COMPARISON OF FLOOD PREDICTION MODELS FOR RIVER LOKOJA, NIGERIA

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ABSTRACT

Flood estimation is one of the major aspects of hydrologic design and is the first in planning for flood regulation and protection measures. This research work was aimed at comparing prediction models for forecasting flood occurrences in River Lokoja, located in Kogi State of Nigeria. Relevant climatic data such as rainfalls, flood discharges, river stages of 24 years duration (1980 – 2003) were collected from Lower Niger River Basin Authority based in Lokoja. Variations in rainfall distribution were analyzed and five plotting positions: California, Cunnane, Grigorton, Hazen and Weibull were used to compute the return periods for the observed flood discharges.

Flood magnitudes and the corresponding return periods were plotted by fitting the used plotting positions into the Log-Pearson Type III distribution. The derived prediction equations (models) from the plots of discharge against return periods were used to forecast flood magnitudes for 5, 10, 15, 20, 25, 50, 100, 200 and 500 years return periods.

Result showed that highest rainfall occurred between months August and September. Standard deviation, skew and variance of rainfall were 83.28, 0.287 and 6935.13 respectively. The rating curve for River Lokoja showed that an exponential relationship exists between the river stage and the associated discharge with reasonably high coefficient of correlation (0.90). Plot of river discharge against the return period showed that the maximum flood discharge (23964.56m^3/s) had a 25 years return period using the weibull's distribution. Derived prediction equations (models) gave flood magnitudes 26065.59, 25660.72 m^3/s for a return period of 50 years using the weibull, Grigorton and California plotting positions respectively.

This research result is very useful to correctly predict the magnitudes of flood occurrences and their return periods from records of storm events in Lokoja metropolitan city.

Keywords: Flood, Rainfall, Rating Curve, Return period, Discharge.

1. Introduction

Flood estimation is one of the major aspect of hydrologic design and is the first step in planning for flood regulation and protective measures (Ayoade,1988).

Istigal (1997) reported that rainfall and river flow monitoring for agricultural and other purposes as well as related early warning approaches play a role in warning farmers as well as inhabitants of urban areas for flood. Although there is much potential support for giving priority to their implementation, even when followed by advice on the use of the information. They have obvious limits in mitigating the consequences of such disasters without improved risk assessments (Stigter et al., 2000). The objectives of this study were to predict storms and associated flood occurrences using hydrological data and to develop a model for River Lokoja in Nigeria from the use of river stages and associated rating curves.

2. Material and methods

A 24 year (1980 -2003) hydrologic record of Lokoja was obtained from the Lower Niger River Basin Authority, Lokoja, Nigeria to generate an annual hydrograph for the study area. Also plotted was the curve of gauge heights against the flows (stage /discharge rating curve). The peak flows of years under study were selected and arranged in descending order of magnitude to form an annual maximum series and the probabilities that ranked annual maximum will be equaled or exceeded in any year were determined by the following plotting positions Hazen's, Weibull's, Cunnane's, California and Grigorton's (Wilson, 1990). The Log-Pearson Type III distribution was fitted into the data series to compute the variance and skewness.

The risk of flood (R) is expressed using:

$$R = 1-\left(1-\frac{1}{T_r}\right)^n \qquad 1$$

where Tr is the return period.
The equation was used to evaluate the risk of flood occurrence in Lokoja River.

3. Result and Discussions

The rating curves for stage – discharge relationship for years 1981 is shown in Figure 1. Generally, river stage increased with increasing discharge for the twenty three (24) years of data observation. The above agrees significantly with the observations of Hodge and Tasker (1995).

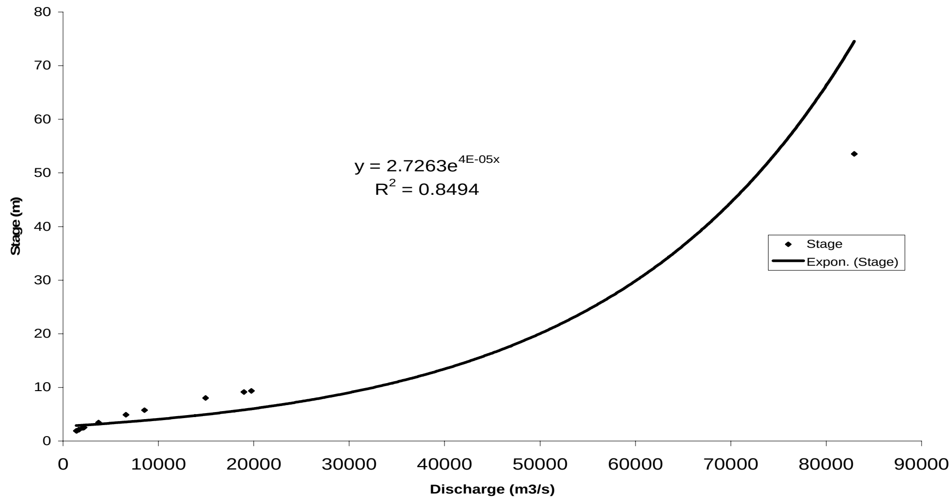

FIG :Rating Curve (1981)

The flood magnitude for each of the return periods of interest using the various plotting positions is presented in Figures 2,3,4,5 and 6. A discharge 23964.56m^3/s was estimated to have a return period of 25 years using the Weibull plotting position. Also, discharges 23152.94 and 22868.32m^3/s have 8 and 5 years return periods respectively.

Hazen's plotting position showed that the highest flood magnitude (24306.78m^3/s) has a return period of 48 years. Flood magnitudes 23279.61 and 22693.33m^3/s have return periods 10 and 5 years respectively. However, the estimated return periods in the California and Weibull's plotting positions are closely correlated (0.97). The return period for highest flood is 43 years in the Grigorton's plotting position and the coefficient of correlation between the annual discharge and the return period is 0.937. Flood predictions using the equations of the line of best fit (prediction models) are shown in Table 1.

Table 1. Flood estimates from 5 -500years using the prediction models

Return Period	Weibull	Grigorton	Hazen	Cunnare	California
5	22307.10	22177.59	22155.06	22191.96	22309.26
10	23438.51	23226.12	23187.85	23250.13	23495.03
15	24100.35	23839.46	23791.99	23869.11	24188.66
20	24569.93	24274.64	24220.64	24308.28	24680.79
25	24934.17	24612.19	24553.12	24648.93	25062.53
50	26065.59	25660.72	25585.91	25707.09	26248.29
100	27396.39	26709.34	26616.70	26765.25	27434.06
200	28575.43	27757.76	27651.49	27823.41	28619.83
500	30134.05	29143.84	29016.77	29222.22	30187.33

The table above shows that flood magnitude increases with increase in return periods. Highest flood magnitude (26248.29m^3/s) has a 50 years returns period in the California plotting position. Statistical analysis of the flood discharges for the return periods showed variances 5511.57, 18959.48, 30745, 40856.92 and 82761.44m^3/s for the Weibull's, Grigorton's, Hazen's, Cunnane's and California distributions respectively.

The probabilities of occurrence of floods at 100, 200 and 500 years return periods are 0.21, 0.11 and 0.05 respectively. This goes to show that floods of high magnitudes may not frequently take place in the study area but could be very risky when it occurs.

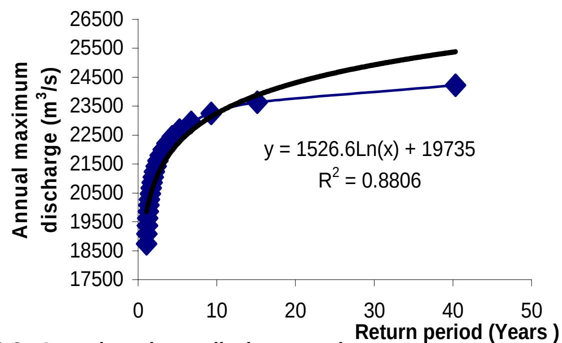

FIG 2. Annual maximum discharge against return period (Cunnane)

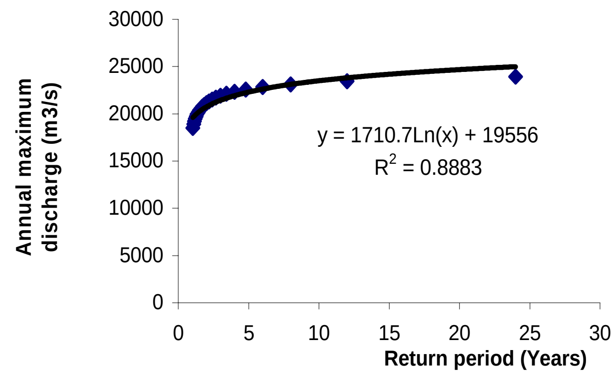

FIG 3. Annual maximum discharge against return period (California)

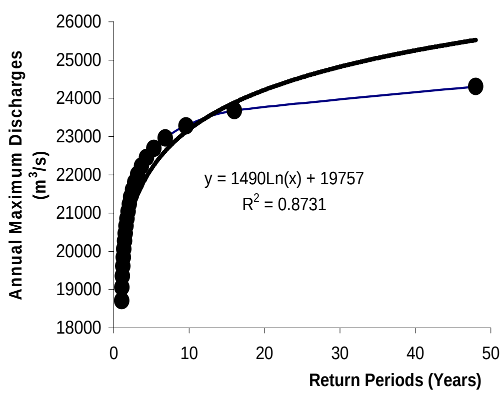

FIG 3. Annual maximum discharge against return period (Hazen)

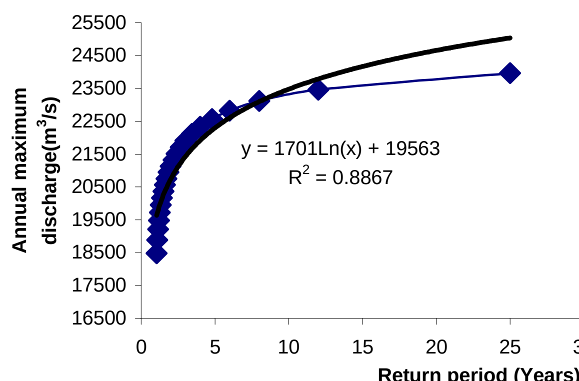

FIG 8. Annual maximum discharge against return period (Weibull)

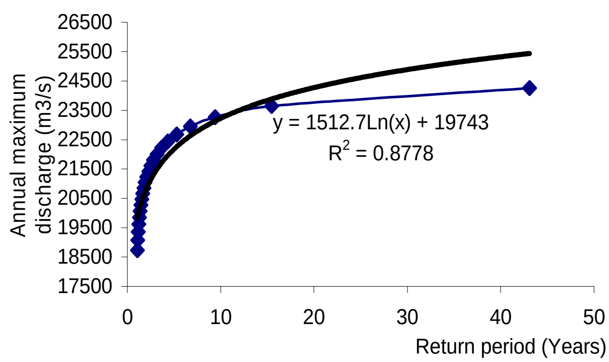

FIG 9. Annual maximum discharge against return period (Grigorton)

3 CONCLUSION

Flood magnitudes were found to increase with an increase in return periods from 5 – 500 years in the Weibull's, Grigorton's, Cunnane's, Hazen's and California plotting positions. The California method gave the highest correlation coefficient (0.94) between the plotted data and the prediction model. Thus, the method enhanced a reliable prediction of flood frequencies and their magnitudes.

REFERENCES

Ayoade J.O., (1998): Tropical Hydrology and Water Resources. Macmillan Publishers Ltd. London. pp 189 – 239.

Hodge, S.A., and Tasker, G.D., (1995): Magnitude and Frequency of Floods in Arkansas: U.S. Geological Survey Water-Resources Investigations Report 95 – 4224, 52p.

Istigal a., (1997): Land and Agrometeorological Information for Agricultural Development. In: M.V.K. Sivakumar, U.S. De, K.C. Sinharay, M. Rajeevan (Eds). User Requirement for Agrometeorological Services. Proceedings of an International Workshops, Rune, India. Pp 241 – 257.

Kite, G.M., (1977): Frequency and Risk Analysis in Hydrology, Water-Resources Publications, Fort Colins, N.Y.

Stigter, C.J., Sivakumar, M.V.K., Rijks, D.A., (2000): Agrometeorology in the 21st Century: Workshop Summary and Recommendation on Needs and Perspectives. In M.K.V. Sivakumar, C.I. Stigter and D. Rijks (Eds), Agrometeorology in the 21st Century: Needs and Perspectives. Agricultural and Forest Meteorology 103: 209 – 227.

Wilson, E.M., (1990): Engineering Hydrology 4th Edition Macmillan Publishers Ltd, London pp 225 – 250.