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EFFECTS OF ERRORS IN ANNUAL MAXIMUM PEAK FLOODS ON FLOOD FREQUENCY ESTIMATES

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NATIONAL INSTITUTE OF HYDROLOGY
JAL VIGYAN BHAWAN
ROORKEE - 247 667 U.P.
INDIA
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PREFACE

Estimation of design flood is one of the important components of planning and design of any water resources project. Flood estimates are required for design of a variety of engineering works. Use of flood frequency analysis is very common for estimation of design floods of different return periods. Observed flood peak records should be adequate, accurate and reliable for the flood frequency analysis in order to estimate the design floods for the hydraulic structures, culverts and bridges etc. However, due to various reasons there is always likelihood of presence of different types of errors including measurement errors in historical records.

The effects of errors in observation of data are highly pronounced in the design flood estimation by frequency analysis, since the peak flood values which are more prone to measurement errors, are used. There is also a possibility of peak flood having passed before or after the actual measurement, as the measurements are taken only at specific time intervals. In such cases, the estimates of the peak discharges are obtained from the rating curve corresponding to the observed values of peak stages. Thus the peak discharges are also subjected to the errors either due to the errors involved in developing rating curve or extrapolating the rating curve for the exceptionally high stage values.

In this study, the effects of errors in annual maximum peak floods on flood frequency estimates have been analyzed by Monte Carlo experiments using at-site and regional flood frequency approach. This study has been carried out by Shri R D Singh and Shri Rakesh Kumar, Scientists of the Institute. It is expected that the study will be able to provide insight for estimating the floods of desired return periods for the gauged catchments in the region, whose coefficients of variation of annual maximum peak floods are significantly different from the regional value of the coefficient of variation.

(S.M. SETH)

DIRECTOR

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ABSTRACT

In this study, the effects of errors in annual maximum peak floods on flood frequency estimates have been examined. The ratio of annual maximum peak floods to the mean annual maximum peak flood($Q_i/\bar{Q}$) have been computed for the respective 22 bridge sites of Mahanadi basin sub-zone 3(d). The $Q_i/\bar{Q}$ values of the different sites have been considered together as a single sample for the region. The sample statistics viz. mean, standard deviation and skewness have been computed. The computed mean and standard deviation of the $Q_i/\bar{Q}$ series have been utilised to generate the samples of size 30 for each of the 22 sites, using Extreme Value Type I(EV1) distribution.

Regional flood frequency analysis has been carried out with the samples of the EV1 generated data using (i) USGS method, (ii) EV1(PWM) method, (iii) GEV(PWM) method and (iv) Wakeby (PWM) method. The values of growth factors ($Q_T/\bar{Q}$) have been obtained for various return periods using the above mentioned 4 different methods. The analysis has been repeated 1000 times with the generated data and the expected values of growth factors have been obtained. Similar analysis has been carried out with the generated data of Pearson Type III population considering the mean, standard deviation and skewness of the historical ($Q_i/\bar{Q}$) values for the region.

Error analysis has been performed based on the expected values of flood estimates obtained from the analysis of the generated data for the different sets of statistical parameter values using EV1 and PT3 distributions following the above procedure. From the study, it is observed that there can be significant errors in the flood estimates due to errors in the annual maximum peak flood data. All the methods viz. USGS method(M1), PWM based EV1 method(M2), PWM based GEV method(M3) and PWM based Wakeby method(M4) over estimate the growth factors for larger values of coefficients of variation than that of the historical value of coefficient of variation; whereas all the methods under estimate the growth factors for the lower values of coefficient of variation than that corresponding to the historical value of coefficient of variation. The percentage errors in growth factors are very much sensitive to the coefficient of variation for a specific value of coefficient of skewness and these are not much sensitive to the coefficient of skewness for a specific value

of coefficient of variation. The percentage errors in growth factors are relatively low for the USGS method (M1) and PWM based EV1 method (M2) when the generated populations of EV1 distribution are fitted with these methods. PWM based GEV distribution in general results in less percentage errors in the growth factors as compared to the other three methods.

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1.0 INTRODUCTION

The magnitudes of floods along with their frequencies are often required for planning and design of various water resources structures. Flood Frequency analysis procedures provide such information from the available limited historical flood records. Use of flood frequency analysis is very common for estimation of design floods of different return periods. Flood frequency analysis deals with univariate process comprising of maximum peak flow values. The peak flood data used for frequency analysis are required to satisfy the following assumptions in order to have the accurate estimates of floods: (a) the characteristics of the sample are true representative of the characteristics of the population, (b) the statistical characteristics derived from the sample are time invariant, (c) the data are random, (d) the data are homogeneous, and (e) the data are accurate and reliable.

In carrying out at-site flood frequency analysis the chosen frequency distributions are fitted to the historical flood records and the parameters of the distributions are estimated using one or more parameter estimation techniques. Then the best fit distribution along with the best method of parameter estimation are selected based on some goodness of fit criteria and the floods of desired return periods are computed using the estimated parameters of the best fit distribution. Whereas, in carrying out at-site and regional flood frequency analysis the parameters of the chosen frequency distribution for a region are estimated considering the annual maximum peak flood data of the various sites of whole of the hydrometeorologically homogeneous region. Then the regional flood frequency parameters calibrated from the historical records are used together with the mean annual maximum peak flood value for the respective site for estimation of flood of a desired return period.

Errors in the annual maximum peak flood data series lead to erroneous assessment of water resources. It may result in very high or low estimates of discharges. If water resource is under-assessed, then some of the scarce water resources remain unutilised and go as waste. On the other hand, if water resources are over-assessed, then planned utilisation falls short of requirement in actual practice. In case of design flood estimation, we rely on peak values and any measurement errors associated with these values lead to wrong estimation of design flood during extrapolation. It further results in over-design or under-design of the water resources structures. If any structure is over-designed, then it leads to extra cost of construction of the structure. Whereas under-design of the structure increases its risk of failure.

In this study, the effects of errors in annual maximum peak floods on flood frequency estimates have been examined. The ratio of annual maximum peak floods to the mean annual maximum peak flood($Q_i/\bar{Q}$) have been computed for the respective 22 bridge sites of Mahanadi basin sub-zone 3(d). The $Q_i/\bar{Q}$ values of the different sites have been considered together as a single sample for the region. The sample statistics viz. mean, standard deviation and skewness have been computed. The computed mean and standard deviation of the $Q_i/\bar{Q}$ series have been utilised to generate the samples of size 30 for each of the 22 sites, using Extreme value type I(EV1) distribution.

Regional flood frequency analysis has been carried out with the samples of the EV1 generated data using (i) USGS method, (ii) EV1(PWM) method, (iii) GEV(PWM) method and (iv) Wakeby (PWM) method. The values of growth factors ($Q_T/\bar{Q}$) have been obtained for various return periods using the above mentioned 4 different methods. The analysis has been repeated 1000 times with the generated data and the expected values of growth factors have been obtained. Similar analysis has been carried out with the generated data of Pearson Type III population considering the mean, standard deviation and skewness of the historical ($Q_i/\bar{Q}$) values for the region.

Error analysis has been performed based on the expected values of flood estimates obtained from the analysis of the generated data for the different sets of statistical parameter values using EV1 and PT3 distributions following the above procedure. From the study, it is observed that there can be significant errors in the flood estimates due to errors in the annual maximum peak flood data. The percentage errors in growth factors are very much sensitive to the coefficient of variation for a specific value of coefficient of skewness and these are not much sensitive to the coefficient of skewness for a specific value of coefficient of variation. The percentage errors in growth factors are relatively low for the USGS method (M1) and PWM based EV1 method (M2) when the generated populations of EV1 distribution are fitted with these methods. PWM based GEV distribution in general results in less percentage errors in the growth factors as compared to the other three methods.

2.0 REVIEW

Laurenson and O'Donnell (1969) state that real hydrologic data contain errors introduced during measurement, recording and processing. It is impossible usually to determine the true values contained within real data. The International Organisation for Standardization (ISO,1969 a & b) states, "No measurement of a physical quantity can be free from uncertainties which may be associated with either systematic bias caused by errors in the standardizing equipment or a random scatter caused by a lack of sensitivity of the measuring equipment. The details of measurement errors which usually occur in river flow measurement are discussed below.

2.1 Errors in Discharge Measurement

The error can be defined as the difference between the measured value and the true value. The true value means the water level/discharge as it occurs at the gauging site.

Measurement errors are usually classified as systematic and random errors.

2.1.1 Systematic errors

Systematic errors are those which can not be reduced by increasing the number of observations, if the instruments and equipment remain unchanged. Systematic errors are essentially due to malfunctioning or incorrect use of instruments or lack of knowledge of observer. In stream flow, systematic errors may be present in water level recorder, in the reference gauge or datum and in the current meter. These errors may be generally small but in some cases, they are quite considerable.

2.1.2 Random errors

Random errors are sometimes referred to as experimental errors and the observations deviate from the mean in accordance with the laws of chance.

2.2 Sources of errors in discharge observation

The errors in discharge observations are of both types namely systematic errors and random errors. Some of the common causes of errors in discharge measurements are as follows.

a) Instrumentation errors

i) Errors in current meter ratings due to over use or errors in current meter observations due to poor maintenance; and

ii) Errors due to mechanical problems with several instruments such as current meter, stop watch, revolution counter etc.

b) Observational errors

i) Errors due to deviations in zero of the gauge, either by mistake in recording or due to disturbance of gauges at site;
ii) Use of current meter for measurement of flow above or below its established ratings;
iii) Errors introduced when the meter is not steady in the current at exact observation point; and
iv) Errors in estimation of discharge when the flow lines are oblique to the lines of cross section.

c) Errors in data recording and processing

i) Misreading and transposing digits;
ii) Misreading because of faulty memory;
iii) Recording data at a wrong place on the recording sheet;
iv) Misplacing the decimal point;
v) Making reading at improper interval;
vi) Incorrect dating of the report; and
vii) Incorrectly reading or communicating the data to a reporting centre.

In addition, there are some specific causes which result in errors in discharge measurement during high and low floods. Some of these are discussed here under.

2.3 Specific Errors Associated with High Flow Measurement

a) During high floods, current meters are rarely used either due to high velocity or due to non-availability of suitable navigational facilities. As a result, the float method or the slope area method is used. These methods are definitely not very reliable. Particularly, the floating debris during flood may affect the correct estimation of flow velocity etc.;

b) The stage measurement sites are away from banks and stage observation is to be made from a distance. This results in introduction of errors, mainly due to considerable wave formation during high flood.

c) Because of overtopping of river banks at the upstream of the discharge measurement site, there is possibility of under estimation of the discharge at the site, and

d) In many cases, due to difficult approaches during flood season, it is the tendency of the observers to skip a few observations, particularly during night hours. This may lead to improper records in respect of peak flood events.

In fact, the standard techniques of discharge observations are adopted only at a few selected sites where all the necessary equipment and navigational facilities are available. For many of the Indian rivers, the normal discharge measurement is rarely adopted during high floods due to lack of suitable equipment and navigational facilities. Generally, either the float method is used for estimation of velocity or slope area method is adopted for discharge estimation under such conditions. These methods are bound to introduce a certain degree of errors in estimated values of discharge. These aspects are rarely given any consideration while using the data for flood frequency analysis. But it remains a fact that the analysis based on such data has definite effect on estimation of design flood.

2.4 Specific Errors Associated With Low flow Measurement

Some of the specific errors associated with low flow measurement are listed below.

(a) During low flow the depth of flow to be measured is quite shallow. This may result in erroneous measurement of the velocity of flow;

(b) In a number of rivers, there is formation of more than one channels, which may lead to erroneous measurement of the flow;

(c) In many rivers ,there are fair weather bridges near to the discharge measurement site. This also affects accuracy of the observed discharge; and

(d) Many a time, the observers do not take proper care in measurement of velocity while adopting wading technique for measurement of the flow.

2.5 Need for Accuracy in Observed Streamflow Data

Need for accuracy in observed streamflow data as well as effects of errors of flow data on planning and design of water resources development schemes are discussed in detail in the Technical Report(NIH, 1990-91). Observed river flow records are required to be accurate, reliable and continuous for the design of hydraulic structures such as dams, bridges, culvetrs, embankments and for the operation of flood warning systems. The records of low flows are also needed for evaluation of drought conditions, control of abstractions and design of water conservation measures etc. Accuracy of flow measurement means the degree of agreement between the apparent flow as measured and the actual flow.

The annual maximum peak flood data used in frequency analysis are generally derived by converting the observed stage values into discharge with the help of a rating curve for the respective site. The errors are likely to occur in measuring the stages of flow in a river as well as in conversion of stage values into discharge using the rating rating curve, particularly in the extrapolation range. Development of rating curve is itself subject to errors as river cross section may change from time to time particularly for alluvial rivers. Also during high floods some of river water enters the flood plains and it may not be taken in account while developing the rating curve.

It may be emphasized that the statistical analysis of river flow data is only applicable if the field data have been obtained by acceptable hydrometric principles and practices. The accuracy of data is very important for carrying out flood frequency analysis and particularly when this approach is used for estimation of design floods for higher return periods by using a shorter record length. At the same time, it remains a fact that there are a number of factors which are responsible for introduction of errors in observations of river flow data. The degree of errors in measurement of discharges during high flood is generally considered to be still higher due to obvious reasons. In a developing country like India, adequate or short record length data added with some erroneous data due to measurement errors may affect the design flood estimates, to a considerable extent. Though every effort is made to identify such erroneous data by application of suitable data processing techniques for making the data consistent, a certain degree of error is bound to be present. Such errors which may be either systematic or random in nature, have definite effects on the estimated values of the design floods.

Potter and Walker (1985) mention that a rating curve is based on repeated direct measurements of river discharge, by means of current meter surveys. The process can be complicated by factors such as channel instability, backwater, and ice effects. For example, even at locations with relatively stable controls, the rating curve changes with time. In general, however, discharges which fall within the concurrent rating curve are accurately estimated. Large flood peak discharges are sometimes beyond the upper limits of the established rating curve. The authors also state that a gaging station, very large peak discharges are usually estimated by extending the rating curve or by making an indirect measurement; hence these discharges are subject to much larger errors than are directly measured discharges. A crude measure of the uncertainty of the largest observed peak discharge at a gaging station is the ratio of the largest directly measured discharge to the largest observed peak discharge. For 46 gaging stations in the State of Wisconsin this ratio ranges from 0.16 to 0.99, with a median of 0.72. for the annual flood series from the half of the gaging stations with the lowest rations, the coefficients of skewness have considerably higher mean and standard deviation than do those of the remaining flood series. These results are consistent with the impact of measurement error, though they can also be explained by the occurrence of single large floods in several of the annual flood series.

Very few studies have been carried out to test comparative performance of the existing regionalization techniques. Lettenmaier and Potter(1985) and Lattenmaier et al.(1987) have conducted some studies, wherein performance of various flood frequency methods were compared. In India, regional flood frequency studies have been carried out using conventional methods such as USGS method, regression based methods and Chow's method etc., for some typical regions. Attempts have been made to study application of the new approaches in the studies conducted at some of the Indian research institutions and academic organizations.

The regional flood frequency analysis has been carried out (NIH, 1990-91) for Godavari Basin Sub-Zone 3(f) using the eight different methods considering (i) at site data, (ii) at site and regional data together , and (iii) regional data alone without using at site data. Eight methods have been considered for simulation study wherein flood frequency analysis were carried out with the samples of different sizes of generated data using the regional EV1 (PWM) and GEV (PWM) parameters derived from the historical data. All regional methods without considering at site data (REV1-I, REV1-II and RGEV) are found to estimate the floods with larger bias, coefficient of variation and root mean square error. It indicated the unreliability associated with the regional methods without considering the at site data whlie estimating the floods for different recurrence intervals. At-site methods generally estimated the floods for higher recurrence intervals with larger bias for the samples of the size of the historical records generally available in india. Thus at-site methods may not always be able to provide reliable and consistent flood estimates in the extrapolation range which are usually needed for design of medium and major water resources structures. PWM based at-site and regional GEV method (SRGEV) in general estimated the floods with less bias and comparable coefficent of variation and root mean square errors for the two test catchments. Thus out of the eight methods considered in the study SRGEV method is found to be the most robust method for this region. Also, the versatility of SRGEV method is established for dealing with limited data situations prevalling in India.

Kumar and Singh(1992) carried out flood frequency analysis for Sub-Himalayan region (Zone-7) using peak flood series data of ten small and medium catchments varying in size from 6 sq.kms. to 2072 sq. kms. The study involved application of Extreme Value Type-I, General Extreme Value and Wakeby distributions using (i) at site data (ii) at site and regional data combined and (iii) regional data alone. The predictive ability of the different methods considered in the study was also tested through Monte Carlo experiments; wherein synthetic flood series have been generated using the regional EV1, GEV and Wakeby parameters derived from the historical data. Generated data sets of specific record lengths (same as the record length of historical data for respective gauging sites) have been considered for the eight sites. For the two independent sites variable record lengths viz. 1, 5, 10, 13 ,20, 30 and 40 one at a time, have been considered. This methodology has been applied to the generated data of different sample sizes for each population for the two independent gauging sites. Performance of 10 different methods has been evaluated based on predictive ability criteria viz. bias, and root mean square error. It is seen that the methods based on EV1(PWM), GEV(PWM) and Wakeby (PWM) approaches using at site and regional data in combined form provide estimates of flood peaks with computationally less bias and comparable root mean square error for the two test catchments.

In a study carried out at NIH(1990-91) an attempt has been made to examine the effects of various types of measurement errors in the data on the estimated values of design floods of different recurrence ntervals using the flood frequency analysis approach. The effect of systematic measurement errors has been studied using the observed data as well as the generated data of the three sites by introducing systematic errors to the annual peak flow sequences pertaining to i) high floods, ii) medium floods, iii) low floods ; iv) all the peak floods; and v) all events except high floods. The effects of random measurement errors on design flood estimates have also been examined. The results of the study indicate that the estimation of design flood values is considerably affected by the degree of error in observed annual peak values. However, the magnitude of the possible error in design flood estimation varies depending upon the return period, frequency distribution used and the nature of errors in the data. Errors in observation of high flood peaks result in larger deviations in the estimated values of the design floods of higher return periods as compared to the errors in the medium and low floods. It indicates that there is need for extra precaution in measurement of flow during high floods.

An over all view of the results of the study indicated that the possibility of different conditions of errors are to be given due weightage while estimating the design floods for different structures. For example, for the design of spillway of a large dam, it would be necessary to ensure accuracy in measurements of high flood peaks as errors in only a few values of the discharges during high floods may result in considerably large variations in the design flood estimates for high return periods. On the other hand, for the design of a small structure like a culvert or flood levees the degree of error in the high flood peaks do not affect the design flood estimation to a great extent. In such cases it is more important to have a flood sequence where the data corresponding to low and medium floods have been measured accurately. It is further observed that effects of errors on design flood estimation follow a well defined trend in case of the systematic errors. Once the type of the error is identified and the extent of errors at a particular site is established, it may be suitably incorporated in the design flood estimation by flood frequency analysis after proper studies.

3.0 STATEMENT OF THE PROBLEM

The errors in annual peak flood series may lead to errorneous flood frequency estimates, which result in over-design or under design of a hydraulic structure. The errors in the data series may be due to errors in measurement of river stages, discharges, conversion of stage values into discharge or extrapolation of the rating curve etc.

When the annual maximum peak flood series is subject to errors, its statistical parameters such as mean, standard deviation, coefficient of variation and skewness etc. may differ from their true values, which leads to errorneous flood frequency estimates particularly for higher return periods. The objectives of this study are:

(a) To estimate the stastical parameters of the sample of historical values of $Q_i/\bar{Q}$ for the region.

(b) To generate Extreme Value Type I(EV1) and Pearson Type III(PT3) distributed data.

(c) To develop regional flood frequency curves for different sets of the generated population values of the sample of $Q_i/\bar{Q}$ values using (i) USGS method, (ii) EV1(PWM) method, (iii) GEV(PWM) method and (iv) Wakeby method.

(d) To compute percent errors in flood frequency estimates between the expected values of floods obtained from the historical parameters derived for the region and the expected values of floods computed on the basis of various sets of the regional parameters with certain degree of introduced errors.

4.0 DESCRIPTION OF THE STUDY AREA

Mahanadi sub-zone 3(d) comprises of Mahanadi, Brahmani and Baitarani basins. The Mahanadi, Brahmani and Baitarani are peninsular rivers which fall into the Bay of Bengal. Important tributaries of Mahanadi river are Seonath, Hasdo, Mand and Ib joining from north, and Jonk, ong and Tel joining from south. The total length of Mahanadi, Brahmani, and Baitarni rivers is 850, 705 and 333 kilometers respectively. Hirakud dam the multi-purpose project in Orissa is located in the middle of the Mahanadi sub-zone. The total drainage area of this sub-zone is about 1,95,256 square kilometers. Out of which the river Mahanadi and its tributaries drain 1,40,628 square kilometers, the river Brahmani covers 35,337 square kilometers and the river Baitarani drains 19,291 square kilometers respectively.

Mahanadi sub-zone 3(d) lies between longitudes 80^{o} 25' to 87^{o} East and latitudes 19^{o} 15' to 23^{o} 35' North. Location of Mahanadi sub-zone 3(d) is shown in Fig. 1. Map of this sub-zone is shown in Fig. 2. Mahanadi basin is fan shaped upto Hirakud reservoir. The Brahmani and Baitarani are oblong catchments. The sub-zone comprises of parts of Maharashtra, Madhya Pradesh, Orissa and Bihar. About half of the area of this sub-zone is hilly varying in height from 300 meters to 1350 metres and rest of the area varies in height from 0 to 300 meters on both sides of the Mahanadi river. The hilly area is mostly on the North, South and Southwest of the region.

The sub-zone receives about 75% to 80% of the annual rainfall from South-West monsoon during the monsoon season from June to September. The variation of normal annual rainfall over the sub-zone is from a minimum of 1200 mm to a maximum of 1600 mm. The convergence between the Bay of Bengal branch and Arabian sea branch of the monsoon sometimes becomes significant and causes heavy precipitation.

The minimum and maximum temperatures are recorded in the months of December and April/May respectively. The temperature begins to rise from January to April/May and then falls down gradually upto December. The mean monthly minimum temperature of about 12^{o} C and mean monthly maximum temperature of 40^{o} C are recorded in this sub-zone.

The red and yellow soils cover major part of the sub-zone. The red sandy and coastal alluvial soils cover the remaining part

FIG.1 : LOCATION MAP OF HYDROMETEOROLOGICAL MAHANADI SUB-ZONE 3(d)

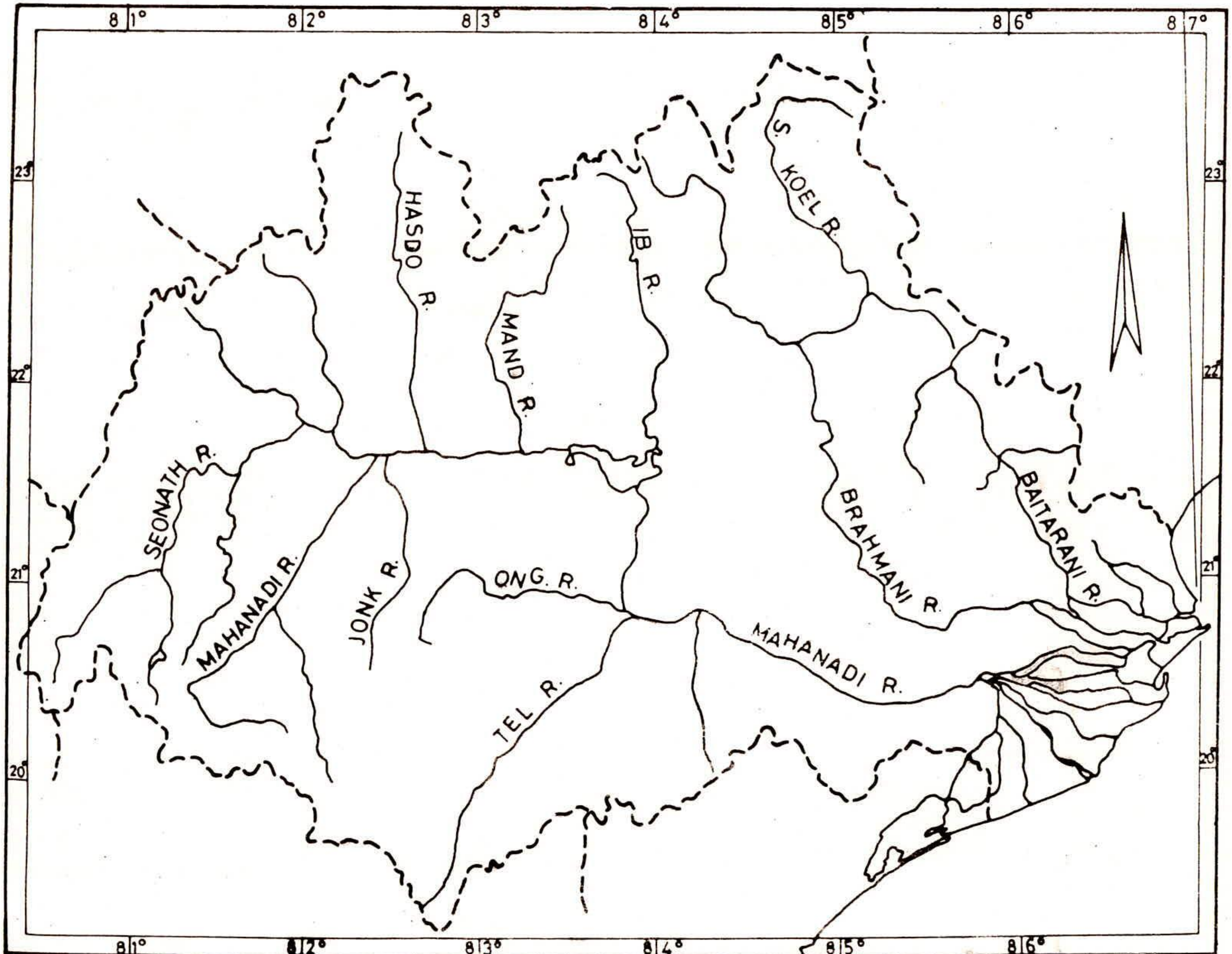

FIG. 2 INDEX MAP OF MAHANADI BASIN SUB-ZONE 3 (d)

KM 50 0 50 100 150 KM
SCALE

of sub-zone. The sub-zone has an extensive area under forest. Paddy is the main crop grown on the cultivable land. Most of the irrigated area is in Sambalpur district under the canals of Hirakud project. In the deltaic area under Cuttack, the irrigation is mostly done by inundation canals.

5.0 DATA AVAILABILITY FOR THE STUDY

The annual peak flood series data for 11 to 31 years varying over the period 1957 to 1989 for 23 gauging sites of the Mahanadi basin sub-zone 3(d) were available for this study(RDSO, 1992). The drainage area of these sites vary between 19 to 1150 square kilometers. The details of catchment area, mean annual peak flood, standard deviation, coefficient of variation, coefficient of skewness and record length of the annual peak floods for the 22 gauging sites passing the USGS homogeneity test and used in this study(discussed in the following Section) are given in Table-1.

Table-1 Catchment area, sample statistics and sample size

S.NO.	Br.No.	Catchment Area (Sq Km)	Mean Flood (Cumec)	Standard Deviation (Cumec)	Coff. of Variation	Coff. of Skewness	Sample Size (Years)
1	66K	154	260.32	201.63	.775	1.611	28
2	48	109	103.90	79.68	.767	1.527	30
3	176	66	81.48	114.36	1.403	4.369	31
4	93K	74	153.07	75.26	.492	.735	28
5	59KGP	30	72.90	55.42	.760	1.262	29
6	308	19	41.22	25.42	.617	.819	27
7	332NGP	225	188.59	99.48	.527	1.158	22
8	59BSP	136	196.23	154.32	.786	1.560	22
9	698	113	247.00	198.48	.804	1.404	25
10	37	64	25.09	20.61	.822	1.054	23
11	121	1150	1003.86	466.53	.465	.521	19
12	385	194	115.40	70.67	.612	.387	21
13	332KGP	175	71.83	39.44	.549	.695	20
14	40K	115	260.67	165.51	.635	1.220	24
15	154	58	160.16	146.75	.916	2.405	21
16	42	49	53.50	20.36	.381	.028	19
17	69	173	238.89	147.75	.618	.916	21
18	90	190	130.73	80.74	.618	.458	20
19	195	615	963.77	385.71	.400	.335	19
20	235	312	176.14	96.65	.549	.764	11
21	325	26	50.00	42.81	.856	.953	13
22	489	823	1071.95	1171.58	1.093	2.003	14

6.0 METHODOLOGY

Frequency distributions used in the study to carry out flood frequency analysis involved the fitting of Extreme Value Type I(EV1), General Extreme Value(GEV) and Wakeby distributions. These distributions are briefly discussed below.

Extreme Value Type-I Distribution (EV1)

This is a two parameter distribution and it is popularly known as Gumbel distribution. The cummulative density function for EV1 distribution is given by:

$$F(x) = e^{-e^{-\frac{(x-u)}{\alpha}}} \quad (1)$$

where, F(x) is the probability of non exceedence and equal to 1-1/T ; T is the recurrence interval in years, u and α are the location and shape parameters respectively. These parameters can be estimated from the sample of annual maximum peak floods using the parameters estimation techiniques available in literature. Method of probability weighted moments (PWM) is one of the parameter estimation techniques which has been successfully applied by Landerwehr et al.(1979) for estimating the parametres of EV1 distribution more efficiently with less bias. The method of probability weighted moments which has been discussed in subsquent section was ,therefore, used for estimating the EV1 distribution parameters.

General Extreme Value Distribution(GEV)

GEV distribution is a generalised three parameter extreme value distribution proposed by Jenkinson (1955). Its theory and practical applications are reviewed in the Flood Studies Report(NERC,1975). The cummulative density function F(x) for GEV distribution is expressed as:

$$F(x) = e^{-\left(1-K\left(\frac{x-u}{\alpha}\right)\right)^{1/K}} \quad (2)$$

where u, α and K are location, scale and shape parameters of GEV distribution respectively. For estimating these parameters, a procedure based on method of probability weighted moments(Singh, 1989) which is described in the subsquent section, is used in the study.

Wakeby Distribution

A random variable x is said to be distributed as Wakeby if

$$x = m+a\,[1-(1-F)^{b}] - c\,[1-(1-F)^{-d}] \qquad (3)$$

where $F = F(x) = 1-1/T$

a, b, c, d and m are the parameters of Wakeby distribution which can be estimated using a special algorithm proposed by Landwehr et al.(1979) based on method of probability weighted moments.

Homogeneity Test

In regional frequency analysis, available historical peak flood data of different sites which belong to a hydrologically homogeneous region are required to be grouped for estimating regional parameters. In this study the hydrologic homogeneity of the region is tested using USGS Homogeneity test as described in NIH(1990-91). Out of the available data data ofthe 23 gauging sites the data of 22 site pass the USGS homogeneity test. The homogeneity test graph is shown in Fig. 3.

The following four methods based on at-site and regional flood frequency analysis have been used in this study.

(i) Modified USGS method
(ii) EV1 PWM method
(iii) GEV PWM method, and
(iv) Wakeby PWM method

6.1 Flood Frequency Analysis Using Modified U.S.G.S. Method Based On At-Site And Regional Data

Following sequential steps are followed :

i) Test for regional homogeneity for the selected gauged catchments using the procedure described by Dalrymple (1960) and discard those catchments which are not homogenious.

ii) Compute the flood of 2.33, 5, 10, 20 and 50 years using the parameters u and α , estimated by the method of least square for different gauging sites after assigning the probabilites by Gringorton plottig position formula:

$$F_i = \frac{i-0.44}{n+0.12} \quad (4)$$

iii) Compute the frequency ratios of floods of 5, 10, 20 and 50 years to mean annual flood (2.33 year flood) for each of the gauging sites and workout the median values of the frequency ratios corresponding to each recurrence interval.

iv) Draw the median values of the frequency ratios against the EV1 reduced variate corresponding to different recurrence intervals. Such curves are known as the regional frequency curves.

v) Estimate the regional frequency ratio corresponding to a recurrence interval using the regional frequency curve for the catchments lying in the region.

vi) Estimate the quantiles Q_T for a particular catchment of the region after multiplying the regional frequency ratio by the at site mean($\bar{Q}$) computed from the sample.

6.2 FFA Using EV1 PWM Method Based On At-Site And Regional Data

Methods based on probability weighted moments generally require expressing the distribution function in inverse form which is given below for EV1 distribution :

$$x = u - \alpha \ln(-\ln F) \quad (5)$$

where, u and α as mentioned ealier are the parameters of the distribution.

Follwing the Landwehr et al. (1979) the rth order probability weighted, M_{10r} is given by the equation:

$$M_{10r} = \frac{1}{n}\sum_{i=1}^{n} x_i \, (1-F_i)^r \quad (6)$$

where, F_i the probability of non exceedence, is computed using the plotting position formulae :

$$F_i = \frac{i-0.35}{n} \quad (7)$$

where, i is the rank in the arranged flood series, and n is the sample size.

Putting r =0,1,2,....etc. in equation (6), M_{100}, M_{101}, M_{102}... etc..are computed from the flood series.

The parameters u and α, of EV1 distribution and quantile Q_T are computed by this method following the steps given below:

i) Test for regional homogeneity of data for selected gauged catchments using homogeneity test.

ii) Rank the flood series of each gauging site and compute the at site values of PWM, $M_{100,j}$ and $M_{101,j}$ as:

$$M_{100,j} = \frac{1}{n(j)} \sum_{i=1}^{n(j)} x_{i,j} \tag{8}$$

$$M_{101,j} = \frac{1}{n(j)} \sum_{i=1}^{n(j)} x_{i,j} \quad (1. - F_{i,j}) \tag{9}$$

where, n(j) is the record length for the jth gauging site,

$M_{100,j}$ is the zeroth order probability weighted moment for the jth gauging site (same as the at site mean).

$M_{101,j}$, is the first order probability weighted moment for the jth gauging site.

$F_{i,j}$, is the probablity of non-exceedence and computed by the following plotting position formula:

$$F_{i,j} = \frac{(i - 0.35)}{n(j)} \tag{10}$$

$x_{i,j}$, is the ith rank value in the sample of annual maximum peak series for the jth gauging site.

iii) Standardize the at site values of PWM obtained from the previous step by the at site mean.Thus:

$$m_{0,j} = \frac{M_{100,j}}{M_{100,j}} = 1.0 \tag{11}$$

$$m_{1,j} = \frac{M_{1\alpha,j}}{M_{1\alpha,j}} \qquad (12)$$

where, $m_{0,j}$ is the zeroth order standardized PWM, for jth gauging site , and

$m_{1,j}$ is the first order standardized PWM for jth gauging site.

iv) Compute the regional values of the standardized PWMs averaged across the ns sites in the region in the ratio of the record lengths. Hence:

$$m_0 = \frac{1}{L} \sum_{i=1}^{ns} m_{0,j} \; n(j) = 1.0 \qquad (13)$$

$$m_1 = \frac{1}{L} \sum_{i=1}^{ns} m_{1,j} \; n(j) \qquad (14)$$

where, $$L = \sum_{j=1}^{ns} n(j) = \text{Total record length} \qquad (15)$$

m_0 , and m_1 are the standardized regional PWMs.

v) Compute the regional EV1 parameters u and α using the relationships:

$$\alpha = \frac{m_0 - 2\, m_1}{\ln 2} \qquad (16)$$

$$u = m_0 - 0.5772\, \alpha \qquad (17)$$

vi) Estimate the regional quantiles x_T using the relation:

$$x_T = u + \alpha\, (-\ln(-\ln(1.- \frac{1}{T}))) \qquad (18)$$

vii) Scale the quantities x_T by at site mean (same as $M_{100,j}$ to estimate quantiles ($Q_{T,j}$) for each gauging site.Hence:

$$Q_{T,j} = M_{100,j}\, x_T \qquad (19)$$

6.3 FFA Using GEV PWM Method Based On At-Site And Regional Data

The inverse form of the GEV distribution is :

$$x = u + \alpha \, (1 - (- \ln (F)^{\kappa})/ \kappa) \qquad (20)$$

where u, α and κ are the location, scale and shape parameters of the distribution.

For κ=o, GEV distribution converges to the EV1 distribution. If $\kappa < 0$ or $\kappa > 0$, it represents the EV2 or EV3 distribution form respectively.

The parameters, u, α and κ, of the distribution for the region and quantiles for a specific site Q_T are estimated using the method of probability weighted moment in the following steps :

i) Arrange the flood series and compute M_{100}, M_{101}, and M_{102} using equations (6) and (7).ii) Standardise the computed values of M_{100}, M_{101}, and M_{102}, obtained from step (i) dividing them by the at site mean (same as M_{100}). Hence:

$$m_0 = \frac{M_{100}}{M_{100}} = 1 \qquad (21)$$

$$m_1 = \frac{M_{101}}{M_{100}} \qquad (22)$$

$$m_2 = \frac{M_{102}}{M_{100}} \qquad (23)$$

iii) From normalized values of m_0 , m_1 , and m_2 obtain M_{110} and M_{120} using the equations :

$$M \quad = m - m \qquad (24)$$

$$M_{120} = m_0 - 2 \, m_1 + m_2 \qquad (25)$$

iv) Calculate a constant C :

$$C = ((2 M_{110} - m_0)/ (3 M_{120} - m_0)) - (ln_2 / ln_3) \quad (26)$$

v) Calculate the shape parameter K using the relation :

$$K = 7.8590 C + 2.9554 C^2 \quad (27)$$

vi) Calculate the scale parameter, α , using the relation:

$$\alpha = ((2 M_{110} - m)* K) / (Gamma(1+K)*(1. -2^{-K})) \quad (28)$$

vii) Calculate the location parameter, u using the relation:

$$u = m_0 + (\alpha (Gamma (1+K) -1)/K) \quad (29)$$

where, Gamma (1+K) is the value of Gamma of (1+K) computed from Gamma function subroutine.

viii) Estimate the regional quantiles x_T using the relation :

$$x_T = u + \alpha (1 -(-ln (1 - \frac{1}{T}))^{K}/K \quad (30)$$

ix) Scale the quantiles x_T by at site mean for the estimation of quantiles $Q_{T,j}$ at any gauging site :

$$Q_{T,j} = M_{100,j} \; x_T \quad (31)$$

6.4 FFA Using Wakeby PWM Method Based On At-site And Regional Data

The following sequential steps are followed while carrying out at-site and regional flood frequency analysis by this method.

i) Test for regional homogeneity of data for selected gauged catchments using homogeneity test.

ii) Estimate at-site values of probablity weighted moments upto fourth order for each gauging site putting r = 0, 1, 2, 3 and 4 in equation:

$$M_{10,j} = \frac{1}{n(j)} \sum_{i=1}^{n(j)} X_{i,j} \, (1-F_{i,j})^{r} \quad (32)$$

iii) Standardize the at-site values of PWMs obtained from step

(ii) dividing them by the at-site mean. Hence,

$$m_{r,j} = \frac{M_{10r,j}}{M_{100,j}} \qquad (33)$$

iv) Compute the regional values of the standardlized PWMs averaged across the NS sites in the region in the ratio of the record lengths using the following equation;

$$m_r = \frac{1}{L} \sum_{i=1}^{ns} m_{r,j} \; n(j) \qquad (34)$$

From this step, the values of m_0 , m_1, m_2, m_3, m_4 are obtained

v) Estimate the regional parameters of the Wakeby distribution using the special algorithm suggested by Landwehr et al.(1979) based on the regional probablity weighted moments m_0, m_1, m_2, m_3, and m_4.

vi) Estimate the regional quantiles X_T using the following relation:

$$X_T = m + a[1-(\frac{1}{T})^b - c\ [1-(\frac{1}{T})^{-d}] \qquad (35)$$

vii) Compute the T-year flood for any particular gauging site after scaling the quantiles X_T obtained from step (vi) by at-site mean.

7.0 ANALYSIS

The analysis is carried out as explained in the following steps.

(i) Test the regional homogeneity using USGS method.

(ii) Standardize the values of annual maximum peak floods taking the ratios of annual maximum peak floods to the at site mean ($Q_i/\bar{Q}$) for different gauged catchments of the region.

(iii) Consider the standardized values of $Q_i/\bar{Q}$ for all the gauged catchments together as a representative sample of $Q_i/\bar{Q}$ values for the region and calculate sample mean(μ), standard deviation(σ) and co-efficient of skewness (S_k). Note that the mean (μ) of the sample of $Q_i/\bar{Q}$ values is 1 and its standard deviation is the same as its coefficient of variation (C_v).

(iv) Generate Extreme Value Type-I (EV1) population using μ = 1 and computed value of C_v from the historical records at step (iii).

(v) Consider the generated data of specific length for each gauging site and carry out regional frequency analysis using USGS method, EV1 (PWM) method, GEV(PWM) method and Wakeby (PWM) method following the methodology discussed in Section 6.

(vi) Estimate growth factors($Q_T/\bar{Q}$) for T-year return period using the different methods of the regional frequency analysis mentioned at step (v).

(vii) Repeat step (v) and (vi) for 1000 replications with the generated data and compute the expected values of $Q_T/\bar{Q}$ for T-year return period.

(viii) Assuming 10% increase in the value of co-efficient of variation(C_v)due to errors in the annual maximum peak floods, generate EV1 population for μ = 1 and co-efficient of variation(C_v) = 1.1 times the coefficient of variation of the historical series obtained at step(iii).

(ix) Repeat step (v) to (vii) with the generated population at step (viii).

(x) Consider different percentages of increase as well as decrease in the value of the co-efficient of variation and subsequently generate different populations of EV1 distribution for $\mu = 1$ and the different values of the co-efficient of variation.

(xi) Repeat step (v) to (vii) with each population generated at step (x) in order to estimate the expected values of $Q/\bar{Q}$ for period, T years using the four different methods of regional frequency analysis.

(xii) Estimate the percentage error in $Q_T/\bar{Q}$ values (EGF) for each generated EV1 population considering the expected values of $Q_T/\bar{Q}$, computed at step (vii), from the generated population with $\mu = 1$ and historical value of C_v for each of the four regional frequency methods as reference estimates.

(xiii) Compute the percentage errors in flood estimate, Q_T, (PER) using the relation :

$$PER = [1 - \{(1-EGF)(1+\frac{\Delta \bar{Q}}{(\bar{Q})})\}] \quad (36)$$

where EGF is the fractional error in $Q_T/\bar{Q}$ values and $\Delta \bar{Q}$ is the error introduced in the $\bar{Q}$ values due to errors in the annual maximum peak flood values. (PGEF is the percentage error in growth factors and is equal to EGF*100).

(xiv) Generate Pearson Type-3 distribution (PT3) population using $\mu = 1$, co-efficient of variation and co-efficient of skewness of the historical series of $Q_i/\bar{Q}$ values for the region.

(xv) Repeat steps (v) to (xiii) for the generated samples of PT3 population for different values of co-efficient variation and co-efficient of skewness and compute the percentage errors in flood estimate, Q_T using different methods of the regional frequency analysis corresponding to different values of $\Delta\bar{Q}$.

8.0 DISCUSSION OF RESULTS

Sample statistics computed from the historical records of 22 gauging sites are given in Table 1. It is observed from the table that the catchment area for the various sites varies from 19 to 1150 square kilometers. The mean annual peak floods for these sites vary from 25.09 cumec to 1071.95 cumec. The sample sizes of the historical flood record vary from 11 to 31 years. The homogeneity of the region has been tested based on USGS homogeneity test. The homogeneity test graph is shown in Fig. 3.

The percentage errors in growth factors ($Q_T/\bar{Q}$) are computed for 50, 100 and 200 year return periods using (i) USGS Method (Method M1), (ii) PWM based EV1 method(Method M2), (iii) PWM based GEV method (Method M3) and (iv) PWM based Wakeby method (Method M4) for using the generated samples of EV1 population with mean(μ) = 1 and different values of coefficient of variation(C_v) e.g. 0.436, 0.508, 0.581, 0.653, 0.726, 0.799, 0.871, 0.944 and 1.016.

The variations of percentage errors in growth factors ($Q_T/\bar{Q}$) with coefficient of variation for a return period of 50 years, 100 years and 200 years, computed by the four different methods are shown in Figs. 4 to 6 respectively. From the figures, it is observed that all the methods over estimate the growth factors for larger values of coefficient of variation with respect to the coefficient of variation derived from the historical data (C_v = 0.726). On the other hand, for the smaller values of coefficient of variation there is under estimation in the values of growth factors. From these figures it is generally observed that there is an over estimation of about 20% in the growth factors using method M3, corresponding to C_v = 1.016. Whereas methods M1 and M2 over estimate the corresponding growth factors with less than 5% error. It may be attributed to fitting EV1 distribution to the generated samples of EV1 populations. However, all the methods under estimate the growth factors by about 30% for C_v = 0.436.

The similar analysis has been performed using the generated Pearson Type 3 (PT3) populations with mean(μ) = 1, and different values of C_v mentioned earlier corresponding to each of the four skewness values (e.g. skewness = 2.306, 2.595, 2.883 and 3.171).

The variation of percentage errors in growth factors, corresponding to 50, 100 and 200 year return periods, with C_v using four different methods are given in Figs. 7 to 21 for each of the five skewness values. From these figures, it is observed that there is over estimation of growth factor values for the

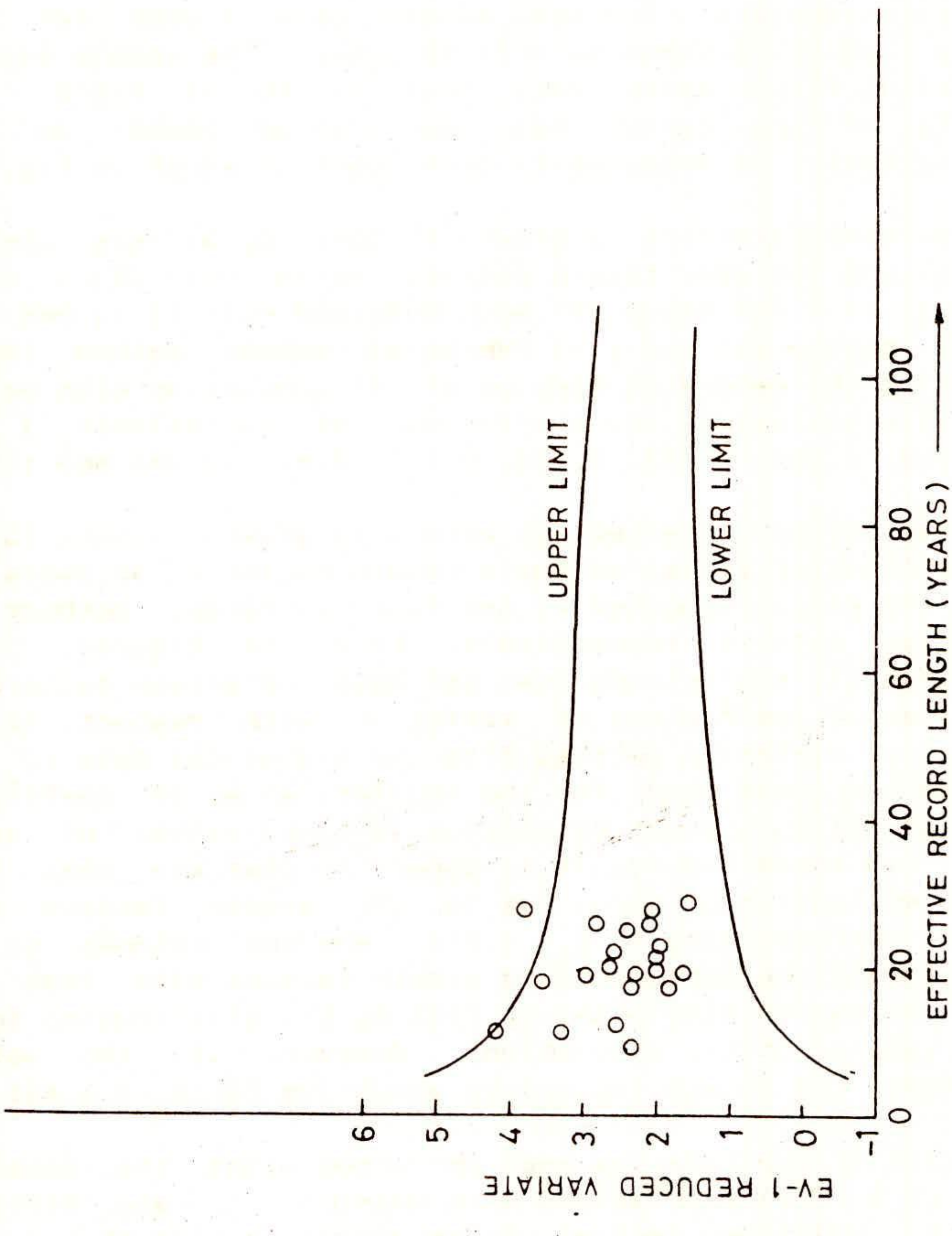

FIG. 3 HOMOGENEITY TEST GRAPH FOR SUB ZONE (3d)

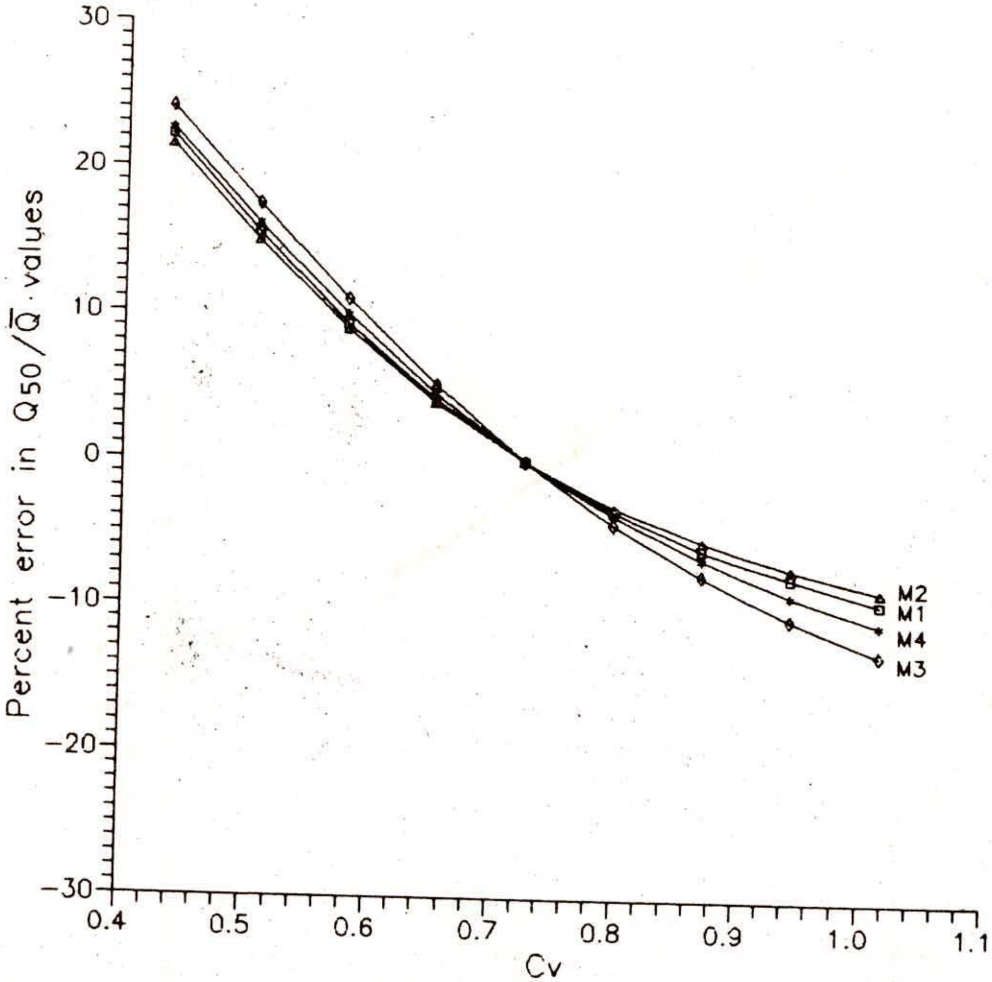

Fig. 4 Variation of percent error in $Q_{50}/\bar{Q}$ values with Cv computed by fitting the generated samples of E.V.I populations using four different methods

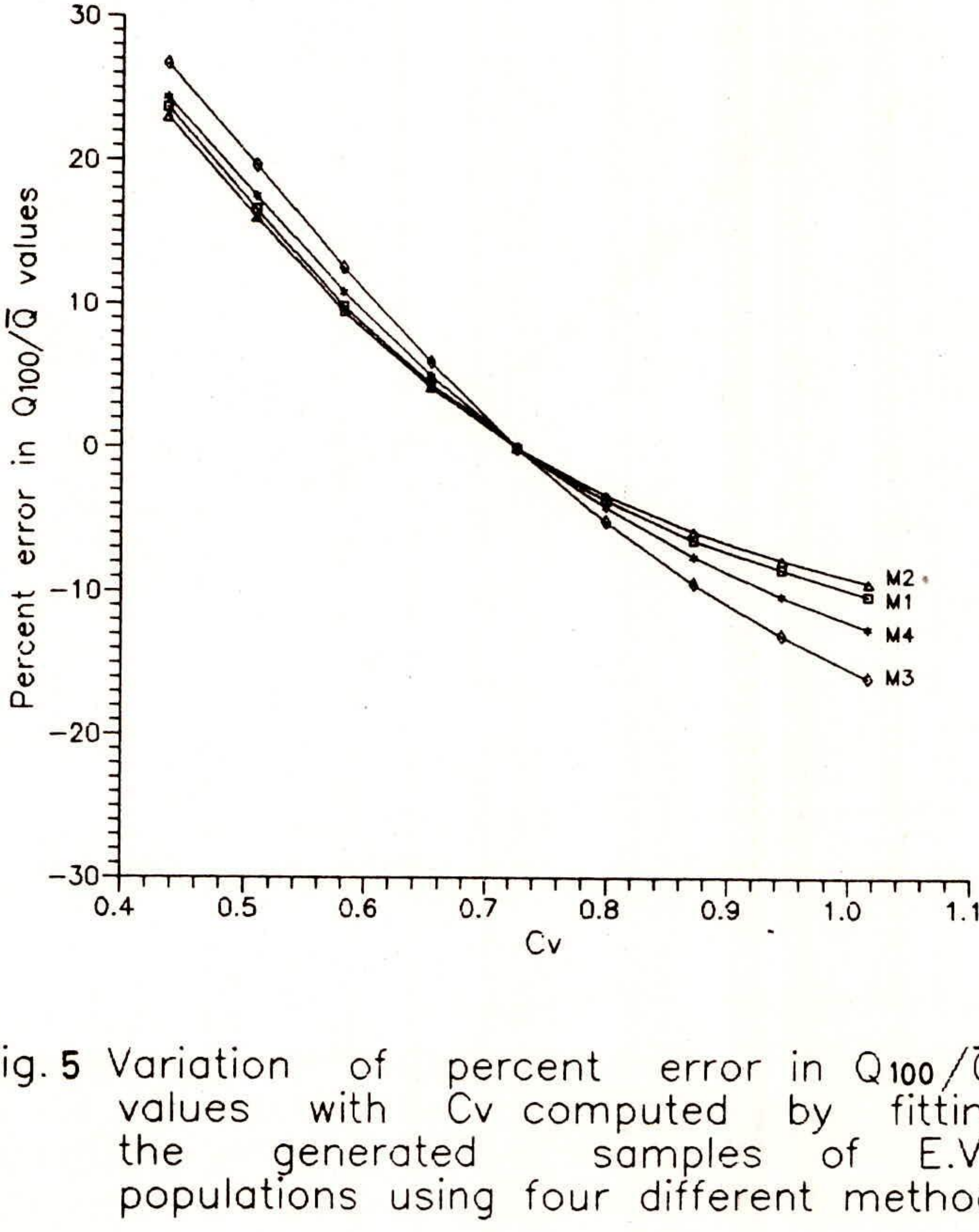

Fig. 5 Variation of percent error in $Q_{100}/\bar{Q}$ values with Cv computed by fitting the generated samples of E.V.I populations using four different methods

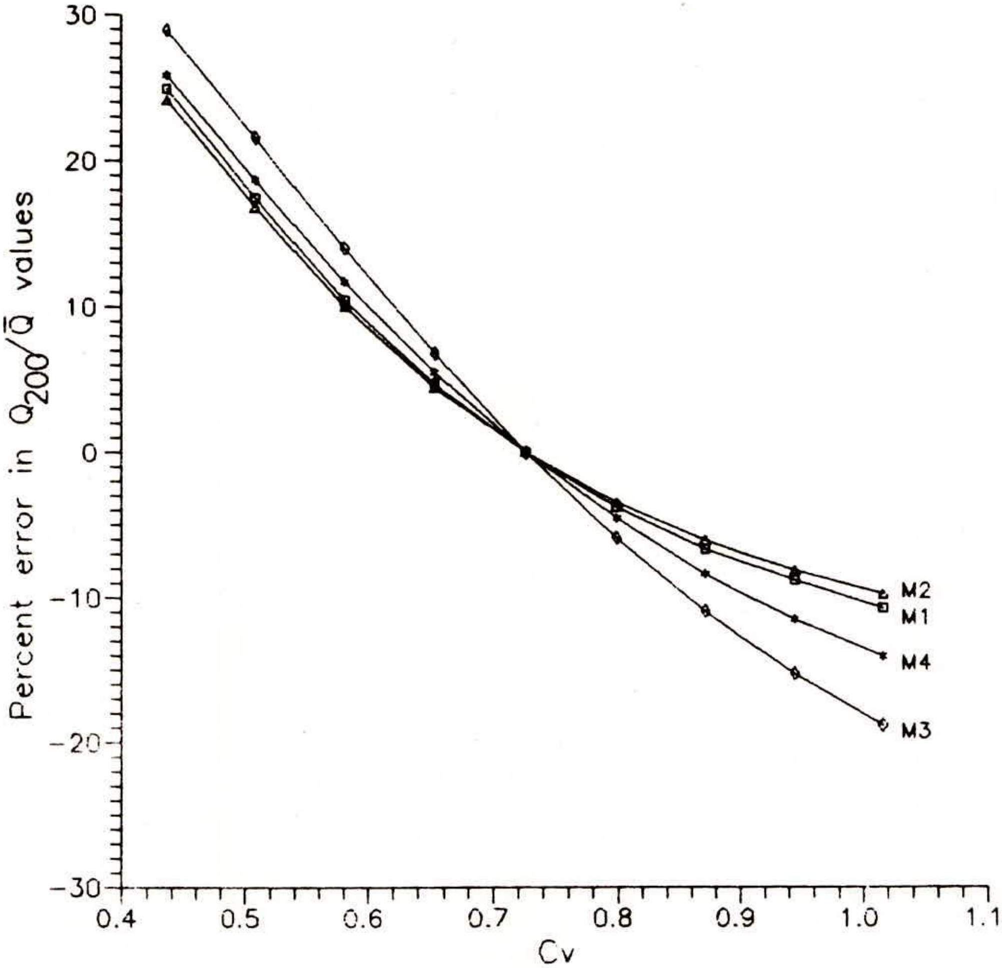

Fig.6 Variation of percent error in $Q_{200}/\bar{Q}$ values with Cv computed by fitting the generated samples of E.V.I populations using four different methods

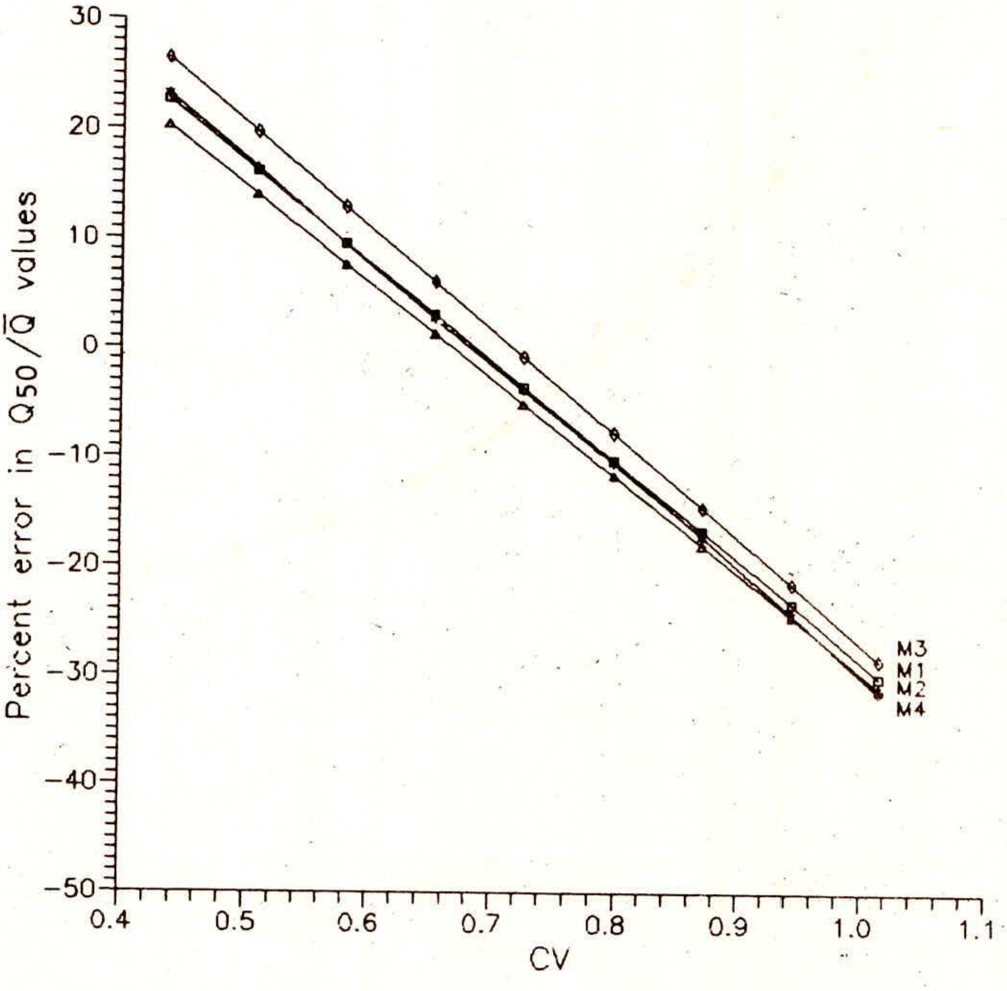

Fig. 7 Variation of percent error in $Q_{50}/\overline{Q}$ values with CV computed by fitting the generated samples of PT3 populations (SKEW=2.306) using four different methods

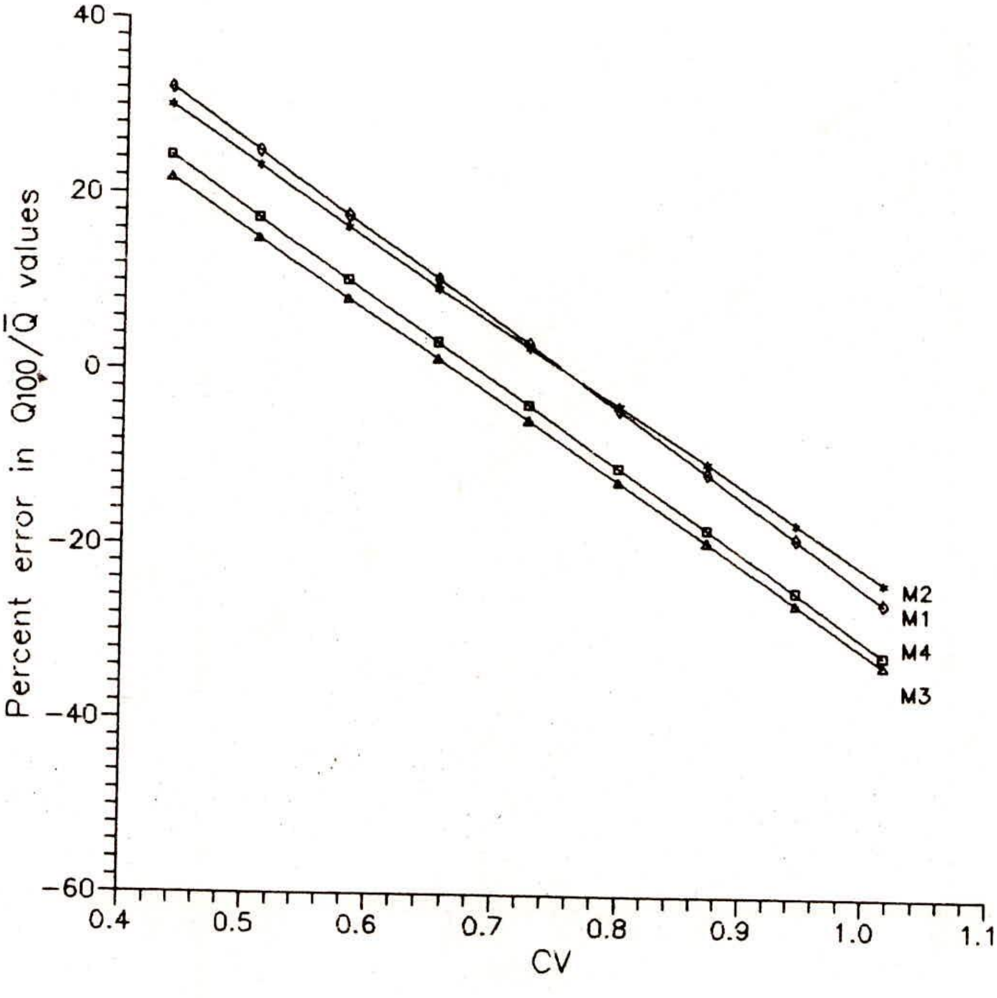

Fig. 8 Variation of percent error in $Q_{100}/\bar{Q}$ values with CV computed by fitting the generated samples of PT3 populations (SKEW=2.306) using four different methods

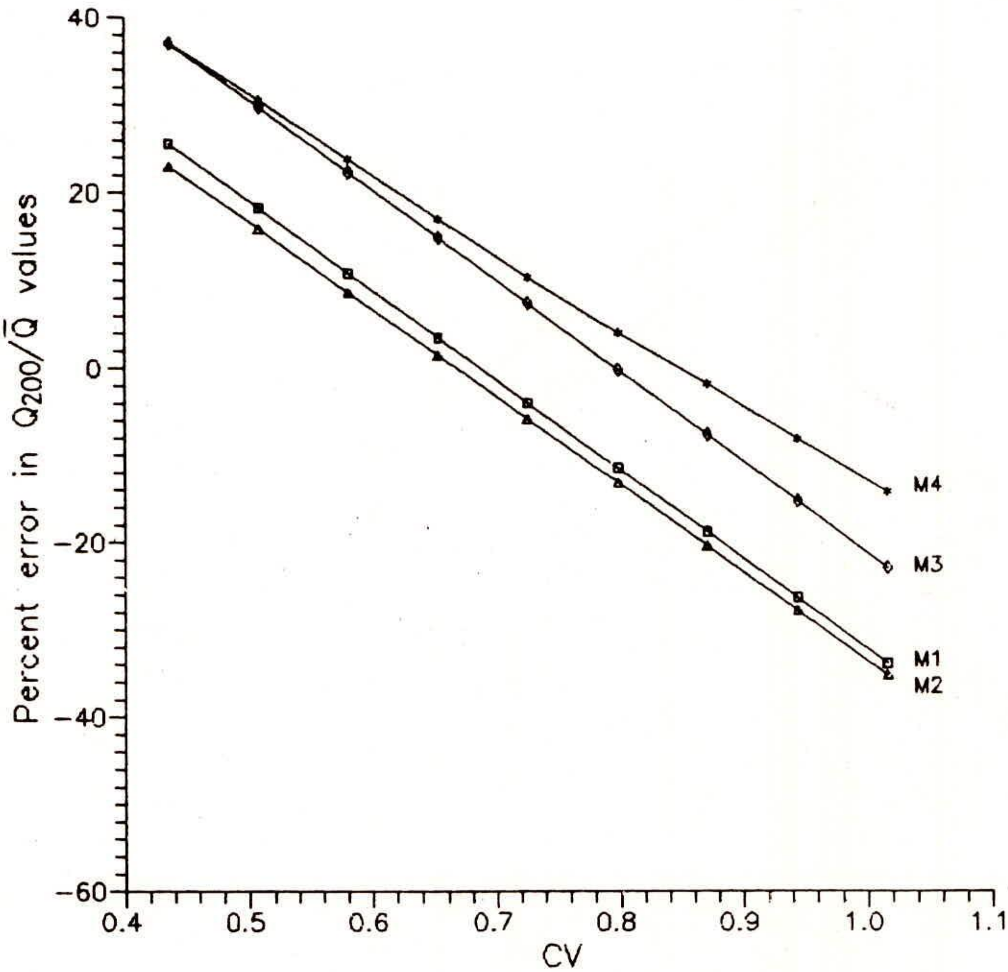

Fig. 9 Variation of percent error in $Q_{200}/\overline{Q}$ values with CV computed by fitting the generated samples of PT3 populations (SKEW=2.306) using four different methods

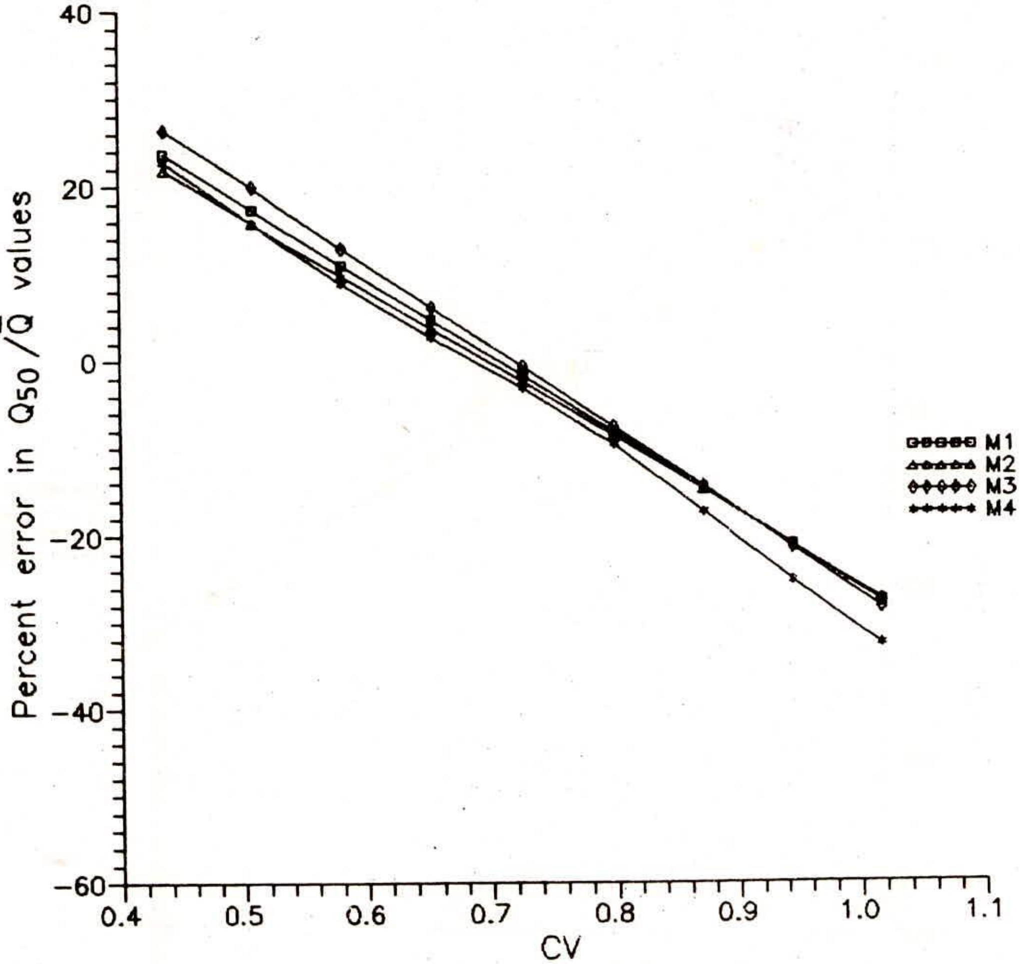

Fig.10 Variation of percent error in $Q_{50}/\bar{Q}$ values with CV computed by fitting the generated samples of PT3 populations (SKEW=2.595) using four different methods

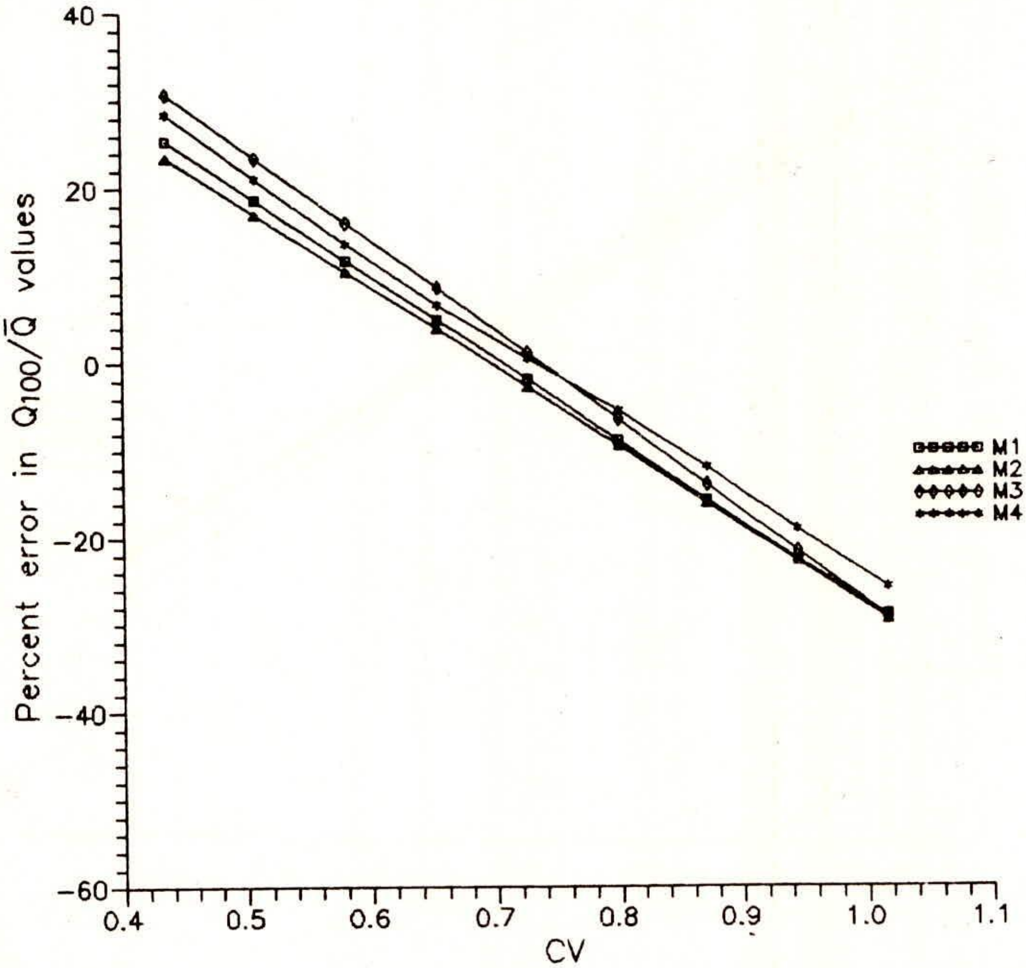

Fig. 11 Variation of percent error in $Q_{100}/\bar{Q}$ values with CV computed by fitting the generated samples of PT3 populations (SKEW=2.595) using four different methods

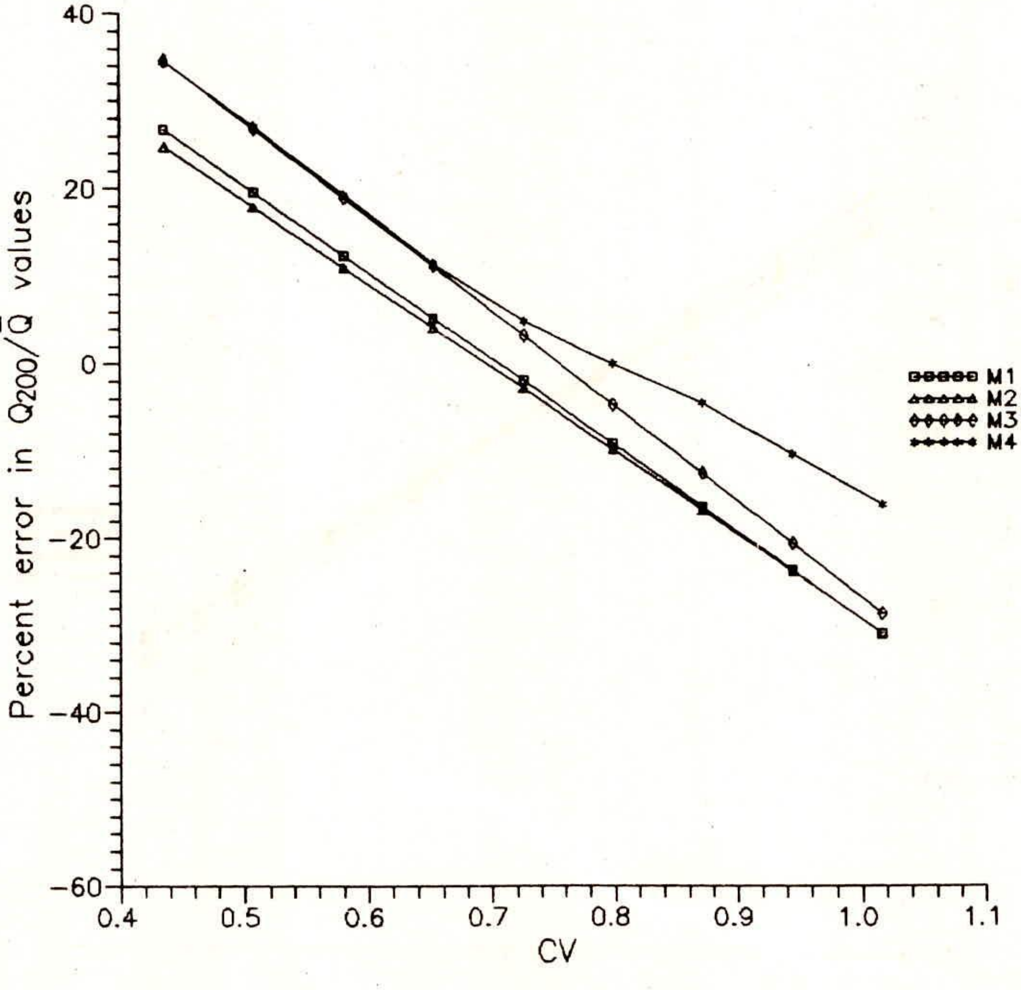

Fig.12 Variation of percent error in $Q_{200}/\bar{Q}$ values with CV computed by fitting the generated samples of PT3 populations (SKEW=2.595) using four different methods

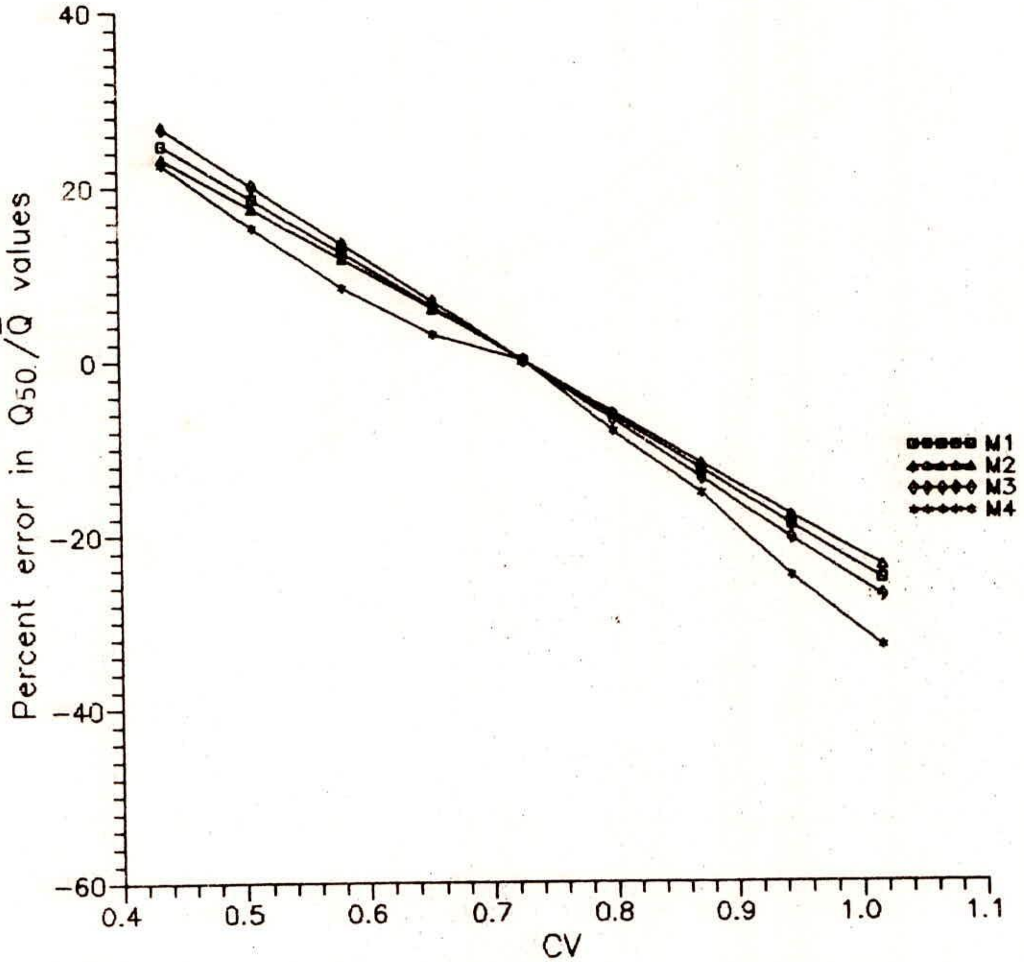

Fig.13 Variation of percent error in $Q_{50}/\bar{Q}$ values with CV computed by fitting the generated samples of PT3 populations · (SKEW=2.883) using four different methods

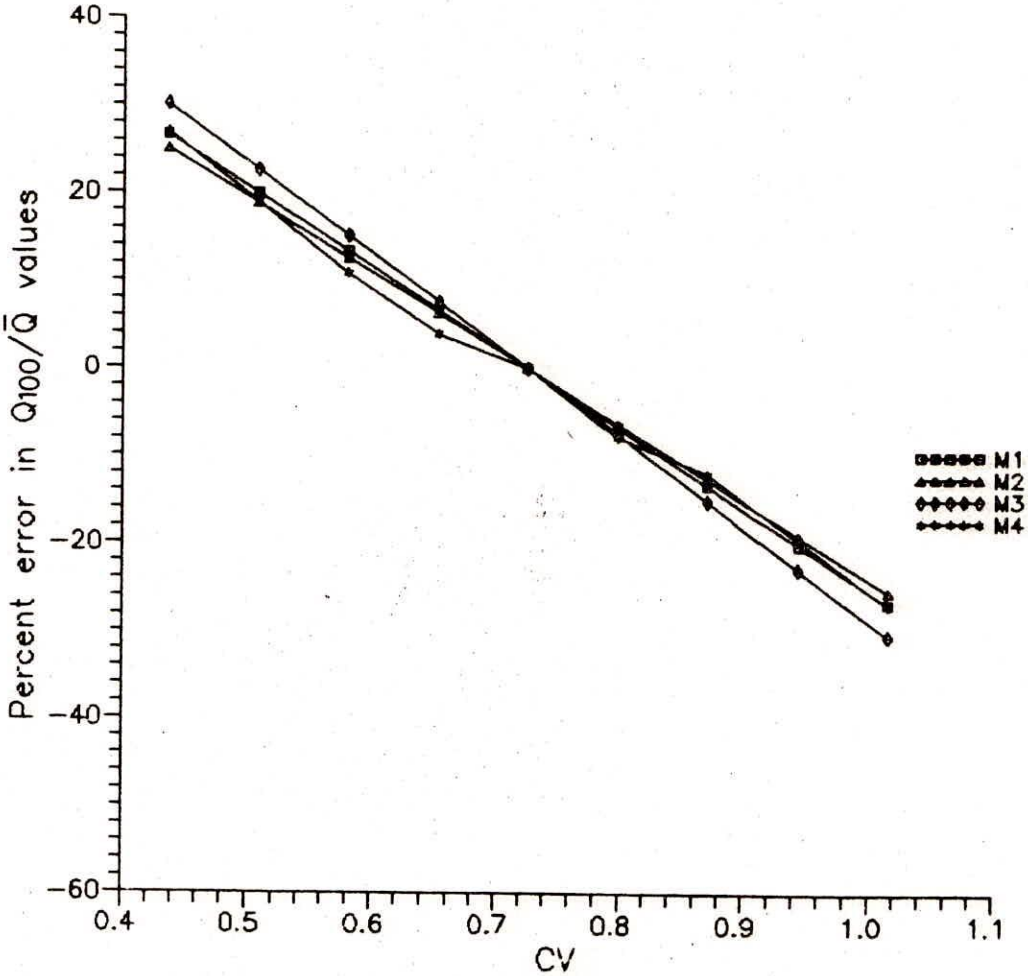

Fig.14 Variation of percent error in $Q_{100}/\overline{Q}$ values with CV computed by fitting the generated samples of PT3 populations (SKEW=2.883) using four different methods

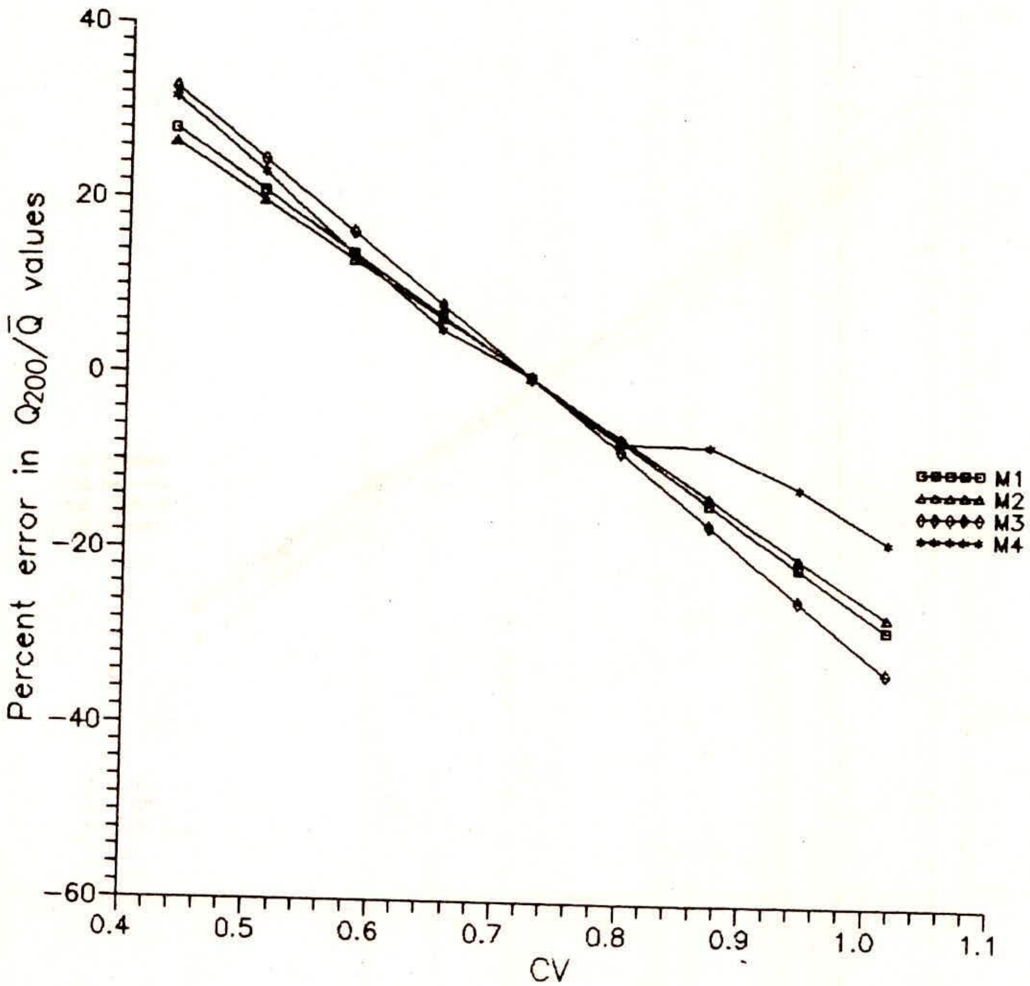

Fig.15 Variation of percent error in $Q_{200}/\bar{Q}$ values with CV computed by fitting the generated samples of PT3 populations (SKEW=2.883) using four different methods

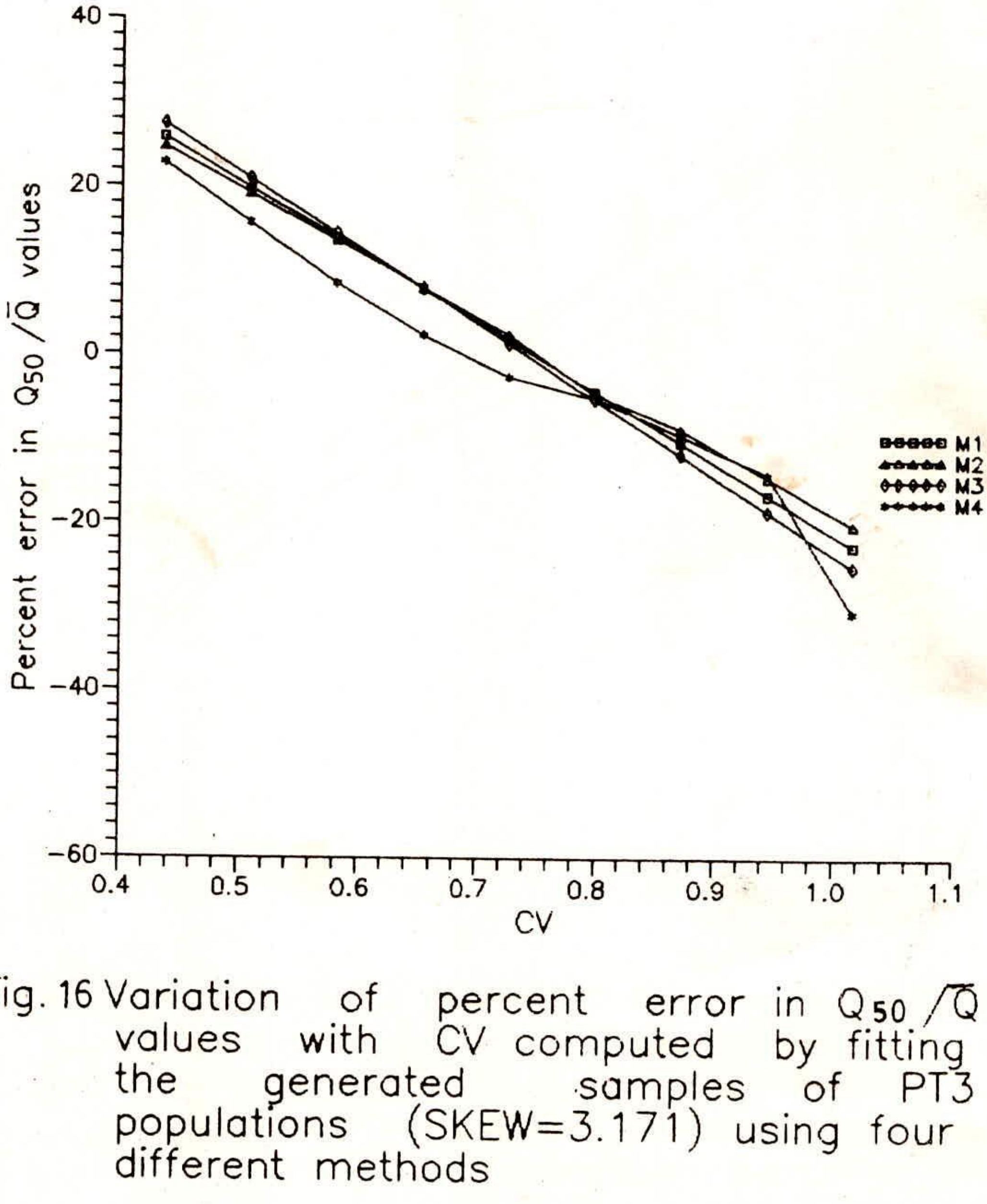

Fig. 16 Variation of percent error in $Q_{50}/\bar{Q}$ values with CV computed by fitting the generated samples of PT3 populations (SKEW=3.171) using four different methods

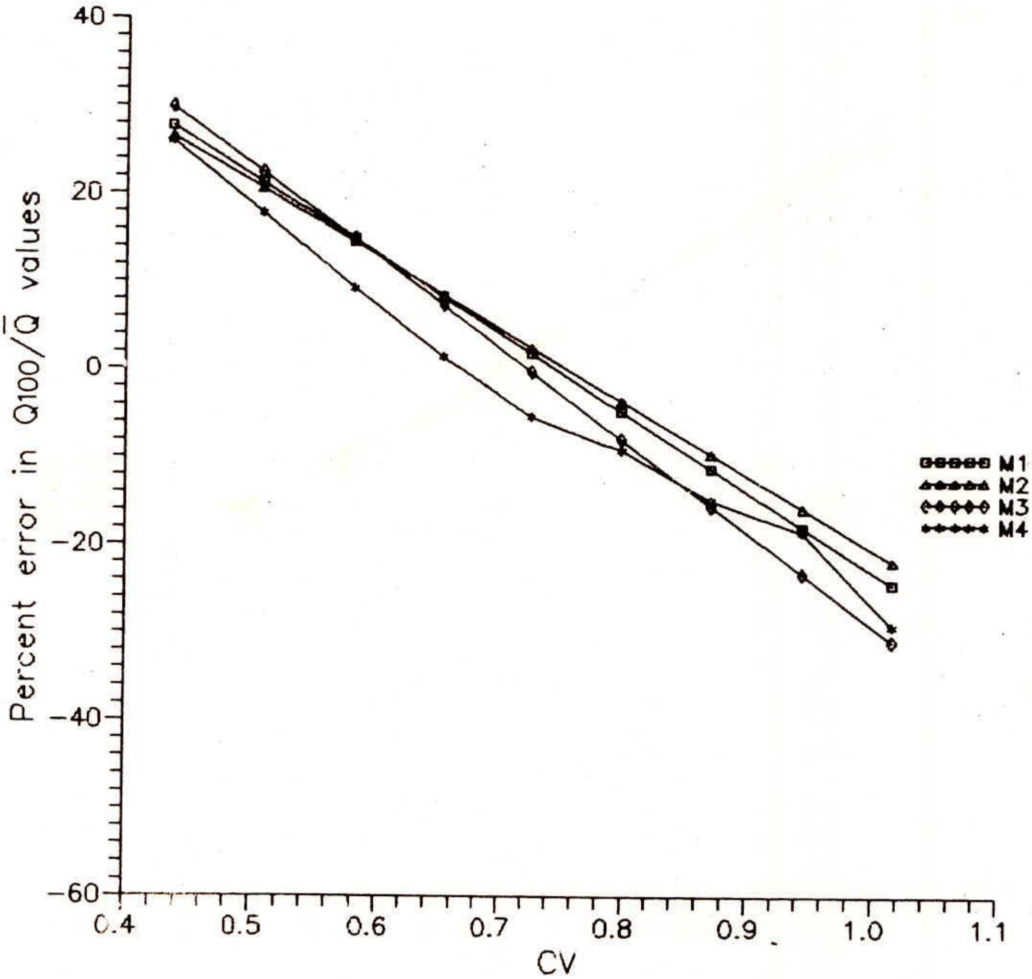

Fig.17 Variation of percent error in $Q_{100}/\bar{Q}$ values with CV computed by fitting the generated samples of PT3 populations (SKEW=3.171) using four different methods

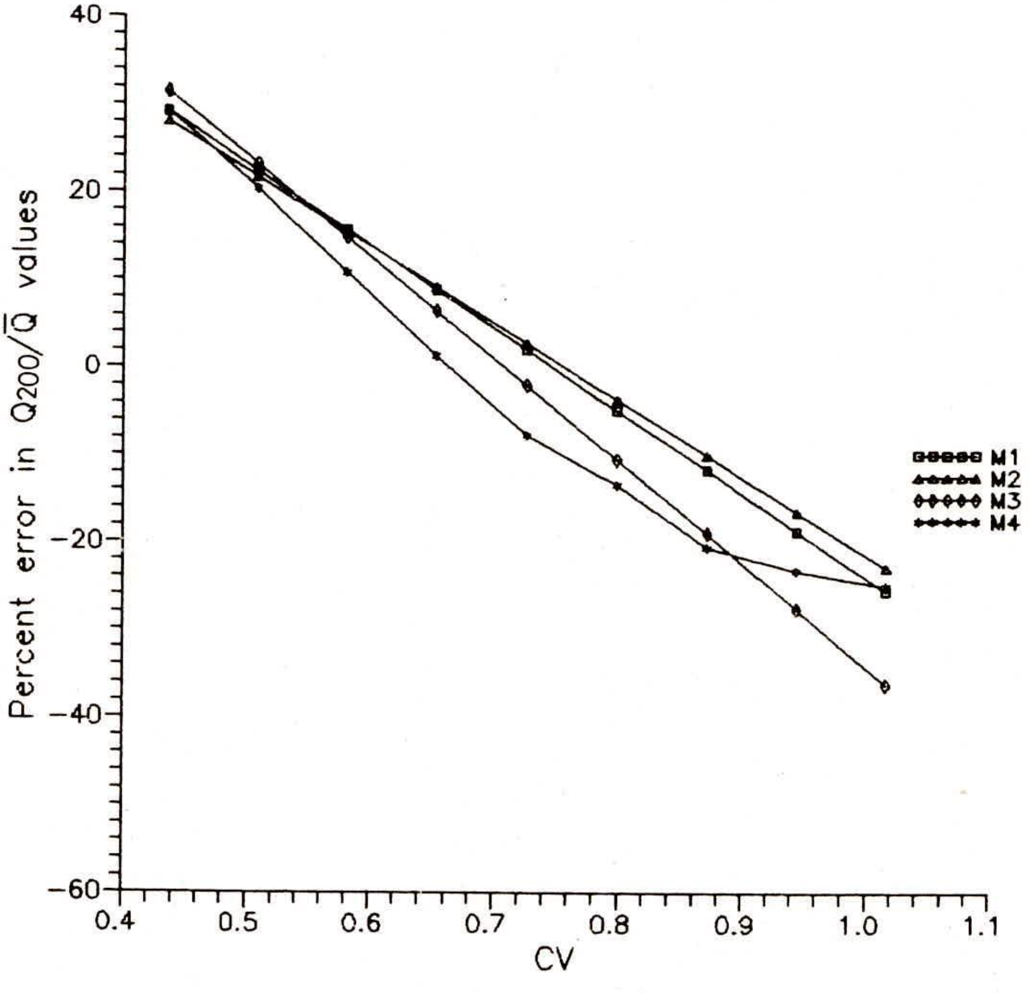

Fig.18 Variation of percent error in $Q_{200}/\bar{Q}$ values with CV computed by fitting the generated samples of PT3 populations (SKEW=3.171) using four different methods

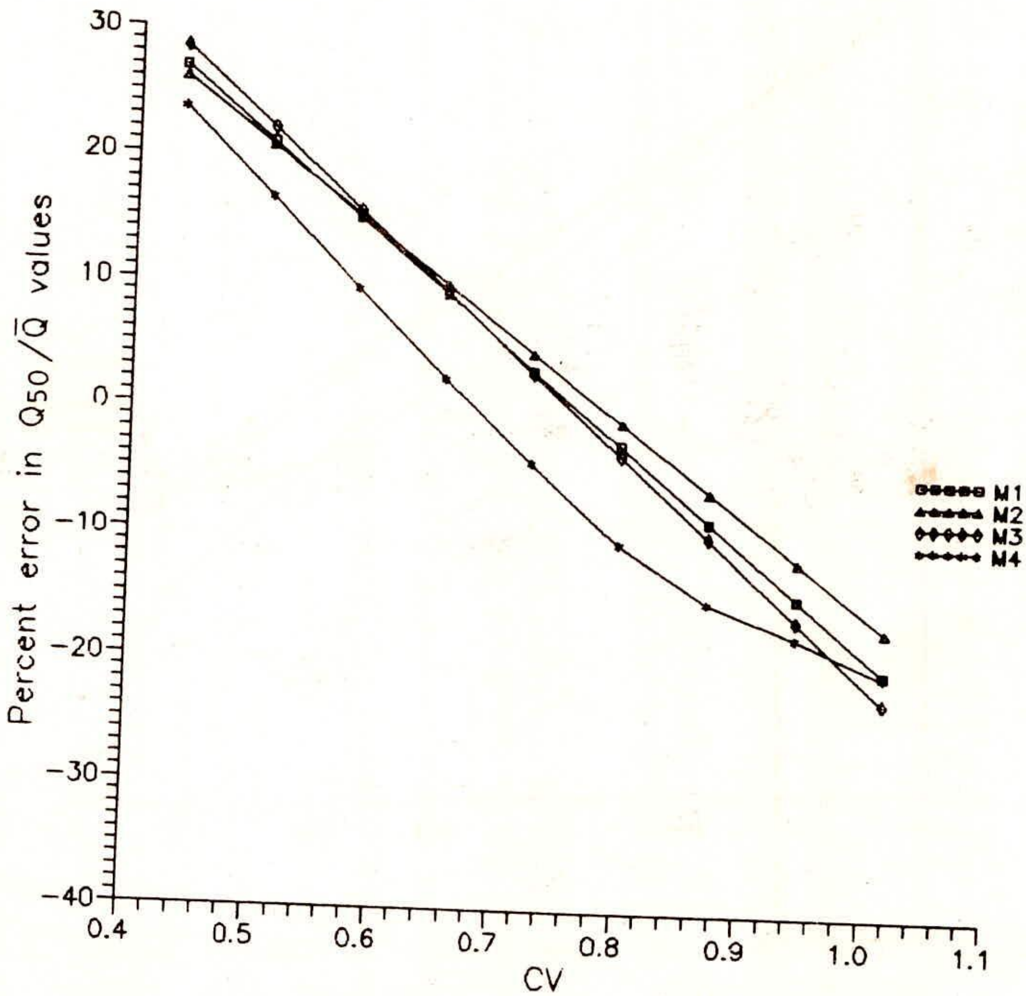

Fig.19 Variation of percent error in $Q_{50}/\bar{Q}$ values with CV computed by fitting the generated samples of PT3 populations (SKEW=3.460) using four different methods

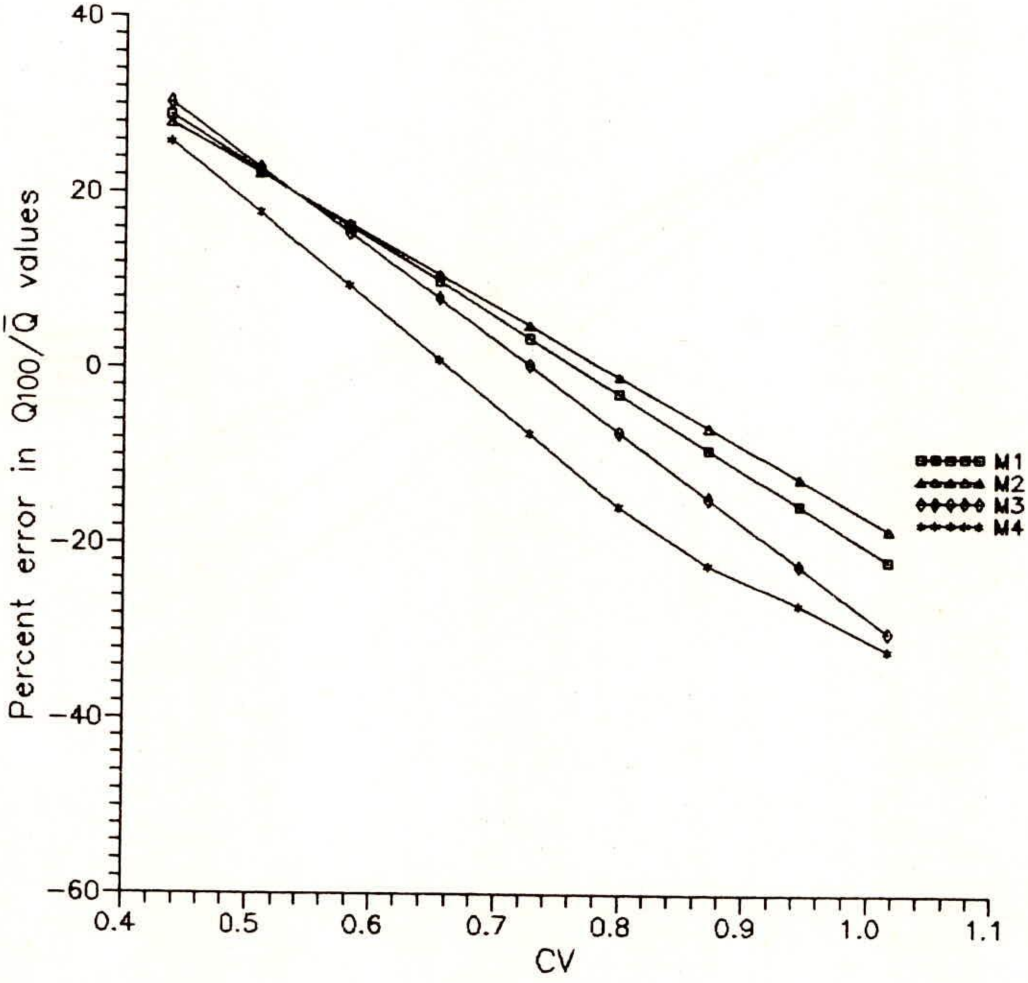

Fig.20 Variation of percent error in $Q_{100}/\bar{Q}$ values with CV computed by fitting the generated samples of PT3 populations (SKEW=3.460) using four different methods

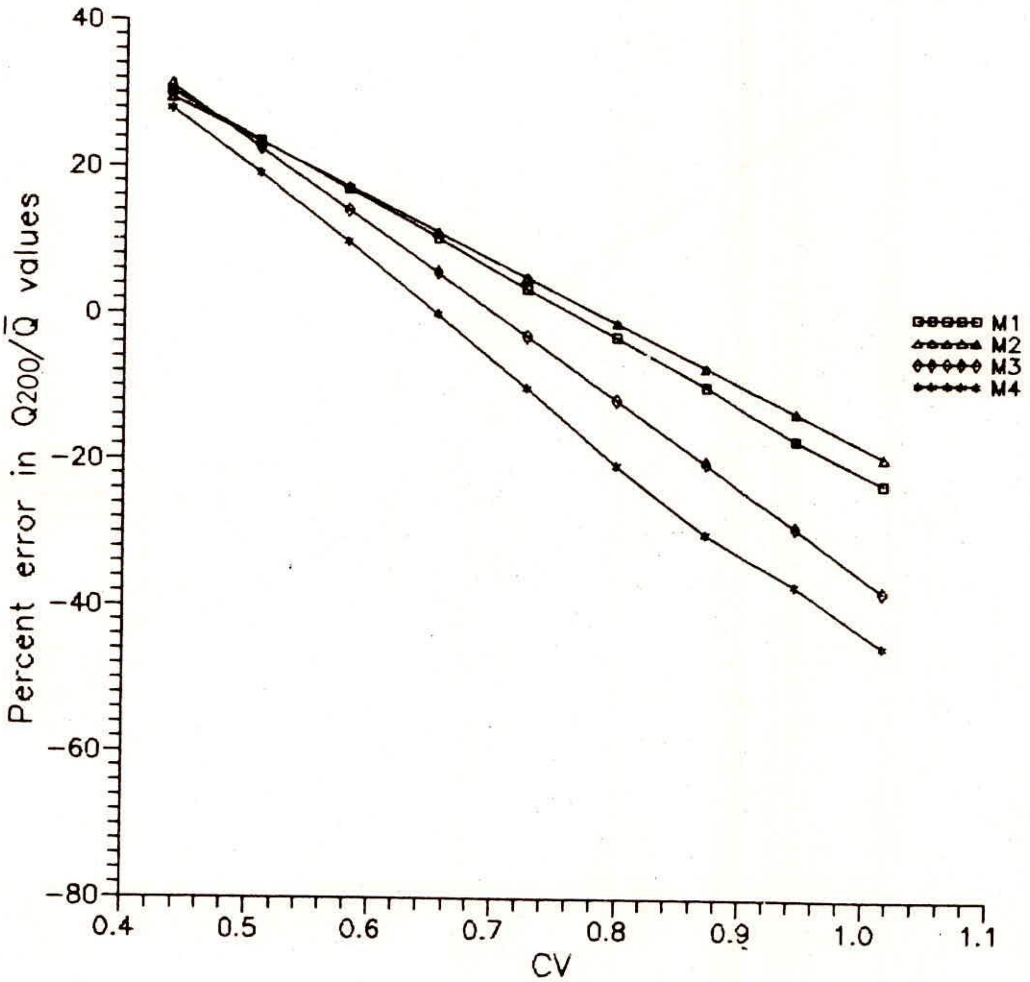

Fig.21 Variation of percent error in $Q_{200}/\bar{Q}$ values with CV computed by fitting the generated samples of PT3 populations (SKEW=3.460) using four different methods

larger values of C_v and there is under estimation in the growth factor values for lesser C_v values. It is also noticed that there is not much of variation in the percentage error of the growth factors with skewness, for the specific C_v value. It indicates that the growth factor values are much sensitive to the coefficient of variation values in comparison to the coefficient of skewness values.

Percentage errors in flood estimates are obtained using equation (36) for different values of percentage errors in mean for a given percentage error in growth factor. Fig. 22 shows variations of percentage errors in flood estimates with percentage error in mean for different percentage errors in growth factors.

The percentage errors in growth factors computed by each one of the four different methods fitted to the EV1 generated population along with percentage error in mean are used in equation (36) to estimate the percentage errors in flood estimates for 50, 100 and 200 year return periods and the same are given in Tables 2 to 5.

In these tables negative percentage errors in flood estimates indicate over estimation, where as positive errors in flood estimates show the under estimation. From these tables, it is observed that for the 40% larger values of C_v (1.016) and larger values of mean (40% more than the true mean) there is an over estimation of more than 50% in flood estimates for each of the four methods as well as for different return periods. On the other hand there is an under estimation of the flood estimates of the same order for the 40% smaller value of C_v (0.436) and 40% smaller value of mean. The percentage errors in flood estimates are also obtained by each one of the four methods analysing the generated PT3 populations. Tables 6 to 41 show the percentage errors in flood estimates for various return periods for different values of S_K using the four methods for specific values of C_v. From these tables, it can be visualised that there is a minor variation of the order of 8% in percentage errors in flood estimates with S_k for a given value of C_v and mean annual peak flood for the various return periods for methods M1 and M2. Whereas for method M3 and M4 the variation in percentage error in flood estimates is of the order 2%. It indicates that fitting 2 parameters distribution to the population of a 3 parameters distribution may lead to an error upto 8% in flood estimates for 40% higher value of mean annual peak flood, but for 40% lower value of mean annual peak flood the percentage error in flood estimate is about 3% for various return periods.

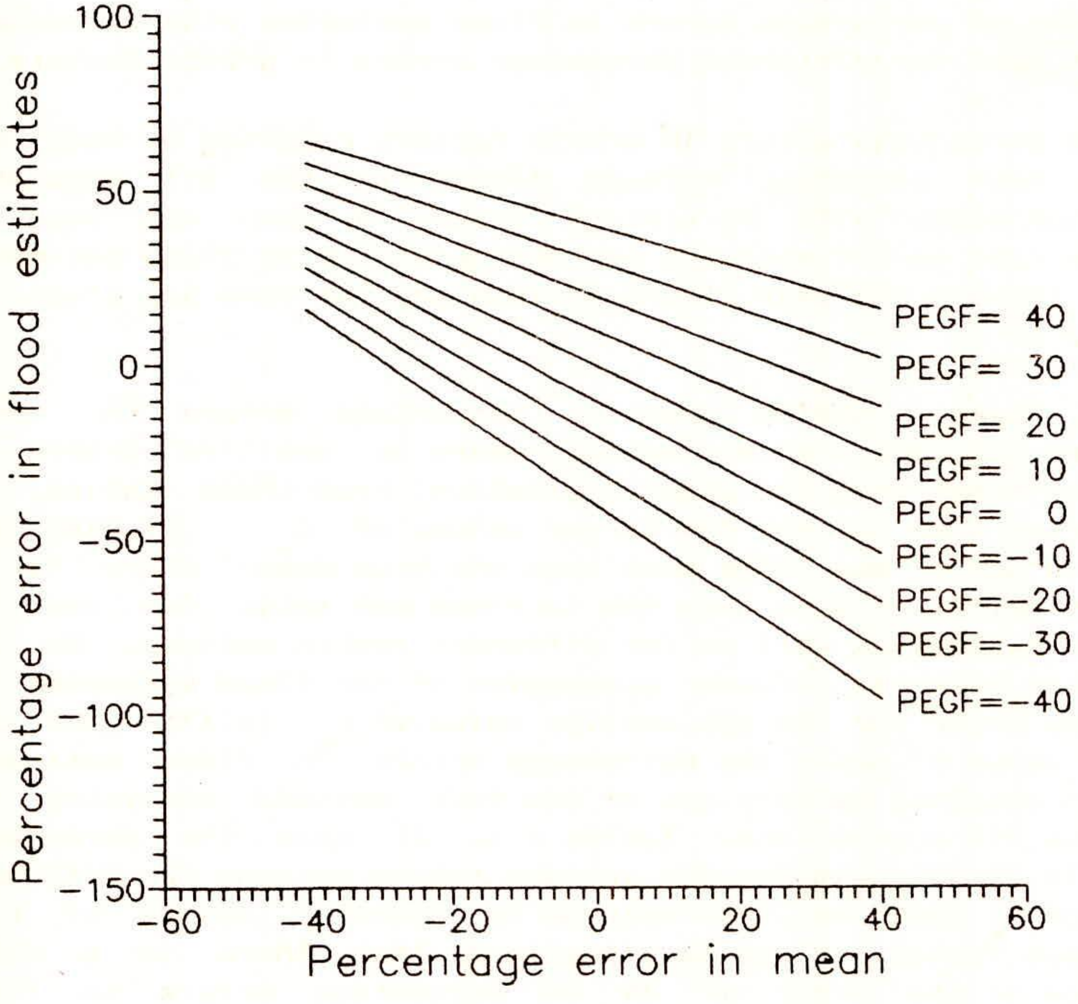

Fig 22 Variations of percentage error in flood estimates with percentage error in mean for different percentage error in growth factors.

Table 2 % error in flood estimates using method 1

Return period (Years)	% error in mean	% error in flood estimates								
		CV1 (0.436)	CV2 (0.508)	CV3 (0.581)	CV4 (0.653)	CV5 (0.726)	CV6 (0.799)	CV7 (0.871)	CV8 (0.944)	CV9 (1.016)
50	-40	53.31	49.32	45.56	42.49	40.00	37.97	36.42	35.30	34.28
	-30	45.53	40.87	36.49	32.91	30.00	27.63	25.83	24.51	23.33
	-20	37.75	32.42	27.42	23.33	20.00	17.29	15.23	13.73	12.38
	-10	29.97	23.97	18.34	13.74	10.00	6.95	4.64	2.95	1.42
	0	22.19	15.53	9.27	4.16	0.00	-3.38	-5.96	-7.84	-9.53
	10	14.40	7.08	0.20	-5.43	-10.00	-13.72	-16.56	-18.62	-20.48
	20	6.62	-1.37	-8.87	-15.01	-20.00	-24.06	-27.15	-29.40	-31.43
	30	-1.16	-9.82	-17.95	-24.60	-30.00	-34.40	-37.75	-40.19	-42.39
	40	-8.94	-18.26	-27.02	-34.18	-40.00	-44.74	-48.34	-50.97	-53.34
100	-40	54.23	49.96	45.94	42.67	40.00	37.84	36.18	34.97	33.88
	-30	46.60	41.62	36.93	33.11	30.00	27.48	25.54	24.13	22.86
	-20	38.97	33.28	27.92	23.56	20.00	17.12	14.91	13.30	11.84
	-10	31.34	24.94	18.92	14.00	10.00	6.76	4.27	2.46	0.82
	0	23.71	16.60	9.91	4.45	0.00	-3.61	-6.37	-8.38	-10.20
	10	16.08	8.26	0.90	-5.11	-10.00	-13.97	-17.00	-19.22	-21.22
	20	8.45	-0.08	-8.11	-14.66	-20.00	-24.33	-27.64	-30.06	32.24
	30	0.82	-8.42	-17.12	-24.22	-30.00	-34.69	-38.28	-40.89	-43.26
	40	-6.81	-16.77	-26.13	-33.77	-40.00	-45.05	-48.31	-51.73	-54.28
200	-40	54.95	50.47	46.26	42.83	40.00	37.75	36.00	34.73	33.58
	-30	47.44	42.21	37.31	33.30	30.00	27.37	25.34	23.85	22.51
	-20	39.94	33.96	28.35	23.77	20.00	17.00	14.67	12.97	11.44
	-10	32.43	25.70	19.40	14.24	10.00	6.62	4.01	2.10	0.37
	0	24.92	17.45	10.44	4.71	0.00	-3.75	-6.66	-8.78	-10.70
	10	17.41	9.19	1.48	-4.82	-10.00	-14.13	-17.32	-19.66	-21.77
	20	9.90	0.94	-7.47	-14.35	-20.00	-24.50	-27.99	-30.54	-32.84
	30	2.40	-7.32	-16.43	-23.88	-30.00	-34.88	-38.66	-41.42	-43.91
	40	-5.11	-15.57	-25.39	-33.41	-40.00	-45.25	-49.32	-52.29	-54.98

Table 3 % error in flood estimates using method 2

Return period (Years)	% error in mean	% error in flood estimates								
		CV1 (0.436)	CV2 (0.508)	CV3 (0.581)	CV4 (0.653)	CV5 (0.726)	CV6 (0.799)	CV7 (0.871)	CV8 (0.944)	CV9 (1.016)
50	-40	52.91	49.00	45.37	42.38	40.00	38.15	36.77	35.67	34.79
	-30	45.06	40.49	36.26	32.77	30.00	27.84	26.23	24.95	23.92
	-20	37.21	31.99	27.16	23.17	20.00	17.54	15.69	14.22	13.05
	-10	29.37	23.49	18.05	13.56	10.00	7.23	5.15	3.50	2.18
	0	21.52	14.99	8.94	3.96	0.00	-3.08	-5.39	-7.22	-8.69
	10	13.67	6.49	-0.16	-5.65	-10.00	-13.39	-15.93	-17.94	-19.56
	20	5.82	-2.01	-9.27	-15.25	-20.00	-23.70	-26.47	-28.67	-30.43
	30	-2.03	-10.51	-18.37	-24.85	-30.00	-34.00	-37.01	-39.39	-41.29
	40	-9.88	-19.01	-27.48	-34.46	-40.00	-44.31	-47.54	-50.11	-52.16
100	-40	53.80	49.61	45.73	42.54	40.00	38.04	36.54	35.36	34.43
	-30	46.10	41.21	36.68	32.47	30.00	27.71	25.97	24.59	23.50
	-20	38.40	32.81	27.64	23.39	20.00	17.39	15.39	13.81	12.57
	-10	30.70	24.41	18.59	13.81	10.00	7.06	4.82	3.04	1.64
	0	23.00	16.01	9.54	4.24	0.00	-3.27	-5.76	-7.73	-9.29
	10	15.30	7.62	0.50	-5.34	-10.00	-13.59	-16.33	-18.51	-20.21
	20	7.60	-0.78	-8.55	-14.91	-20.00	-23.92	-26.91	-29.28	-31.14
	30	-0.10	-9.18	-17.59	-24.49	-30.00	-34.25	-37.49	-40.05	-42.07
	40	-7.80	-17.58	-26.64	-34.07	-40.00	-44.57	-48.06	-50.82	-53.00
200	-40	54.49	50.10	46.01	42.68	40.00	37.95	36.39	35.15	34.16
	-30	46.91	41.78	37.01	33.12	30.00	27.61	25.78	24.34	23.19
	-20	39.32	33.46	28.02	23.57	20.00	17.27	15.18	13.54	12.22
	-10	31.74	25.14	19.02	14.01	10.00	6.92	4.58	2.73	1.24
	0	24.15	16.83	10.02	4.46	0.00	-3.42	-6.02	-8.08	-9.73
	10	16.57	8.51	1.02	-5.09	-10.00	-13.76	-16.63	-18.89	-20.70
	20	8.98	0.19	-7.98	-14.65	-20.00	-24.10	-27.23	-29.70	-31.68
	30	1.40	-8.13	-16.97	-24.20	-30.00	-34.44	-37.83	-40.50	-42.65
	40	-6.19	-16.44	-25.97	-33.76	-40.00	-44.78	-48.43	-51.31	-53.62

Table 4 % error in flood estimates using method 3

Return period (Years)	% error in mean	% error in flood estimates								
		CV1 (0.436)	CV2 (0.508)	CV3 (0.581)	CV4 (0.653)	CV5 (0.726)	CV6 (0.799)	CV7 (0.871)	CV8 (0.944)	CV9 (1.016)
50	-40	54.46	50.49	46.61	43.10	40.00	37.45	35.36	33.60	32..19
	-30	46.87	42.24	37.71	33.62	30.00	27.02	24.58	22.54	20.89
	-20	39.28	33.99	28.81	24.14	20.00	16.59	13.81	11.47	9.58
	-10	31.69	25.74	19.91	14.66	10.00	6.17	3.03	0.40	-1.72
	0	24.10	17.49	11.01	5.17	0.00	-4.26	-7.74	-10.66	-13.02
	10	16.51	9.24	2.11	-4.31	-10.00	-14.68	-18.52	-21.73	-24.32
	20	8.92	0.99	-6.78	-13.79	-20.00	-25.11	-29.29	-32.79	-35.62
	30	1.33	-7.27	-15.68	-23.28	-30.00	-35.53	-40.06	-43.86	-46.92
	40	-6.26	-15.52	-24.58	-32.76	-40.00	-45.96	-50.84	-54.93	-58.23
100	-40	56.02	51.80	47.56	43.62	40.00	36.95	34.39	32.22	30.45
	-30	48.69	43.77	38.82	34.22	30.00	26.44	23.46	20.92	18.86
	-20	41.36	35.73	30.08	24.82	20.00	15.93	12.52	9.63	7.26
	-10	34.03	27.70	21.34	15.42	10.00	5.42	1.59	-1.67	-4.33
	0	26.70	19.67	12.60	6.03	0.00	-5.08	-9.35	-12.97	-15.92
	10	19.37	11.63	3.86	-3.37	-10.00	-15.59	-20.28	-24.26	-27.51
	20	12.04	3.60	-4.88	-12.77	-20.00	-26.10	-31.21	-35.56	39.11
	30	4.71	-4.44	-13.62	-22.16	-30.00	-36.61	-42.15	-46.86	-50.70
	40	-2.62	-12.47	-22.36	-31.56	-40.00	-47.12	-53.08	-58.16	-62.29
200	-40	57.36	52.96	48.42	44.10	40.00	36.48	33.45	30.85	28.71
	-30	50.26	45.12	39.83	34.78	30.00	25.89	22.36	19.33	16.83
	-20	43.15	37.28	31.23	25.47	20.00	15.30	11.27	7.81	4.94
	-10	36.04	29.44	22.64	16.15	10.00	4.71	0.17	-3.72	-6.94
	0	28.94	21.60	14.04	6.83	0.00	-5.87	-10.92	-15.24	-18.82
	10	21.83	13.76	5.45	-2.48	-10.00	-16.46	-22.01	-26.77	-30.70
	20	14.73	5.92	-3.15	-11.80	-20.00	-27.05	-33.10	-38.29	-42.58
	30	7.62	-1.92	-11.75	-21.12	-30.00	-37.63	-44.19	-49.82	-54.47
	40	0.51	-9.77	-20.34	-30.43	-40.00	-48.22	-55.29	-61.34	-66.35

Table 5 % error in flood estimates using method 4

Return period (Years)	% error in mean	% error in flood estimates								
		CV1 (0.436)	CV2 (0.508)	CV3 (0.581)	CV4 (0.653)	CV5 (0.726)	CV6 (0.799)	CV7 (0.871)	CV8 (0.944)	CV9 (1.016)
50	-40	53.57	49.66	45.97	42.76	40.00	37.81	36.03	34.56	33.42
	-30	45.83	41.30	36.96	33.22	30.00	27.45	25.37	23.66	22.32
	-20	38.10	32.91	27.96	23.68	20.00	17.08	14.70	12.75	11.22
	-10	30.36	24.53	18.95	14.14	10.00	6.72	4.04	1.84	0.12
	0	22.62	16.14	9.95	4.60	0.00	-3.65	-6.62	-9.06	-10.97
	10	14.88	7.76	0.94	-4.94	-10.00	-14.01	-17.28	-19.97	-22.07
	20	7.14	-0.63	-8.06	-14.48	-20.00	-24.38	-27.94	-30.87	-33.17
	30	-0.59	-9.02	-17.07	-24.02	-30.00	-34.74	-38.61	-41.78	-44.27
	40	-8.33	-17.40	-26.07	-33.56	-40.00	-45.10	-49.27	-52.69	-55.36
100	-40	54.63	50.53	46.53	43.04	40.00	37.55	35.51	33.86	32.52
	-30	47.07	42.28	37.62	33.55	30.00	27.14	24.76	22.83	21.27
	-20	39.50	34.03	28.71	24.06	20.00	16.73	14.01	11.81	10.02
	-10	31.94	25.79	19.80	14.57	10.00	6.32	3.26	0.78	- 1.22
	0	24.38	17.54	10.89	5.07	0.00	-4.08	-7.49	-10.24	-12.47
	10	16.82	9.30	1.98	-4.42	-10.00	-14.49	-18.24	-21.27	-23.72
	20	9.26	1.05	-6.93	-13.91	-20.00	-24.90	-28.99	-32.29	34.96
	30	1.70	-7.19	-15.84	-23.40	-30.00	-35.31	-39.73	-43.31	-46.21
	40	-5.87	-15.44	-24.75	-32.90	-40.00	-45.72	-50.48	-54.34	-57.46
200	-40	55.50	51.23	47.02	43.31	40.00	37.30	34.99	33.12	31.57
	-30	48.08	43.10	38.19	33.87	30.00	26.85	24.15	21.98	20.17
	-20	40.67	34.97	29.37	24.42	20.00	16.39	13.32	10.83	8.77
	-10	33.25	26.84	20.54	14.97	10.00	5.94	2.48	-0.31	-2.64
	0	25.83	18.71	11.71	5.52	0.00	-4.51	-8.35	-11.46	-14.04
	10	18.41	10.59	2.88	-3.92	-10.00	-14.96	-19.19	-22.61	-25.45
	20	11.00	2.46	-5.95	-13.37	-20.00	-25.41	-30.02	-33.75	-36.85
	30	3.58	-5.67	-14.78	-22.82	-30.00	-35.86	-40.86	-44.90	-48.26
	40	-3.84	-13.80	-23.61	-32.27	-40.00	-46.31	-51.70	-56.04	-59.66

Table: 6 % error in flood estimates for diffrent skewness using method-1, CV=0.436

Return period (Years)	% error in mean peak flood	% error in flood estimates				
		SK1 (2.306)	SK2 (2.595)	SK3 (2.883)	SK4 (3.171)	SK5 (3.460)
50	-40	53.61	54.23	54.89	53.52	56.16
	-30	45.88	46.60	47.37	48.11	48.85
	-20	38.15	38.97	39.85	40.70	41.55
	-10	30.42	31.34	32.33	33.29	34.24
	0	22.69	23.71	24.81	25.87	26.93
	10	14.95	16.08	17.29	18.46	19.63
	20	7.22	8.45	9.77	11.05	12.32
	30	-0.51	0.82	2.23	3.63	5.02
	40	-8.24	-6.81	-5.27	-3.78	-2.29
100	-40	54.58	55.24	55.95	56.63	57.30
	-30	47.01	47.78	48.60	49.40	50.18
	-20	39.44	40.32	41.26	42.17	43.06
	-10	31.87	32.86	33.92	34.95	35.94
	0	24.30	25.40	26.58	27.72	28.83
	10	16.72	17.94	19.23	20.49	21.71
	20	9.15	10.48	11.89	13.26	14.59
	30	1.58	3.02	4.55	6.03	7.47
	40	-5.99	-4.11	-2.79	-1.19	0.36
200	-40	55.35	56.03	56.77	57.50	58.20
	-30	47.91	48.71	49.57	50.41	51.43
	-20	40.46	41.38	42.37	43.33	44.27
	-10	33.02	34.05	35.16	36.24	37.30
	0	25.58	26.72	27.96	29.16	30.33
	10	18.14	19.40	20.75	22.08	23.37
	20	10.70	12.07	13.55	14.99	16.40
	30	3.25	4.74	6.34	7.91	9.43
	40	-4.19	-2.59	-0.86	0.82	2.47

Table: 7 % error in flood estimates for diffrent skewness using method-2, CV=0.436

Return period (Years)	% error in mean peak flood	% error in flood estimates				
		SK1 (2.306)	SK2 (2.595)	SK3 (2.883)	SK4 (3.171)	SK5 (3.460)
50	-40	52.20	53.11	53.99	54.85	55.63
	-30	44.24	45.29	46.32	47.32	48.24
	-20	36.27	37.48	38.65	39.79	40.84
	-10	28.31	29.66	30.98	32.27	33.45
	0	20.34	21.85	23.31	24.74	26.05
	10	12.38	14.03	15.65	17.22	18.66
	20	4.41	6.22	7.98	9.69	11.26
	30	-3.56	-1.60	0.31	2.16	3.86
	40	-11.52	-9.41	-7.36	-5.36	-3.53
100	-40	53.09	54.07	55.02	55.92	56.77
	-30	45.28	46.41	47.52	48.58	49.56
	-20	37.46	38.75	40.02	41.23	42.36
	-10	29.64	31.10	32.52	33.89	35.15
	0	21.82	23.44	25.03	26.54	27.95
	10	14.01	15.79	17.53	19.19	20.74
	20	6.19	8.13	10.03	11.85	13.54
	30	-1.63	0.48	2.53	4.50	6.33
	40	-9.45	-7.18	-4.96	-2.84	-0.87
200	-40	53.82	54.83	55.85	56.80	57.70
	-30	46.13	47.30	48.50	49.60	50.65
	-20	38.43	39.77	41.14	42.41	43.59
	-10	30.73	32.24	33.78	35.21	36.54
	0	23.04	24.72	26.42	28.01	29.49
	10	15.34	17.19	19.07	20.81	22.44
	20	7.65	9.66	11.71	13.61	15.39
	30	-0.05	2.13	4.35	6.41	8.34
	40	-7.75	-5.40	-3.01	-0.79	1.29

Table: 8 % error in flood estimates for diffrent skewness using method-3, CV=0.436

Return period (Years)	% error in mean peak flood	% error in flood estimates				
		SK1 (2.306)	SK2 (2.595)	SK3 (2.883)	SK4 (3.171)	SK5 (3.460)
50	-40	55.88	55.84	56.07	56.49	57.08
	-30	48.53	48.48	48.75	49.24	49.92
	-20	41.17	41.12	41.43	41.98	42.77
	-10	33.82	33.77	34.11	34.73	35.61
	0	26.47	26.41	26.78	27.48	28.46
	10	19.12	19.05	19.46	20.23	21.30
	20	11.76	11.69	12.14	12.98	14.15
	30	4.41	4.33	4.82	5.72	7.00
	40	-2.94	-3.03	-2.50	-1.73	-0.16
100	-40	59.24	58.46	58.04	57.94	58.15
	-30	52.44	51.53	51.05	50.93	51.18
	-20	45.65	44.61	44.05	43.92	44.21
	-10	38.85	37.69	37.06	36.91	37.23
	0	32.06	30.76	30.06	29.90	30.26
	10	25.27	23.84	23.07	22.89	23.28
	20	18.47	16.91	16.08	15.88	16.31
	30	11.68	9.99	9.08	8.87	9.33
	40	4.88	3.07	2.09	1.86	2.36
200	-40	62.20	60.75	59.59	58.86	58.63
	-30	55.91	54.21	52.85	52.01	51.74
	-20	49.61	47.67	46.12	45.15	44.85
	-10	43.31	41.13	39.38	38.30	37.95
	0	37.01	34.59	32.65	31.44	31.06
	10	30.71	28.05	25.91	24.59	24.16
	20	24.41	21.51	19.18	17.73	17.27
	30	18.11	14.97	12.44	10.87	10.37
	40	11.81	8.43	5.71	4.02	3.48

Table: 9 % error in flood estimates for diffrent skewness using method-4, CV=0.436

Return period (Years)	% error in mean peak flood	% error in flood estimates				
		SK1 (2.306)	SK2 (2.595)	SK3 (2.883)	SK4 (3.171)	SK5 (3.460)
50	-40	53.95	53.69	53.57	53.71	54.15
	-30	46.27	45.97	45.83	45.99	46.50
	-20	38.59	38.25	38.09	38.28	38.86
	-10	30.92	30.53	30.35	30.56	31.22
	0	23.24	22.81	22.61	22.84	23.58
	10	15.57	15.09	14.87	15.13	15.93
	20	7.89	7.37	7.13	7.41	8.29
	30	0.22	-0.35	-0.61	-0.30	0.65
	40	-7.46	-8.07	-8.34	-8.02	-6.99
100	-40	58.00	57.08	56.16	55.56	55.45
	-30	51.01	49.93	48.85	48.15	48.03
	-20	44.01	42.77	41.54	40.75	40.60
	-10	37.01	35.62	34.23	33.34	33.18
	0	30.01	28.47	26.93	25.93	25.75
	10	23.01	21.31	19.62	18.53	18.33
	20	16.01	14.16	12.31	11.12	10.90
	30	9.01	7.01	5.00	3.71	3.48
	40	2.01	-0.15	-2.30	-3.69	-3.95
200	-40	62.23	60.68	58.93	57.54	56.78
	-30	55.94	54.12	52.08	50.46	49.58
	-20	49.65	47.57	45.23	43.39	42.37
	-10	43.35	41.02	38.39	36.31	35.17
	0	37.06	34.46	31.54	29.23	27.97
	10	30.76	27.91	24.70	22.16	20.76
	20	24.47	21.36	17.85	15.08	13.56
	30	18.18	14.80	11.01	8.50	6.36
	40	11.88	8.25	4.16	0.93	-0.85

Table: 10 % error in flood estimates for diffrent skewness using method-1, CV=0.508

Return period (Years)	% error in mean peak flood	% error in flood estimates				
		SK1 (2.306)	SK2 (2.595)	SK3 (2.883)	SK4 (3.171)	SK5 (3.460)
50	-40	49.72	50.42	51.18	51.90	52.59
	-30	41.34	42.16	43.04	43.89	44.69
	-20	32.96	35.90	34.90	35.87	36.78
	-10	24.58	25.64	26.76	27.86	28.88
	0	16.20	17.37	18.63	19.84	20.98
	10	7.82	9.11	10.49	11.82	13.08
	20	-0.56	0.85	2.35	3.81	5.17
	30	-8.94	-7.41	-5.79	-4.21	-2.73
	40	-17.32	-15.68	-13.92	-12.22	-10.63
100	-40	50.41	51.17	51.98	52.77	53.49
	-30	42.14	43.04	43.98	44.89	45.74
	-20	33.88	34.90	35.97	37.02	37.99
	-10	25.61	26.76	27.97	29.15	30.23
	0	17.35	18.62	19.97	21.28	22.48
	10	9.08	10.49	11.96	13.40	14.73
	20	0.82	2.35	3.96	5.53	6.98
	30	-7.45	-5.79	-4.04	-2.34	-0.77
	40	-15.71	-13.93	-12.05	-10.21	-8.52
200	-40	50.96	51.75	52.60	53.43	54.19
	-30	42.79	43.71	44.70	45.67	46.56
	-20	34.61	35.67	36.80	37.91	38.92
	-10	26.44	27.63	28.90	30.15	31.29
	0	18.27	19.59	21.01	22.39	23.65
	10	10.09	11.55	13.11	14.63	16.02
	20	1.92	3.51	5.21	6.87	8.38
	30	-6.25	-4.53	-2.69	-0.89	0.75
	40	-14.43	-12.57	-10.59	-8.65	-6.89

Table: 11 % error in flood estimates for diffrent skewness using method-2, CV=0.508

Return period (Years)	% error in mean peak flood	% error in flood estimates				
		SK1 (2.306)	SK2 (2.595)	SK3 (2.883)	SK4 (3.171)	SK5 (3.460)
50	-40	48.42	49.49	50.54	51.51	52.42
	-30	39.83	41.07	42.30	43.43	44.49
	-20	31.23	32.66	34.05	35.35	36.56
	-10	22.63	24.24	25.81	27.27	28.63
	0	14.04	15.82	17.57	19.19	20.70
	10	5.44	7.40	9.32	11.11	12.77
	20	-3.16	-1.02	1.08	3.03	4.84
	30	-11.75	-9.43	-7.16	-5.05	-3.09
	40	-20.35	-17.85	-15.41	-13.13	-11.02
100	-40	49.04	50.18	51.30	52.35	53.33
	-30	40.55	41.88	43.18	44.41	45.55
	-20	32.05	33.57	35.07	36.47	37.77
	-10	23.56	25.27	26.95	28.53	29.99
	0	15.07	16.97	18.83	20.59	22.21
	10	6.57	8.66	10.71	12.65	14.43
	20	-1.92	0.36	2.60	4.71	6.65
	30	-10.42	-7.94	-5.52	-3.23	-1.13
	40	-18.91	-16.25	-13.14	-11.17	-8.91
200	-40	49.55	50.75	51.92	53.04	54.07
	-30	41.14	42.54	43.91	45.22	46.41
	-20	32.73	34.33	35.90	37.39	38.76
	-10	24.33	26.12	27.89	29.57	31.10
	0	15.92	17.91	19.87	21.74	23.45
	10	7.91	9.70	11.86	13.91	15.79
	20	-0.90	1.49	3.85	6.09	8.14
	30	-9.31	-6.72	-4.16	-1.74	0.48
	40	-17.72	-14.92	-12.18	-9.56	-7.17

Table: 12 % error in flood estimates for diffrent skewness using method-3, CV=0.508

Return period (Years)	% error in mean peak flood	% error in flood estimates				
		SK1 (2.306)	SK2 (2.595)	SK3 (2.883)	SK4 (3.171)	SK5 (3.460)
50	-40	51.84	51.98	52.09	52.60	53.27
	-30	43.82	43.97	44.11	44.70	45.48
	-20	35.79	35.97	36.12	36.80	37.69
	-10	27.77	27.97	28.14	28.90	29.90
	0	19.74	19.96	20.15	21.00	22.11
	10	11.72	11.96	12.17	13.10	14.32
	20	3.69	3.95	4.18	5.21	6.53
	30	-4.34	-4.05	-3.80	-2.69	-1.26
	40	-12.36	-12.05	-11.79	-10.59	-9.05
100	-40	54.94	54.06	53.57	53.47	53.70
	-30	47.43	46.40	45.83	45.71	43.98
	-20	39.92	38.75	38.09	37.96	38.26
	-10	32.41	31.09	30.35	30.02	30.55
	0	24.90	23.43	22.61	22.45	22.83
	10	17.39	15.78	14.88	14.69	15.11
	20	9.88	8.12	7.14	6.94	7.40
	30	2.37	0.46	-0.60	-0.82	-0.32
	40	-5.14	-7.20	-8.34	-8.57	-8.04
200	-40	57.88	56.10	54.74	53.90	53.59
	-30	50.86	48.78	47.20	46.21	45.86
	-20	43.83	41.46	39.66	38.53	38.12
	-10	36.81	34.14	32.12	30.85	30.39
	0	29.79	26.83	24.57	23.16	22.65
	10	22.77	19.51	17.03	15.48	14.92
	20	15.75	12.19	9.49	7.80	7.18
	30	8.73	4.87	1.95	0.11	-0.55
	40	1.71	-2.44	-5.60	-7.57	-8.29

Table: 13 % error in flood estimates for diffrent skewness using method-4, CV=0.508

Return period (Years)	% error in mean peak flood	% error in flood estimates				
		SK1 (2.306)	SK2 (2.595)	SK3 (2.883)	SK4 (3.171)	SK5 (3.460)
50	-40	49.87	49.45	49.21	49.41	49.95
	-30	41.52	41.03	40.75	40.98	41.61
	-20	33.16	32.60	32.28	32.55	33.27
	-10	24.81	24.18	23.82	24.12	24.93
	0	16.45	15.75	15.35	15.68	16.98
	10	8.10	7.33	6.89	7.25	8.24
	20	-0.26	-1.10	-1.58	-1.18	-0.10
	30	-8.61	-9.52	-10.04	-9.61	-8.44
	40	-16.97	-17.95	-18.51	-18.04	-16.78
100	-40	53.95	52.65	51.36	50.67	50.62
	-30	46.27	44.75	43.25	42.45	42.39
	-20	38.59	36.86	35.15	34.23	34.17
	-10	30.92	28.97	27.04	26.01	25.94
	0	23.24	21.08	18.93	17.79	17.71
	10	15.57	13.18	10.83	9.56	9.48
	20	7.89	5.29	2.72	1.34	1.25
	30	0.22	-2.60	-5.39	-6.88	-6.98
	40	-7.46	-10.49	-13.49	-15.10	-15.21
200	-40	58.35	56.22	53.86	52.22	51.49
	-30	51.41	48.92	46.17	44.26	43.40
	-20	44.47	41.62	38.48	36.29	35.31
	-10	37.92	34.32	30.79	28.33	27.23
	0	30.98	27.03	23.11	20.37	19.14
	10	23.64	19.73	15.42	12.40	11.06
	20	16.70	12.43	7.73	4.44	2.97
	30	9.76	5.14	0.04	-3.52	-5.12
	40	2.82	-2.16	-7.65	-11.49	-13.20

Table: 14 % error in flood estimates for diffrent skewness using method-1, CV=0.581

Return period (Years)	% error in mean peak flood	% error in flood estimates				
		SK1 (2.306)	SK2 (2.595)	SK3 (2.883)	SK4 (3.171)	SK5 (3.460)
50	-40	45.76	46.58	47.49	48.33	49.06
	-30	36.72	37.67	38.74	39.72	40.57
	-20	27.68	28.77	29.98	31.11	32.08
	-10	18.64	19.87	21.23	22.50	23.54
	0	9.60	10.96	12.48	13.88	15.10
	10	0.56	2.06	3.73	5.27	6.61
	20	-8.48	-6.84	-5.02	-3.34	-1.88
	30	-17.52	-15.75	-13.77	-11.95	-10.37
	40	-26.56	-24.65	-22.53	-20.56	-18.86
100	-40	46.18	47.05	48.05	48.94	49.70
	-30	37.21	38.22	39.35	40.43	41.32
	-20	28.24	29.40	30.68	31.92	32.94
	-10	19.17	20.57	22.02	23.41	24.56
	0	10.30	11.74	13.36	14.90	16.17
	10	1.33	2.92	4.69	6.39	7.79
	20	-7.64	-5.91	-3.97	-2.12	-0.59
	30	-16.61	-14.73	-12.64	-10.63	-8.97
	40	-25.58	-23.56	-21.30	-19.14	-17.36
200	-40	46.50	47.42	48.43	49.41	50.22
	-30	37.58	38.66	39.84	40.98	41.92
	-20	28.67	29.89	31.24	32.54	33.63
	-10	19.75	21.13	22.65	24.11	25.33
	0	10.83	12.37	14.05	15.68	17.03
	10	1.92	3.61	5.46	7.25	8.71
	20	-7.00	-5.16	-3.14	-1.19	0.44
	30	-15.92	-13.92	-11.73	-9.62	-7.86
	40	-24.83	-22.68	-20.33	-18.05	-16.15

Table: 15 % error in flood estimates for diffrent skewness using method-2, CV=0.581

Return period (Years)	% error in mean peak flood	% error in flood estimates				
		SK1 (2.306)	SK2 (2.595)	SK3 (2.883)	SK4 (3.171)	SK5 (3.460)
50	-40	44.59	45.83	47.02	48.16	49.18
	-30	35.36	36.80	38.19	39.52	40.71
	-20	26.12	27.77	29.36	30.88	32.24
	-10	16.89	18.74	20.53	22.24	23.77
	0	7.65	9.71	11.70	13.60	15.31
	10	-1.58	0.69	2.87	4.96	6.84
	20	-10.82	-8.34	-5.96	-3.68	-1.63
	30	-20.05	-17.37	-14.79	-12.32	-10.10
	40	-29.29	-26.40	-23.65	-20.96	-18.57
100	-40	44.92	46.23	47.52	48.74	49.86
	-30	35.74	37.27	38.77	40.20	41.51
	-20	26.56	28.31	30.02	31.66	33.15
	-10	17.38	19.35	21.28	23.12	24.79
	0	8.20	10.38	12.53	14.57	16.44
	10	-0.98	1.42	3.78	6.03	8.08
	20	-10.16	-7.54	-4.96	-2.51	-0.27
	30	-19.34	-16.50	-13.71	-11.06	-8.63
	40	-28.52	-25.46	-22.46	-19.60	-16.99
200	-40	45.20	46.59	47.94	49.25	50.41
	-30	36.07	37.69	39.26	40.79	42.14
	-20	26.94	28.78	30.58	32.33	33.87
	-10	17.80	19.88	21.99	23.87	25.61
	0	8.67	10.98	13.23	15.41	17.34
	10	-0.46	2.08	4.55	6.95	9.08
	20	-9.59	-6.82	-4.13	-1.51	0.81
	30	-18.73	-15.72	-12.80	-9.97	-7.46
	40	-27.86	-24.63	-21.48	-18.42	-15.72

Table: 16 % error in flood estimates for diffrent skewness using method-3, CV=0.581

Return period (Years)	% error in mean peak flood	% error in flood estimates				
		SK1 (2.306)	SK2 (2.595)	SK3 (2.883)	SK4 (3.171)	SK5 (3.460)
50	-40	47.75	47.73	48.05	48.66	49.44
	-30	39.04	39.02	39.40	40.10	41.01
	-20	30.33	30.31	30.74	31.55	32.58
	-10	21.63	21.60	22.08	22.99	24.16
	0	12.92	12.89	13.42	14.43	15.73
	10	4.21	4.18	4.77	5.88	7.30
	20	-4.50	-4.54	-3.89	-2.68	-1.12
	30	-13.21	-13.25	-12.55	-11.24	-9.55
	40	-21.91	-21.96	-21.21	-19.79	-17.98
100	-40	50.60	49.60	49.06	48.94	49.21
	-30	42.36	41.20	40.56	40.43	40.75
	-20	34.13	32.80	32.07	31.92	32.29
	-10	25.90	24.41	23.58	23.41	23.82
	0	17.66	16.01	15.09	14.90	15.36
	10	9.43	7.61	6.60	6.39	6.89
	20	1.20	-0.79	-1.89	-2.12	-1.57
	30	-7.04	-9.19	-10.38	-10.63	-10.04
	40	-15.27	-17.59	-18.87	-19.14	-18.50
200	-40	53.40	51.38	49.83	48.87	48.49
	-30	45.64	43.28	41.47	40.34	39.91
	-20	37.87	35.18	33.11	31.82	31.32
	-10	30.11	27.07	24.75	23.30	22.74
	0	22.34	18.97	16.39	14.78	14.15
	10	14.57	10.87	8.03	6.26	5.57
	20	6.81	2.77	-0.33	-2.27	-3.01
	30	-0.96	-5.34	-8.69	-10.79	-11.60
	40	-8.72	-13.44	-17.06	-19.31	-20.18

Table: 17 % error in flood estimates for diffrent skewness using method-4, CV=0.581

Return period (Years)	% error in mean peak flood	% error in flood estimates				
		SK1 (2.306)	SK2 (2.595)	SK3 (2.883)	SK4 (3.171)	SK5 (3.460)
50	-40	45.71	45.31	45.03	45.07	45.68
	-30	36.67	36.20	35.87	35.92	36.62
	-20	27.62	27.09	26.71	26.77	27.57
	-10	18.57	17.97	17.55	17.61	18.51
	0	9.52	8.86	8.39	8.46	9.46
	10	0.48	-0.26	-0.77	-0.70	0.40
	20	-8.57	-9.37	-9.93	-9.85	-8.65
	30	-17.62	-18.48	-19.09	-19.00	-17.71
	40	-26.67	-27.60	-28.25	-28.16	-26768
100	-40	49.78	48.18	46.49	45.56	45.64
	-30	41.41	39.54	37.57	36.49	36.58
	-20	33.04	30.91	28.65	27.42	27.52
	-10	24.67	22.27	19.73	18.34	18.46
	0	16.30	13.63	10.81	9.27	9.40
	10	7.93	5.00	1.89	0.20	0.34
	20	0.44	-3.64	-7.03	-8.87	-8.72
	30	-8.81	-12.28	-15.94	-17.95	-17.78
	40	-17.18	-20.91	-24.86	-27.02	-26.84
200	-40	54.32	51.56	48.38	46.44	45.92
	-30	46.70	43.49	39.78	37.51	36.91
	-20	39.09	35.41	31.18	28.58	27.89
	-10	31.39	27.34	22.58	19.65	18.88
	0	23.86	19.26	13.97	10.73	9.87
	10	16.25	11.19	5.37	1.80	0.85
	20	8.63	3.12	-3.23	-7.13	-8.16
	30	1.02	-4.96	-11.83	-16.06	-17.17
	40	-6.59	-13.03	-20.44	-24.98	-26.19

Table: 18 % error in flood estimates for diffrent skewness using method-1, CV=0.653

Return period (Years)	% error in mean peak flood	% error in flood estimates				
		SK1 (2.306)	SK2 (2.595)	SK3 (2.883)	SK4 (3.171)	SK5 (3.460)
50	-40	41.87	42.78	43.71	44.67	45.55
	-30	32.18	33.24	34.33	35.44	36.48
	-20	22.49	23.70	24.95	26.22	27.41
	-10	12.80	14.17	15.57	17.00	18.33
	0	3.11	4.63	6.18	7.78	9.26
	10	-6.58	-4.91	-3.20	-1.45	0.18
	20	-16.27	-14.45	-12.58	-10.67	-8.19
	30	-25.96	-23.98	-21.96	-19.89	-17.97
	40	-35.64	-33.52	-31.34	-29.11	-27.04
100	-40	41.99	42.98	43.99	44.99	45.94
	-30	32.33	33.48	34.65	35.83	36.93
	-20	22.66	23.97	25.32	26.66	27.92
	-10	12.99	14.47	15.98	17.49	18.91
	0	3.32	4.97	6.64	8.32	9.90
	10	-6.35	-4.54	-2.69	-0.85	-0.89
	20	-16.01	-14.04	-12.03	-10.01	-8.12
	30	-25.68	-23.54	-21.36	-19.18	-17.13
	40	-35.35	-33.05	-30.70	-28.35	-26.14
200	-40	42.11	43.14	44.21	45.27	46.27
	-30	32.46	33.68	34.91	36.15	37.31
	-20	22.82	24.19	25.61	27.03	28.35
	-10	13.17	14.71	16.31	17.91	19.40
	0	3.52	5.24	7.01	8.79	10.44
	10	-6.13	-4.24	-2.29	-0.33	1.49
	20	-15.77	-13.72	-11.59	-9.46	-7.47
	30	-25.42	-23.17	-20.88	-18.58	-16.42
	40	-35.07	-32.68	-30.18	-27.70	-25.38

Table: 19 % error in flood estimates for diffrent skewness using method-2, CV=0.653

Return period (Years)	% error in mean peak flood	% error in flood estimates				
		SK1 (2.306)	SK2 (2.595)	SK3 (2.883)	SK4 (3.171)	SK5 (3.460)
50	-40	40.81	42.19	43.54	44.81	46.00
	-30	30.94	32.55	34.14	35.61	36.99
	-20	21.08	22.92	24.73	26.41	27.99
	-10	11.21	13.28	15.32	17.21	18.99
	0	1.35	3.65	5.91	8.01	9.99
	10	-8.52	-5.99	-3.50	-1.19	0.99
	20	-18.38	-15.62	-12.91	-10.39	-8.01
	30	-28.25	-25.26	-22.32	-19.59	-17.01
	40	-38.11	-34.89	-31.73	-28.79	-26.01
100	-40	40.84	42.34	43.78	45.15	46.42
	-30	30.99	32.73	34.41	36.01	37.49
	-20	21.13	23.13	25.04	26.87	28.56
	-10	11.27	13.52	15.67	17.73	19.63
	0	1.41	3.91	6.30	8.59	10.70
	10	-8.45	-5.70	-3.07	-0.55	1.77
	20	-18.31	-15.31	-12.44	-9.69	-7.16
	30	-28.17	-24.92	-21.81	-18.83	-16.09
	40	-38.03	-34.53	-31.18	-27.98	-25.02
200	-40	40.91	42.47	44.01	45.45	46.72
	-30	31.06	32.88	34.68	36.36	37.91
	-20	21.22	23.29	25.34	27.27	29.04
	-10	11.37	13.70	16.01	18.17	20.17
	0	1.52	4.11	6.62	9.08	11.30
	10	-8.33	-5.47	-2.66	-0.01	2.43
	20	-18.18	-15.06	-11.99	-9.10	-6.44
	30	-28.03	-24.65	-21.32	-18.19	-15.31
	40	-37.87	-34.27	-30.65	-27.28	-24.18

Table: 20 % error in flood estimates for diffrent skewness using method-3, CV=0.653

Return period (Years)	% error in mean peak flood	% error in flood estimates				
		SK1 (2.306)	SK2 (2.595)	SK3 (2.883)	SK4 (3.171)	SK5 (3.460)
50	-40	43.68	43.68	44.06	44.74	45.65
	-30	34.29	34.29	34.73	35.53	36.59
	-20	24.90	24.90	25.41	26.32	27.53
	-10	15.51	15.51	16.08	17.11	18.47
	0	6.13	6.13	6.76	7.90	9.41
	10	-3.26	-3.26	-2.56	-1.31	0.35
	20	-12.65	-12.65	-11.89	-10.32	-8.70
	30	-22.03	-22.03	-21.21	-19.73	-17.76
	40	-31.42	-31.42	-30.54	-28.95	-26.82
100	-40	46.29	45.18	44.56	44.43	44.74
	-30	37.33	36.04	35.32	33.16	35.53
	-20	28.38	26.90	26.08	25.90	26.33
	-10	19.43	17.76	16.83	16.64	17.12
	0	10.81	8.63	7.59	7.38	7.91
	10	1.53	-0.51	-1.65	-1.88	1.30
	20	-7.43	-9.65	-10.89	-11.15	-10.51
	30	-16.38	-18.78	-20.13	-20.41	-19.72
	40	-25.33	-27.92	-29.37	-29.67	-28.93
200	-40	48.97	46.70	44.96	43.82	43.43
	-30	40.46	37.82	35.78	34.46	34.00
	-20	31.95	28.94	26.61	25.10	24.57
	-10	23.45	20.05	17.43	15.74	15.14
	0	14.94	11.17	8.26	6.37	5.71
	10	6.44	2.27	-0.92	-2.99	-3.72
	20	-2.07	-6.60	-10.09	-12.35	-13.14
	30	-10.57	-15.48	-19.26	-21.72	-22.57
	40	-19.08	-24.36	-28.44	-31.08	-32.00

Table:21 % error in flood estimates for diffrent skewness using method-4, CV=0.653

Return period (Years)	% error in mean peak flood	% error in flood estimates				
		SK1 (2.306)	SK2 (2.595)	SK3 (2.883)	SK4 (3.171)	SK5 (3.460)
50	-40	41.62	41.58	41.80	41.38	41.44
	-30	31.89	31.84	32.10	31.61	31.68
	-20	22.16	22.10	22.40	21.84	21.92
	-10	12.43	12.37	12.70	12.07	12.16
	0	2.70	2.63	3.00	2.30	2.40
	10	-7.03	-7.11	-6.70	-7.47	-7.36
	20	-16.76	-16.84	-16.40	-17.24	-17.12
	30	-26.49	-26.58	-26.10	-27.01	-26.88
	40	-36.22	-36.32	-35.80	-36.78	-36.64
100	-40	45.61	43.96	42.35	40.88	40.55
	-30	36.54	34.63	32.74	31.02	30.64
	-20	27.48	25.29	23.13	21.17	20.73
	-10	18.41	15.95	13.53	11.32	10.82
	0	9.35	6.61	3.92	1.46	0.91
	10	0.28	-2.73	-5.69	-8.39	-8.99
	20	-8.78	-12.07	-15.30	-18.24	-18.90
	30	-17.85	-21.41	-24.91	-28.10	-28.81
	40	-26.91	-30.75	-34.52	-37.95	-38.72
200	-40	50.23	46.86	43.22	40.74	40.05
	-30	41.95	38.01	33.76	30.86	30.06
	-20	33.65	29.15	24.30	20.98	20.07
	-10	25.35	20.30	14.84	11.10	10.07
	0	17.06	11.44	5.37	1.23	0.08
	10	8.76	2.58	-4.09	-8.65	-9.91
	20	0.47	-6.27	-13.55	-18.53	-19.90
	30	-7.82	-15.13	-23.02	-28.41	-29.89
	40	-16.12	-23.98	-32.48	-38.28	-39.89

Table: 22 % error in flood estimates for diffrent skewness using method-1, CV=0.726

Return period (Years)	% error in mean peak flood	% error in flood estimates				
		SK1 (2.306)	SK2 (2.595)	SK3 (2.883)	SK4 (3.171)	SK5 (3.460)
50	-40	37.88	38.95	40.00	41.05	41.91
	-30	27.53	28.78	30.00	31.22	32.23
	-20	17.18	18.60	20.00	21.40	22.55
	-10	6.82	8.43	10.00	11.57	12.87
	0	-3.52	-1.75	0.00	1.75	3.19
	10	-13.88	-11.92	-10.00	-8.08	-6.49
	20	-24.23	-22.09	-20.00	-17.91	-16.18
	30	-34.59	-32.27	-30.00	-27.73	-25.86
	40	-44.94	-42.44	-40.00	-37.56	-35.54
100	-40	37.74	38.89	40.00	41.13	42.05
	-30	27.37	28.71	30.00	31.32	32.40
	-20	16.99	18.52	20.00	21.50	22.74
	-10	6.62	8.34	10.00	11.69	13.08
	0	-3.76	-1.85	0.00	1.88	3.42
	10	-14.13	-12.03	-10.00	-7.93	-6.23
	20	-24.51	-22.21	-20.00	-17.74	-15.89
	30	-34.89	-32.40	-30.00	-27.56	-25.55
	40	-45.26	-42.58	-40.00	-37.37	-35.21
200	-40	37.63	38.84	40.00	41.19	42.17
	-30	27.24	28.65	30.00	31.39	32.53
	-20	16.85	18.46	20.00	21.59	22.89
	-10	6.45	8.27	10.00	11.79	13.25
	0	-3.94	-1.93	0.00	1.99	3.61
	10	-14.34	-12.12	-10.00	-7.82	-6.03
	20	-24.73	-22.31	-20.00	-17.62	-15.67
	30	-35.12	-32.50	-30.00	-27.42	-25.31
	40	-45.52	-42.70	-40.00	-37.22	-34.94

Table:23 % error in flood estimates for diffrent skewness using method-2, CV=0.726

Return period (Years)	% error in mean peak flood	% error in flood estimates				
		SK1 (2.306)	SK2 (2.595)	SK3 (2.883)	SK4 (3.171)	SK5 (3.460)
50	-40	36.95	38.50	40.00	41.43	42.76
	-30	26.45	28.25	30.00	31.67	33.22
	-20	15.94	18.00	20.00	21.90	23.68
	-10	5.43	7.75	10.00	12.14	14.14
	0	-5.08	-2.50	0.00	2.38	4.60
	10	-15.58	-12.75	-10.00	-7.38	-4.94
	20	-26.09	-23.00	-20.00	-17.15	-14.48
	30	-36.60	-33.25	-30.00	-26.91	-24.02
	40	-47.11	-43.50	-40.00	-36.67	-33.56
100	-40	36.71	38.37	40.00	41.52	42.96
	-30	26.16	28.10	30.00	31.77	33.45
	-20	15.61	17.83	20.00	22.03	23.94
	-10	5.06	7.56	10.00	12.28	14.44
	0	-5.49	-2.71	0.00	2.53	4.93
	10	-16.04	-12.98	-10.00	-7.21	-4.98
	20	-26.59	-23.25	-20.00	-16.96	-14.09
	30	-37.14	-33.52	-30.00	-26.71	-23.59
	40	-47.69	-43.79	-40.00	-36.45	-33.10
200	-40	36.54	38.29	40.00	41.61	43.11
	-30	25.97	28.01	30.00	31.88	33.63
	-20	15.39	17.72	20.00	22.15	24.15
	-10	4.82	7.44	10.00	12.42	14.67
	0	-5.76	-2.85	0.00	2.69	5.19
	10	-16.34	-13.13	-10.00	-7.04	-4.29
	20	-26.91	-23.42	-20.00	-16.77	-13.77
	30	-37.49	-33.70	-30.00	-26.50	-23.25
	40	-48.06	-43.99	-40.00	-36.23	-32.73

Table:24 % error in flood estimates for diffrent skewness using method-3, CV=0.726

Return period (Years)	% error in mean peak flood	% error in flood estimates				
		SK1 (2.306)	SK2 (2.595)	SK3 (2.883)	SK4 (3.171)	SK5 (3.460)
50	-40	39.56	39.56	40.00	40.78	41.80
	-30	29.49	29.49	30.00	30.91	32.10
	-20	19.42	19.42	20.00	21.04	22.40
	-10	9.35	9.35	10.00	11.17	12.70
	0	-0.73	-0.73	0.00	1.30	3.00
	10	-10.80	-10.80	-10.00	-8.58	-6.70
	20	-20.87	-20.87	-20.00	-18.45	-16.40
	30	-30.94	-30.94	-30.00	-28.32	-26.10
	40	-41.02	-41.02	-40.00	-38.19	-35.80
100	-40	41.90	40.69	40.00	39.87	40.23
	-30	32.32	30.81	30.00	29.85	30.27
	-20	22.54	20.94	20.00	19.83	20.31
	-10	12.86	11.04	10.00	9.81	10.35
	0	3.17	1.15	0.00	-0.22	-0.38
	10	-6.51	-8.73	-10.00	-10.24	-9.58
	20	-16.19	-18.62	-20.00	-20.26	-19.54
	30	-25.88	-28.50	-30.00	-30.28	-29.50
	40	-35.56	-38.39	-40.00	-40.30	-39.46
200	-40	44.47	41.94	40.00	38.76	38.28
	-30	35.22	32.27	30.00	28.55	27.99
	-20	25.96	22.59	20.00	18.34	17.70
	-10	16.71	12.92	10.00	8.14	7.41
	0	7.45	3.24	0.00	-2.07	-2.87
	10	-1.80	-6.43	-10.00	-12.28	-13.16
	20	-11.06	-16.11	-20.00	-22.48	-23.45
	30	-20.31	-25.79	-30.00	-32.69	-33.74
	40	-29.57	-35.46	-40.00	-42.90	-44.02

Table:25 % error in flood estimates for diffrent skewness using method-4, CV=0.726

Return period (Years)	% error in mean peak flood	% error in flood estimates				
		SK1 (2.306)	SK2 (2.595)	SK3 (2.883)	SK4 (3.171)	SK5 (3.460)
50	-40	37.70	38.10	40.00	38.40	37.48
	-30	27.32	27.79	30.00	28.14	27.06
	-20	16.94	17.47	20.00	17.87	16.64
	-10	6.55	7.15	10.00	7.60	6.22
	0	-3.83	-3.16	0.00	-2.66	-4.20
	10	-14.21	-13.48	-10.00	-12.93	-14.62
	20	-24.60	-23.80	-20.00	-23.20	-25.03
	30	-34.98	-34.11	-30.00	-33.46	-35.45
	40	-45.36	-44.43	-40.00	-43.73	-45.87
100	-40	41.61	40.28	40.00	36.82	35.57
	-30	31.88	30.33	30.00	26.29	24.83
	-20	22.15	20.38	20.00	15.76	14.09
	-10	12.42	10.42	10.00	5.23	3.35
	0	2.69	0.47	0.00	-5.30	-7.39
	10	-7.04	-9.48	-10.00	-15.83	-18.13
	20	-16.77	-19.44	-20.00	-26.36	-28.87
	30	-26.50	-29.39	-30.00	-36.89	-39.61
	40	-36.23	-39.34	-40.00	-47.42	-50.35
200	-40	46.24	42.94	40.00	35.33	34.02
	-30	37.28	33.43	30.00	24.55	23.02
	-20	28.32	23.92	20.00	13.77	12.02
	-10	19.36	14.41	10.00	2.99	1.03
	0	10.40	4.90	0.00	-7.78	-9.97
	10	1.44	-4.61	-10.00	-18.56	-20.97
	20	-7.52	-14.12	-20.00	-29.34	-31.96
	30	-16.48	-23.63	-30.00	-40.12	-42.96
	40	-25.44	-33.14	-40.00	-50.90	-53.96

Table: 26 % error in flood estimates for diffrent skewness using method-1, CV=0.799

Return period (Years)	% error in mean peak flood	% error in flood estimates				
		SK1 (2.306)	SK2 (2.595)	SK3 (2.883)	SK4 (3.171)	SK5 (3.460)
50	-40	33.90	35.04	36.22	37.36	38.43
	-30	22.88	24.26	25.59	26.92	28.17
	-20	11.87	13.44	14.96	16.48	17.91
	-10	0.85	2.63	4.33	6.04	7.64
	0	-10.17	-8.19	-6.30	-4.40	-2.62
	10	-21.18	-19.01	-16.93	-14.84	-12.88
	20	-32.20	-29.83	-27.56	-25.28	-23.14
	30	-43.22	-40.65	-38.19	-35.72	-33.40
	40	-54.23	-51.47	-48.82	-46.16	-43.66
100	-40	33.48	34.74	35.97	37.18	38.31
	-30	22.39	23.87	25.30	26.71	28.03
	-20	11.30	12.99	14.63	16.24	17.74
	-10	0.21	2.12	3.96	5.77	7.46
	0	-10.87	-8.76	-6.71	-4.70	-2.82
	10	-21.96	-19.63	-17.38	-15.17	-13.10
	20	-33.05	-30.51	-28.05	-25.64	-23.38
	30	-44.13	-41.39	-38.72	-36.11	-35.66
	40	-55.22	-52.26	-49.40	-46.58	-43.95
200	-40	33.16	34.49	35.77	37.04	38.25
	-30	22.02	23.58	25.07	26.55	27.96
	-20	10.88	12.66	14.37	16.05	17.66
	-10	-0.26	1.74	3.66	5.56	7.37
	0	-11.41	-9.18	-7.04	-4.94	-2.92
	10	-22.55	-20.10	-17.75	-15.43	-13.21
	20	-33.69	-31.01	-28.45	-25.92	-23.50
	30	-44.83	-41.93	-39.15	-36.42	-33.29
	40	-55.97	-52.85	-49.86	-46.91	-44.09

Table:27 % error in flood estimates for diffrent skewness using method-2, CV=0.799

Return period (Years)	% error in mean peak flood	% error in flood estimates				
		SK1 (2.306)	SK2 (2.595)	SK3 (2.883)	SK4 (3.171)	SK5 (3.460)
50	-40	33.08	34.79	36.46	37.19	39.50
	-30	21.92	23.92	25.86	26.72	29.42
	-20	10.77	13.05	15.27	16.26	19.33
	-10	-0.38	2.18	4.68	5.79	9.25
	0	-11.54	-8.68	-5.91	-4.68	-0.83
	10	-22.69	-19.55	-16.50	-15.15	-10.92
	20	-35.85	-30.42	-27.09	-25.61	-21.00
	30	-45.00	-41.29	-37.68	-36.08	-31.08
	40	-56.15	-52.16	-48.27	-46.55	-41.17
100	-40	32.54	34.38	36.20	37.89	39.45
	-30	21.30	23.45	25.56	27.54	29.36
	-20	10.06	12.51	14.93	17.18	19.27
	-10	-1.18	1.57	4.30	6.83	9.18
	0	-12.43	-9.36	-6.34	-3.52	-0.52
	10	-23.67	-20.30	-16.97	-13.87	-11.01
	20	-34.91	-31.24	-27.60	-24.22	-21.10
	30	-46.15	-422.17	-38.24	-34.54	-31.19
	40	-57.40	-53.11	-48.87	-44.93	-41.28
200	-40	32.16	34.09	35.99	37.78	39.43
	-30	20.85	23.11	25.33	27.41	29.34
	-20	9.54	12.13	14.66	17.04	19.24
	-10	-1.76	1.14	3.99	6.67	9.15
	0	-13.07	-9.84	-6.68	-3.70	-0.95
	10	-24.38	-20.83	-17.34	-14.07	-11.04
	20	-35.68	-31.81	-28.01	-24.44	-21.14
	30	-46.99	-42.77	-38.68	-34.81	-31.23
	40	-58.30	-53.78	-49.35	-45.18	-41.33

Table: 28 % error in flood estimates for diffrent skewness using method-3, CV=0.799

Return period (Years)	% error in mean peak flood	% error in flood estimates				
		SK1 (2.306)	SK2 (2.595)	SK3 (2.883)	SK4 (3.171)	SK5 (3.460)
50	-40	39.39	35.43	35.94	36.82	37.93
	-30	24.63	24.67	25.27	26.29	27.59
	-20	13.86	13.91	14.59	15.75	17.25
	-10	3.09	3.15	3.92	5.22	6.90
	0	-18.44	-18.37	-17.44	-15.84	-13.79
	10	-18.44	-18.37	-17.44	-15.84	-13.79
	20	-29.21	-29.13	-28.11	-26.37	-24.13
	30	-39.98	-39.90	-38.79	-36.90	-34.48
	40	-50.75	-50.66	-49.46	-47.43	-44.82
100	-40	37.49	36.18	35.50	35.30	35.66
	-30	27.07	25.54	24.75	24.52	24.94
	-20	16.65	14.91	14.00	13.73	14.21
	-10	6.24	4.27	3.25	2.95	3.49
	0	-4.18	-6.37	-7.50	-7.83	-7.23
	10	-14.60	-17.01	-18.25	-18.62	-17.96
	20	-25.02	-27.64	-29.00	-29.40	-28.68
	30	-35.44	-38.26	-39.75	-40.19	-39.40
	40	-45.85	-48.92	-50.50	-50.97	-50.13
200	-40	39.93	37.17	35.06	33.66	33.06
	-30	29.92	26.61	24.23	22.60	21.90
	-20	19.91	16.22	13.41	11.55	10.74
	-10	9.90	5.75	2.58	0.49	-0.42
	0	-0.11	-4.72	-8.24	-10.57	-11.57
	10	-10.12	-15.20	-19.06	-21.62	-22.73
	20	-20.13	-25.67	-29.89	-32.68	-35.89
	30	-30.14	-36.14	-40.79	-43.74	-45.04
	40	-40.15	-46.61	-51.54	-54.79	-56.20

Table:29 % error in flood estimates for diffrent skewness using method-4, CV=0.799

Return period (Years)	% error in mean peak flood	% error in flood estimates				
		SK1 (2.306)	SK2 (2.595)	SK3 (2.883)	SK4 (3.171)	SK5 (3.460)
50	-40	33.77	34.21	35.14	36.92	33.71
	-30	22.73	23.24	24.34	26.41	22.66
	-20	11.69	12.27	13.53	15.90	11.61
	-10	0.65	1.31	2.72	5.38	0.56
	0	-10.39	-9.66	-8.09	-5.31	-10.49
	10	-21.43	-20.22	-18.90	-15.64	-21.54
	20	-32.47	-31.59	-29.71	-26.15	-32.59
	30	-43.51	-42.55	-40.52	-36.67	-43.64
	40	-54.55	-53.52	-51.53	-47.18	-54.69
100	-40	37.73	36.77	35.27	34.55	30.57
	-30	27.35	26.23	24.48	23.64	18.99
	-20	16.97	15.70	13.69	12.73	7.42
	-10	6.59	5.16	2.90	1.82	-4.15
	0	-3.79	-5.38	-7.89	-9.09	-15.72
	10	-14.17	-15.92	-18.68	-20.00	-27.29
	20	-24.54	-26.46	-29.46	-30.91	-38.87
	30	-34.92	-36.77	-40.25	-41.82	-50.44
	40	-45.30	-47.53	-51.04	-52.72	-62.01
200	-40	42.45	39.98	35.62	31.93	27.69
	-30	32.86	29.97	24.89	20.59	15.64
	-20	23.27	19.97	14.17	9.25	3.59
	-10	13.68	9.96	3.44	-2.10	-8.46
	0	4.09	-0.04	-7.29	-13.44	-20.51
	10	-5.51	-10.04	-18.02	-24.79	-32.56
	20	-15.10	-20.05	-28.75	-36.13	-44.61
	30	-24.69	-30.05	-39.48	-47.47	-56.66
	40	-34.28	-40.06	-50.21	-58.82	-68.72

Table:30 % error in flood estimates for diffrent skewness using method-1, CV=0.871

Return period (Years)	% error in mean peak flood	% error in flood estimates				
		SK1 (2.306)	SK2 (2.595)	SK3 (2.883)	SK4 (3.171)	SK5 (3.460)
50	-40	30.01	31.21	32.49	33.72	34.83
	-30	18.34	19.75	21.24	22.67	23.97
	-20	6.68	8.29	9.98	11.62	13.11
	-10	-4.99	-3.18	-1.27	0.58	2.25
	0	-16.65	-14.64	-12.52	-10.47	-8.61
	10	-28.32	-26.11	-23.77	-21.52	-19.47
	20	-39.98	-37.57	-35.02	-32.56	-30.33
	30	-51.65	-49.04	-46.27	-43.61	-41.19
	40	-63.32	-60.00	-57.53	-54.66	-52.06
100	-40	29.31	30.60	31.97	33.30	34.46
	-30	17.35	19.03	20.63	22.18	23.54
	-20	5.74	7.46	9.29	11.06	12.62
	-10	-6.04	-4.10	-2.05	-0.06	-1.69
	0	-17.82	-15.67	-13.39	-11.17	-9.23
	10	-29.60	-27.24	-24.73	-22.29	-20.15
	20	-41.38	-38.81	-36.07	-33.41	-31.07
	30	-53.16	-50.37	-47.41	-44.53	-42.00
	40	-64.95	-61.94	-58.74	-55.64	-52.92
200	-40	28.37	30.11	31.55	32.96	34.19
	-30	16.90	18.46	20.14	21.27	23.22
	-20	5.03	6.81	8.73	10.61	12.25
	-10	-6.85	-4.84	-2.68	-0.56	1.28
	0	-18.72	-16.49	-14.08	-11.74	-9.69
	10	-30.59	-28.14	-25.49	-22.91	-20.66
	20	-42.46	-39.79	-36.90	-34.08	-31.63
	30	-54.33	-51.44	-48.31	-45.26	-42.60
	40	-66.21	-63.09	-59.72	-56.43	-53.57

Table:31 % error in flood estimates for diffrent skewness using method-2, CV=0.871

Return period (Years)	% error in mean peak flood	% error in flood estimates				
		SK1 (2.306)	SK2 (2.595)	SK3 (2.883)	SK4 (3.171)	SK5 (3.460)
50	-40	29.22	31.10	32.93	34.69	36.29
	-30	17.43	19.62	21.76	23.81	25.67
	-20	5.63	8.14	10.58	12.93	15.05
	-10	-6.17	-3.35	-0.60	2.04	4.43
	0	-17.96	-14.83	-11.78	-8.84	-6.19
	10	-29.76	-26.31	-22.95	-19.73	-16.80
	20	-41.55	-37.80	-34.13	-30.61	-27.42
	30	-53.35	-49.28	-45.31	-41.49	-38.04
	40	-65.15	-60.76	-56.49	-52.38	-48.66
100	-40	28.43	30.43	32.40	34.28	35.99
	-30	16.50	18.84	21.13	23.32	25.32
	-20	4.57	7.24	9.86	12.37	14.65
	-10	-7.36	-4.35	-1.40	1.41	3.98
	0	-19.29	-15.95	-12.67	-9.54	-6.69
	10	-31.22	-27.54	-23.94	-20.49	-17.36
	20	-43.15	-39.13	-35.21	-31.45	-28.03
	30	-55.08	-50.73	-46.47	-42.40	-38.69
	40	-67.00	-62.32	-57.74	-53.35	-49.36
200	-40	27.79	29.92	32.01	33.98	35.78
	-30	15.76	18.24	20.67	22.98	25.08
	-20	3.72	6.56	9.34	11.97	14.38
	-10	-8.31	-5.12	-1.99	0.97	3.68
	0	-20.35	-16.80	-13.32	-10.03	-7.03
	10	-32.38	-28.48	-24.66	-21.03	-17.73
	20	-44.42	-40.16	-35.99	-32.04	-28.43
	30	-56.45	-51.84	-47.32	-43.04	-39.13
	40	-68.49	-63.53	-58.65	-54.04	-49.84

Table:32 % error in flood estimates for diffrent skewness using method-3, CV=0.871

Return period (Years)	% error in mean peak flood	% error in flood estimates				
		SK1 (2.306)	SK2 (2.595)	SK3 (2.883)	SK4 (3.171)	SK5 (3.460)
50	-40	31.30	31.34	31.89	32.87	34.11
	-30	19.85	19.90	20.54	21.69	23.12
	-20	8.40	8.45	9.19	10.50	12.14
	-10	-3.05	-2.99	-2.17	-0.69	1.16
	0	-14.50	-14.43	-13.52	-11.88	-9.82
	10	-25.95	-25.88	-24.87	-23.06	-20.81
	20	-37.40	-37.32	-36.22	-34.25	-31.79
	30	-48.85	-48.77	-47.57	-45.44	-42.77
	40	-60.30	-60.21	-58.93	-56.63	-53.75
100	-40	33.14	31.68	30.90	30.74	31.13
	-30	21.99	20.29	19.38	19.20	19.65
	-20	10.85	8.91	7.87	7.66	8.18
	-10	-0.30	-2.48	-3.65	-3.89	-3.30
	0	-11.44	-13.87	-15.16	-15.43	-14.78
	10	-22.58	-25.25	-26.68	-26.97	-26.26
	20	-33.73	-36.64	-38.20	-38.51	-37.74
	30	-44.87	-48.03	-49.71	-50.06	-49.21
	40	-56.02	-59.41	-61.23	-61.60	-60.69
200	-40	35.46	32.41	30.10	28.57	27.89
	-30	24.71	21.14	18.45	16.67	15.89
	-20	13.95	9.88	6.80	4.76	3.86
	-10	3.19	-1.39	-4.85	-7.14	-8.16
	0	-7.56	-12.65	-16.50	-19.04	-20.18
	10	-18.32	-23.92	-28.15	-30.95	-32.20
	20	-29.08	-35.18	-39.80	-42.85	-44.22
	30	-39.83	-46.45	-51.45	-54.76	-56.23
	40	-50.59	-57.71	-63.10	-66.66	-68.25

Table:33 % error in flood estimates for diffrent skewness using method-4, CV=0.871

Return period (Years)	% error in mean peak flood	% error in flood estimates				
		SK1 (2.306)	SK2 (2.595)	SK3 (2.883)	SK4 (3.171)	SK5 (3.460)
50	-40	29.69	29.59	30.85	34.23	31.01
	-30	17.97	17.86	19.32	23.26	19.51
	-20	6.25	6.12	7.80	12.30	8.01
	-10	-5.46	-5.61	-3.73	1.34	-3.49
	0	-17.18	-17.35	-15.25	-9.62	-14.99
	10	-28.90	-29.08	-26.78	-20.59	-26.48
	20	-40.62	-40.82	-38.30	-31.55	-37.98
	30	-52.34	-52.55	-49.83	-42.51	-49.48
	40	-64.06	-64.29	-61.35	-53.47	-60.98
100	-40	33.83	32.92	32.78	31.15	26.59
	-30	22.80	21.74	21.57	19.67	14.35
	-20	11.77	10.56	10.37	8.20	2.12
	-10	0.74	-0.62	-0.84	-3.28	-10.12
	0	-10.29	-11.80	-12.04	-14.76	-22.36
	10	-21.32	-22.99	-23.24	-26.23	-34.59
	20	-32.35	-34.17	-34.45	-37.71	-46.23
	30	-43.38	-45.35	-45.65	-49.18	-59.06
	40	-54.41	-56.53	-56.86	-60.66	-71.30
200	-40	38.95	37.25	35.50	15.34	22.09
	-30	28.77	26.80	24.75	1.23	9.11
	-20	18.59	16.34	14.00	-12.88	-3.88
	-10	8.42	5.88	3.25	-26.99	-16.86
	0	-1.76	-4.58	-7.50	-41.10	-29.85
	10	-11.93	-15.03	-18.25	-55.21	-42.83
	20	-22.11	-25.49	-29.00	-69.32	-55.82
	30	-32.28	-35.95	-39.75	-83.43	-68.80
	40	-42.46	-46.41	-50.50	-97.54	-81.79

Table:34 % error in flood estimates for diffrent skewness using method-1, CV=0.944

Return period (Years)	% error in mean peak flood	% error in flood estimates				
		SK1 (2.306)	SK2 (2.595)	SK3 (2.883)	SK4 (3.171)	SK5 (3.460)
50	-40	26.00	27.37	28.66	29.98	31.28
	-30	13.67	15.26	16.73	18.32	19.83
	-20	1.34	3.16	4.89	6.65	8.38
	-10	-11.00	-8.95	-7.00	-5.02	-3.08
	0	-23.33	-21.05	-18.89	-16.69	-14.53
	10	-35.66	-33.16	-30.78	-28.36	-25.98
	20	-48.00	-45.27	-42.67	-40.03	-37.44
	30	-60.33	-57.37	-54.56	-51.70	-48.89
	40	-72.66	-69.48	-66.45	-63.37	-80.34
100	-40	25.04	26.49	27.88	29.29	30.68
	-30	12.55	14.24	15.86	17.50	19.12
	-20	0.05	1.99	3.84	5.72	7.57
	-10	-12.44	-10.27	-8.18	-6.07	-3.98
	0	-24.93	-22.52	-20.20	-17.85	-15.54
	10	-37.43	-34.77	-32.22	-29.64	-27.09
	20	-49.92	-47.02	-44.24	-41.42	-38.64
	30	-62.41	-59.27	-56.26	-53.21	-50.20
	40	-74.91	-71.52	-68.28	-64.19	-61.75
200	-40	24.26	25.79	27.25	28.73	29.83
	-30	11.63	13.42	15.13	16.86	18.43
	-20	-0.99	1.05	3.00	4.98	6.45
	-10	-13.62	-11.32	-9.12	-6.90	-5.25
	0	-26.24	-23.68	-22.25	-18.78	-16.94
	10	-38.87	-36.05	-33.37	-30.66	-28.64
	20	-51.49	-48.42	-45.50	-42.53	-40.33
	30	-64.11	-60.79	-57.62	-54.41	-52.03
	40	-76.74	-73.16	-69.74	-66.29	-63.72

Table:35 % error in flood estimates for diffrent skewness using method-2, CV=0.944

Return period (Years)	% error in mean peak flood	% error in flood estimates				
		SK1 (2.306)	SK2 (2.595)	SK3 (2.883)	SK4 (3.171)	SK5 (3.460)
50	-40	25.30	27.34	29.34	31.27	33.03
	-30	12.85	15.23	17.57	19.81	21.87
	-20	0.40	3.12	5.79	8.36	10.71
	-10	-12.05	-8.98	-5.99	-3.10	-0.46
	0	-24.50	-21.09	-17.76	-14.55	-11.62
	10	-36.95	-33.20	-29.54	-26.01	-22.78
	20	-49.41	-45.31	-41.32	-37.46	-35.94
	30	-61.86	-57.42	-53.09	-48.92	-45.10
	40	-74.31	-69.53	-64.87	-60.37	-56.26
100	-40	24.20	26.40	28.53	30.60	32.50
	-30	11.57	14.13	16.62	19.04	21.25
	-20	-1.06	1.87	4.71	7.49	10.00
	-10	-13.70	-10.40	-7.20	-4.10	-1.25
	0	-26.33	-22.67	-19.11	-15.66	-12.50
	10	-38.96	-34.93	-31.02	-27.23	-23.75
	20	-51.59	-47.20	-42.94	-38.80	-34.99
	30	-64.23	-59.47	-54.85	-50.36	-46.24
	40	-76.86	-71.74	-66.76	-61.93	-57.49
200	-40	23.35	25.66	27.92	30.09	32.12
	-30	10.57	13.28	15.91	18.44	20.81
	-20	-2.20	0.89	3.90	6.78	9.49
	-10	-14.98	-11.50	-8.11	-4.87	-1.82
	0	-27.75	-23.89	-20.13	-16.52	-13.13
	10	-40.53	-36.28	-32.14	-28.17	-24.45
	20	-53.30	-48.67	-44.15	-39.82	-35.76
	30	-66.08	-61.06	-56.16	-41.47	-47.07
	40	-78.85	-73.45	-68.18	-63.13	-58.39

Table:36 % error in flood estimates for diffrent skewness using method-3, CV=0.944

Return period (Years)	% error in mean peak flood	% error in flood estimates				
		SK1 (2.306)	SK2 (2.595)	SK3 (2.883)	SK4 (3.171)	SK5 (3.460)
50	-40	27.09	27.17	27.76	28.84	30.24
	-30	14.94	15.03	15.72	16.98	18.61
	-20	2.79	2.89	3.68	5.12	6.99
	-10	-9.36	-9.25	-8.36	-6.74	-4.64
	0	-21.51	-21.38	-20.40	-18.60	-16.27
	10	-33.66	-33.52	-32.44	-30.46	-27.89
	20	-45.81	-45.66	-44.49	-42.32	-39.52
	30	-57.96	-57.80	-56.53	-54.19	-51.15
	40	-70.11	-69.94	-68.57	-66.05	-62.77
100	-40	28.70	27.12	26.24	26.10	26.56
	-30	16.81	14.98	13.95	13.78	14.32
	-20	4.93	2.83	1.66	1.47	2.08
	-10	-6.96	-9.32	-10.63	-10.85	-10.16
	0	-18.84	-21.46	-20.93	-23.17	-22.40
	10	-30.73	-33.61	-35.22	-35.48	-34.64
	20	-42.61	-45.75	-47.51	-47.80	-46.88
	30	-54.49	-57.90	-59.81	-60.12	-59.12
	40	-66.38	-70.05	-72.10	-72.43	-71.36
200	-40	30.89	27.60	25.01	23.39	22.65
	-30	19.37	15.53	12.52	10.62	9.76
	-20	7.86	3.46	0.02	-2.15	-3.13
	-10	-3.66	-8.61	-12.48	-14.92	-16.02
	0	-15.18	-20.67	-24.98	-27.69	-28.91
	10	-26.70	-32.74	-37.47	-40.46	-41.81
	20	-38.22	-44.81	-49.97	-53.52	-54.70
	30	-49.73	-56.88	-62.47	-65.99	-67.59
	40	-61.25	-68.94	-74.97	-78.76	-80.48

Table:37 % error in flood estimates for diffrent skewness using method-4, CV=0.944

Return period (Years)	% error in mean peak flood	% error in flood estimates				
		SK1 (2.306)	SK2 (2.595)	SK3 (2.883)	SK4 (3.171)	SK5 (3.460)
50	-40	25.43	24.90	25.13	31.49	29.43
	-30	13.01	12.38	12.66	20.07	17.67
	-20	0.58	-0.14	0.18	8.65	5.91
	-10	-11.85	-12.66	-12.30	-22.77	-5.85
	0	-24.28	-25.17	-24.78	-14.19	-17.62
	10	-36.70	-37.69	-37.25	-25.60	-29.38
	20	-49.13	-50.21	-49.73	-37.02	-41.14
	30	-61.56	-62.73	-62.21	-48.44	-52.90
	40	-73.99	-75.24	-74.69	-59.86	-64.66
100	-40	29.74	28.65	28.25	28.96	23.89
	-30	18.03	16.76	16.29	17.15	11.21
	-20	6.31	4.87	4.33	5.31	-1.48
	-10	-5.40	-7.02	-7.63	-6.52	-14.16
	0	-17.11	-18.91	-19.59	-18.36	-26.85
	10	-28.82	-30.80	-31.55	-30.20	-39.53
	20	-40.53	-42.69	-43.50	-42.03	-52.22
	30	-52.24	-54.58	-55.46	-53.87	-64.90
	40	-63.95	-66.47	-67.42	-65.70	-77.59
200	-40	35.17	35.72	32.73	26.03	17.89
	-30	24.37	22.68	21.52	13.70	4.20
	-20	13.56	11.63	10.31	1.37	-9.48
	-10	2.76	0.59	-0.90	-10.96	-23.17
	0	-8.05	-10.46	-12.11	-23.29	-36.85
	10	-18.85	-21.51	-23.33	-35.62	-50.54
	20	-29.66	-32.55	-34.54	-47.95	-64.22
	30	-40.46	-43.60	-45.75	-60.28	-77.91
	40	-51.27	-54.64	-56.96	-72.60	-91.60

Table:38 % error in flood estimates for diffrent skewness using method-1, CV=1.016

Return period (Years)	% error in mean peak flood	% error in flood estimates				
		SK1 (2.306)	SK2 (2.595)	SK3 (2.883)	SK4 (3.171)	SK5 (3.460)
50	-40	21.97	23.45	24.93	26.34	27.78
	-30	8.97	10.69	12.42	14.07	15.74
	-20	-4.04	-2.06	-0.09	1.79	3.70
	-10	-17.04	-14.82	-12.60	-10.49	-8.33
	0	-30.05	-27.58	-25.11	-22.76	-20.37
	10	-43.05	-40.34	-37.63	-35.04	-32.41
	20	-56.05	-53.10	-50.14	-47.31	-44.45
	30	-69.06	-65.85	-62.65	-59.59	-56.48
	40	-82.06	-78.61	-75.16	-71.87	-68.92
100	-40	20.69	27.70	23.89	25.40	26.91
	-30	7.47	9.82	11.21	12.97	14.73
	-20	-5.74	-3.06	-1.48	0.54	2.55
	-10	-18.96	-15.94	-14.16	-11.90	-9.68
	0	-32.18	-28.83	-26.85	-24.33	-21.81
	10	-45.40	-41.71	-39.53	-36.76	-33.99
	20	-58.62	-54.59	-52.21	-49.19	-46.17
	30	-71.84	-67.47	-64.90	-61.63	-58.36
	40	-85.05	-80.36	-77.58	-74.06	-70.54
200	-40	19.71	21.38	23.06	24.65	26.26
	-30	6.32	8.28	10.24	12.09	13.97
	-20	-7.06	-4.82	-2.58	-0.46	1.68
	-10	-20.44	-17.92	-15.40	-13.02	-10.61
	0	-33.82	-31.03	-28.23	-25.58	-22.90
	10	-47.21	-44.13	-41.05	-38.14	-35.19
	20	-60.59	-57.23	-53.87	-50.70	-47.48
	30	-73.97	-70.33	-66.70	-63.25	-59.77
	40	-87.35	-83.44	-79.52	-75.81	-72.06

Table:39 % error in flood estimates for diffrent skewness using method-2, CV=1.016

Return period (Years)	% error in mean peak flood	% error in flood estimates				
		SK1 (2.306)	SK2 (2.595)	SK3 (2.883)	SK4 (3.171)	SK5 (3.460)
50	-40	21.40	23.63	25.82	27.87	29.82
	-30	8.30	10.90	13.46	15.84	18.12
	-20	-4.81	-1.82	1.09	3.82	6.42
	-10	-17.91	-14.55	-11.27	-8.20	-5.27
	0	-31.01	-27.28	-23.63	-20.22	-16.97
	10	-44.11	-40.01	-36.00	-32.24	-28.68
	20	-57.21	-52.74	-48.36	-44.27	-40.36
	30	-70.31	-65.46	-60.72	-56.29	-52.06
	40	-83.41	-78.19	-73.08	-68.31	-63.76
100	-40	20.00	22.39	24.75	26.95	29.04
	-30	6.67	9.45	12.21	14.77	17.21
	-20	-6.67	-3.48	-0.33	2.60	5.39
	-10	-20.00	-16.42	-12.87	-9.58	-6.44
	0	-33.33	-29.36	-25.41	-21.75	-18.27
	10	-46.67	-42.29	-37.95	-33.93	-30.10
	20	-60.00	-55.23	-50.50	-46.10	-41.92
	30	-73.33	-68.16	-63.04	-58.28	-53.75
	40	-86.67	-81.10	-75.58	-70.45	-65.58
200	-40	18.92	21.45	23.94	26.25	28.46
	-30	5.41	8.36	11.26	13.96	16.53
	-20	-8.10	-4.73	-1.42	1.67	4.61
	-10	-21.61	-17.83	-14.09	-10.62	-7.32
	0	-35.13	-30.92	-26.77	-22.91	-19.24
	10	-48.64	-44.01	-39.45	-35.20	-31.16
	20	-62.15	-57.10	-52.13	-47.49	-43.09
	30	-75.66	-70.19	-64.80	-59.78	-55.01
	40	-89.18	-83.28	-77.48	-72.08	-66.94

Table:40 % error in flood estimates for diffrent skewness using method-3, CV=1.016

Return period (Years)	% error in mean peak flood	% error in flood estimates				
		SK1 (2.306)	SK2 (2.595)	SK3 (2.883)	SK4 (3.171)	SK5 (3.460)
50	-40	22.91	23.00	23.72	24.86	26.39
	-30	10.06	10.17	11.01	12.33	14.13
	-20	-2.79	-2.67	-1.71	-0.19	1.86
	-10	-15.64	-15.50	-14.42	-12.71	-10.41
	0	-28.49	-28.33	-27.13	-25.24	-22.68
	10	-31.34	-41.17	-39.85	-37.76	-34.95
	20	-54.19	-54.00	-52.56	-50.28	-47.21
	30	-67.04	-66.84	-65.27	-62.81	-59.48
	40	-79.89	-79.67	-77.98	-75.33	-71.75
100	-40	24.24	22.58	21.70	21.50	21.99
	-30	11.61	9.68	8.65	8.42	8.99
	-20	-1.01	-3.23	-4.04	-4.67	-4.01
	-10	-13.64	-16.13	-17.45	-17.75	-17.02
	0	-26.27	-29.03	-30.50	-30.83	-30.02
	10	-38.89	-41.93	-43.55	-43.92	-43.02
	20	-51.52	-54.84	-56.60	-57.00	-56.02
	30	-64.15	-67.74	-69.65	-70.08	-69.02
	40	-76.77	-80.64	-82.70	-83.17	-82.02
200	-40	26.31	22.77	20.09	18.23	17.41
	-30	14.03	9.90	6.77	4.61	3.65
	-20	1.75	-2.97	-6.65	-9.02	-10.12
	-10	-10.53	-15.84	-19.36	-22.65	-23.88
	0	-22.82	-28.71	-33.18	-36.28	-37.65
	10	-35.10	-41.58	-46.50	-49.90	-51.41
	20	-47.38	-54.46	-59.82	-63.53	-65.18
	30	-59.66	-67.33	-73.13	-77.16	-78.94
	40	-71.94	-80.20	-86.45	-90.79	-92.71

Table:41 % error in flood estimates for diffrent skewness using method-4, CV=1.016

Return period (Years)	% error in mean peak flood	% error in flood estimates				
		SK1 (2.306)	SK2 (2.595)	SK3 (2.883)	SK4 (3.171)	SK5 (3.460)
50	-40	21.14	20.48	20.26	21.60	27.65
	-30	8.00	7.23	6.97	8.53	15.59
	-20	-5.15	-6.03	-6.32	-4.54	3.54
	-10	-18.29	-19.28	-19.61	-17.60	-8.52
	0	-31.44	-32.53	-32.90	-30.67	-20.58
	10	-44.58	-45.79	-46.19	-43.74	-32.64
	20	-57.72	-59.04	-59.48	-56.80	-44.70
	30	-70.87	-72.29	-72.77	-69.87	-56.75
	40	-84.01	-85.55	-86.06	-82.94	-68.81
100	-40	25.66	24.60	23.81	22.56	20.77
	-30	13.27	12.03	11.22	9.65	7.57
	-20	0.88	-0.54	-1.58	-3.25	-5.64
	-10	-11.51	-13.11	-14.28	-16.16	-18.84
	0	-23.90	-25.68	-26.98	-29.07	-32.04
	10	-36.29	-38.24	-39.68	-41.97	-45.25
	20	-48.68	-50.81	-52.37	-54.88	-58.45
	30	-61.07	-63.37	-65.07	-67.79	-71.66
	40	-73.46	-75.94	-77.77	-80.69	-84.86
200	-40	31.53	30.28	29.10	24.98	12.86
	-30	20.12	18.66	17.29	12.48	-1665
	-20	8.71	7.04	5.47	-0.02	-16.18
	-10	-2.70	-4.58	-6.35	-12.52	-30.71
	0	-14.12	-16.20	-18.16	-25.03	-45.23
	10	-25.53	-27.82	-29.98	-37.53	-59.75
	20	-36.94	-39.54	-41.79	-50.03	-74.28
	30	-48.35	-51.06	-53.61	-62.53	-88.80
	40	-59.76	-62.68	-65.43	-75.04	-103.32

9.0 CONCLUSIONS

On the basis of this study, the following conclusions are drawn.

i) All the methods viz. USGS method(M1), PWM based EV1 method(M2), PWM based GEV method(M3) and PWM based Wakeby method(M4) over estimate the growth factors for larger values of coefficient of variation than that of the historical value of coefficient of variation; whereas all the methods under estimate the growth factors for the lower values of coefficient of variation than that corresponding to its historical value.

ii) The percentage errors in growth factors are very much sensitive to the coefficient of variation for a specific value of coefficient of skewness.

iii) The percentage errors in growth factor are not much sensitive to the coefficient of skewness for a specific value of coefficient of variation.

iv) The percentage errors in growth factors are relatively low for the USGS method (M1) and PWM based EV1 method (M2) when the generated populations of EV1 distribution are fitted with these methods.

v) PWM based GEV distribution in general results in less percentage errors in the growth factors as compared to the other three methods.

vi) PWM based Wakeby distribution appears to be the second best method for estimating the percentage errors in growth factors when it is fitted to the generated populations of EV1 and PT3 distribution.

vii) For larger value of coefficient of variation i.e. 1.016 (with respect to the historical value of coefficient of variation i.e. 0.726) and 40% larger mean annual peak flood, than the historical at-site mean of the specfic site in the region the flood estimate is over estimated by more than 50% ; whereas the smaller value of coefficient of variation(0.436) and 40% lower mean annual peak flood, results in more than 50% under estimation of flood estimate.

viii) As the growth factors are quite sensitive to the coefficient of variation, the study provides a methodology to estimate the flood of desired return periods for a gauged catchment in the region; whose coefficient of variation is significantly different from the regional value of the coefficient of variation. For this the respective plot(Figs. 4 to 6) between the percentage error in growth factors and coefficient of variation may be utilised to obtain the reviced value of growth factors. These revised values of the growth factors, together with the at-site mean may provide the desired flood frequency estimates. In case, the at site mean annual peak floods are also subjected to errors; then the Fig. 22 may be used to estimate the floods of desired return periods.

ix) Further studies may be carried out to examine the applicability of the relationships between coefficient of variation and percentage errors in growth factors for the catchments exhibiting hydrologically non-homogenous behaviour.

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DIRECTOR DR. S.M. SETH

STUDY GROUP

R.D. SINGH

RAKESH KUMAR