Chapter 6

Comparative Study Among the Methods of Parameter Estimation.

6.1. Introduction

In this chapter a comparative study among the methods of parameter estimation discussed in the previous chapters has been done. For this purpose, Monte Carlo simulation proposed by Meshgi and Khalili [31] has been conducted for relative root mean square error (RRMSE) and relative bias (RBIAS). Also box plot, a graphical tool introduced by Tukey [49] has been used to study the RRMSE and RBIAS values.

6.2. Monte Carlo simulation

Monte Carlo simulation proposed by Meshgi and Khalili [31] are used to evaluate error between simulated and calculated rainfall quantiles. Two error functions, relative root mean square error (RRMSE) and relative bias (RBIAS) are given by

$$RRMSE = \sqrt{\frac{1}{M}\sum_{m=1}^{M}\left(\frac{Q_T^m - Q_T^c}{Q_T^c}\right)^2} \quad (6.2.1)$$

$$RBIAS = \frac{1}{M}\sum_{m=1}^{M}\left(\frac{Q_T^m - Q_T^c}{Q_T^c}\right) \quad (6.2.2)$$

where M is the total number of samples, Q_T^m and Q_T^c are the simulated quantiles of mth sample and calculated quantiles from observed data respectively. The minimum RRMSE and RBIAS values and their associated variability are used to select the most suitable probability distribution function.

The steps of Monte Carlo simulation conducted for this study are as follows:

1. Select the method of parameter estimation and respective best fit distribution.
2. Calculate the regional parameters of the best fit distribution using respective methods.
3. Calculate the quantiles at different return periods using the regional parameters of the best fit distribution of step 1.
4. Generate random samples of size 30, 50 and 80 using the regional parameters of the best fit distribution.
5. Calculate the parameters of the best fit distribution for the generated samples and estimates the growth factors at different return periods of step 3.
6. Repeat the step 4 and 5 for 10000 times.
7. Calculate RRMSE and RBIAS values at different return periods of step 3.

For all calculation Fortran 77 programs are developed.

6.3 Box Plot

Tukey [49] introduced a graphical tool called box plot. Box plot is a simple plot of five quantities. They are the minimum value, the 1st quantile, the median, the 3rd quantile, and maximum value. This provides the location of the median and associated dispersion of the data at specific probability levels. The probability distribution with the minimum achieved median RRMSE or RBIAS values, as well as the minimum dispersion in the median RRMSE or RBIAS values, indicated by both ends of the box plot are selected as the suitable distribution.

6.4 Comparison Between L-moment and LQ-moment Methods

In chapter 2 using L-moment methods it is found that PE3 distribution is the best fit distribution for maximum rainfall frequency analysis of North East India. In chapter 3 using LQ-moment methods it is found that GPA distribution is the best fit distribution.

RRMSE and RBIAS values are calculated using Monte Carlo simulation for 10000 simulated data samples of sample size 30, 50 and 80 each. Calculated RRMSE and RBIAS values for both the distributions are given in Table 6.1 and Table 6.2 respectively. From Table 6.1 it is observed that the RRMSE values of PE3 distribution designated by L-moment are less than the respective RRMSE values of GPA distribution designated by LQ-moment. Also from Table 6.2 it is observed that the absolute RBIAS values of PE3 distribution designated by L-moment are smaller than the respective RBIAS values of GPA distribution designated by LQ-moment. Figure 6.1, Figure 6.2 and Figure 6.3 represent the box plots of RRMSE values for sample size 30, 50 and 80 respectively. Figure 6.4, Figure 6.5 and Figure 6.6 represent the box plots of RBIAS values for sample size 30, 50 and 80 respectively. From Figure 6.1 to Figure 6.6 it is observed that PE3 distribution designated by L-moment method has the minimum median RRMSE and RBIAS values as well as minimum dispersion. Hence PE3 distribution is selected as suitable and the best fit distribution for rainfall frequency analysis of North East India. Also the L-moment method is significantly more efficient than LQ-moment for rainfall frequency analysis of North East India.

Table 6.1 RRMSE values at different return periods of PE3 distribution and GPA distribution for L-moment and LQ-moment method respectively.

Methods	Sample size	Best fit Distributions	Return period (in years)				
			2	10	20	100	1000
L-moment	30	PE3	0.064	0.068	0.084	0.124	0.172
LQ-moment		GPA	0.067	0.109	0.187	0.568	3.387
L-moment	50	PE3	0.050	0.053	0.065	0.095	0.131
LQ-moment		GPA	0.052	0.083	0.137	0.340	1.042
L-moment	80	PE3	0.039	0.042	0.051	0.075	0.103
LQ-moment		GPA	0.041	0.064	0.104	0.232	0.530

Table 6.2 RBIAS values of different quantiles of PE3 distribution and GPA distribution for L-moment and LQ-moment method respectively.

Methods	Sample size	Best fit Distributions	Return period (in years)				
			2	10	20	100	1000
L-moment	30	PE3	0.000	-0.002	-0.001	0.001	0.003
LQ-moment		GPA	0.004	0.028	0.058	0.188	0.676
L-moment	50	PE3	0.000	-0.002	-0.002	-0.001	0.000
LQ-moment		GPA	0.003	0.016	0.034	0.105	0.301
L-moment	80	PE3	0.000	-0.001	0.000	0.000	0.001
LQ-moment		GPA	0.002	0.010	0.021	0.063	0.161

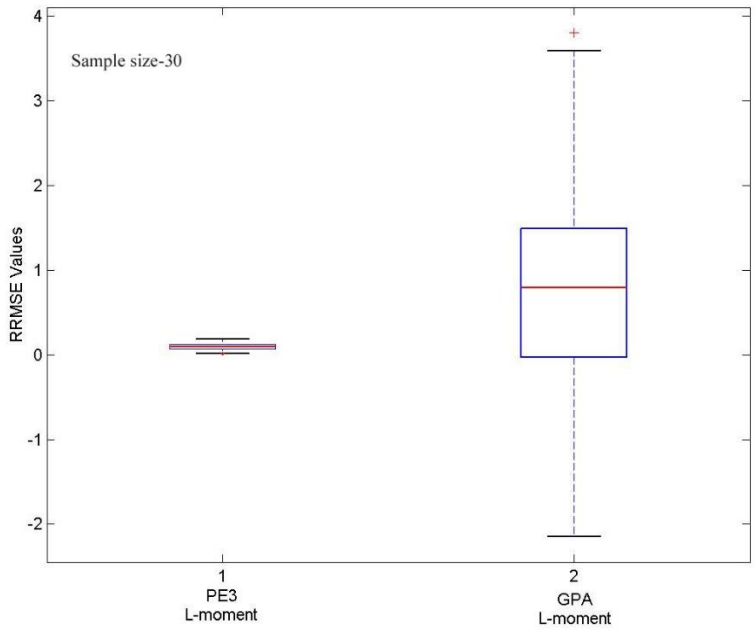

Figure 6.1 Box plot of RRMSE values for PE3 and GPA distribution for sample size 30.

(Red horizontal lines inside the boxes indicate medians of the RRMSE values. PE3 distribution has minimum median and minimum dispersion than GPA distribution.)

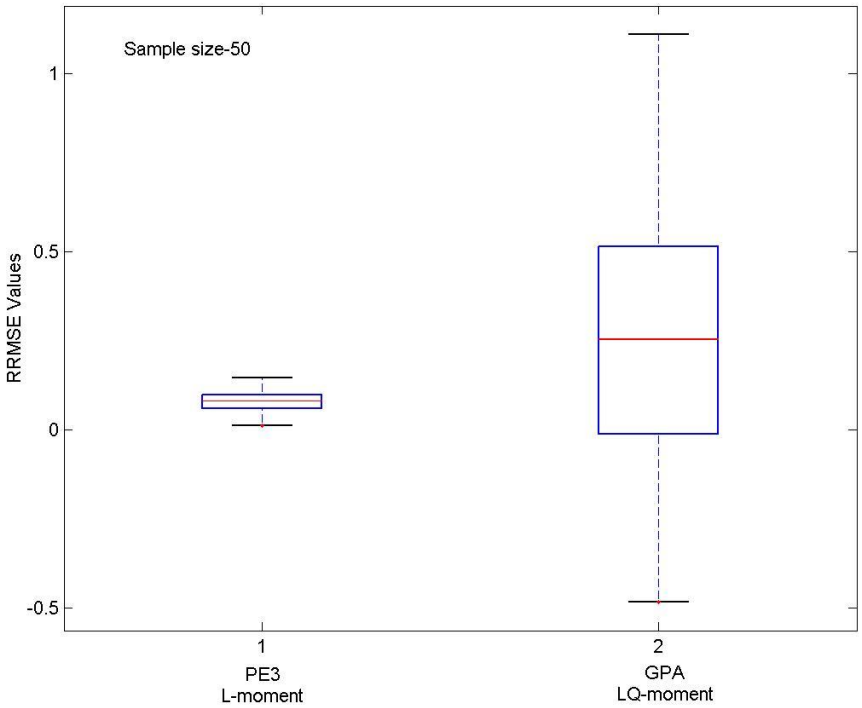

Figure 6.2 Box plot of RRMSE values for PE3 and GPA distribution for sample size 50.

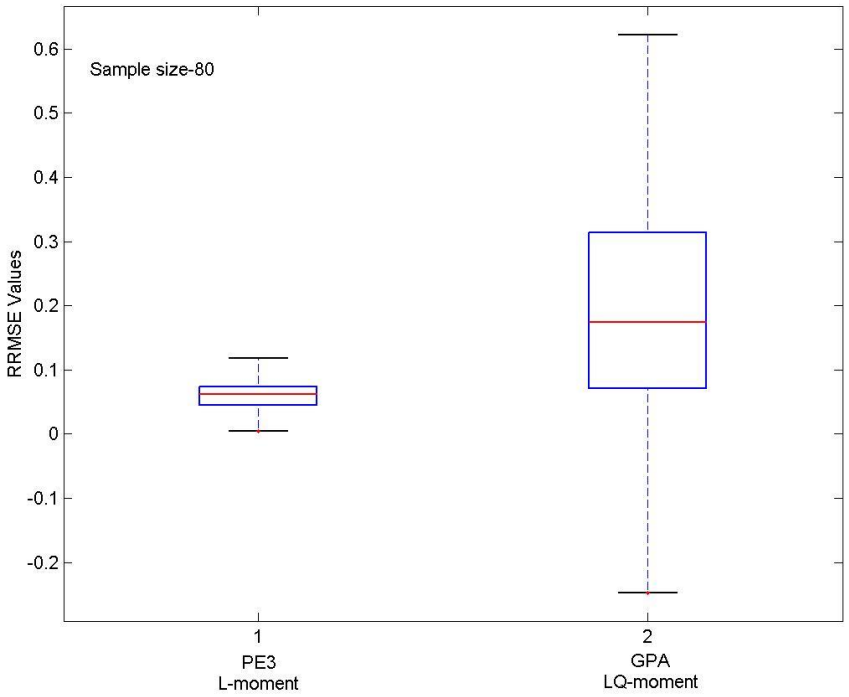

Figure 6.3 Box plot of RRMSE values for PE3 and GPA distribution for sample size 80.

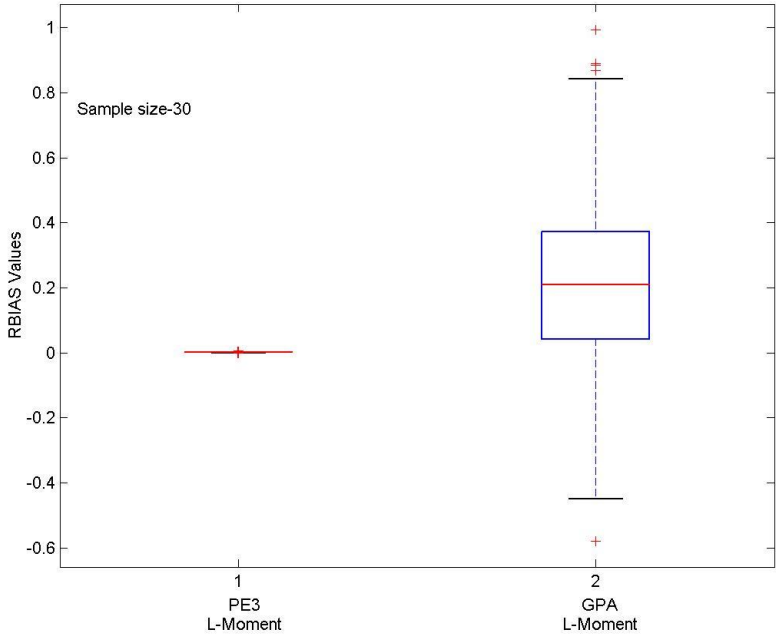

Figure 6.4 Box plot of RBIAS values for PE3 and GPA distribution for sample size 30

(Red horizontal lines inside the boxes indicate medians of the RBIAS values. PE3 distribution has minimum median and minimum dispersion than GPA distribution.)

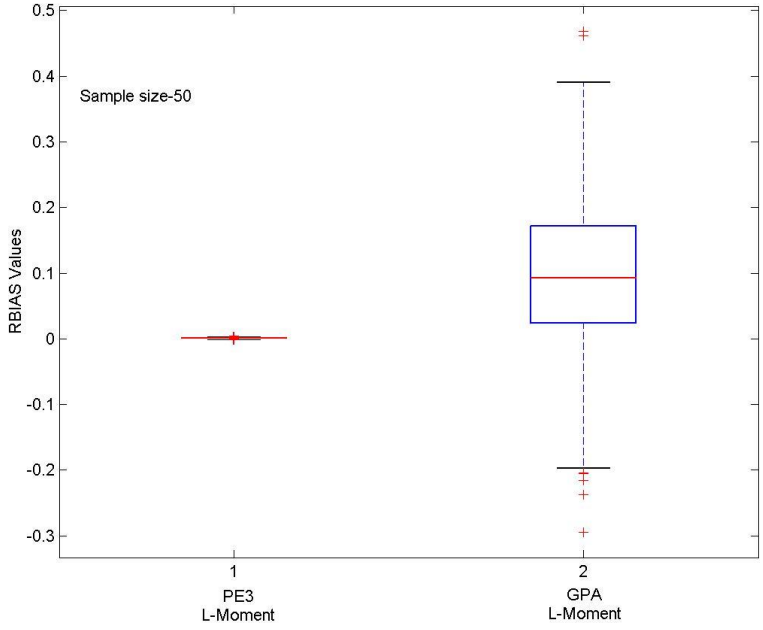

Figure 6.5 Box plot of RBIAS values for PE3 and GPA distribution for sample size 50

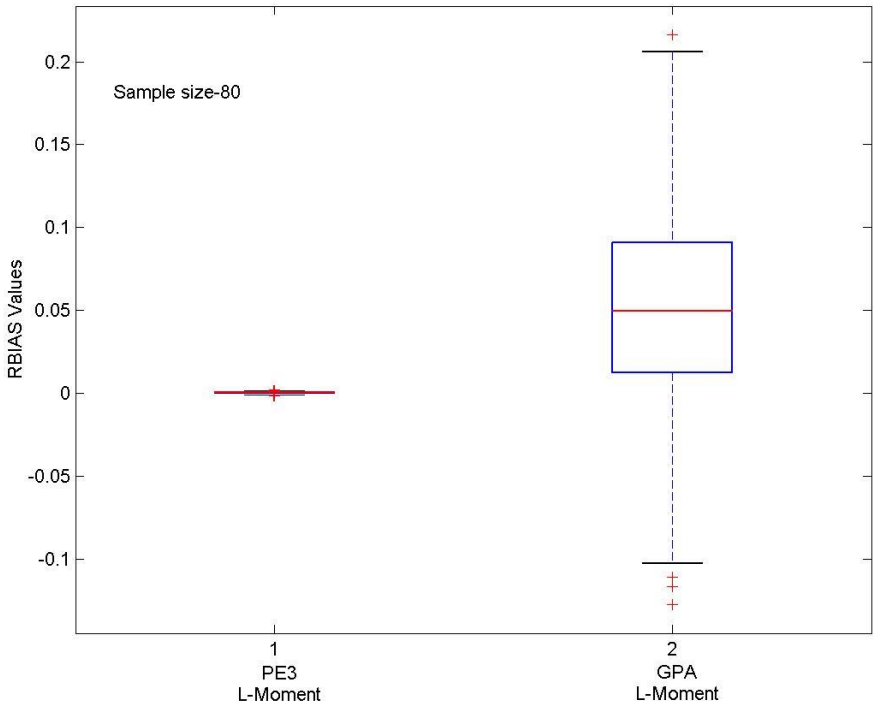

Figure 6.6 Box plot of RBIAS values for PE3 and GPA distribution for sample size 80

6.5 Comparison between L-moment and LH-moment methods

In chapter 4 using LH-moment it is found that GPA distribution is selected as the best fit distribution for L_1-moment and GLO distribution for L_2, L_3& L_4-moments. Also in chapter 2 using L-moment it is found that PE3 distribution is the best fit distribution.

Calculated RRMSE and RBIAS values are given in Table 6.3 and Table 6.4 respectively. From Table 6.3 it is observed that the RRMSE values of GPA distribution designated by L_1-moment method are less than the respective RRMSE values of PE3 distribution designated by L-moment and GLO distribution designated by L_2, L_3& L_4-moments. Also from Table 6.4 it is observed that the RBIAS values (absolute) of GPA distribution designated by L_1-moment are smaller than the respective RBIAS values of PE3 distribution designated by L-moment and GLO distribution designated by L_2, L_3& L_4-moments. Figure 6.7, Figure 6.8 and Figure 6.9 represent the box plots of RRMSE values for sample size 30, 50 and 80 respectively. Also Figure 6.10, Figure 6.11 and Figure 6.12 represent the box plots of RBIAS values for sample size 30, 50

and 80 respectively. From Figure 6.7 to Figure 6.9 it is observed that GPA distribution designated by L_1-moment has the minimum median RRMSE as well as minimum dispersion. Also from Figure 6.10 to Figure 6.12 it is observed that GPA distribution designated by L_1-moment has the minimum median and minimum dispersion. Hence GPA distribution is selected as suitable and the best fitting distribution for rainfall frequency analysis of North East India. Also the L_1-moment method is significantly more efficient than L-moment and other orders of LH-moment for rainfall frequency analysis of North east India.

Table 6.3 RRMSE values at different return periods of best fit distributions designated by L-moment and LH-moment of four orders.

Methods	Sample size	Best fit Distribution	Return period (in years)				
			2	10	20	100	1000
L-moment	30	PE3	0.064	0.068	0.084	0.124	0.172
L1-moment		GPA	0.025	0.036	0.043	0.067	0.078
L2-moment		GLO	0.070	0.082	0.090	0.160	0.457
L3-moment		GLO	0.089	0.077	0.087	0.161	0.417
L4-moment		GLO	0.099	0.083	0.090	0.154	0.407
L-moment	50	PE3	0.050	0.053	0.065	0.095	0.131
L1-moment		GPA	0.024	0.032	0.043	0.064	0.084
L2-moment		GLO	0.055	0.064	0.070	0.126	0.345
L3-moment		GLO	0.069	0.060	0.068	0.126	0.302
L4-moment		GLO	0.076	0.064	0.069	0.121	0.292
L-moment	80	PE3	0.039	0.042	0.051	0.075	0.103
L1-moment		GPA	0.001	0.001	0.000	0.000	0.001
L2-moment		GLO	0.043	0.051	0.055	0.103	0.282
L3-moment		GLO	0.053	0.047	0.054	0.102	0.236
L4-moment		GLO	0.059	0.050	0.055	0.097	0.226

Table 6.4 RBIAS values at different return periods of best fit distributions designated by L-moment and LH-moment of four orders.

Methods	Sample size	Best fit Distributions	Return period (in years)				
			2	10	20	100	1000
L-moment	30	PE3	0.000	-0.002	-0.001	0.001	0.003
L1-moment		GPA	0.002	-0.001	-0.001	0.000	0.001
L2-moment		GLO	0.011	-0.019	-0.014	0.028	0.180
L3-moment		GLO	0.006	-0.005	-0.010	-0.008	0.049
L4-moment		GLO	0.004	-0.004	-0.010	-0.010	0.050
L-moment	50	PE3	0.000	-0.002	-0.002	-0.001	0.000
L1-moment		GPA	0.001	0.000	-0.001	-0.001	0.001
L2-moment		GLO	0.008	-0.018	-0.011	0.029	0.156
L3-moment		GLO	0.003	-0.004	-0.006	-0.007	0.023
L4-moment		GLO	0.001	-0.003	-0.007	-0.008	0.023
L-moment	80	PE3	0.000	-0.001	0.000	0.000	0.001
L1-moment		GPA	-0.001	0.001	0.000	0.000	0.000
L2-moment		GLO	0.007	-0.016	-0.008	0.033	0.150
L3-moment		GLO	0.002	-0.002	-0.003	-0.003	0.017
L4-moment		GLO	0.001	-0.001	-0.003	-0.004	0.016

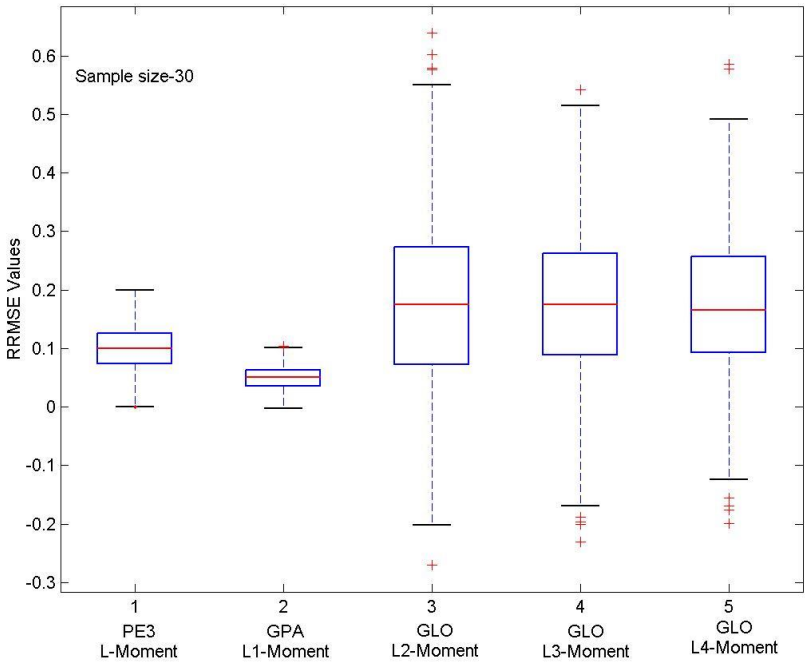

Figure 6.7 Box plot of RRMSE values of best distributions designated by L-moment and LH-moment of four orders for sample size 30.

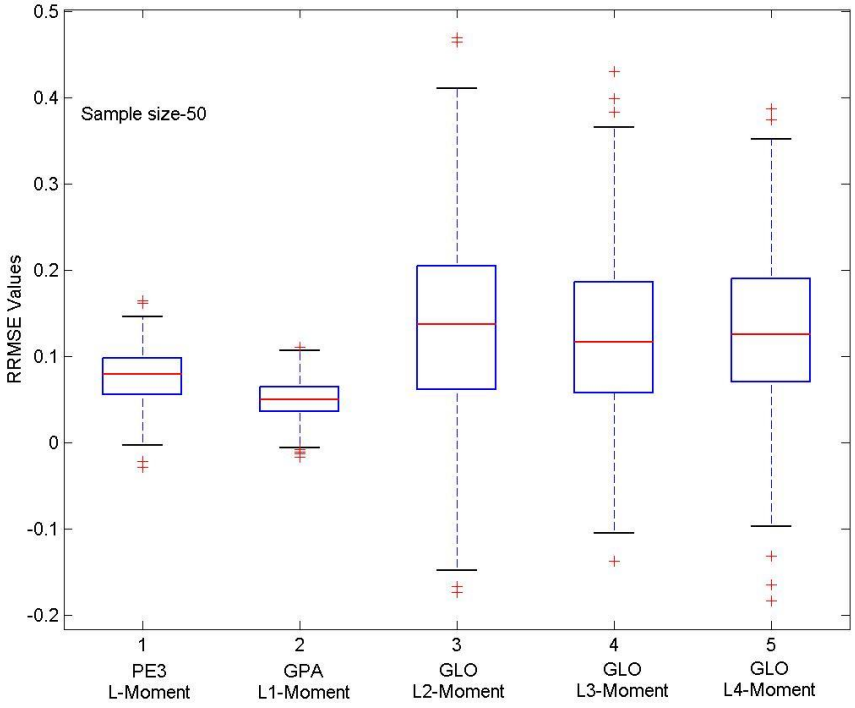

Figure 6.8 Box plot of RRMSE values of best distributions designated by L-moment and LH-moment of four orders for sample size 50.

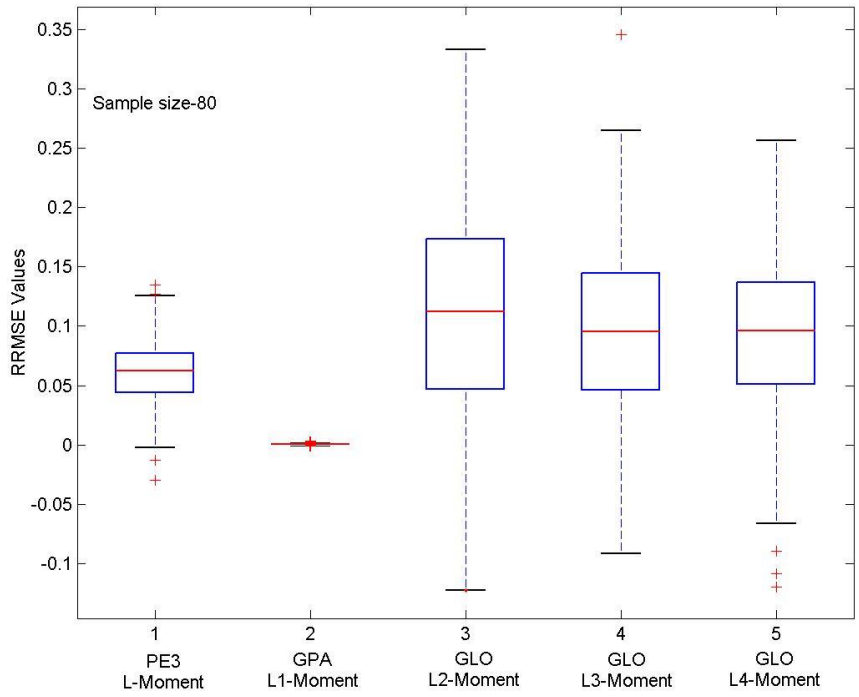

Figure 6.9 Box plot of RRMSE values of best distributions designated by L-moment and LH-moment of four orders for sample size 80.

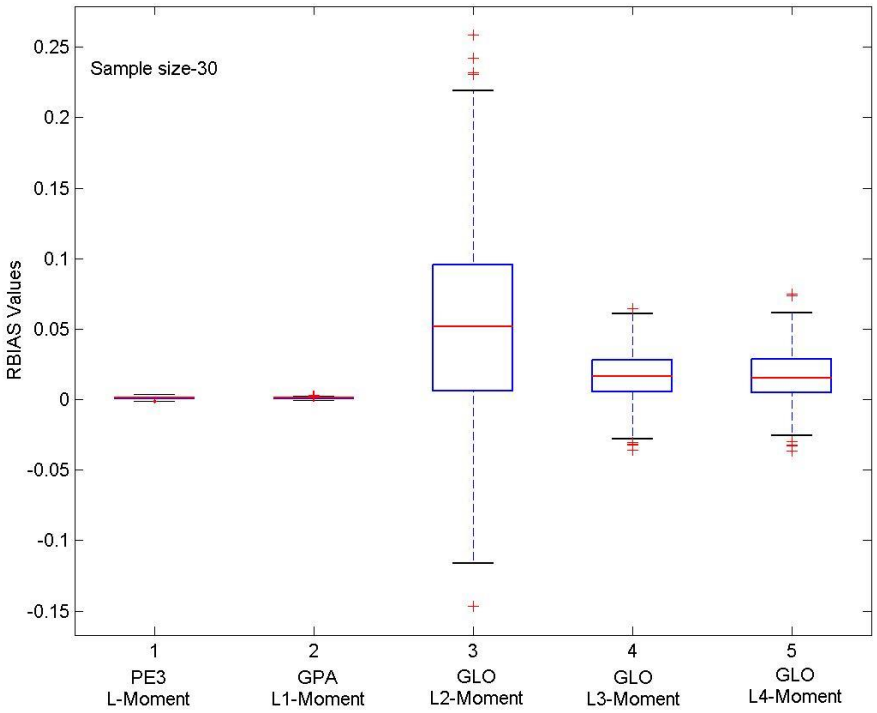

Figure 6.10 Box plot of RBIAS values of best distributions designated by L-moment and LH-moment of four orders for sample size 30.

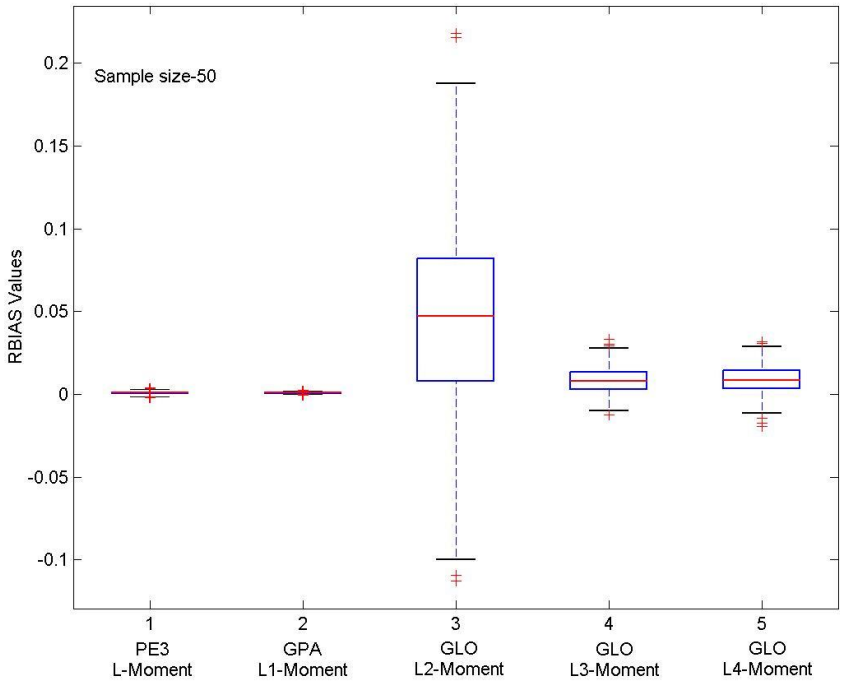

Figure 6.11 Box plot of RBIAS values of best distributions designated by L-moment and LH-moment of four orders for sample size 50.

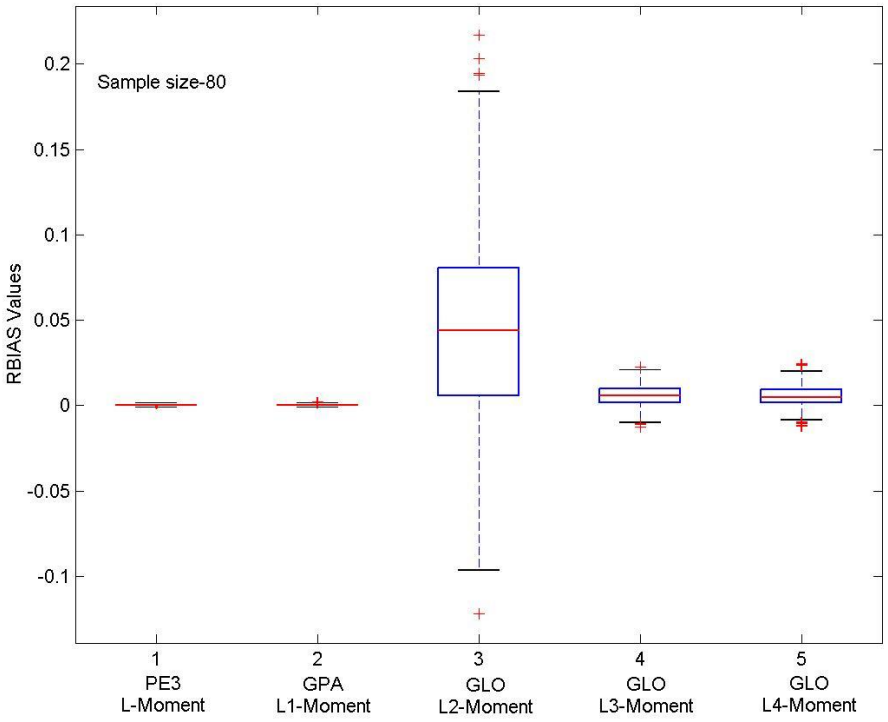

Figure. 6.12 Box plot of RBIAS values of best distributions designated by L-moment and LH-moment of four orders for sample size 80.

6.6 Comparison between TL-moment and LH-moment methods

In Chapter 4, LH-moment analysis shows that GPA distribution is the best fit distribution for L_1-moment and GLO distribution for L_2, L_3& L_4-moments. Also in chapter 5 using TL-moment it is found that GPA distribution is the best fit distribution.

Table 6.5 and Table 6.6 represents the RRMSE and RBIAS values of the best fit distributions. From Table 6.5 and Table 6.6 it is observed that the RRMSE and absolute RBIAS values of GPA distribution designated by L_1-moment method are less than or equal to the respective RRMSE and absolute RBIAS values of other distributions designated by TL-moment and other orders of LH-moment. Figure 6.13, Figure 6.14 and Figure 6.15 represent the box plots of RRMSE values for sample size 30, 50 and 80 respectively. Figure 16, Figure 17 and Figure 18 represent the box plots of RBIAS values for sample size 30, 50 and 80 respectively. From Figure 6.13 to Figure 6.15 it is observed that GPA distribution designated by L_1-moment has the minimum median RRMSE values as well as minimum dispersion. Also from Figure 16 to Figure 18 it is observed that the GPA distribution designated by L_1-moment has the minimum median RBIAS values as well as minimum dispersion. Hence GPA distribution is selected as suitable and the best fitting distribution for maximum rainfall frequency analysis of North East India. Also the L_1-moment method is significantly more efficient than TL-moment and other orders of LH-moment for maximum rainfall frequency analysis of North East India.

Table 6.5 RRMSE values at different return periods of best fit distributions designated by TL-moment and LH-moment of four orders.

Methods	Sample size	Best fit Distribution	Return period (in years)				
			2	10	20	100	1000
TL-moment	30	GPA	0.067	0.077	0.115	0.260	0.665
L1-moment		GPA	0.025	0.036	0.043	0.067	0.078
L2-moment		GLO	0.070	0.082	0.090	0.160	0.457
L3-moment		GLO	0.089	0.077	0.087	0.161	0.417
L4-moment		GLO	0.099	0.083	0.090	0.154	0.407
TL-moment	50	GPA	0.052	0.058	0.086	0.176	0.352
L1-moment		GPA	0.024	0.032	0.043	0.064	0.084
L2-moment		GLO	0.055	0.064	0.070	0.126	0.345
L3-moment		GLO	0.069	0.060	0.068	0.126	0.302
L4-moment		GLO	0.076	0.064	0.069	0.121	0.292
TL-moment	80	GPA	0.041	0.046	0.066	0.131	0.236
L1-moment		GPA	0.001	0.001	0.000	0.000	0.001
L2-moment		GLO	0.043	0.051	0.055	0.103	0.282
L3-moment		GLO	0.053	0.047	0.054	0.102	0.236
L4-moment		GLO	0.059	0.050	0.055	0.097	0.226

Table 6.6 RBIAS values at different return periods of best fit distributions designated by TL-moment and LH-moment of four orders.

Methods	Sample size	Best fit Distributions	Return period (in years)				
			2	10	20	100	1000
TL-moment	30	GPA	0.001	-0.001	0.009	0.056	0.184
L1-moment		GPA	0.002	-0.001	-0.001	0.000	0.001
L2-moment		GLO	0.011	-0.019	-0.014	0.028	0.180
L3-moment		GLO	0.006	-0.005	-0.010	-0.008	0.049
L4-moment		GLO	0.004	-0.004	-0.010	-0.010	0.050
TL-moment	50	GPA	0.001	-0.001	0.004	0.030	0.089
L1-moment		GPA	0.001	0.000	-0.001	-0.001	0.001
L2-moment		GLO	0.008	-0.018	-0.011	0.029	0.156
L3-moment		GLO	0.003	-0.004	-0.006	-0.007	0.023
L4-moment		GLO	0.001	-0.003	-0.007	-0.008	0.023
TL-moment	80	GPA	0.001	0.000	0.003	0.019	0.053
L1-moment		GPA	-0.001	0.001	0.000	0.000	0.000
L2-moment		GLO	0.007	-0.016	-0.008	0.033	0.150
L3-moment		GLO	0.002	-0.002	-0.003	-0.003	0.017
L4-moment		GLO	0.001	-0.001	-0.003	-0.004	0.016

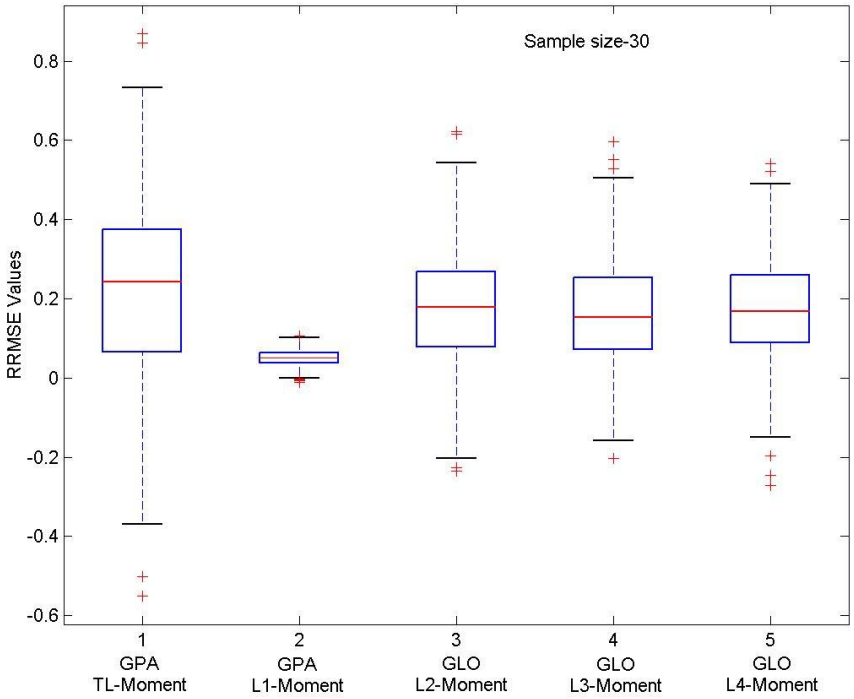

Figure. 6.13 Box plot of RRMSE values of best distributions designated by TL-moment and LH-moment of four orders for sample size 30.

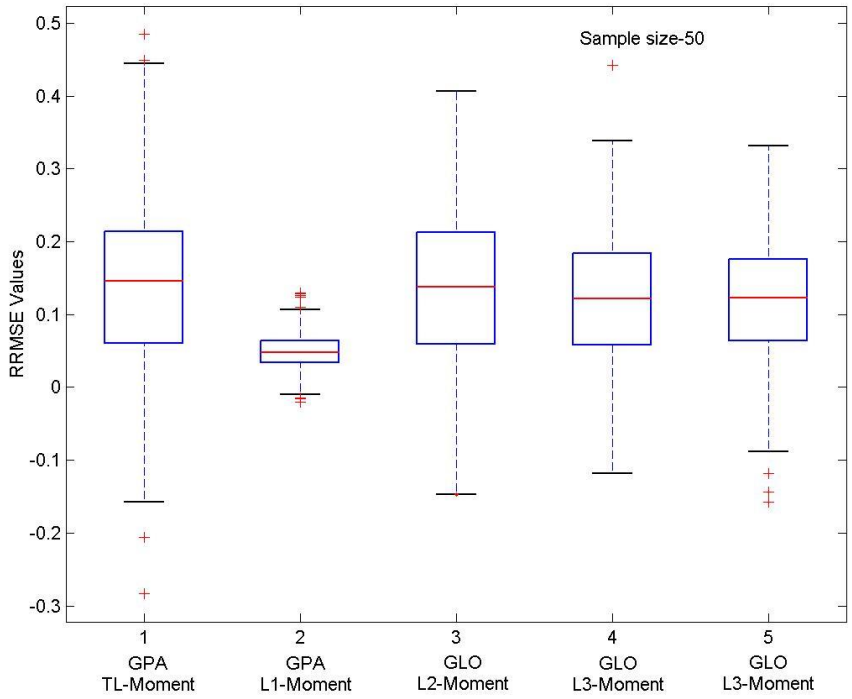

Figure 6.14 Box plot of RRMSE values of best distributions designated by TL-moment and LH-moment of four orders for sample size 50.

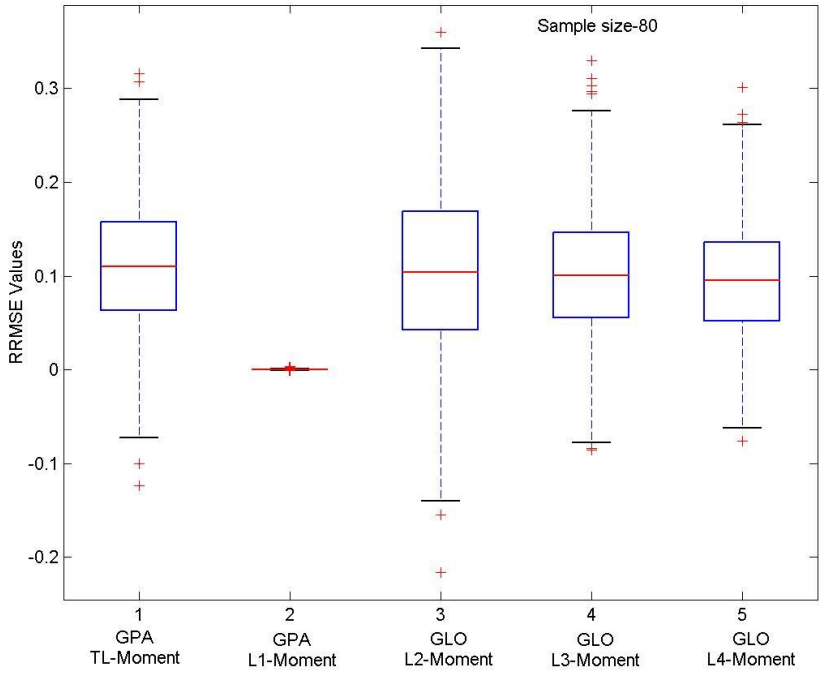

Figure 6.15 Box plot of RRMSE values of best distributions designated by TL-moment and LH-moment of four orders for sample size 80.

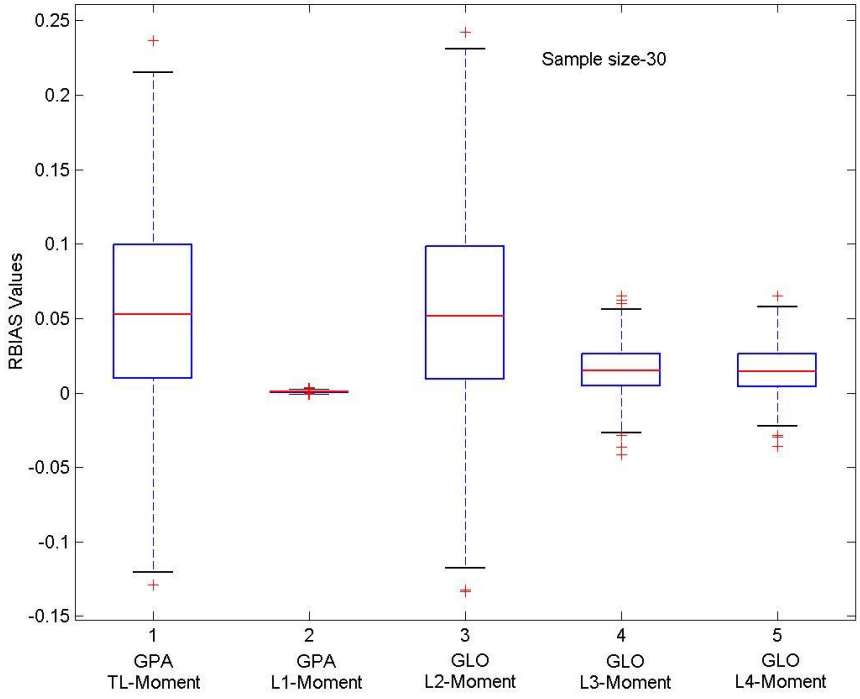

Figure 6.16 Box plot of RBIAS values of best distributions designated by TL-moment and LH-moment of four orders for sample size 30.

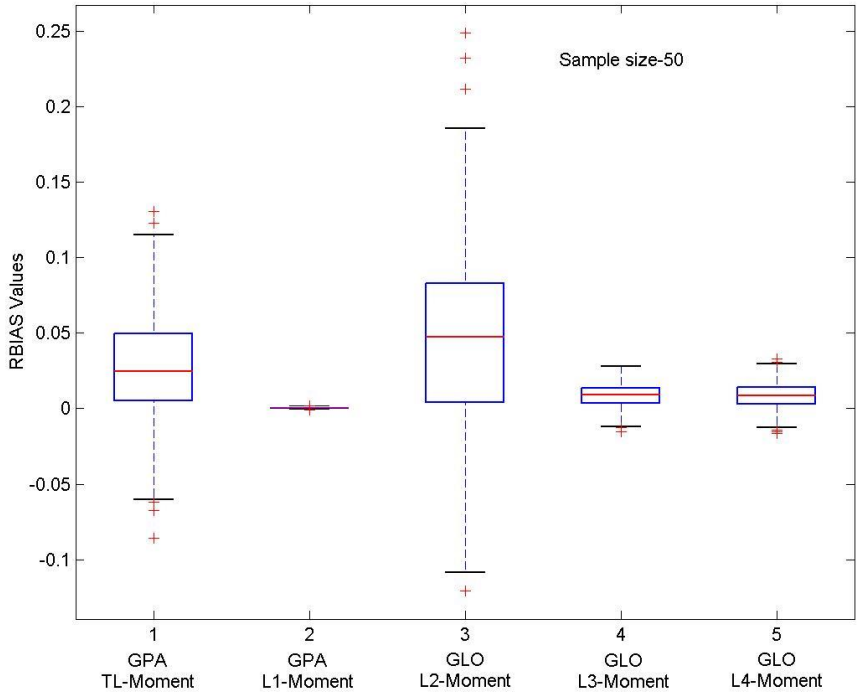

Figure 6.17 Box plot of RBIAS values of best distributions designated by TL-moment and LH-moment of four orders for sample size 50.

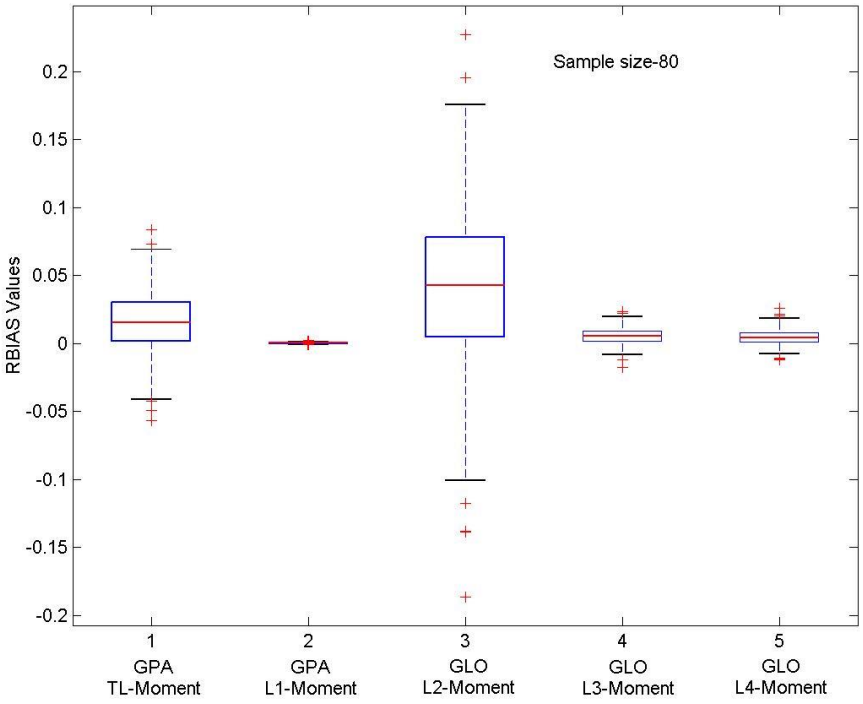

Figure 6.18 Box plot of RBIAS values of best distributions designated by TL-moment and LH-moment of four orders for sample size 80.

6.7 Comparison between L-moment and TL-moment methods

In Chapter 2, L-moment analysis shows that PE3 distribution is the best fit distribution whereas in Chapter 5, TL-moment analysis designates GPA distribution as the best fit distribution for maximum rainfall estimates of North East India.

Using Monte Carlo simulation RRMSE and RBIAS values are calculated. Calculated RRMSE and RBIAS values are given in Table 6.7 and Table 6.8 respectively. From Table 6.7 and Table 6.8 it is observed that PE3 distribution designated by L-moment method has achieved the minimum RRMSE and minimum absolute RBIAS values than GPA distribution designated by TL-moment. Figure 6.19, Figure 6.20 and Figure 6.21 represent the box plots of RRMSE values for sample size 30, 50 and 80 respectively. Also Figure 6.22, Figure 6.23 and Figure 6.24 represent the box plots of RBIAS values for sample size 30, 50 and 80 respectively. From these box plots it is clear that PE3 distribution has minimum median RRMSE and RBIAS and minimum dispersion. Hence it can be concluded that PE3 distribution designated by L-moment is more suitable than GPA distribution designated by TL-moment for maximum rainfall estimates of North East India. Also L-moment is significantly more efficient than TL-moment for maximum rainfall estimates of the region.

Table 6.7 RRMSE values at different return periods of PE3 distribution and GPA distribution for L-moment and TL-moment method respectively.

Methods	Sample size	Best fit Distributions	Return period (in years)				
			2	10	20	100	1000
L-moment	30	PE3	0.064	0.068	0.084	0.124	0.172
TL-moment		GPA	0.067	0.077	0.115	0.260	0.665
L-moment	50	PE3	0.050	0.053	0.065	0.095	0.131
TL-moment		GPA	0.052	0.058	0.086	0.176	0.352
L-moment	80	PE3	0.039	0.042	0.051	0.075	0.103
TL-moment		GPA	0.041	0.046	0.066	0.131	0.236

Table 6.8 RBIAS values of different quantiles of PE3 distribution and GPA distribution for L-moment and TL-moment method respectively.

Methods	Sample size	Best fit Distributions	Return period (in years)				
			2	10	20	100	1000
L-moment	30	PE3	0.000	-0.002	-0.001	0.001	0.003
TL-moment		GPA	0.001	-0.001	0.009	0.056	0.184
L-moment	50	PE3	0.000	-0.002	-0.002	-0.001	0.000
TL-moment		GPA	0.001	-0.001	0.004	0.030	0.089
L-moment	80	PE3	0.000	-0.001	0.000	0.000	0.001
TL-moment		GPA	0.001	0.000	0.003	0.019	0.053

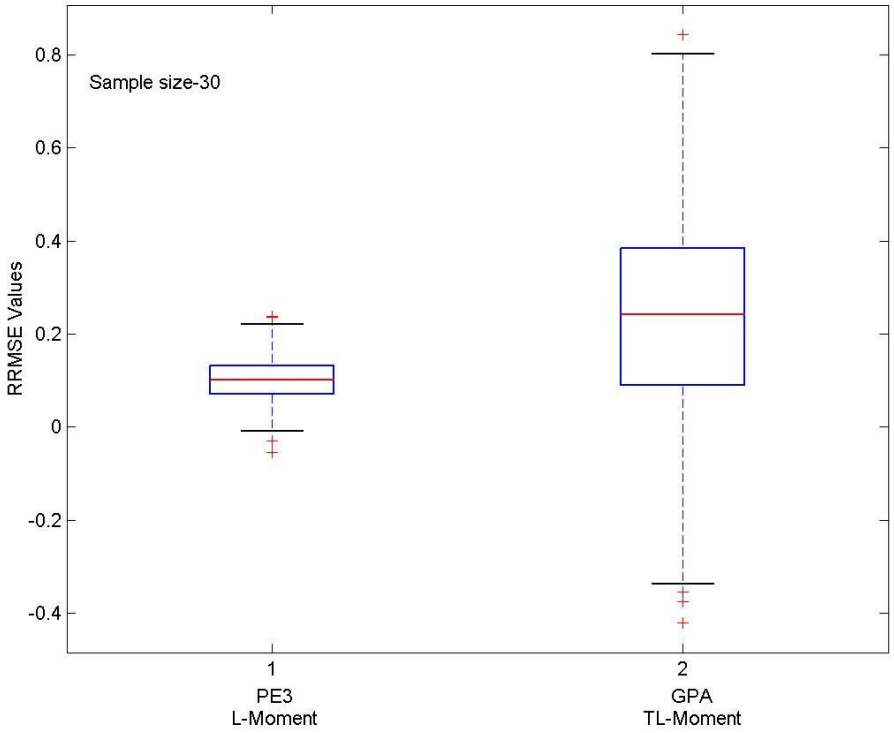

Figure 6.19 Box plot of RRMSE values of best distributions designated by L-moment and TL-moment for sample size 30.

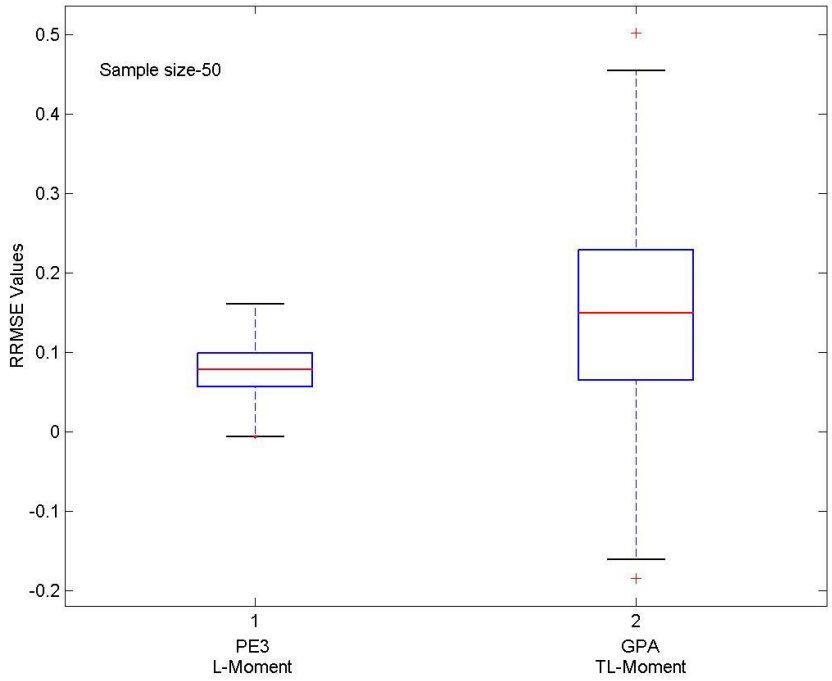

Figure 6.20 Box plot of RRMSE values of best distributions designated by L-moment and TL-moment for sample size 50.

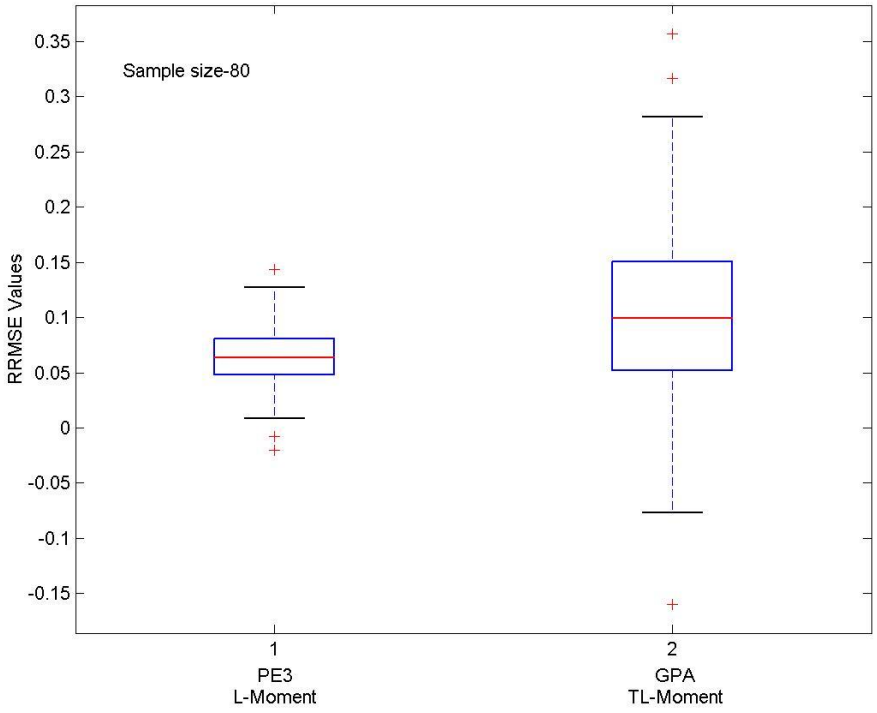

Figure 6.21 Box plot of RRMSE values of best distributions designated by L-moment and TL-moment for sample size 80.

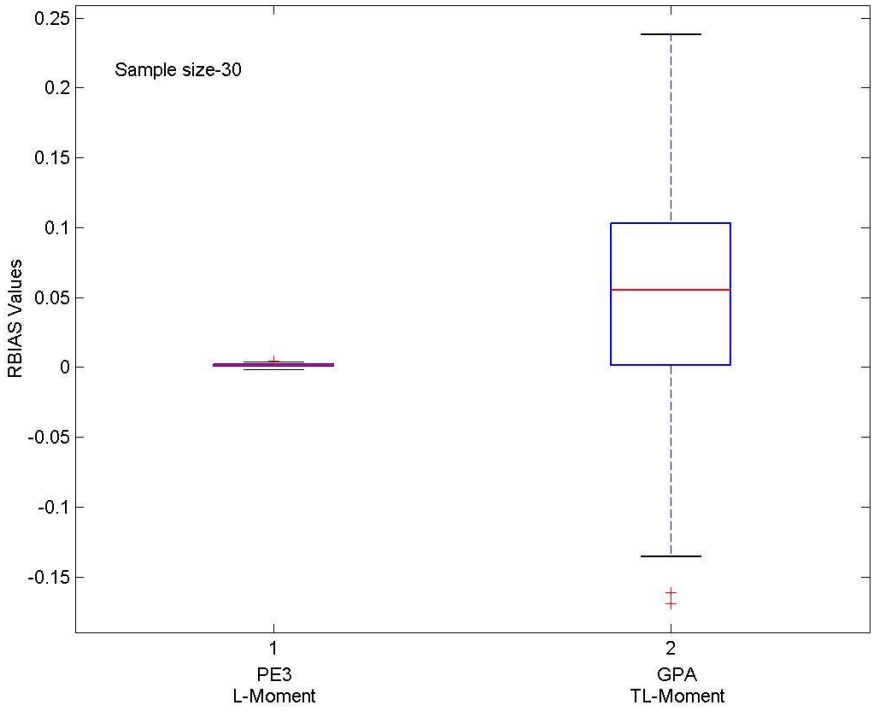

Figure 6.22 Box plot of RBIAS values of best distributions designated by L-moment and TL-moment for sample size 30.

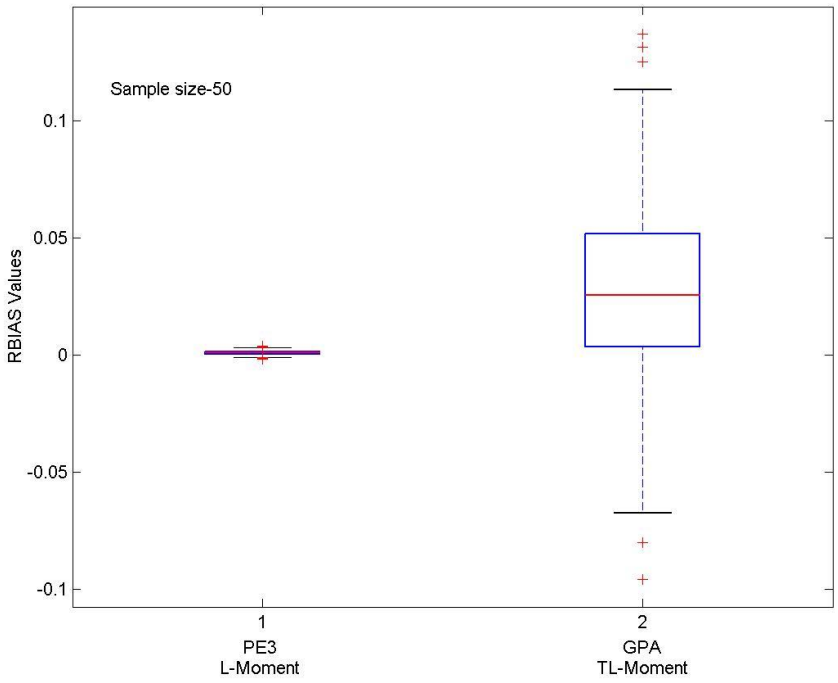

Figure 6.23 Box plot of RBIAS values of best distributions designated by L-moment and TL-moment for sample size 50.

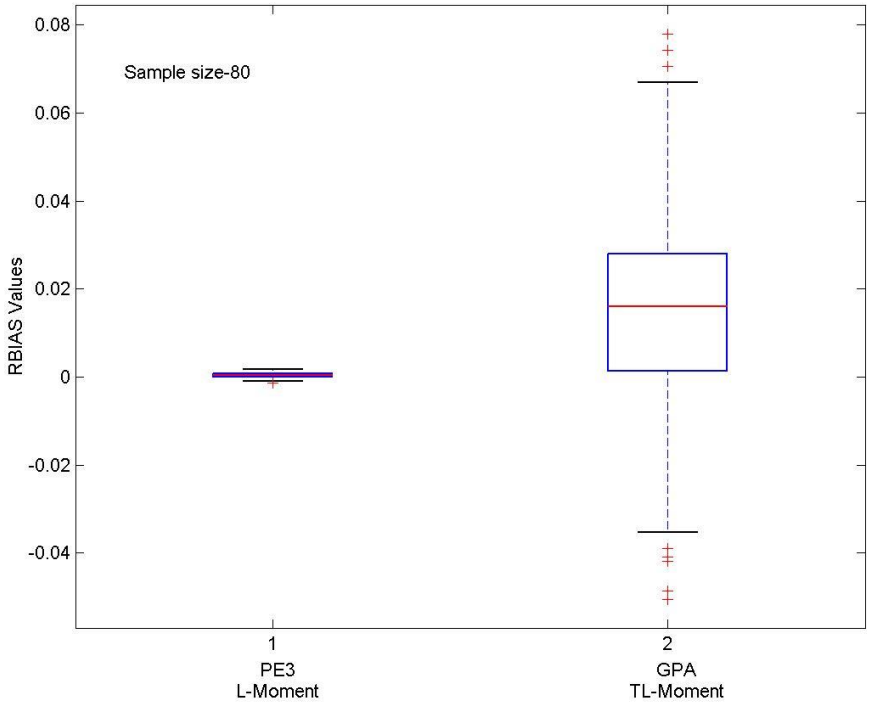

Figure 6.24 Box plot of RBIAS values of best distributions designated by L-moment and TL-moment for sample size 80.

6.8 Comparison between LQ-moment and TL-moment methods

In Chapter 3 and Chapter 5, both the method LQ-moment and TL-moment designate GPA distribution as the best fit distribution for maximum rainfall estimates of North East India.

Calculated RRMSE and RBIAS values are given in Table 6.9 and Table 6.10 respectively. From Table 6.9 and Table 6.10 it is observed that GPA distribution designated by TL-moment method has achieved the minimum RRMSE and minimum absolute RBIAS values than GPA distribution designated by LQ-moment. Figure 6.25, Figure 6.26 and Figure 6.27 represent the box plots of RRMSE values for sample size 30, 50 and 80 respectively. Also Figure 6.28, Figure 6.29 and Figure 6.30 represent the box plots of RBIAS values for sample size 30, 50 and 80 respectively. From these box plots it is clear that GPA distribution designated by TL-moment has minimum median RRMSE and RBIAS and minimum dispersion. Hence it can be concluded that

TL-moment is significantly more efficient than LQ-moment for maximum rainfall estimates of the region.

Table 6.9 RRMSE values at different return periods of best fit distributions designated by LQ-moment and TL-moment method respectively.

Methods	Sample size	Best fit Distributions	Return period (in years)				
			2	10	20	100	1000
LQ-moment	30	GPA	0.067	0.109	0.187	0.568	3.387
TL-moment		GPA	0.067	0.077	0.115	0.260	0.665
LQ-moment	50	GPA	0.052	0.083	0.137	0.340	1.042
TL-moment		GPA	0.052	0.058	0.086	0.176	0.352
LQ-moment	80	GPA	0.041	0.064	0.104	0.232	0.530
TL-moment		GPA	0.041	0.046	0.066	0.131	0.236

Table 6.10 RBIAS values at different return periods of best fit distributions designated by LQ-moment and TL-moment method respectively.

Methods	Sample size	Best fit Distributions	Return period (in years)				
			2	10	20	100	1000
LQ-moment	30	GPA	0.004	0.028	0.058	0.188	0.676
TL-moment		GPA	0.001	-0.001	0.009	0.056	0.184
LQ-moment	50	GPA	0.003	0.016	0.034	0.105	0.301
TL-moment		GPA	0.001	-0.001	0.004	0.030	0.089
LQ-moment	80	GPA	0.002	0.010	0.021	0.063	0.161
TL-moment		GPA	0.001	0.000	0.003	0.019	0.053

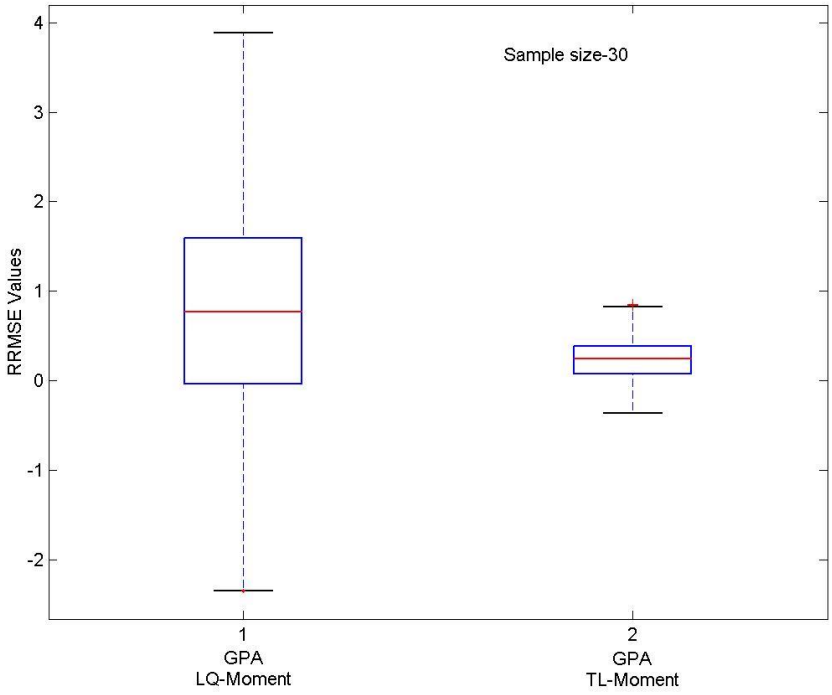

Figure 6.25 Box plot of RRMSE values of best distributions designated by LQ-moment and TL-moment for sample size 30.

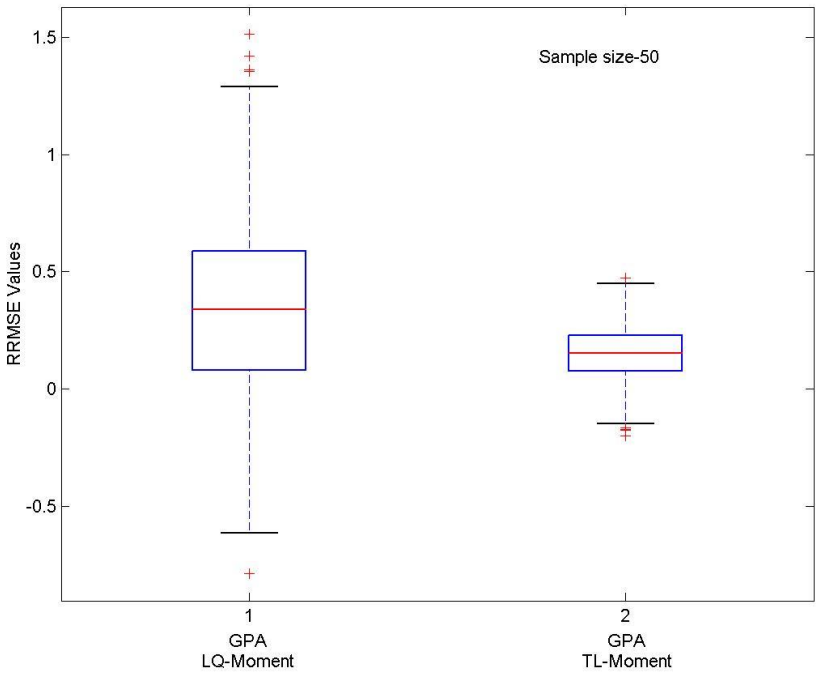

Figure 6.26 Box plot of RRMSE values of best distributions designated by LQ-moment and TL-moment for sample size 50.

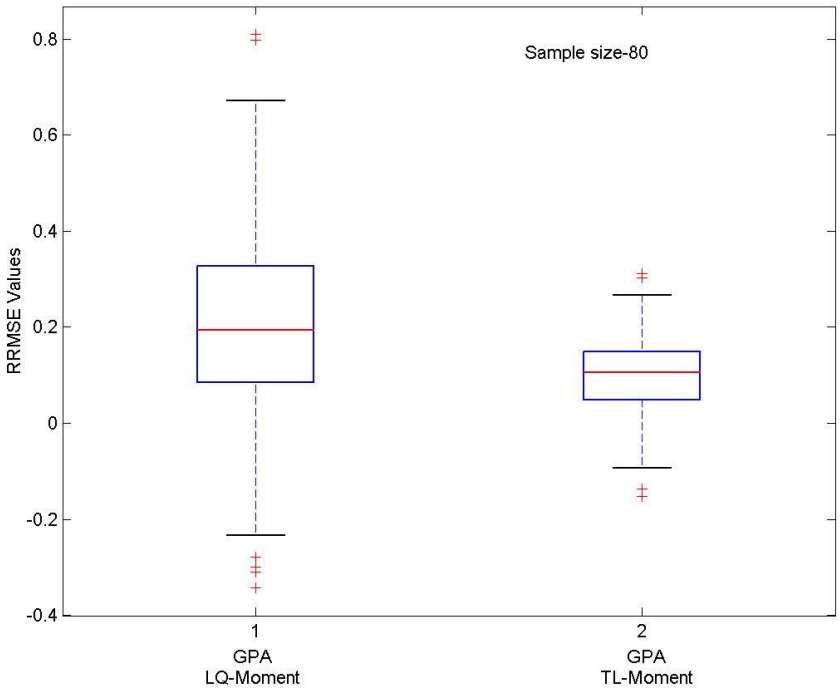

Figure 6.27 Box plot of RRMSE values of best distributions designated by LQ-moment and TL-moment for sample size 80.

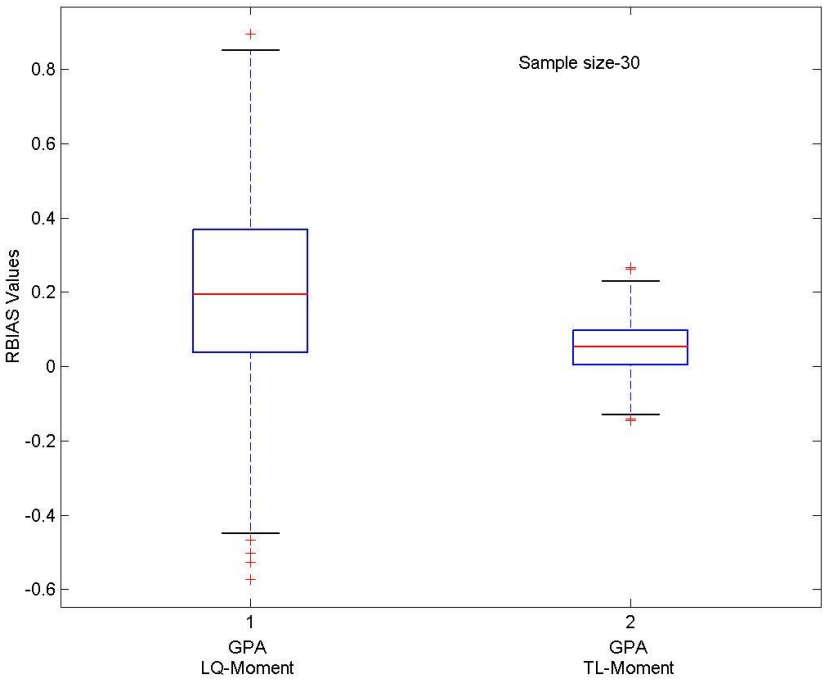

Figure 6.28 Box plot of RBIAS values of best distributions designated by LQ-moment and TL-moment for sample size 30.

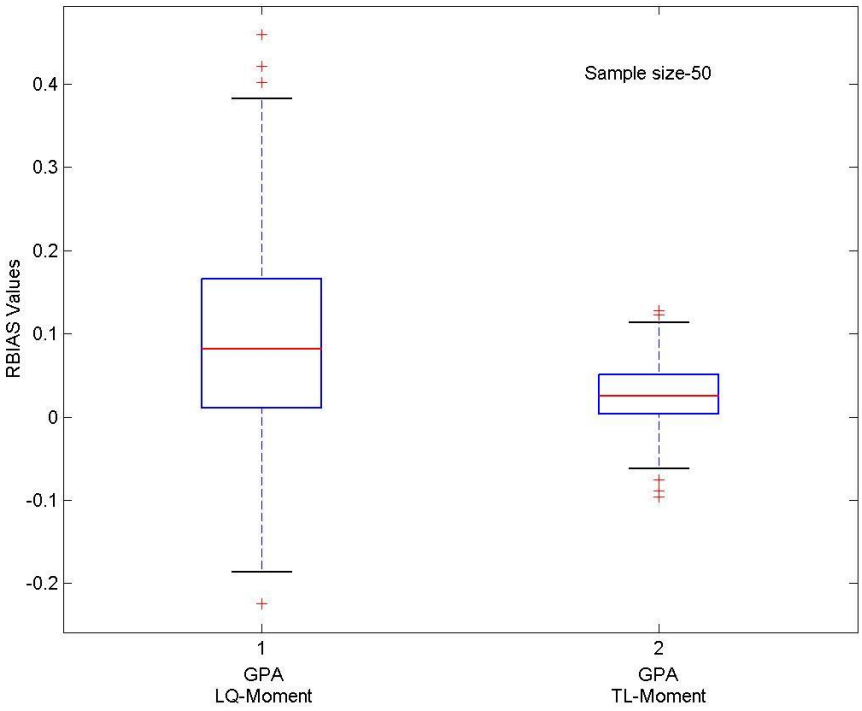

Figure 6.29 Box plot of RBIAS values of best distributions designated by LQ-moment and TL-moment for sample size 50.

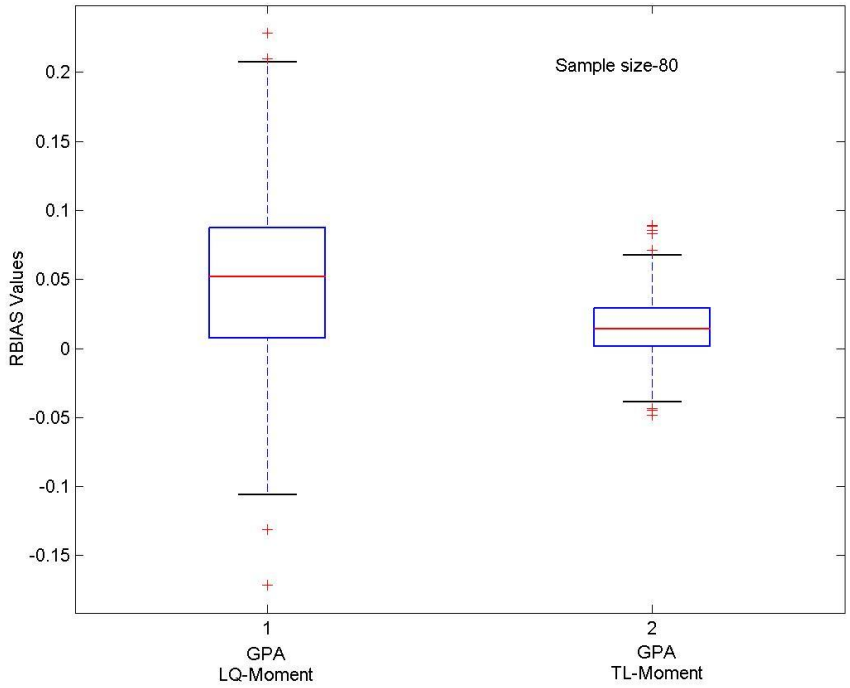

Figure 6.30 Box plot of RBIAS values of best distributions designated by LQ-moment and TL-moment for sample size 80.

6.9 Comparison between LQ-moment and LH-moment methods

In chapter 4, using LH-moment it is found that GPA distribution is selected as the best fit distribution for L_1-moment and GLO distribution for L_2, L_3& L_4-moments. Also in chapter 3, using LQ-moment it is found that GPA distribution is the best fit distribution.

Calculated RRMSE and RBIAS values are given in Table 6.11 and Table 6.12 respectively. From Table 6.11 it is observed that the RRMSE values of GPA distribution designated by L_1-moment method are less than the respective RRMSE values of GPA distribution designated by LQ-moment and GLO distribution designated by L_2, L_3& L_4-moments. Also from Table 6.12 it is observed that the RBIAS values (absolute) of GPA distribution designated by L_1-moment are smaller than the respective RBIAS values of GPA distribution designated by LQ-moment and GLO distribution designated by L_2, L_3& L_4-moments. Figure 6.31, Figure 6.32 and Figure 6.33 represent the box plots of RRMSE values for sample size 30, 50 and 80 respectively. Also Figure 6.34, Figure 6.35 and Figure 6.36 represent the box plots of RBIAS values for sample size 30, 50 and 80 respectively. From Figure 6.31 to Figure 6.33 it is observed that GPA distribution designated by L_1-moment has the minimum median RRMSE as well as minimum dispersion. Also from Figure 6.34 to Figure 6.36 it is observed that GPA distribution designated by L_1-moment has the minimum median RBIAS and minimum dispersion. Hence GPA distribution is selected as suitable and the best fitting distribution for maximum rainfall frequency analysis of North East India. Also the L_1-moment method is significantly more efficient than LQ-moment and other orders of LH-moment for maximum rainfall frequency analysis of North east India.

Table 6.11 RRMSE values at different return periods of best fit distributions designated by TL-moment and LH-moment of four orders.

Methods	Sample size	Best fit Distribution	Return period (in years)				
			2	10	20	100	1000
LQ-moment	30	GPA	0.067	0.109	0.187	0.568	3.387
L1-moment		GPA	0.025	0.036	0.043	0.067	0.078
L2-moment		GLO	0.070	0.082	0.090	0.160	0.457
L3-moment		GLO	0.089	0.077	0.087	0.161	0.417
L4-moment		GLO	0.099	0.083	0.090	0.154	0.407
LQ-moment	50	GPA	0.052	0.083	0.137	0.340	1.042
L1-moment		GPA	0.024	0.032	0.043	0.064	0.084
L2-moment		GLO	0.055	0.064	0.070	0.126	0.345
L3-moment		GLO	0.069	0.060	0.068	0.126	0.302
L4-moment		GLO	0.076	0.064	0.069	0.121	0.292
LQ-moment	80	GPA	0.041	0.064	0.104	0.232	0.530
L1-moment		GPA	0.001	0.001	0.000	0.000	0.001
L2-moment		GLO	0.043	0.051	0.055	0.103	0.282
L3-moment		GLO	0.053	0.047	0.054	0.102	0.236
L4-moment		GLO	0.059	0.050	0.055	0.097	0.226

Table 6.12 RBIAS values at different return periods of best fit distributions designated by TL-moment and LH-moment of four orders.

Methods	Sample size	Best fit Distributions	Return period (in years)				
			2	10	20	100	1000
LQ-moment	30	GPA	0.004	0.028	0.058	0.188	0.676
L1-moment		GPA	0.002	-0.001	-0.001	0.000	0.001
L2-moment		GLO	0.011	-0.019	-0.014	0.028	0.180
L3-moment		GLO	0.006	-0.005	-0.010	-0.008	0.049
L4-moment		GLO	0.004	-0.004	-0.010	-0.010	0.050
LQ-moment	50	GPA	0.003	0.016	0.034	0.105	0.301
L1-moment		GPA	0.001	0.000	-0.001	-0.001	0.001
L2-moment		GLO	0.008	-0.018	-0.011	0.029	0.156
L3-moment		GLO	0.003	-0.004	-0.006	-0.007	0.023
L4-moment		GLO	0.001	-0.003	-0.007	-0.008	0.023
LQ-moment	80	GPA	0.002	0.010	0.021	0.063	0.161
L1-moment		GPA	-0.001	0.001	0.000	0.000	0.000
L2-moment		GLO	0.007	-0.016	-0.008	0.033	0.150
L3-moment		GLO	0.002	-0.002	-0.003	-0.003	0.017
L4-moment		GLO	0.001	-0.001	-0.003	-0.004	0.016

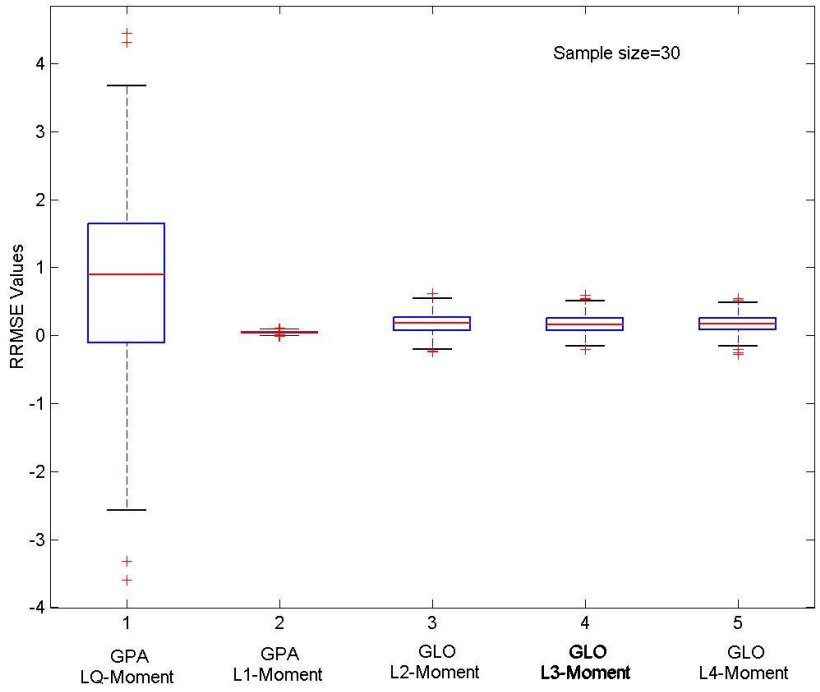

Figure 6.31 Box plot of RRMSE values of best distributions designated by LQ-moment and LH-moment of four orders for sample size 30.

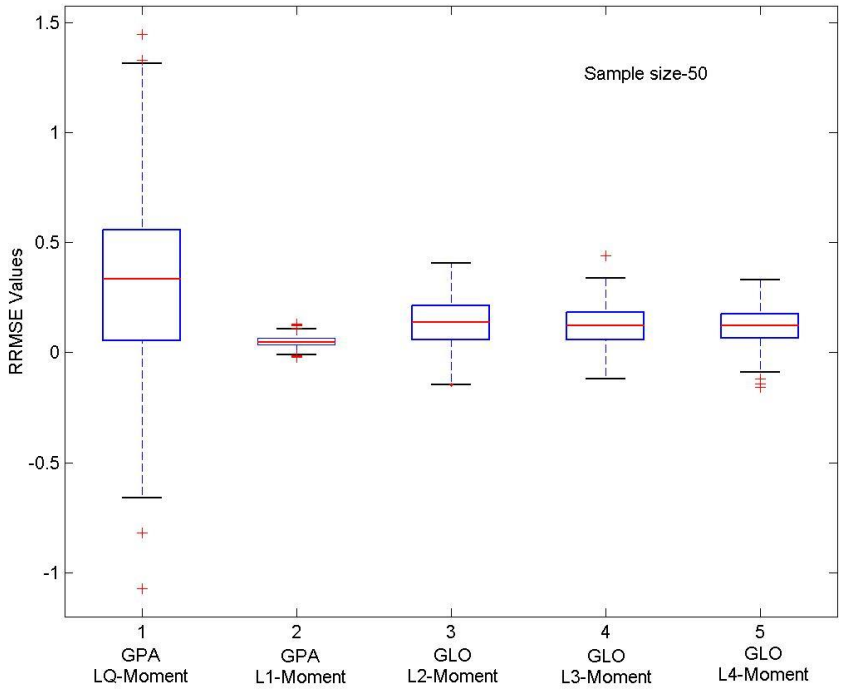

Figure 6.32 Box plot of RRMSE values of best distributions designated by LQ-moment and LH-moment of four orders for sample size 50.

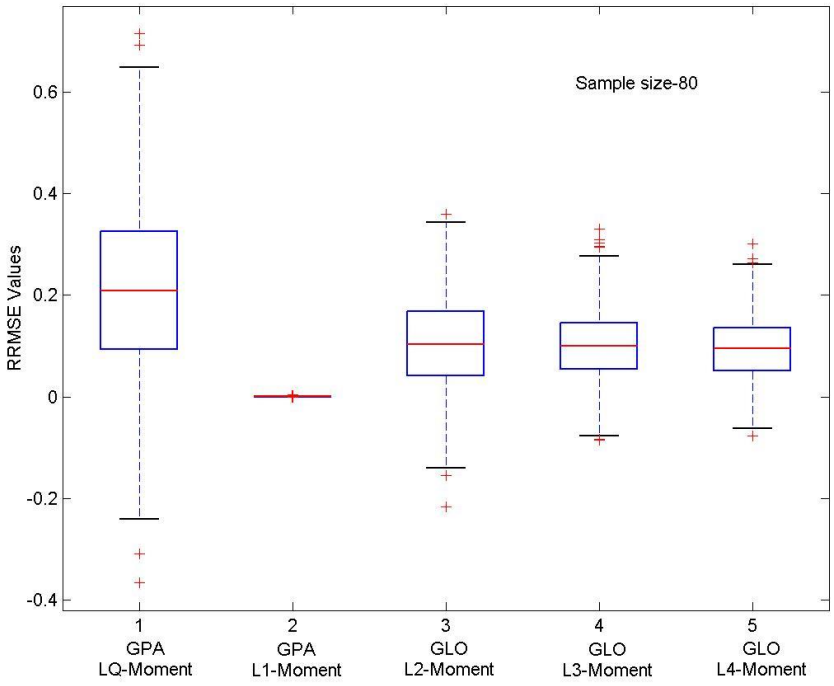

Figure 6.33 Box plot of RRMSE values of best distributions designated by LQ-moment and LH-moment of four orders for sample size 80.

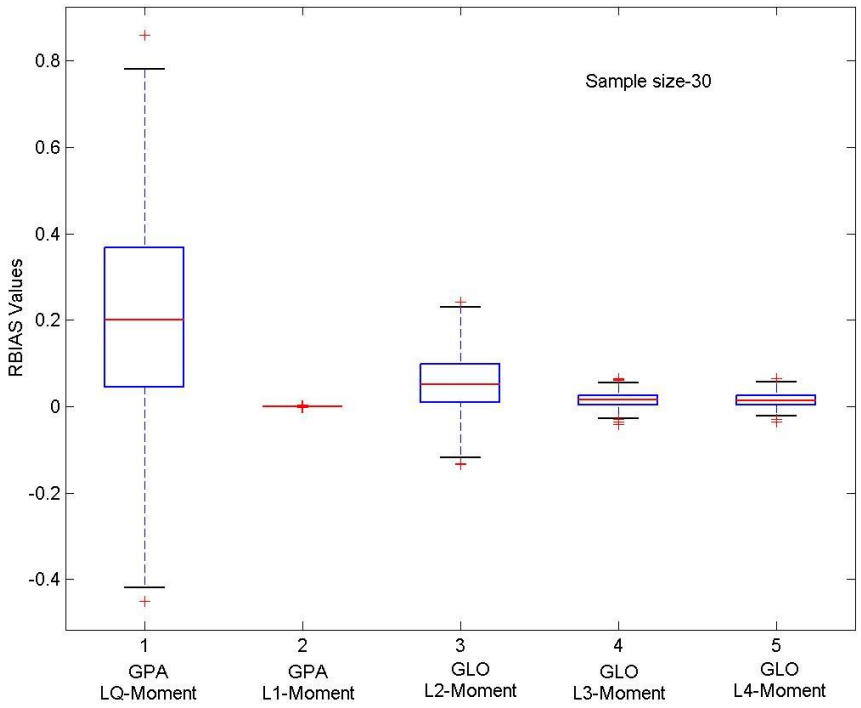

Figure 6.34 Box plot of RBIAS values of best distributions designated by LQ-moment and LH-moment of four orders for sample size 30.

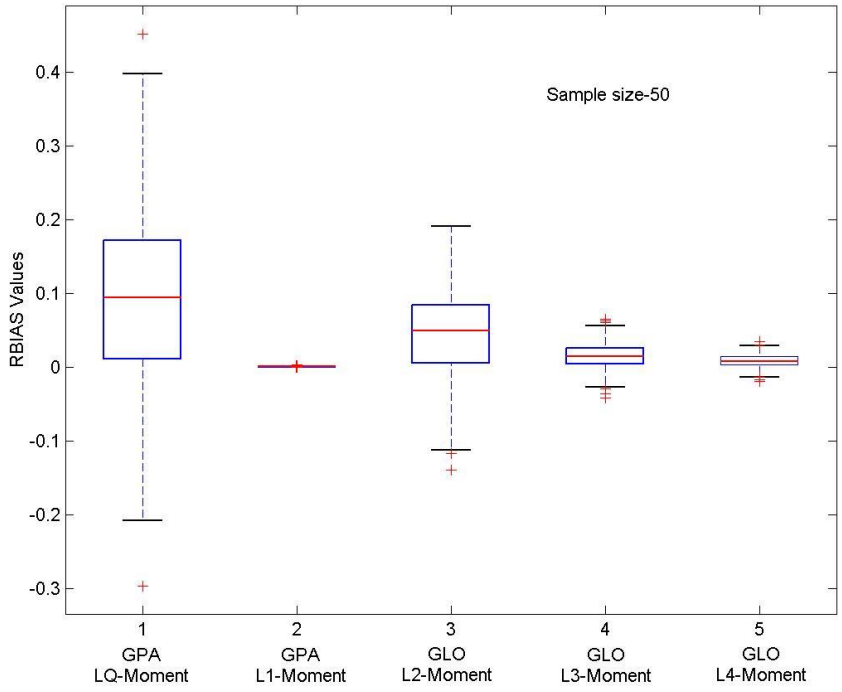

Figure 6.35 Box plot of RBIAS values of best distributions designated by LQ-moment and LH-moment of four orders for sample size 50.

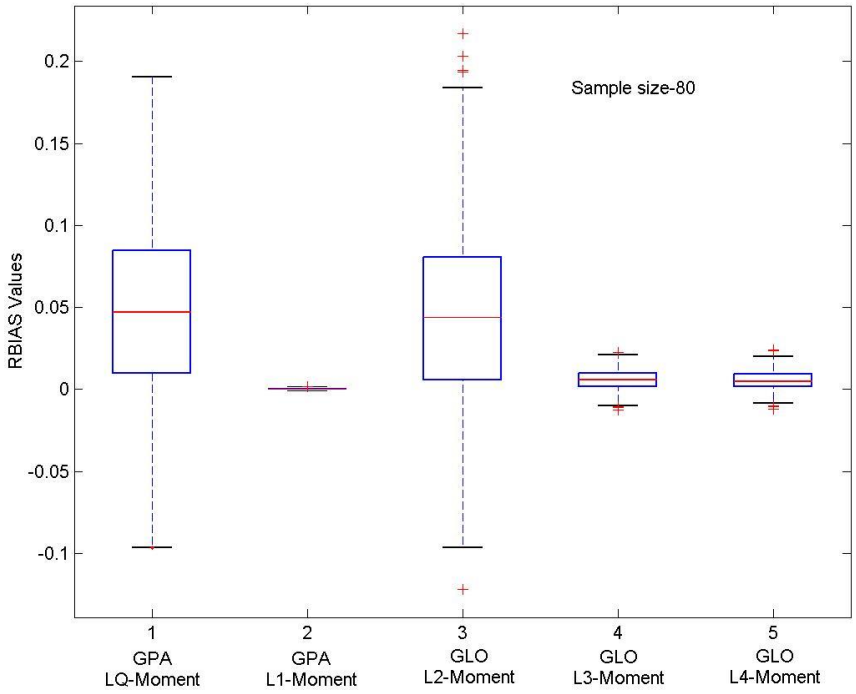

Figure 6.36 Box plot of RBIAS values of best distributions designated by LQ-moment and LH-moment of four orders for sample size 80.

6.10 Conclusion

From comparison between L-moment and LQ-moment, it is found that PE3 distribution designated by L-moment is more robust distribution. Also L-moment method is significantly more efficient than LQ-moment method. From comparison between L-moment and LH-moment it is found that GPA distribution designated by L_1-moment method is more suitable distribution and L_1-moment method is significantly more efficient than L-moment and other orders of LH-moment. Again from comparison between LH-moment and TL-moment it is found that GPA distribution designated by L_1-moment method is more suitable and L_1-moment method is significantly more efficient than TL-moment and other orders of LH-moment. From comparison between L-moment and TL-moment it is found that PE3 distribution designated by L-moment is more suitable than GPA distribution designated by TL-moment method and L-moment method is significantly more efficient than TL-moment. Also from comparison between LQ-moment and TL-moment it is found that TL-moment is significantly more efficient than LQ-moment. Again from comparison between LQ-moment and LH-moment it is found that L_1-moment is significantly more efficient than LQ-moment and other order of LH-moment.

Hence from comparison among the methods of parameter estimation it can be concluded that the GPA distribution designated by L_1-moment is the best fit distribution for regional maximum rainfall frequency estimates of North East India. Also L_1-moment method is the most significant method for parameter estimation and quantile estimation of maximum rainfall estimation of the 12 gauzed stations of North East India.

Also if we grade the methods in descending order based on performance then it will be as follows

1. LH-moment of order 1
2. L-moment
3. TL-moment
4. LQ-moment.

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