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Application of L-moments in Flood Frequency Analysis

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Abstract: In this study we analysed that how much L-moments application is valuable in flood frequency analysis. These give the simple and proper estimation of distribution parameters and characteristics of the data which are used in hydrologic application. Generally, engineers or a hydrologists and researchers face problem for calculating the reliable floods where there is no record available of river flow as well as rainfall for both small to medium size catchments. L-moments are useful to find out the statistical properties of hydrological data for particular region.
Keywords: Probability Weighted Moments (PWMS), L-moments, Mathematical Expression of L-moments L- moments Ratio, Application of L-moments,

I. INTRODUCTION

Floods cause a number of severe causes as economic loss, loss of human life etc. Hence for controlling this problem it is necessary to estimates the flood, design and economic appraisal of a variety of engineering works, including hydraulic structures, economic evaluation of flood protection projects etc. Deterministic approach and Statistical approach are the two methods used for flood estimation. Uncertainties involved is more in case of Deterministic approach and less in statistical approach for the analysis of data, hence statistical approaches generally used. Frequency analysis is the method of estimation which specified us how an event will occur. For a many year in hydrology regional frequency analysis method is established, flood procedure by Dalrymple (1960) is an example of this. Chaudhary *et al* (1991) suggested using General extreme distribution (GEV) of index-based approach for estimation of food frequency model. In India flood frequency analysis using probability weighted moments (PWM) has been carried out (1992, NIH, Kumar *et al.*) for which GEV method found out to be the best. According to Karim and Chaudhary (1995) the three-parameter distribution i.e. GEV method is the best method for flood frequency analysis in case of Bangladesh (India) flood using both the analysis L-moment ratio diagram and best-of –fit analysis.
L- Moments were found out first time by the Hosking (1990), defined L-moments as are the linear combination of Probability Weighted Moments. These give the simple and proper estimation of distribution parameters and characteristics of the data which are used in hydrologic application. The significance of L-moments in flood analysis:

A. The diagram of L-moments is helpful for analysing the high skewed data used for a particular study area (Vogel et al., 1993).
B. Because L-moments are linear combination of probability weighted moments its estimated parameters shown less sensitiveness for a lengthy study data for a particular large area.
C. The L-moment ratio diagram can be proved as the best fit tool for identifying the robust distribution for a selected study area.

II. RESEARCH METHODLOGY

A. Probability Weighted Moments (PWMs) and L-Moments

1) L-moments: Recently in many hydrologic applications L-moments provides simple and reasonable estimation for analysing characteristic and distribution parameters for a hydrologic data. L-moments of a random variable were first introduced by Hosking (1990). According the Hosking definition of L-moments is the linear combination of order of statics also an alternative technique which information about shapes of probability distributions. L-moments are mostly superior for to those that have been used previously, and are nowadays being used by many research organizations worldwide (Hosking and Wallis, 1997). L-moments provided significant application in analyzing flood as:

a) Application of L-moment for flood frequency analysis, it is recommended that a flood frequency relationship can be derived for a selected regional area.
b) It can be adopted for developing a regional flood formula for estimation of floods of desired return periods for provided catchments.
c) Best tool for measuring the density of gauging network for a river basin which provides the possibility of planning and development water resources for a country.
d) Flood hazard map can be prepared relating flood magnitude with flood levels for different return periods.

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2) *Probability Weighted Moments (PWMs):* According to Hosking and Wallis (1997), the L-moments are an alternative tool for describing the shapes of probability distribution. Historically they arose as the modified form of the probability weighted moments (PWMs) of greenwood et al (1979).

III. MATHMATICAL EXPRESSION AND SYMBOLS

A. *Expression for Probability Weighted Moments (PWMs)*

Greenwood *et al.* (1979) gives the definition of Probability weighted moments as:

$$M_{i,j,k} = \int_0^1 x(F)^i \ (F)^j \ (1-F)^k \ dF \qquad (1)$$

Where, F = F (x) = $\int_{-x}^{x} f(x)\,dx$ is the cumulative density function and x (F) is the inverse of it; i, j, k are the real numbers. Design value of flood frequency x(F) calculated by the probability F or (F-1), which is called as the weighted probability moments.

B. *Expression for L-moments*

In general, in terms of α_k and β_k, L-moments (Hosking, 1990) are defined as:

$$\lambda_{r+1} = (-1)^r \sum_{k=0}^{r} p^*_{r,k} \ \alpha_k \ = \ \sum_{k=0}^{r} p^*_{r,k} \ \beta_k \qquad (2)$$

Where, $p^r_{r,k}$ is an orthogonal polynomial (shifted Legendre polynomial) expressed as:

$$p^*_{r,k} = (-1)^{r-k} \ {}^rC_k \ {}^{r+k}C_k = \frac{(-1)^{r-k}(r+k)!}{(k!)^2 (r-k)!} \qquad (3)$$

L-moments are easily calculated using Probability weighted moments.

IV. RESULT AND DISCUSSION

As a result, we can say that L-moments summarized characteristics or we can say that shapes of theoretical probability distribution studied for a particular regional area and other observed sample data. Both moments types offered measured of distributional location (mean) skewness (shape), scale (variance) and kurtosis (peakdness). L-moments are easily calculated using Probability weighted moments. Expressions for L-moments are given as in above mathematical expression paragraph. This method depend upon the probability weighted moments and L-moments alike L-moments is more convenient as these are measure directly the value of shape and scale of probability distributions.

Clearly λ_1, the mean, is a measure of location, λ_2 is a measure of scale or dispersion of random variable. It is often convenient to standardise the higher moments so that they are independent of units of measurement.

$$\tau_r = \frac{\lambda_r}{\lambda_2} \quad \text{for} \quad r = 3, 4 \qquad (4)$$

Analogous to conventional moment ratios (Hosking, 1990), such as coefficient of skewness τ_3 is the L-skewness defines shape or symmetry of the sample. Similarly, τ_4 is a measure of peakdness and defined as L-kurtosis, and expressed as:

L-coefficient of variation (L-CV), (τ) = λ_2 / λ_1 (5)

L-coefficient of Skewness, (τ_3) = λ_3 / λ_2 (6)

L-coefficient of kurtosis, L-kurtosis (τ_4) = $\lambda_4 / \lambda 2$ (7)

Symmetric distributions have τ_3 = 0 and its values lie between -1 and +1. Although theory and applications of L-moments considered as alike that of conventional moments, L-moment has several important advantages.

As estimations of samples values of L-moments always are linear combination of observable values and less bias than the ordinary product moments. This is because ordinary product moments require a square or a cubic calculation for provided observations. Because of this it is considered as greater in weight and the observations far from the mean, resulting in substantial bias and variance.

V. CONCLUSION

On the basis L-moments application in the field of flood frequency analysis it has to be concluded that:

A. It may be used for estimation of floods of desired return periods for gauged catchments of the study area as well as for ungauged catchments may be used.

B. Applying various distribution viz. Logistic (LOG), kappa (KAP), generalized logistic (GLO), generalized normal (GNO), logistic (LOS), extreme value (EVI), Pearson type III PE (3), general extreme value (GEV), exponential (EXP), and wakeby (WAK) and finding out its regional parameters using L-moments and getting help of L-moments diagram, proved as best tool for find out the robust distribution for a selected regional area.

C. Regional flood frequency relationship using L-moments can be refined for obtaining more accurate flood frequency relationship when the data for some more gauging sites become available and physiographic characteristics are also used for developed flood frequency relationship.

D. L-moments are good application tool for analysing the flood for any selected region or need to be studied by including more stations with large number of data lengths.

E. L-moments helped to performed screening of the available data, testing of regional homogeneity, and identification of the regional distribution and development of regional flood frequency relationships.

F. The best fit distribution is determined by matching the regional L-kurtosis and L-skewness with L-skewness and L-kurtosis of the fitted distribution and how well it is.

G. For testing regional homogeneity of a particular study area, a homogeneity measures have to be carried out and it compares the inner site variations in sample L-moments for the group of sites with what would be expected of a homogeneous region.

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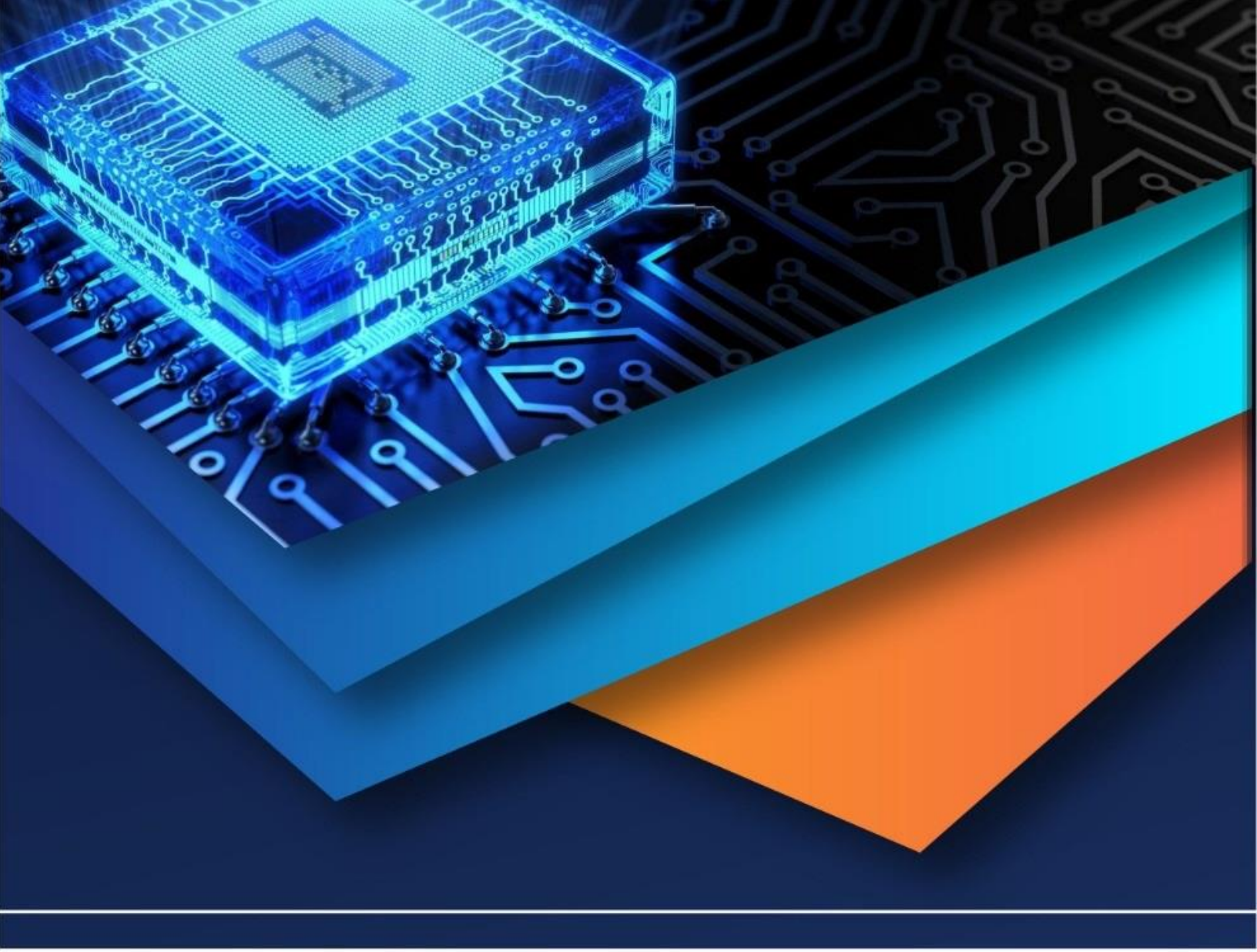

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