, the value computed for Warri [604.3mm] in the southern most part of Nigeria was quite high[Ayoade,1976]. These stations had mean maximum daily rainfall of 109.2mm, 110.7mm, 103.4mm, 89.9mm and 134.9mm respectively[ Ayoade, op cit]

In conclusion, the analysis of the temporal pattern of the concentration of rainfall in storms of varying sizes and estimates of PMP presented in this study will be useful in planning for flood abatement and erosion control in Uyo urban

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