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PREDICTION OF MEAN ANNUAL FLOOD (MAF) FOR OGUN DRAINAGE BASIN, SOUTH WESTERN, NIGERIA

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ABSTRACT

Regression analyses was applied to develop regression model to predict mean annual flood (MAF) from ungauged catchments using catchment characteristic in Ogun Drainage Basin. The results of the analysis showed that AREA gives a better correlation with MAF with a correlation coefficient of 94%. The results explained that AREA contributed the larger proportion of the variance of MAF in the derived regression model with a coefficient of determination of 94%. In this regard AREA has been proved to be an important independent variable to be included in the development of regression model to predict MAF. The derived equation for Ogun Basin is $Q_M = 0.038A^{0.96}$,the equation compared very well with those derived for Southern Africa.

Keywords: Regression, Model, Mean Annual Flood (MAF), Drainage Basin.

INTRODUCTION

The need for the developing nations to carry out the design of hydraulic structures cannot allow an indefinite wait for adequate data. The hydrologist therefore has to use his skills to appropriately choose those methods, which will as accurately as possible predict the design-oriented parameters. The basic problem is to find the relation between flood magnitude and return period at a site for which no record of flows is available. The nature of stream flow in a region is a function of the hydrologic input and the physical, vegetative and climatic characteristics of the region. The physical characteristics of a catchment may be grouped under a number of general headings e.g. size and shape, density and distribution of streams, overland and channel slope, catchment storage, soils, geology and rainfall or climate. The geometric characteristics i.e. area, shape, length of streams and average main-stream slope affect the form of the hydrograph and peak discharge from a given watershed area. The relationship and effect of the geometric characteristic of Ogun drainage basin and the flood frequency will be investigated.

Study Area

The Ogun River Basin lies in the Southwestern Nigeria between latitudes 6° 33′ and 8° 58′ and longitudes 2° 4′ and 4° 10′ occupying a total area of approximately 23,700 km^2 . The Basin can be divided into two; Upper-Central and Lower Ogun River Basin.

The Upper-Central constitutes the main body of the basin and includes the Oyan-Ofiki river system, which is the main tributary of the Ogun River. The confluence of the Oyan and Ogun River marks the boundary between the Upper-Central Basin to the North and Lower Basin to the South (Tahal Consultants, 1980, Fig. 1).

Average annual rainfall for the entire basin is estimated at between 1,500-2,000mm. The duration of rainfall in Upper-Central ranges from (April - September) five to six months while that of Lower Ogun River Basin is at least seven months. The mean wet season in the North ranges from 510mm to 1015mm, while in the South it ranges from1015mm to 1525mm (Tahal Consultants, 1982).

Three vegetation zones can be distinguished within the basin: the Savannas in the northern part are well marked against the high forest vegetation in the central and eastern part of the basin. Swamp and mangrove forests cover the southern coastal as well as the riverine areas adjacent to the lagoon.

MATERIALS AND METHODS

Source Of Data

Annual maximum discharge series were obtained from Ogun Oshun River Basin Development Authority and reports (Fig. 2). Four stations were found to have a complete

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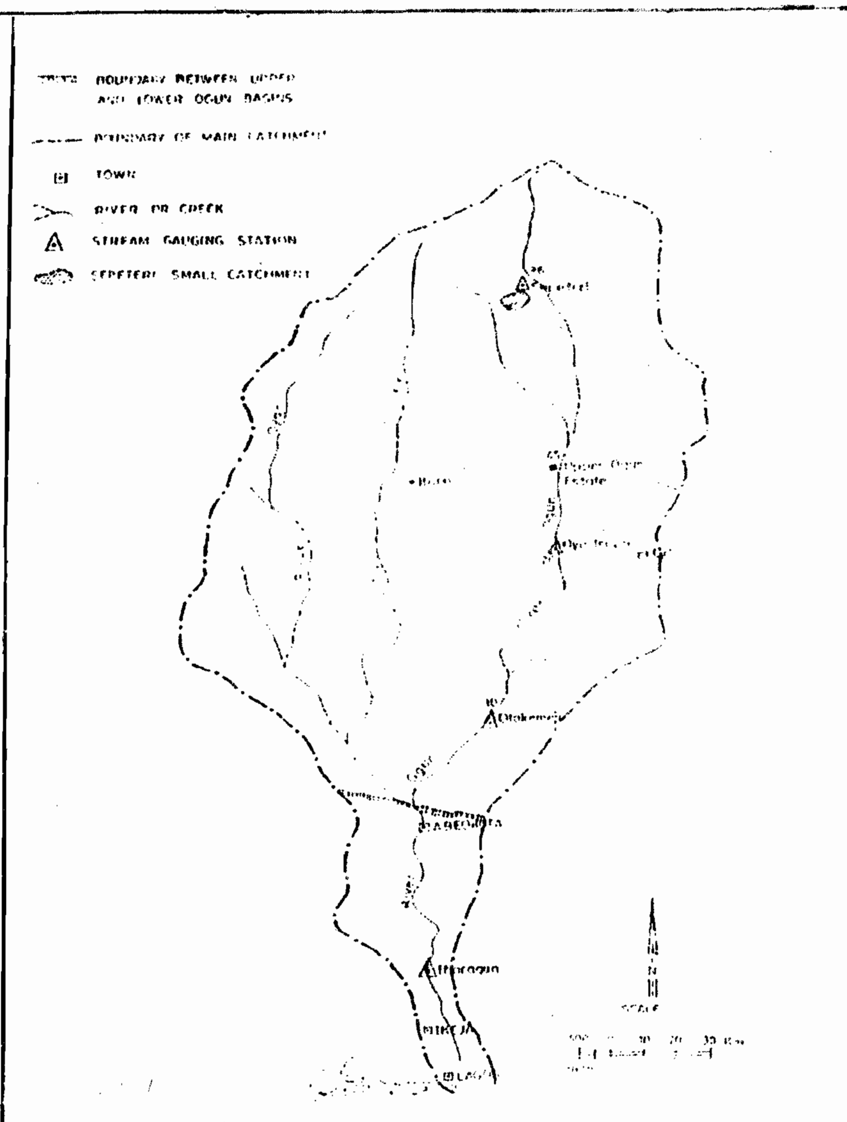

Fig 1: Location of the Ogun River Basin

22 years data and their corresponding catchment areas; the stations are Ibaragun, Olokemeji, Oyo/Iseyin and Shepeteri gauging stations. Ibaragun gauging station is located in Ogun State, almost at the lowest reach of the river, while others are located in Oyo State (Fig. 1). The catchment areas obtained from reports are Ibaragun 21600 km^2, Olokemeji 9140km^2, Oyo/Iseyin 5740 km^2 and Shepeteri 1190 km^2 respectively.

Method of Analysis

Flood Statistics of Ogun Basin : The flood statistics computed from the selected stations and the catchment area for each of the stations are shown in Table 1.

Four commonly used flood frequency distributions were tested; Normal Distribution (Gaussian Distribution), Exponential Distribution, Extreme Value Type 1 Distribution (Gumbel or EV1), 2 Parameter Log Normal Distribution. All these methods are basically reduced to commonly used regression analysis technique (Kite,1985).

Discharge-Area-Frequency (Q-A-T) Analysis

Drainage area has long been used as a parameter in precipitation runoff equations or in simple equations indexing stream flow to area, the quantity of discharge from a drainage basin is a function of the area extent of the basin. The basic empirical equation of the form:

$$Q = cA^m \quad .....1$$

Where **Q** is a measure of flow such as mean annual runoff (m^3/s), **A** is the size of the contributing drainage area (km^2), while **c** and **m**

TABLE 1: FLOOD STATISTICS FOR ALL STATIONS.

PARAMETERS	Ibaragun	Olokemeji	Oyo/Iseyin	Shepeteri
MEAN (M)	828.53	195.15	101.38	43.91
STANDARD DEVIATION (S)	458.16	102.77	48.63	53.28
COEFFICIENT OF VARIATION (CV)	0.55	0.53	0.48	1.21
CATCHMENT AREA (KM^2)	**21660**	9140	5740	**1190**

Source: (Awokola,2001)

TABLE 2. RESULTS OF THE COMPUTATION OF THE MEDIAN FLOOD RATIO (Q_T/Q_M) EV1 DISTRIBUTION.

Return Period T (Years)	Flood Ratio (Q_T/Q_M)
2	0.92
5	1.37
10	1.66
25	2.03
50	2.30

Source: (Awokola, 2001)

are constants that can be determined by regression analysis (Linsley et al, 1975).

Regression analysis of the areas on the discharges were carried out for both mean of the four distributions and the EV1 distribution results. Goodness of fit was checked by calculating the correlation coefficient (r) , Tables 3 and 4.

Prediction of mean annual flood

The derived mean annual flood obtained from the frequency analysis from the mean of the four distributions , the EV1 distributions and the mean annual flood from the Q-A-T analysis were used to obtain the logarithmic equation i.e equation 1.

$$Q_M = cA^m \quad \text{.......................................1}$$

$$\text{Log } Q_M = \text{Log } c + m\text{Log } A$$

Log Q_M = -1.[illegible] + 0.96Log A

$$Q_M = 0.038A^{0.96} \quad \text{.......................................2}$$

RESULTS AND DISCUSSIONS

The coefficient of variation provides a useful measure of hydrological variability; the result in Table 1 indicates that the distribution of floods in these catchments is highly variable. The different levels of variability in the observed flood samples may be attributed to varying hydrological phenomena responsible for generating the flood events over the different catchment areas; e.g. geometric characteristics, geology, soils, vegetation physiography and mean annual rainfall.

Simon and Raj (1997) indicated that the tropical climate and the large catchment areas are the most likely factors which have resulted in obtaining a gentle frequency curve for

Table 3. DISCHARGE-AREA-FREQUENCY (Q-A-T) ANALYSIS FOR MEAN OF THE FOUR DISTRIBUTIONS.

Return Periods T (Years)	Equations (m^3/s)	Correlation Coefficient (r)
2	Q= 0.04A – 82.83	0.98
5	Q= 0.06A - 116.2	0.97
10	Q=0.07A - 137.63	0.97
25	Q=0.08A – 163.45	0.97
50	Q=0.1A – 181.55	0.97
MEAN	**Q_M=0.07A – 136.73**	0.97 (r^2=0.94)

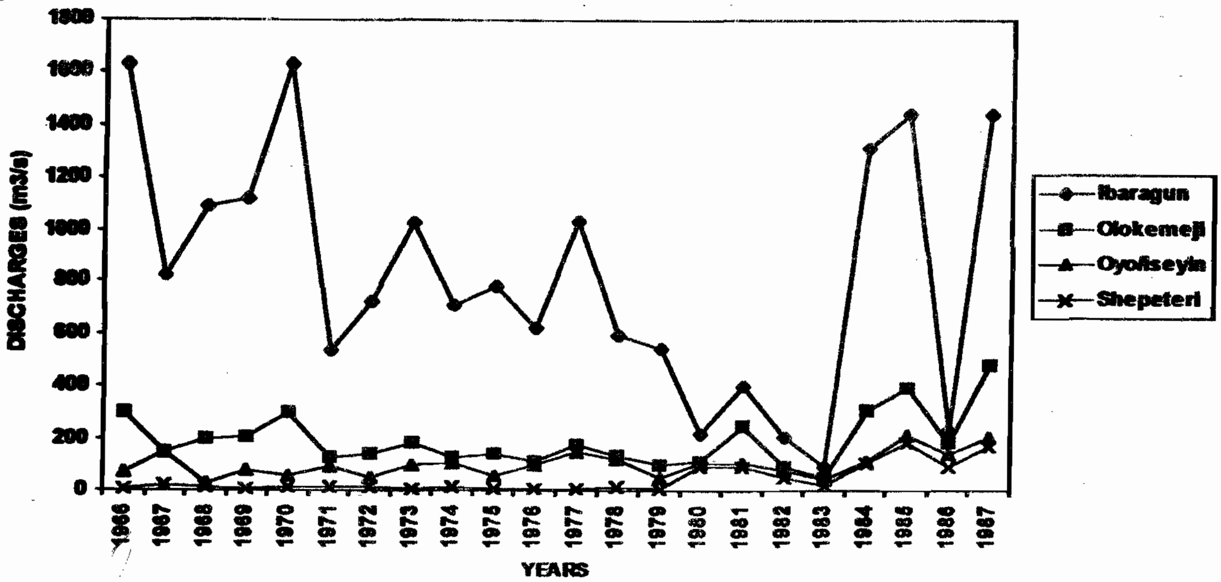

Figure 2. Annual Maximum Flood Of Ogun Basin

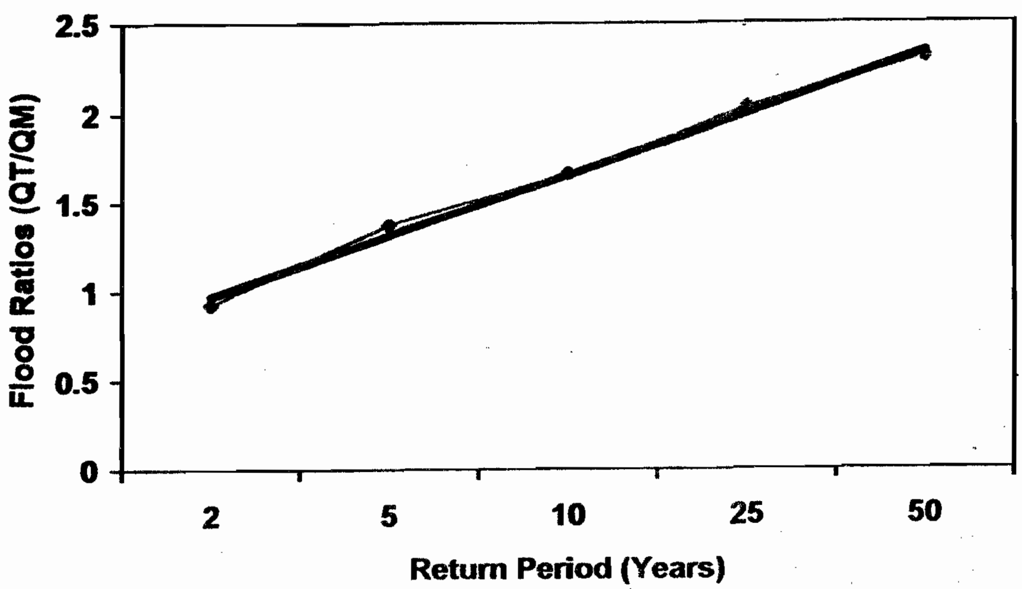

Fig. 3. Regional Flood Frequency Curve For Ogun Basin

Table 4. DISCHARGE-AREA-FREQUENCY (Q-A-T) ANALYSIS FOR EV1 DISTRIBUTION.

Return Periods T (Years)	Equations (m^3/s)	Correlation Coefficient (r)
2	Q= 0.04A – 82.57	0.98
5	Q= 0.06A – 114.97	0.97
10	Q=0.07A – 136.44	0.97
25	Q=0.08A – 163.02	0.97
50	Q=0.1A – 183.03	0.97
MEAN	**Q_M=0.07A – 136**	**0.97 (r^2=0.94)**

Zambia (cv=0.44). The fact may be used to explain the high variability of flood events in the catchment areas in Ogun drainage basin that ranges between 0.48-1.21 and the relatively high variability of rainfall between the Upper Central and lower Ogun basin i.e 510-1015mm to 1015-1525mm.

The flood frequency distribution analysis confirmed that Extreme Value Type 1 Distribution best fits Ogun River out of the four distributions considered. The Regional Flood Frequency Curve developed for Ogun drainage basin Fig.3 using the result of the computation of the median flood ratios (Q_T/Q_M) for EV1 distribution shown in Table.2 (Awokola,2001). The results of linear regression analysis obtained for the discharge **Q** and area **A** for each of the return period considered are shown in Tables 3 and 4. The mean coefficient of determination and correlation coefficient obtained are 0.94 and 0.97 respectively. In cases where two or more independent variables were available to develop a regression model, the selection of the best model could usually be based on the computed value of coefficient of determination (r^2) or correlation coefficient (r).

Simon and Raj (1997) confirmed that development of the relationship between the mean annual flood or index flood and the catchment characteristics was a necessary step in predicting flood magnitude at any point

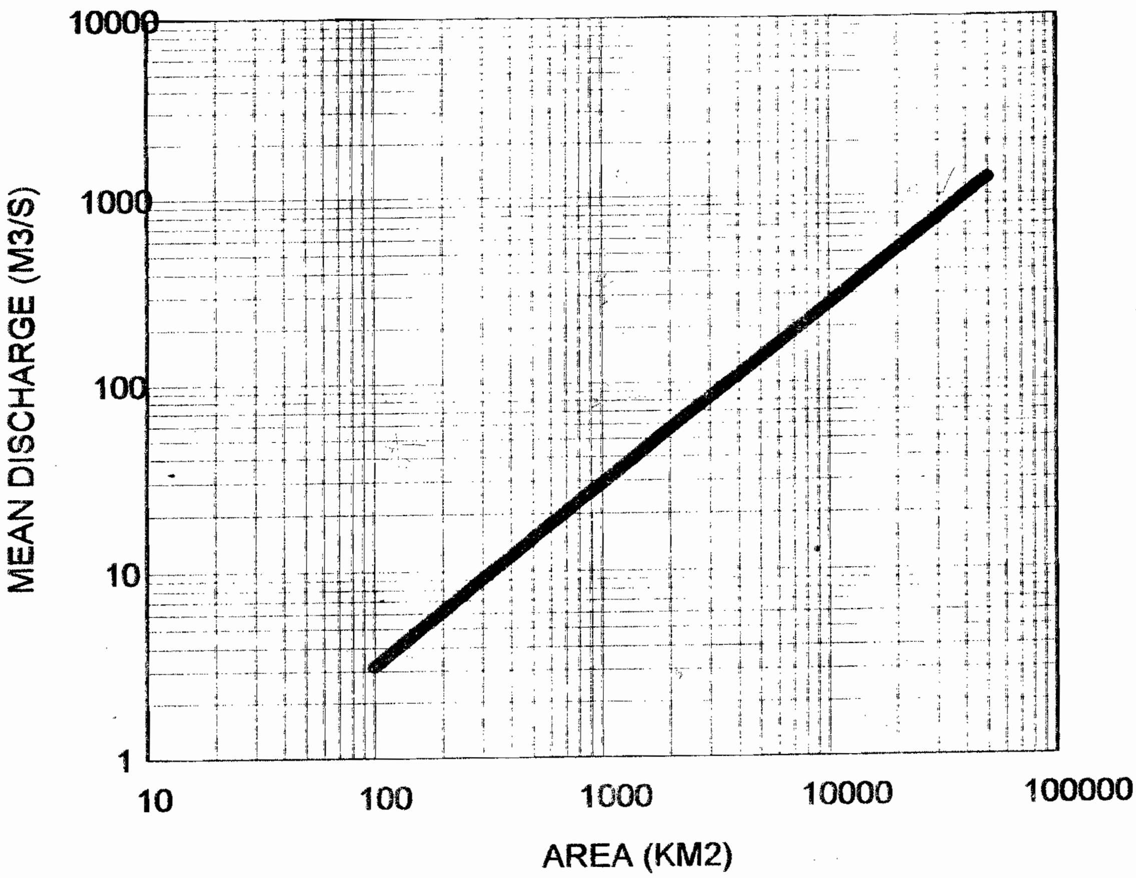

FIGURE 4: MEAN DISCHARGE VERSUS AREA

TABLE 5. REGRESSION MODELS TO PREDICT MEAN ANNUAL FLOODS FROM CATCHMENT CHARACTERISTICS IN SOUTHERN AFRICA AND OGUN DRAINAGE BASIN SOUTHWEST NIGERIA.

Location	Regression equations	Coefficient of Determination (r^2)	Correlation Coefficient (r)
***Angola**	$Q_M=0.156A^{0.768}$	0.749	0.865
***Swaziland**	$Q_M=5.779A^{0.468}$	0.608	0.78
***Zambia**	$Q_M=0.339A^{0.687}$	O.78	0.883
***Zimbabwe**	$Q_M=1.58A^{0.630}$	0.732	0.856
Ogun drainage basin	$\mathbf{Q_M=0.038A^{0.96}}$	**0.94**	**0.97**

*Source: Simon and Raj (1997)

in a region where the frequency curve has been derived. The correlation coefficient and coefficient of determination of the logarithmic regression model derived for Ogun basin (equation 2) to predict mean annual flood from catchment characteristic are 94% and 88% respectively. The regression model derived for the study area gave reasonable good fitting. The graph of the discharge against the area obtained for the derived equation is shown in Figure 4.

CONCLUSION

It can be concluded that the derived equation 2, $Q_M = 0.038A^{0.96}$ and the graph in Figure 4 can be used to predict the mean annual flood (MAF) for ungauged catchments in Ogun drainage basin. The value obtained can be used in conjunction with Regional Flood Frequency Curve derived for the drainage basin (Table 2 or Figure 3) to obtain the discharge for specified return period. The regression models to predict mean annual floods from catchment characteristics in Southern Africa and Ogun basin compared very well as shown in Table 5. The value of the coefficient of determination obtained for Ogun Basin (94%) which expresses the proportion of the variance of MAF which is explained by the regression. The results of the regression analysis also show that the value of the exponent of AREA for most of the derived regressions in Southern Africa range between 0.4 – 0.8 while that derived for Ogun Basin is 0.96. This range of values seem to agree on average with typical values obtained in many other regions of the world.

REFERENCES

Awokola, O.S. , 2001. Regional Flood Frequency Analysis For Ogun Drainage Basin South Western Nigeria. The Nigerian Journal of Environmental Resources Management, 1: 2001.

Beard, R. L., 1962. Statistical methods in Hydrology". (Revised Edition) Civil work Investigations Project cw - 151, U.S. Army Corps of Engineers, Scaraments, Carlifornia.

Benson, M. A., 1968. Uniform flood frequency estimating methods for federal agencies. Wat.Resour Res., 4(5): 891-908.

Chow, V.T., 1964. Hand book of Applied Hydrology. Mc Graw - Hill, New York.

Cunnane, C., 1989. Statistical distribution for flood frequency analysis".WMO Operational Hydrology Report, No.33, 72pp.

Dalrymple, T., 1960. Flood Frequency Analyses. United States Geological Survey. Wata Supply Paper 1543A 80pp.

Kite. G.W., 1985. Frequency and Risk Analysis in Hydrology. Water Reseources Publications Book Crafts Chelsea, Michigan U.S.A.

Linsley, R.K. Kohler, M.A. and Paulhus, J. L. H., 1975. Hydrology for Engineer, 2nd edn. Mc Graw. Hill, New York.

Natural Environment Research Council, 1975. Flood Studies Report, Hydrological Studies. Volume I, London.

Ngana, J.O., 1978. Estimation of Flood Peaks with limited Hydrological Data. BRALUP University of Dar Es salaam, Research Report No. 33.

Simon Mkhandi and Raj Kachroo, 1997. Regional flood frequency analysis for Southern Africa. Intrernational Hydrological Programme IHP-V, Technical Documents in Hydrology No15 UNESCO, Paris, 1997 pp130-150

Tahal, Consultants, 1980. Ogun River Basin Feasibility Study. Vol, 2, Report submitted to Ogun-Oshun River Basin Development Authority.

Tahal Consultants, 1982. Ogun River Basin Feasibility Study. Vol. 7, Report submitted to Ogun-Oshun River Basin Development Authority.

U.S. Water Resources Council, 1967. A uniform technique for determining flood flow frequencies. Bulletin 15, Hydrology Committee, Water Resource Council Washington.

Watkins. L.H. and Fiddes. D., 1984. Highway and Urban Hydrology in the Tropics. Pentch Press Limited Estover Road Plymouth, Devon.