Multi-criteria decision-making analysis in selecting suitable plotting positions for IDF curves of Mandya District, Karnataka

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ABSTRACT

In this study the calculation procedure and comparative results of IDF curves for the area of Mandya are presented. Rainfall data of 19 (Ninteen) hydrological years of stations Srirangapatna, Kikkere and Bindganarole were used. Maximum rainfall frequency analysis was made by Four methods (Normal, Gumbel, Pearson type III and logarithmic Pearson type III) and subsequently the IDF curves with Four methods (two forms of excessive functions and a polynomial function) were exported. Finally, comparative testing with the IDF which were prepared by Chi-square test and it was found that the log-normal distribution suits the best fit for all the stations considered.

Key words: *Gumbel Distribution, Intensity Duration Frequency (IDF), Log Normal Distribution, Normal Distribution, Pearson Type III Distribution, Log Pearson Type III Distribution Rainfall Duration.*

I INTRODUCTION

Finding suitable distributions, regardless of parametric or nonparametric distributions, to fit rainfall data has long been a subject of interest in various fields of study including hydrology, meteorology, economy and agriculture. Several studies have been conducted to find the best-fit distribution for rainfall data using various parameter estimation methods such as maximum likelihood estimation (MLE) and L-moments. However, determining the best-fit distribution is usually tedious, complex and subjective. This is due to the different rankings provided by different goodness-of-fit indices being used in the study. This study aims to incorporate multi-criteria decision-making(MCDM) analysis by taking the rankings given by several goodness-of-fit indices as criteria in choosing the best distribution to represent annual maximum storm intensities for constructing intensity–duration–frequency (IDF) curves of rainfall stations.

Degradation of water quality, property damage and potential loss of life due to flooding is caused by extreme rainfall events. Historic rainfall event statistics (in terms of intensity, duration, and return period) are used to design flood protection structures, and many other civil engineering structures involving hydrologic flows. Since rainfall characteristics are often used to design water structures, reviewing and updating rainfall characteristics (i.e., Intensity–Duration–Frequency (IDF) curves) for future climate scenarios is necessary.

The relation between rainfall and runoff is influenced by various storm and basin characteristics. Because of these complexities and the frequent paucity of adequate runoff data, many approximate formulae have been developed to relate rainfall and runoff. The earliest of these formulae were usually empirical statements.

II MATERIALS AND METHODS

A Study Area

The Study Area is located between Latitude 12º12′21″ N to 13º2′27″ N and 76º20′8″ E to 77º19′58″ E Longitude. The average mean daily temperature is 23^0C and average rainfall varies from 700mm to 800mm. Mandya District

has five rivers: Kaveri River and four tributaries main Hemavathi, Shimsha, Lokapavani, Veeravaishnavi, Three Raingauges Stations were considered as shown in Figure 1.

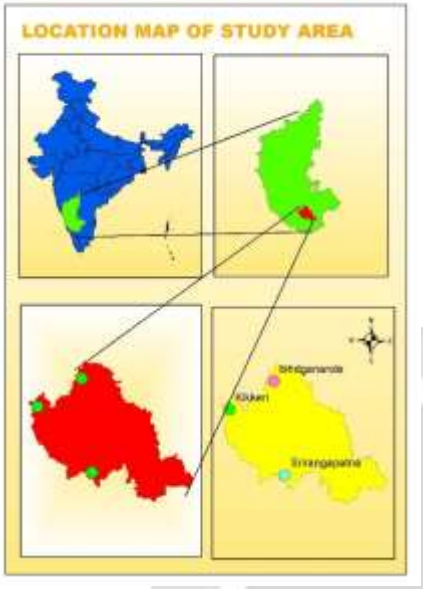


Figure 1 Location Map of Study Area

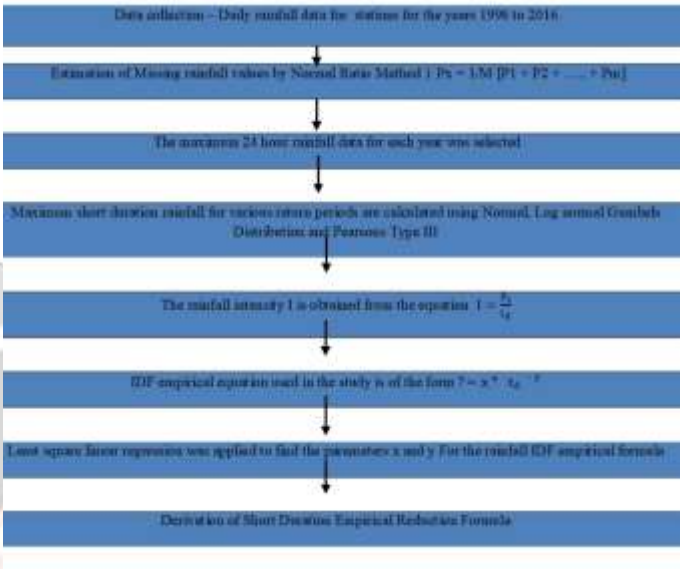


Figure 2 Methodology adopted for IDF curves

B Methodology

Indian Meteorological Department (IMD) use an empirical reduction formula (Equation A) for estimation of various duration like 1-hr, 2-hr, 3-hr, 5-hr, 8-hr rainfall values from annual maximum values. Chowdhury et al. (2007), used IMD empirical reduction formula to estimate the short duration rainfall from daily rainfall data in Sylhet city and found that this formula give the best estimation of short duration rainfall. (Rashid et al, 2012)

$$P_t = P_{24}\left(\frac{t}{24}\right)^{\frac{1}{3}} \qquad \text{(equation A)}$$

where, P_t is the required rainfall depth in mm at t-hr duration,

P_{24} is the daily rainfall in mm and t is the duration of rainfall for which the rainfall depth is required in hr.

Short duration rainfall by using IMD empirical formula for For various stations is tabulated in Table 1 to Table 3.

III Results and Discussions

A Estimation of Short Duration Rainfall

Table 1 Short duration rainfall for Kikkere

Year	Rainfall (mm)	$P_t = P_{24}\left(\frac{t}{24}\right)^{\frac{1}{3}}$ in mm where, time t is in hours							
Duration in Minutes		**5**	**10**	**15**	**30**	**60**	**120**	**720**	**1440**
1998	46.400	7.026	8.852	10.134	12.767	16.086	20.267	36.828	46.400
1999	48.900	7.405	9.329	10.680	13.455	16.953	21.359	38.812	48.900
2000	65.800	9.964	12.554	14.370	18.106	22.812	28.741	52.225	65.800
2001	67.400	10.206	12.859	14.720	18.546	23.366	29.440	53.495	67.400
2002	62.400	9.449	11.905	13.628	17.170	21.633	27.256	49.527	62.400
2003	63.200	9.570	12.058	13.803	17.390	21.910	27.605	50.162	63.200
2004	83.400	12.629	15.912	18.214	22.948	28.913	36.428	66.195	83.400
2005	115.200	17.444	21.979	25.159	31.699	39.938	50.318	91.434	115.200
2006	65.400	9.903	12.477	14.283	17.996	22.673	28.566	51.908	65.400
2007	60.200	9.116	11.485	13.147	16.565	20.870	26.295	47.781	60.200
2008	67.800	10.267	12.935	14.807	18.656	23.505	29.614	53.813	67.800
2009	88.000	13.326	16.789	19.219	24.214	30.508	38.438	69.846	88.000
2010	75.600	11.448	14.423	16.511	20.802	26.209	33.021	60.004	75.600
2011	48.300	7.314	9.215	10.548	13.290	16.745	21.097	38.336	48.300
2012	45.800	6.935	8.738	10.002	12.602	15.878	20.005	36.351	45.800
2013	68.800	10.418	13.126	15.026	18.931	23.852	30.051	54.607	68.800
2014	36.600	5.542	6.983	7.993	10.071	12.689	15.987	29.049	36.600
2015	80.500	12.190	15.358	17.581	22.150	27.908	35.162	63.893	80.500
2016	29.200	4.422	5.571	6.377	8.035	10.123	12.754	23.176	29.200

Table 2 Short duration rainfall for Srirangapatna

Year	Rainfall (mm)	$P_t = P_{24}\left(\frac{t}{24}\right)^{\frac{1}{3}}$ in mm where, time t is in hours							
Duration in Minutes		**5**	**10**	**15**	**30**	**60**	**120**	**720**	**1440**
1998	80.400	12.175	15.339	17.559	22.123	27.873	35.118	63.814	80.400
1999	61.000	9.237	11.638	13.322	16.785	21.148	26.644	48.416	61.000
2000	104.000	15.748	19.842	22.713	28.617	36.055	45.426	82.545	104.000
2001	80.600	12.205	15.377	17.603	22.178	27.942	35.205	63.972	80.600
2002	67.800	10.267	12.935	14.807	18.656	23.505	29.614	53.813	67.800
2003	54.000	8.177	10.302	11.793	14.859	18.721	23.587	42.860	54.000
2004	77.000	11.660	14.691	16.816	21.187	26.694	33.633	61.115	77.000
2005	68.400	10.358	13.050	14.938	18.821	23.713	29.876	54.289	68.400
2006	55.200	8.359	10.531	12.055	15.189	19.137	24.111	43.812	55.200
2007	104.200	15.779	19.880	22.757	28.672	36.124	45.514	82.704	104.200
2008	49.000	7.420	9.349	10.701	13.483	16.987	21.403	38.891	49.000
2009	77.800	11.781	14.843	16.991	21.407	26.972	33.982	61.750	77.800
2010	60.400	9.146	11.523	13.191	16.620	20.940	26.382	47.940	60.400
2011	81.400	12.326	15.530	17.777	22.398	28.220	35.555	64.607	81.400
2012	43.200	6.542	8.242	9.435	11.887	14.977	18.869	34.288	43.200
2013	126.200	19.110	24.077	27.561	34.725	43.751	55.123	100.165	126.200
2014	72.000	10.903	13.737	15.724	19.812	24.961	31.449	57.146	72.000
2015	68.200	10.327	13.012	14.895	18.766	23.644	29.789	54.130	68.200
2016	47.000	7.117	8.967	10.265	12.933	16.294	20.529	37.304	47.000

Table 3 Short duration rainfall for Bindganarole

Year	Rainfall (mm)	$P_t = P_{24}\left(\frac{t}{24}\right)^{\frac{1}{3}}$ in mm where, time t is in hours							
Duration in Minutes		**5**	**10**	**15**	**30**	**60**	**120**	**720**	**1440**
1998	58.400	8.843	11.142	12.754	16.069	20.246	25.509	46.352	58.400
1999	64.000	9.691	12.210	13.977	17.610	22.188	27.955	50.797	64.000
2000	75.000	11.357	14.309	16.380	20.637	26.001	32.759	59.528	75.000
2001	65.200	9.873	12.439	14.239	17.940	22.604	28.479	51.749	65.200

2002	80.000	12.114	15.263	17.472	22.013	27.734	34.943	63.496	80.000
2003	43.000	6.511	8.204	9.391	11.832	14.907	18.782	34.129	43.000
2004	68.000	10.297	12.973	14.851	18.711	23.574	29.702	53.972	68.000
2005	80.000	12.114	15.263	17.472	22.013	27.734	34.943	63.496	80.000
2006	50.200	7.602	9.577	10.963	13.813	17.403	21.927	39.844	50.200
2007	60.000	9.086	11.447	13.104	16.510	20.801	26.207	47.622	60.000
2008	40.000	6.057	7.631	8.736	11.006	13.867	17.472	31.748	40.000
2009	42.400	6.420	8.089	9.260	11.667	14.699	18.520	33.653	42.400
2010	56.600	8.571	10.798	12.361	15.574	19.622	24.722	44.923	56.600
2011	61.400	9.298	11.714	13.409	16.895	21.286	26.819	48.733	61.400
2012	90.000	13.628	17.171	19.656	24.764	31.201	39.311	71.433	90.000
2013	77.000	11.660	14.691	16.816	21.187	26.694	33.633	61.115	77.000
2014	57.200	8.662	10.913	12.492	15.739	19.830	24.984	45.400	57.200
2015	71.400	10.812	13.622	15.593	19.646	24.753	31.187	56.670	71.400
2016	64.400	9.752	12.287	14.065	17.720	22.326	28.129	51.114	64.400

B Normal Distribution

Table 4 Estimation of maximum rainfall intensity for various return period by Normal Distribution For Kikkere Raingauge Station

Duration in minutes	Return period 2 yrs		Return period 5 yrs		Return period 10 yrs		Return period 25 yrs		Return period 50 yrs		Return period 75 yrs		Return period 100 yrs	
	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)
5	11.80	141.58	12.09	145.07	12.17	146.08	12.22	146.64	12.24	146.82	12.24	146.88	12.24	146.91
10	14.86	89.19	15.23	91.39	15.34	92.02	15.40	92.38	15.42	92.49	15.42	92.53	15.42	92.55
15	17.02	68.06	17.44	69.74	17.56	70.23	17.62	70.50	17.65	70.58	17.65	70.61	17.66	70.63
30	21.44	42.88	21.97	43.94	22.12	44.24	22.21	44.41	22.23	44.47	22.24	44.48	22.25	44.49
60	27.01	27.01	27.68	27.68	27.87	27.87	27.98	27.98	28.01	28.01	28.02	28.02	28.03	28.03
120	34.03	17.02	34.87	17.44	35.11	17.56	35.25	17.62	35.29	17.65	35.31	17.65	35.31	17.66
720	61.84	5.15	63.37	5.28	63.81	5.32	64.05	5.34	64.13	5.34	64.16	5.35	64.17	5.35
1440	77.91	3.25	79.84	3.33	80.39	3.35	80.70	3.36	80.80	3.37	80.83	3.37	80.85	3.37

Table 5 Estimation of maximum rainfall intensity for various return period by Normal Distribution For Srirangapatna Raingauge station

Duration in minutes	Return period 2 yrs		Return period 5 yrs		Return period 10 yrs		Return period 25 yrs		Return period 50 yrs		Return period 75 yrs		Return period 100 yrs	
	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)
5	13.21	158.55	13.52	162.29	13.61	163.37	13.66	163.97	13.68	164.16	13.69	164.23	13.69	164.26
10	16.65	99.88	17.04	102.24	17.15	102.92	17.22	103.29	17.24	103.42	17.24	103.46	17.25	103.48
15	19.06	76.22	19.51	78.02	19.63	78.54	19.71	78.83	19.73	78.92	19.74	78.95	19.74	78.97
30	24.01	48.02	24.58	49.15	24.74	49.48	24.83	49.66	24.86	49.72	24.87	49.74	24.87	49.75
60	30.25	30.25	30.96	30.96	31.17	31.17	31.28	31.28	31.32	31.32	31.33	31.33	31.34	31.34
120	38.11	19.06	39.01	19.51	39.27	19.63	39.41	19.71	39.46	19.73	39.48	19.74	39.48	19.74
720	69.25	5.77	70.89	5.91	71.36	5.95	71.62	5.97	71.70	5.98	71.73	5.98	71.75	5.98
1440	87.25	3.64	89.31	3.72	89.90	3.75	90.24	3.76	90.34	3.76	90.38	3.77	90.39	3.77

C Log Normal Distribution

Table 6 Estimation of maximum rainfall intensity for various return period by Normal Distribution For Bindganarole Raingauge Station

Duration in minutes	Return period 2 yrs		Return period 5 yrs		Return period 10 yrs		Return period 25 yrs		Return period 50 yrs		Return period 75 yrs		Return period 100 yrs	
	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)
5	11.03	132.36	11.23	134.77	11.29	135.46	11.32	135.85	11.33	135.97	11.33	136.01	11.34	136.03
10	13.90	83.38	14.15	84.90	14.22	85.34	14.26	85.58	14.28	85.66	14.28	85.68	14.28	85.69
15	15.91	63.63	16.20	64.79	16.28	65.12	16.33	65.31	16.34	65.37	16.35	65.39	16.35	65.40
30	20.04	40.09	20.41	40.82	20.51	41.02	20.57	41.14	20.59	41.18	20.60	41.19	20.60	41.20
60	25.25	25.25	25.71	25.71	25.84	25.84	25.92	25.92	25.94	25.94	25.95	25.95	25.95	25.95
120	31.82	15.91	32.40	16.20	32.56	16.28	32.65	16.33	32.68	16.34	32.69	16.35	32.70	16.35
720	57.82	4.82	58.87	4.91	59.17	4.93	59.34	4.94	59.39	4.95	59.41	4.95	59.42	4.95
1440	72.84	3.04	74.17	3.09	74.55	3.11	74.76	3.11	74.83	3.12	74.85	3.12	74.86	3.12

C Log Normal Distribution

Table 7 Estimation of maximum rainfall intensity for various return period by Log Normal Distribution For Kikkere Raingauge Station

Duration in minutes	Return period 2 yrs		Return period 5 yrs		Return period 10 yrs		Return period 25 yrs		Return period 50 yrs		Return period 75 yrs		Return period 100 yrs	
	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)
5	11.44	137.30	11.78	141.38	11.88	142.58	11.94	143.25	11.96	143.47	11.96	143.54	11.96	143.58
10	14.42	86.49	14.84	89.07	14.97	89.82	15.04	90.24	15.06	90.38	15.07	90.43	15.07	90.45
15	16.50	66.01	16.99	67.97	17.14	68.55	17.22	68.87	17.24	68.97	17.25	69.01	17.26	69.02
30	20.79	41.58	21.41	42.82	21.59	43.18	21.69	43.38	21.73	43.45	21.74	43.47	21.74	43.48
60	26.20	26.20	26.97	26.97	27.20	27.20	27.33	27.33	27.37	27.37	27.39	27.39	27.39	27.39
120	33.00	16.50	33.99	16.99	34.27	17.14	34.43	17.22	34.49	17.24	34.50	17.25	34.51	17.26
720	59.97	5.00	61.76	5.15	62.28	5.19	62.57	5.21	62.67	5.22	62.70	5.22	62.71	5.23
1440	75.56	3.15	77.81	3.24	78.47	3.27	78.84	3.28	78.95	3.29	78.99	3.29	79.01	3.29

Table 8 Estimation of maximum rainfall intensity for various return period by Log Normal Distribution For Srirangapatna Station

Duration in minutes	Return period 2 yrs		Return period 5 yrs		Return period 10 yrs		Return period 25 yrs		Return period 50 yrs		Return period 75 yrs		Return period 100 yrs	
	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)
5	12.86	154.26	13.22	158.61	13.32	159.89	13.38	160.61	13.40	160.84	13.41	160.91	13.41	160.95
10	16.20	97.18	16.65	99.92	16.79	100.72	16.86	101.18	16.89	101.32	16.89	101.37	16.90	101.39
15	18.54	74.16	19.06	76.25	19.22	76.87	19.30	77.21	19.33	77.32	19.34	77.36	19.34	77.38
30	23.36	46.72	24.02	48.04	24.21	48.42	24.32	48.64	24.35	48.71	24.37	48.73	24.37	48.74
60	29.43	29.43	30.26	30.26	30.50	30.50	30.64	30.64	30.69	30.69	30.70	30.70	30.71	30.71
120	37.08	18.54	38.13	19.06	38.43	19.22	38.61	19.30	38.66	19.33	38.68	19.34	38.69	19.34
720	67.38	5.62	69.28	5.77	69.84	5.82	70.15	5.85	70.25	5.85	70.28	5.86	70.30	5.86
1440	84.89	3.54	87.29	3.64	87.99	3.67	88.38	3.68	88.51	3.69	88.55	3.69	88.57	3.69

Table 9 Estimation of maximum rainfall intensity for various return period by Log Normal Distribution For Bindganarole Station

Duration in minutes	Return period 2 yrs		Return period 5 yrs		Return period 10 yrs		Return period 25 yrs		Return period 50 yrs		Return period 75 yrs		Return period 100 yrs	
	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)
5	10.87	130.48	11.10	133.20	11.17	133.99	11.20	134.44	11.22	134.58	11.22	134.63	11.22	134.65
10	13.70	82.20	13.99	83.91	14.07	84.41	14.12	84.69	14.13	84.78	14.14	84.81	14.14	84.83
15	15.68	62.73	16.01	64.04	16.10	64.42	16.16	64.63	16.18	64.70	16.18	64.72	16.18	64.73
30	19.76	39.52	20.17	40.34	20.29	40.58	20.36	40.72	20.38	40.76	20.39	40.77	20.39	40.78
60	24.89	24.89	25.41	25.41	25.56	25.56	25.65	25.65	25.68	25.68	25.69	25.69	25.69	25.69
120	31.36	15.68	32.02	16.01	32.21	16.10	32.32	16.16	32.35	16.18	32.36	16.18	32.37	16.18
720	56.99	4.75	58.18	4.85	58.53	4.88	58.72	4.89	58.78	4.90	58.81	4.90	58.82	4.90
1440	71.81	2.99	73.30	3.05	73.74	3.07	73.98	3.08	74.06	3.09	74.09	3.09	74.10	3.09

Table 10 Estimation of maximum rainfall intensity for various return period by Gumbel's Distribution For Kikkere Station

Duration in minutes	Return period 2 yrs		Return period 5 yrs		Return period 10 yrs		Return period 25 yrs		Return period 50 yrs		Return period 75 yrs		Return period 100 yrs	
	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)
5	9.22	110.63	11.90	142.75	13.65	163.77	15.88	190.52	17.53	210.37	18.49	221.90	19.17	230.06
10	11.62	69.69	14.99	89.92	17.20	103.17	20.00	120.02	22.09	132.52	23.30	139.79	24.16	144.93
15	13.30	53.19	17.16	68.62	19.68	78.73	22.90	91.59	25.28	101.13	26.67	106.68	27.65	110.60
30	16.75	33.50	21.62	43.23	24.80	49.60	28.85	57.70	31.86	63.71	33.60	67.20	34.84	69.68
60	21.11	21.11	27.23	27.23	31.25	31.25	36.35	36.35	40.14	40.14	42.34	42.34	43.89	43.89
120	26.59	13.30	34.31	17.16	39.37	19.68	45.80	22.90	50.57	25.28	53.34	26.67	55.30	27.65
720	48.32	4.03	62.35	5.20	71.54	5.96	83.22	6.93	91.89	7.66	96.92	8.08	100.49	8.37
1440	60.88	2.54	78.56	3.27	90.13	3.76	104.85	4.37	115.77	4.82	122.12	5.09	126.61	5.28

D Gumbel's Distribution

Table 11 Estimation of maximum rainfall intensity for various return period by Gumbel's Distribution For Srirangapatna Station

Duration in minutes	Return period 2 yrs		Return period 5 yrs		Return period 10 yrs		Return period 25 yrs		Return period 50 yrs		Return period 75 yrs		Return period 100 yrs	
	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)
5	10.45	125.41	13.32	159.80	15.19	182.32	17.58	210.96	19.35	232.21	20.38	244.56	21.11	253.30
10	13.17	79.00	16.78	100.67	19.14	114.85	22.15	132.90	24.38	146.28	25.68	154.06	26.59	159.57
15	15.07	60.29	19.21	76.82	21.91	87.65	25.35	101.42	27.91	111.63	29.39	117.57	30.44	121.77
30	18.99	37.98	24.20	48.39	27.61	55.21	31.94	63.89	35.16	70.33	37.03	74.07	38.36	76.71
60	23.93	23.93	30.49	30.49	34.78	34.78	40.25	40.25	44.30	44.30	46.66	46.66	48.33	48.33
120	30.14	15.07	38.41	19.21	43.82	21.91	50.71	25.35	55.82	27.91	58.79	29.39	60.89	30.44
720	54.78	4.56	69.80	5.82	79.63	6.64	92.14	7.68	101.43	8.45	106.82	8.90	110.64	9.22
1440	69.01	2.88	87.94	3.66	100.33	4.18	116.10	4.84	127.79	5.32	134.59	5.61	139.40	5.81

Table 12 Estimation of maximum rainfall intensity for various return period by Gumbel's Distribution For Bindganarole Station

Duration in minutes	Return period 2 yrs		Return period 5 yrs		Return period 10 yrs		Return period 25 yrs		Return period 50 yrs		Return period 75 yrs		Return period 100 yrs	
	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)
5	9.26	111.08	11.10	133.17	12.30	147.63	13.84	166.03	14.97	179.67	15.63	187.61	16.10	193.22
10	11.66	69.98	13.98	83.89	15.50	93.00	17.43	104.59	18.86	113.19	19.70	118.18	20.29	121.72
15	13.35	53.40	16.01	64.02	17.74	70.97	19.95	79.82	21.59	86.38	22.55	90.19	23.22	92.89
30	16.82	33.64	20.17	40.33	22.36	44.71	25.14	50.28	27.21	54.41	28.41	56.82	29.26	58.52
60	21.19	21.19	25.41	25.41	28.17	28.17	31.68	31.68	34.28	34.28	35.79	35.79	36.86	36.86
120	26.70	13.35	32.01	16.01	35.49	17.74	39.91	19.95	43.19	21.59	45.10	22.55	46.45	23.22
720	48.52	4.04	58.17	4.85	64.48	5.37	72.52	6.04	78.48	6.54	81.94	6.83	84.40	7.03
1440	61.13	2.55	73.28	3.05	81.24	3.39	91.37	3.81	98.88	4.12	103.24	4.30	106.33	4.43

E Pearson Type III Distribution

Table 13 Estimation of maximum rainfall intensity for various return period by Pearson Type III Distribution For Kikkere Station

Duration in minutes	Return period 2 yrs		Return period 5 yrs		Return period 10 yrs		Return period 25 yrs		Return period 50 yrs		Return period 75 yrs		Return period 100 yrs	
	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)
5	9.71	116.57	12.25	147.02	13.58	162.93	14.99	179.90	15.90	190.85	16.72	200.69	17.48	209.73
10	12.24	73.44	15.44	92.62	17.11	102.64	18.89	113.33	20.04	120.23	21.07	126.43	22.02	132.12
15	14.01	56.04	17.67	70.68	19.58	78.33	21.62	86.48	22.94	91.75	24.12	96.48	25.21	100.83
30	17.65	35.30	22.26	44.53	24.67	49.35	27.24	54.48	28.90	57.80	30.39	60.78	31.76	63.52
60	22.24	22.24	28.05	28.05	31.09	31.09	34.32	34.32	36.41	36.41	38.29	38.29	40.01	40.01
120	28.02	14.01	35.34	17.67	39.17	19.58	43.24	21.62	45.88	22.94	48.24	24.12	50.41	25.21
720	50.92	4.24	64.22	5.35	71.17	5.93	78.58	6.55	83.36	6.95	87.66	7.30	91.61	7.63
1440	64.15	2.67	80.91	3.37	89.67	3.74	99.00	4.13	105.03	4.38	110.44	4.60	115.42	4.81

Table 14 Estimation of maximum rainfall intensity for various return period by Pearson Type III Distribution For Srirangapatna Station

Duration in minutes	Return period 2 yrs		Return period 5 yrs		Return period 10 yrs		Return period 25 yrs		Return period 50 yrs		Return period 75 yrs		Return period 100 yrs	
	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)
5	10.98	131.77	13.70	164.38	15.12	181.42	16.63	199.58	17.61	211.31	18.49	221.85	19.29	231.53
10	13.83	83.01	17.26	103.55	19.05	114.29	20.95	125.73	22.19	133.12	23.29	139.75	24.31	145.85
15	15.84	63.35	19.76	79.02	21.80	87.22	23.99	95.95	25.40	101.59	26.66	106.65	27.83	111.31
30	19.95	39.91	24.89	49.78	27.47	54.94	30.22	60.44	32.00	64.00	33.59	67.19	35.06	70.12
60	25.14	25.14	31.36	31.36	34.61	34.61	38.08	38.08	40.32	40.32	42.32	42.32	44.17	44.17
120	31.67	15.84	39.51	19.76	43.61	21.80	47.97	23.99	50.79	25.40	53.33	26.66	55.65	27.83
720	57.56	4.80	71.80	5.98	79.24	6.60	87.17	7.26	92.30	7.69	96.90	8.07	101.13	8.43
1440	72.52	3.02	90.46	3.77	99.84	4.16	109.83	4.58	116.29	4.85	122.09	5.09	127.41	5.31

F Chi-Square Test

To identify a specific theoretical distribution for the available data it is important to do a test. The aim of the test is to find how good a fit is between the observed and the predicted data. Chi-square is one of the most widely used tests to find the best fit theoretical distribution of any specific dataset which is represented by Equation B.

$$\chi 2 = \sum_{i=1}^{n} (O_i - E_i)^2 / E_i \qquad (B)$$

Table 15 Estimation of maximum rainfall intensity for various return period by Pearson Type III Distribution For Bindganarole Station

Duration in minutes	Return period 2 yrs		Return period 5 yrs		Return period 10 yrs		Return period 25 yrs		Return period 50 yrs		Return period 75 yrs		Return period 100 yrs	
	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)
5	9.60	115.17	11.34	136.11	12.25	147.05	13.23	158.72	13.85	166.25	14.42	173.02	14.94	179.24
10	12.09	72.55	14.29	85.74	15.44	92.64	16.66	99.99	17.46	104.73	18.17	108.99	18.82	112.91
15	13.84	55.37	16.36	65.43	17.67	70.70	19.08	76.30	19.98	79.93	20.79	83.18	21.54	86.17
30	17.44	34.88	20.61	41.22	22.27	44.54	24.03	48.07	25.18	50.35	26.20	52.40	27.14	54.28
60	21.97	21.97	25.97	25.97	28.06	28.06	30.28	30.28	31.72	31.72	33.01	33.01	34.20	34.20
120	27.68	13.84	32.72	16.36	35.35	17.67	38.15	19.08	39.96	19.98	41.59	20.79	43.08	21.54
720	50.30	4.19	59.45	4.95	64.23	5.35	69.33	5.78	72.62	6.05	75.57	6.30	78.29	6.52
1440	63.38	2.64	74.90	3.12	80.93	3.37	87.35	3.64	91.49	3.81	95.22	3.97	98.64	4.11

where, O_i and E_i represent the observed and expected frequencies respectively. If the observed frequencies are close to the corresponding expected frequencies, the $\chi 2$ value will be small, indicating a good fit; otherwise it will be a poor fit. (Rashid et al, 2012)

Table 16 : Chi –Square Test For Kikkeri Raingauge Station

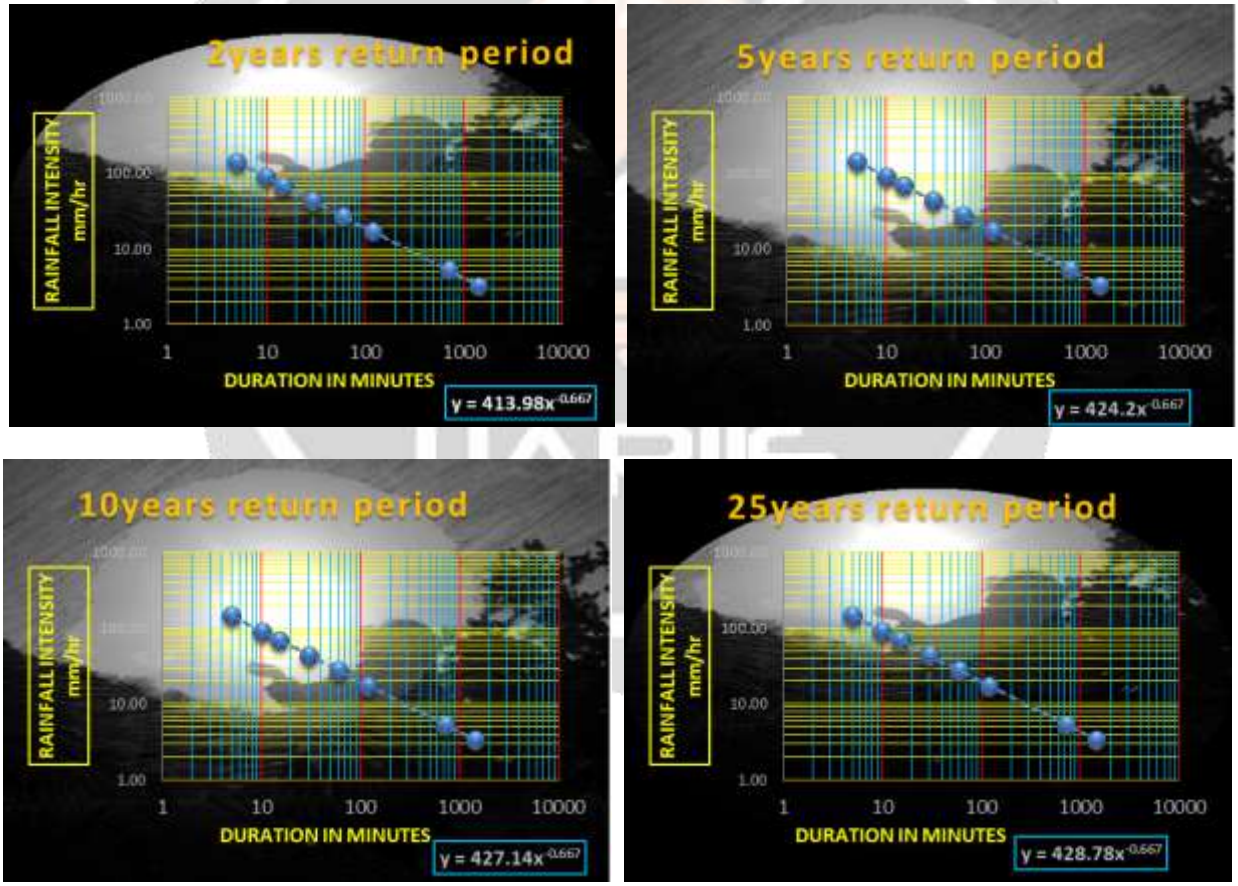
Duration in minutes	Observed values	NORMAL DISTRIBUTION		LOG-NORMAL DISTRIBUTION		GUMBELS DISTRIBUTION		PEARSON TYPE III	
		Expected values	Chi-square values	Expected values	Chi-square values	Expected values	Chi-square values	Expected values	Chi-square values
5	9.71	12.14	0.49	11.85	0.38	15.12	1.93	14.38	1.51
10	12.24	15.30	0.61	14.93	0.48	19.05	2.43	18.11	1.91
15	14.01	17.51	0.70	17.09	0.55	21.81	2.79	20.74	2.18
30	17.65	22.06	0.88	21.53	0.70	27.47	3.51	26.13	2.75
60	22.24	27.80	1.11	27.12	0.88	34.61	4.42	32.92	3.46
120	28.02	35.03	1.40	34.17	1.11	43.61	5.57	41.47	4.36
720	50.92	63.65	2.55	62.09	2.01	79.25	10.13	75.36	7.93
1440	64.15	80.19	3.21	78.23	2.53	99.84	12.76	94.95	9.99

Table 17 : Chi –Square Test For Srirangapatna Raingauge Station

Duration in minutes	Observed values	NORMAL DISTRIBUTION		LOG-NORMAL DISTRIBUTION		GUMBELS DISTRIBUTION		PEARSON TYPE III	
		Expected values	Chi-square values	Expected values	Chi-square values	Expected values	Chi-square values	Expected values	Chi-square values
5	10.98	13.58	0.50	13.29	0.40	16.77	2.00	15.97	1.56
10	13.83	17.11	0.63	16.74	0.50	21.13	2.52	20.13	1.97
15	15.84	19.59	0.72	19.16	0.58	24.18	2.88	23.04	2.25
30	19.95	24.68	0.90	24.14	0.73	30.47	3.63	29.03	2.84
60	25.14	31.09	1.14	30.42	0.92	38.39	4.57	36.57	3.57
120	31.67	39.17	1.44	38.33	1.15	48.37	5.76	46.08	4.50
720	57.56	71.19	2.61	69.64	2.10	87.89	10.47	83.73	8.18
1440	72.52	89.69	3.29	87.74	2.64	110.74	13.19	105.49	10.31

Table 18 : Chi –Square Test For Bindganarole Raingauge Station									
Duration in minutes	Observed values	NORMAL DISTRIBUTION		LOG-NORMAL DISTRIBUTION		GUMBELS DISTRIBUTION		PEARSON TYPE III	
		Expected values	Chi-square values	Expected values	Chi-square values	Expected values	Chi-square values	Expected values	Chi-square values
5	9.60	11.27	0.25	11.14	0.21	13.31	1.04	12.80	0.80
10	12.09	14.20	0.31	14.04	0.27	16.78	1.31	16.13	1.01
15	13.84	16.25	0.36	16.07	0.31	19.20	1.50	18.47	1.16
30	17.44	20.47	0.45	20.25	0.39	24.19	1.89	23.27	1.46
60	21.97	25.80	0.57	25.51	0.49	30.48	2.38	29.31	1.84
120	27.68	32.50	0.71	32.14	0.62	38.41	2.99	36.93	2.32
720	50.30	59.06	1.30	58.40	1.12	69.79	5.44	67.11	4.21
1440	63.38	74.41	1.63	73.58	1.42	87.93	6.85	84.56	5.30

Figure 3 IDF Curves for Different Return Period Using Normal Distribution for Kikkeri station



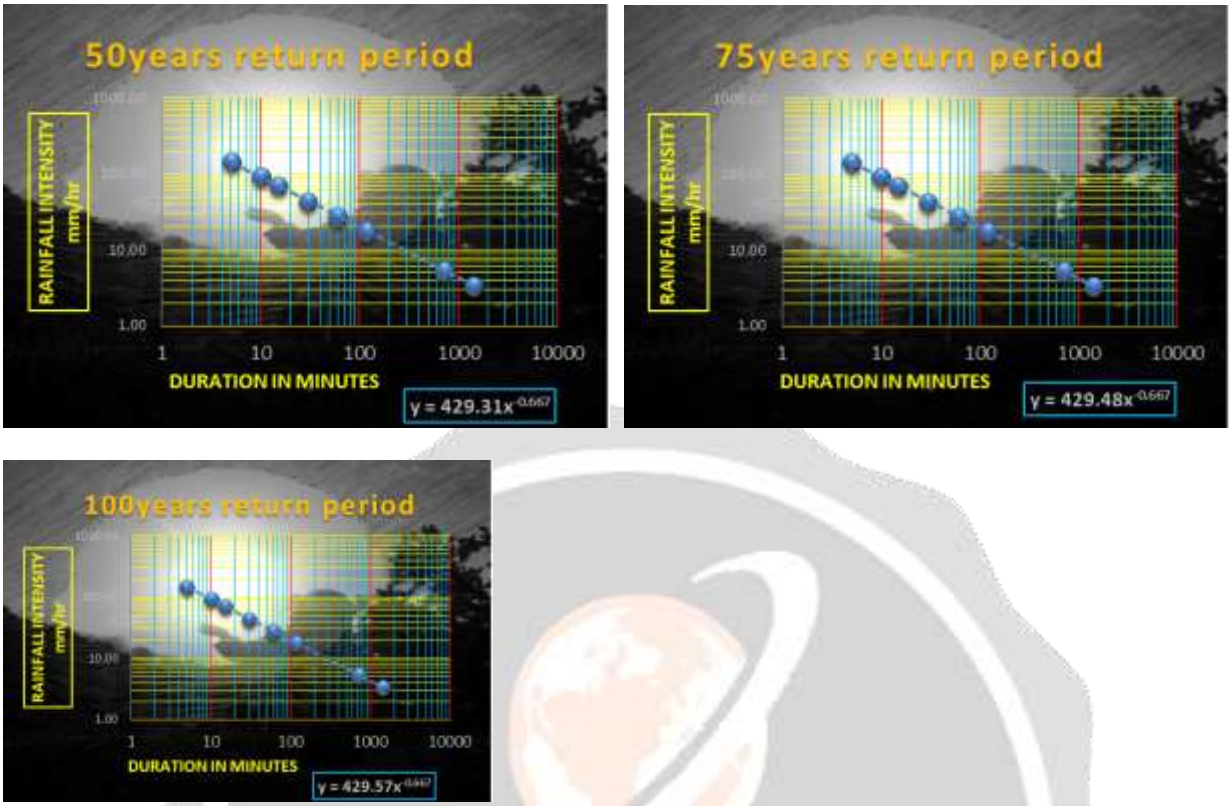
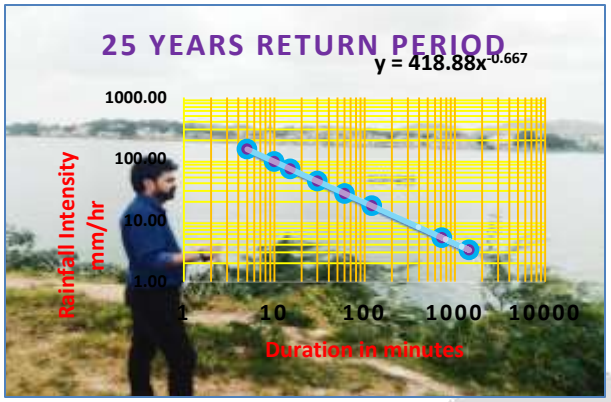
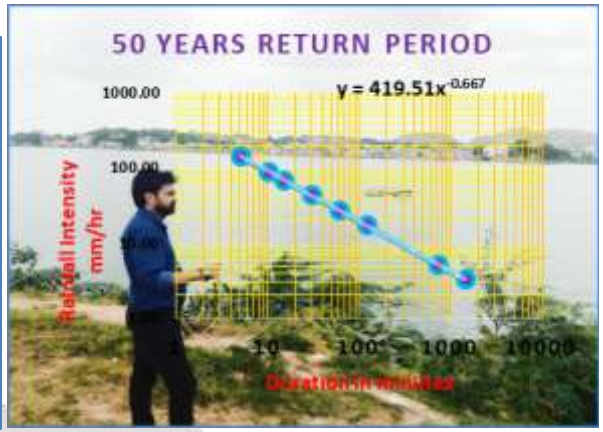
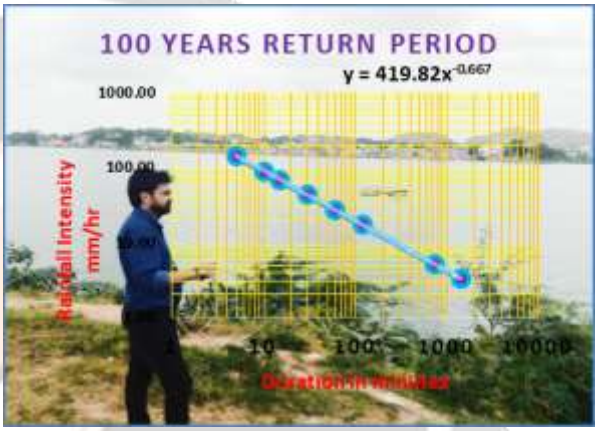


Figure 4 IDF Curves for Different Return Period Using Log Normal Distribution for Kikkeri station


25 YEARS RETURN PERIOD
y = 418.88x^-0.667
1000.00
100.00
10.00
1.00
Rainfall Intensity mm/hr
1
10
100
1000
10000
Duration in minutes


50 YEARS RETURN PERIOD
y = 419.51x^-0.667
1000.00
Rainfall Intensity mm/hr


75 YEARS RETURN PERIOD
y = 419.72x^-0.667
1000.00
100.00
Rainfall Intensity mm/hr


100 YEARS RETURN PERIOD
y = 419.82x^-0.667
1000.00
Rainfall Intensity mm/hr


2 YEARS RETURN PERIOD
y = 401.47x^-0.667
1000.00
Rainfall Intensity mm/hr

Figure 5 IDF Curves for Different Return Period Using Gumbel's Distribution for Kikkeri station

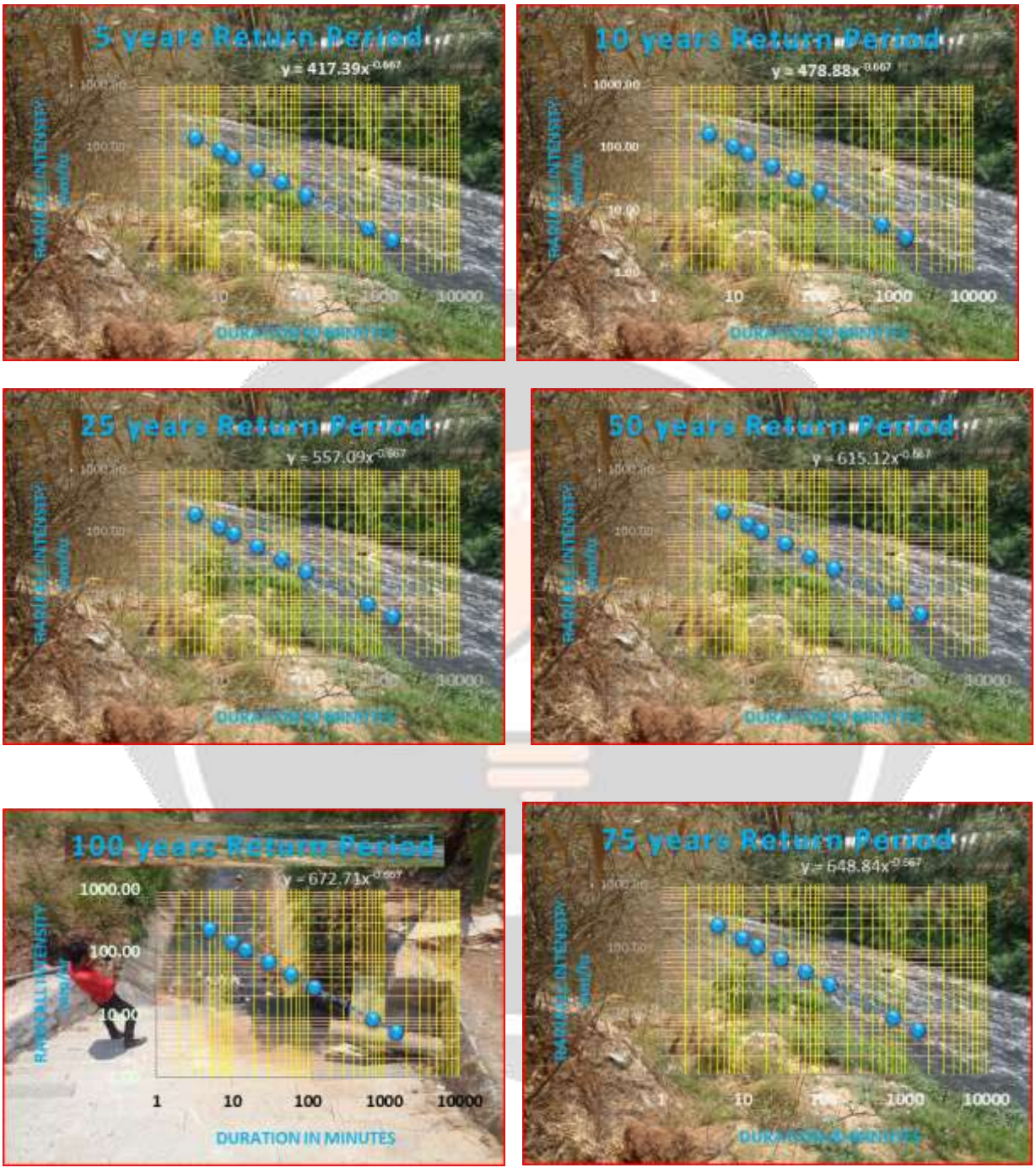
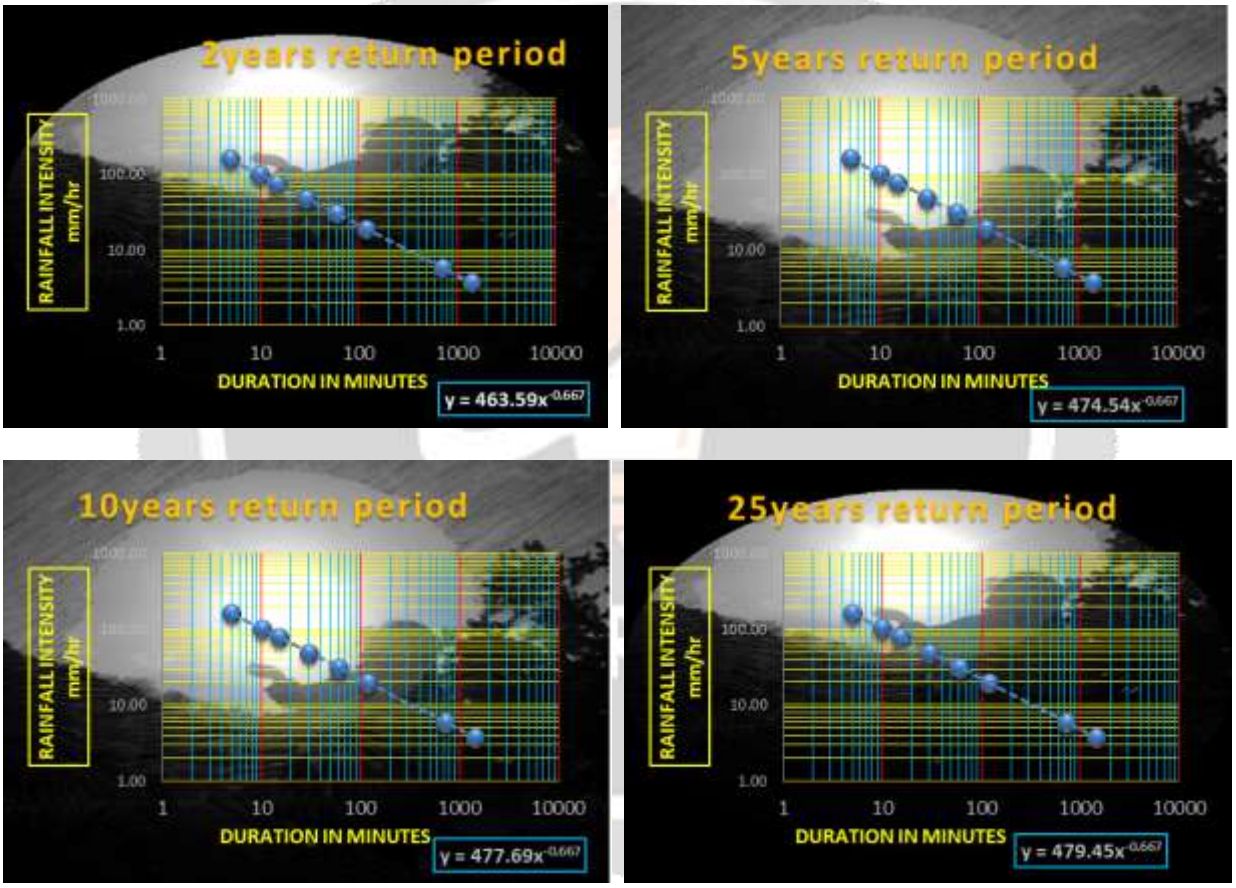


Figure 6 IDF Curves for Different Return Period Using Pearson TYPE III Distribution for Kikkeri station

Figure 7 IDF Curves for Different Return Period Using Normal Distribution for Srirangapatna station



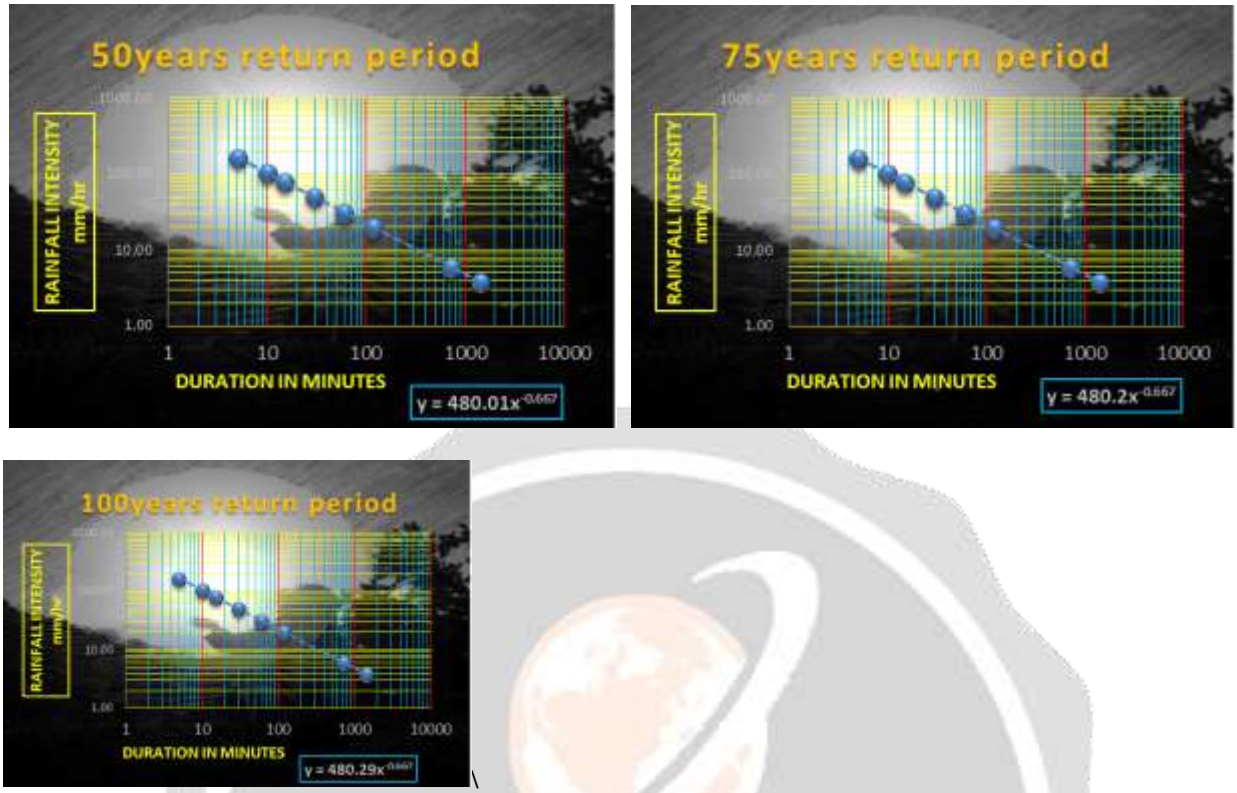
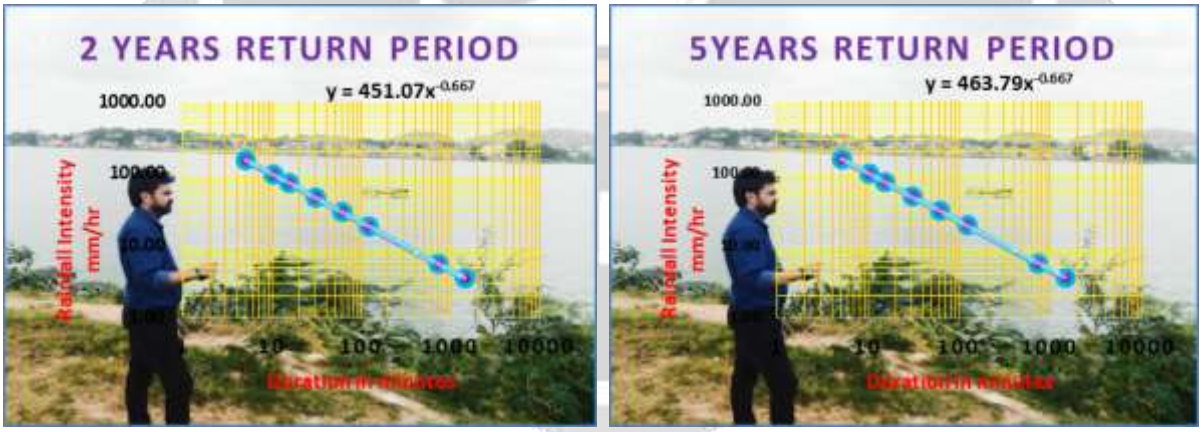
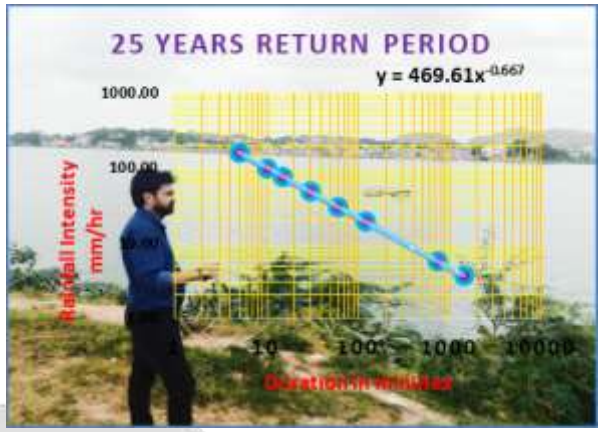
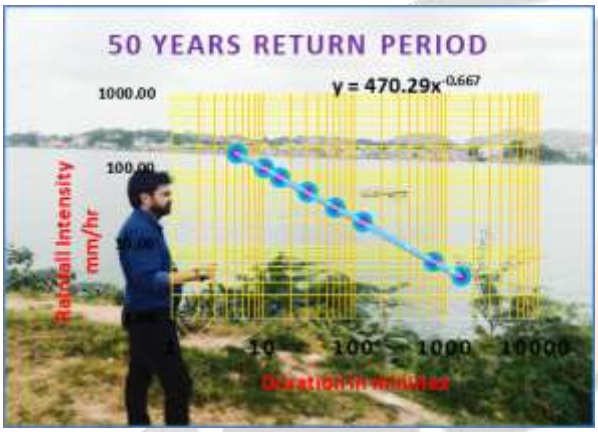


Figure 8 IDF Curves for Different Return Period Using Log Normal Distribution for Srirangapatna station




10 YEARS RETURN PERIOD
y = 467.52x^-0.667
1000.00
100.00
Rainfall Intensity mm/hr
1
10
100
1000
10000
Duration in minutes


25 YEARS RETURN PERIOD
y = 469.61x^-0.667
1000.00
100.00
Rainfall Intensity mm/hr
10
100
1000
10000


50 YEARS RETURN PERIOD
y = 470.29x^-0.667
1000.00
100.00
Rainfall Intensity mm/hr
10
100
1000
10000


75 YEARS RETURN PERIOD
y = 470.51x^-0.667
1000.00
100.00
Rainfall Intensity mm/hr
1
10
100
1000
10000

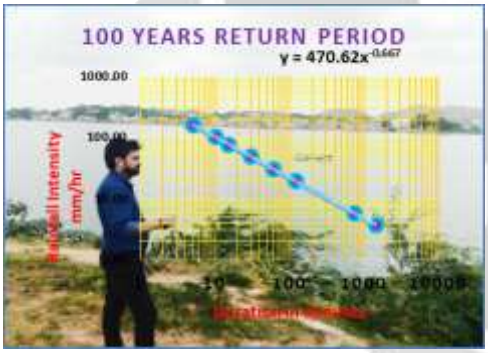
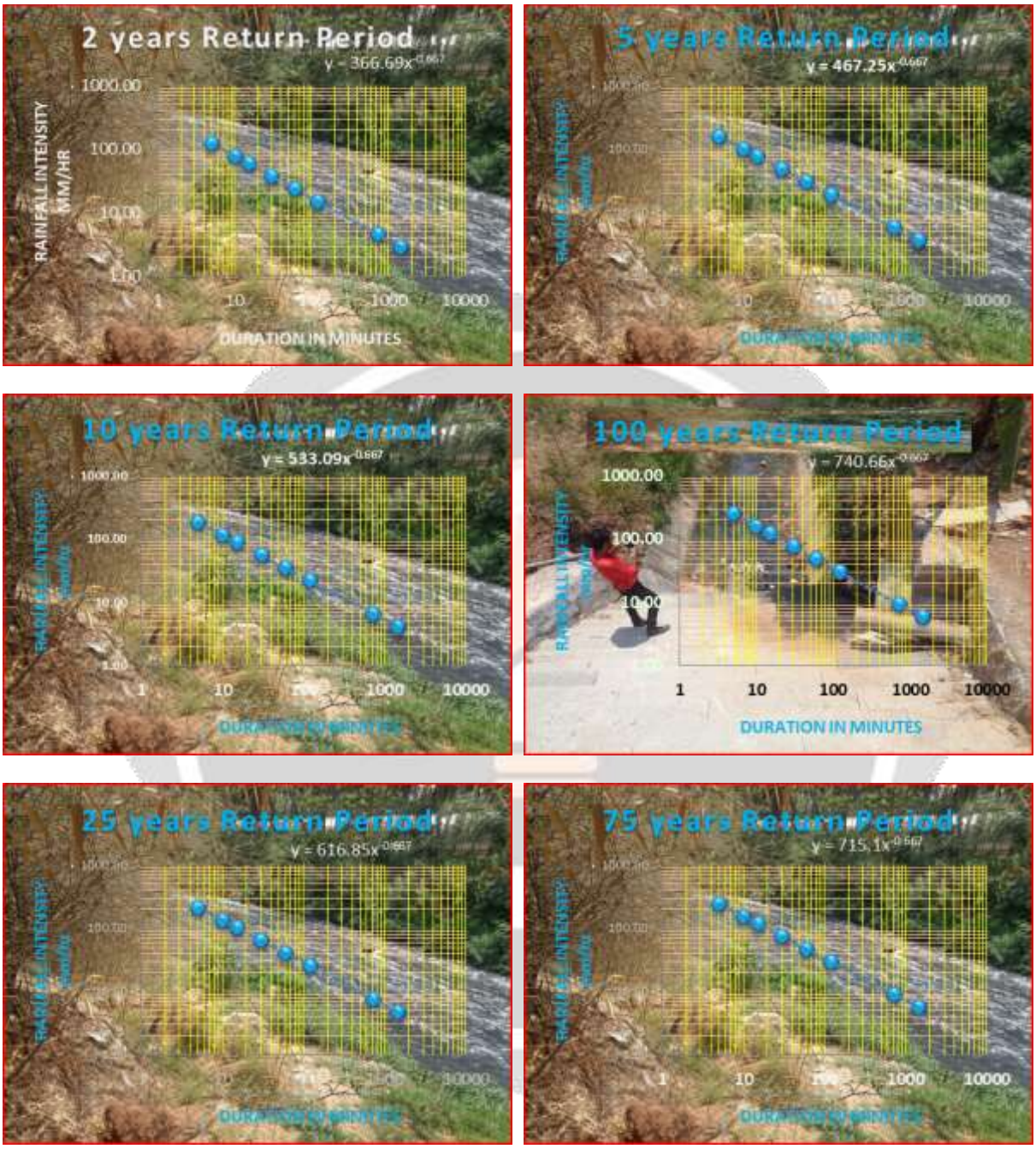

100 YEARS RETURN PERIOD
y = 470.62x^-0.667
1000.00
100.00
Rainfall Intensity mm/hr
10
100
1000
10000

Figure 9 IDF Curves for Different Return Period Using Gumbel's Distribution for Srirangapatna station



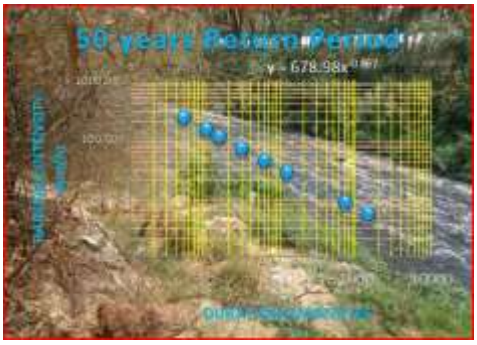
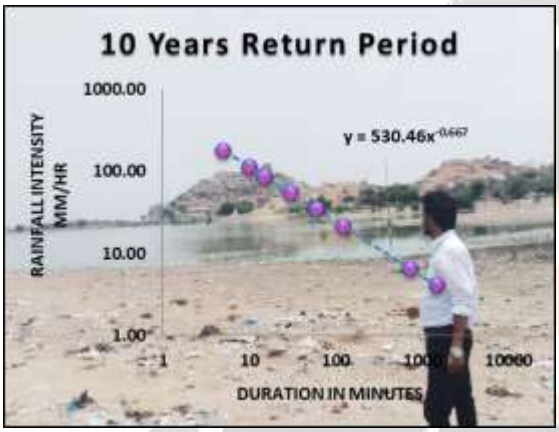


Figure 10 IDF Curves for Different Return Period Using Pearson TYPE III Distribution for Srirangapatna station



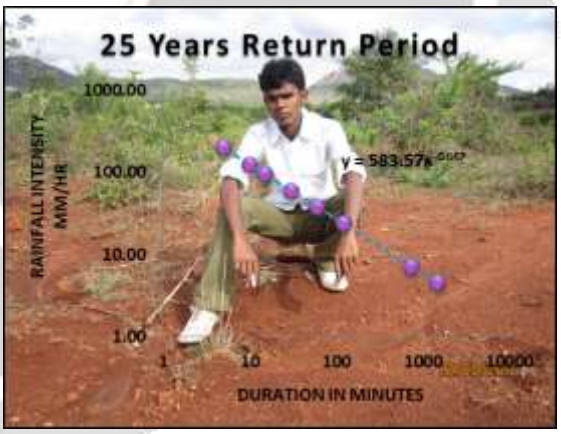
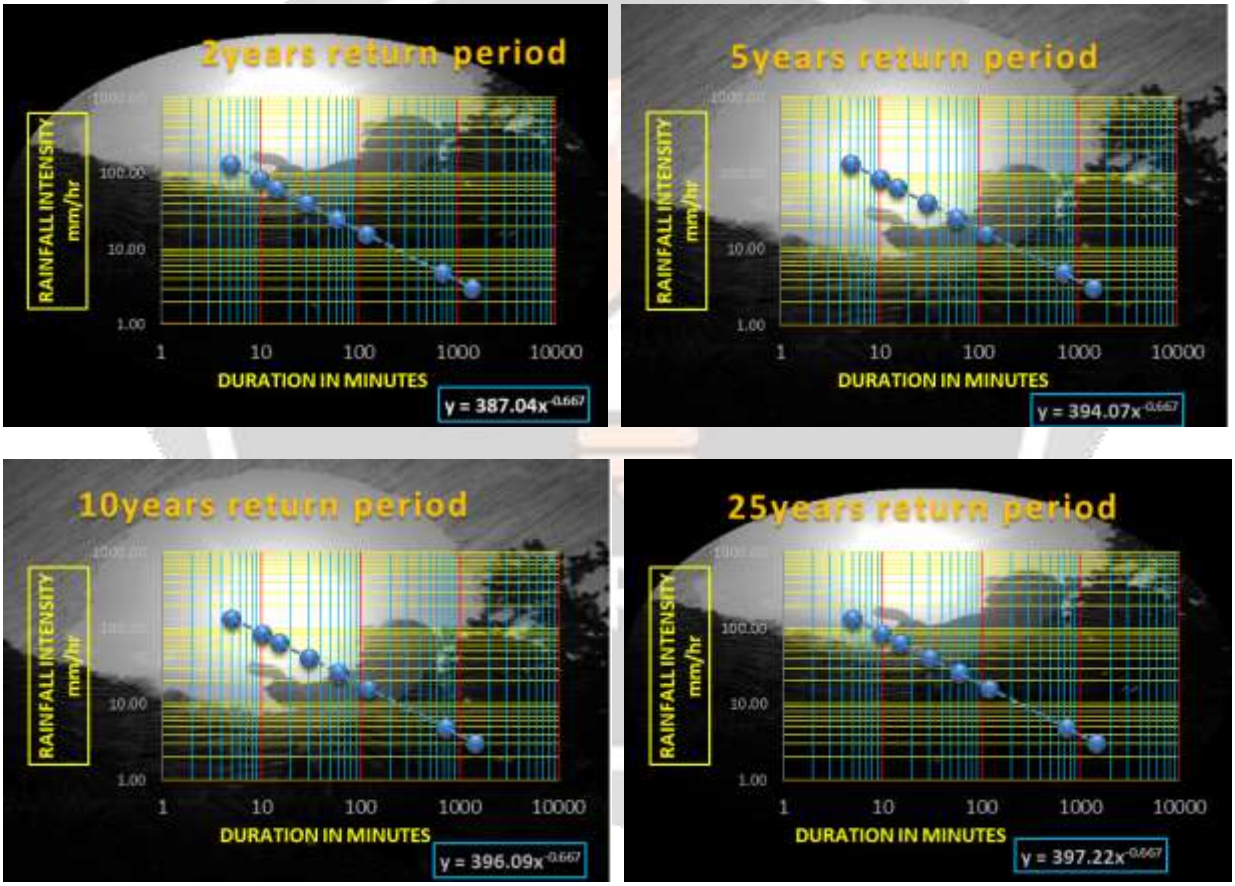


Figure 11 IDF Curves for Different Return Period Using Normal Distribution for Bindganole station



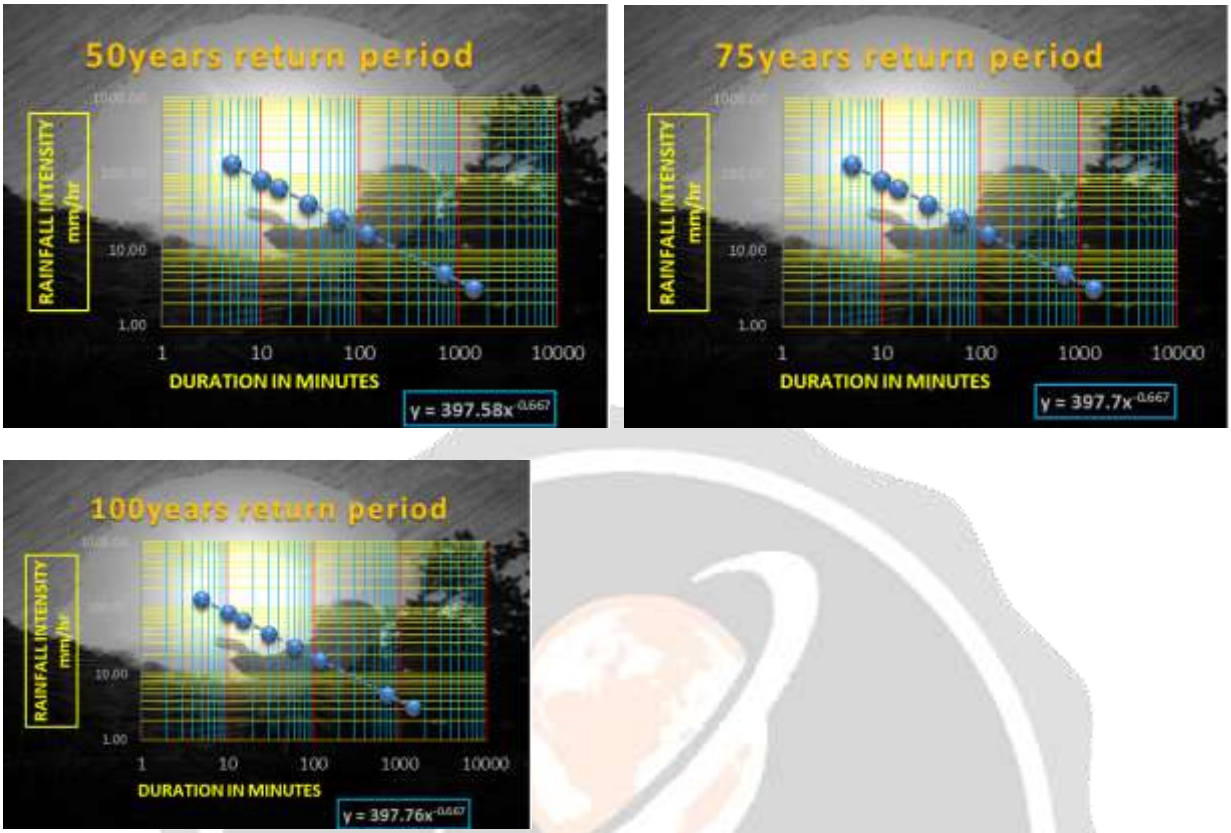


Figure 12 IDF Curves for Different Return Period Using Log-Normal Distribution for Bindganole station

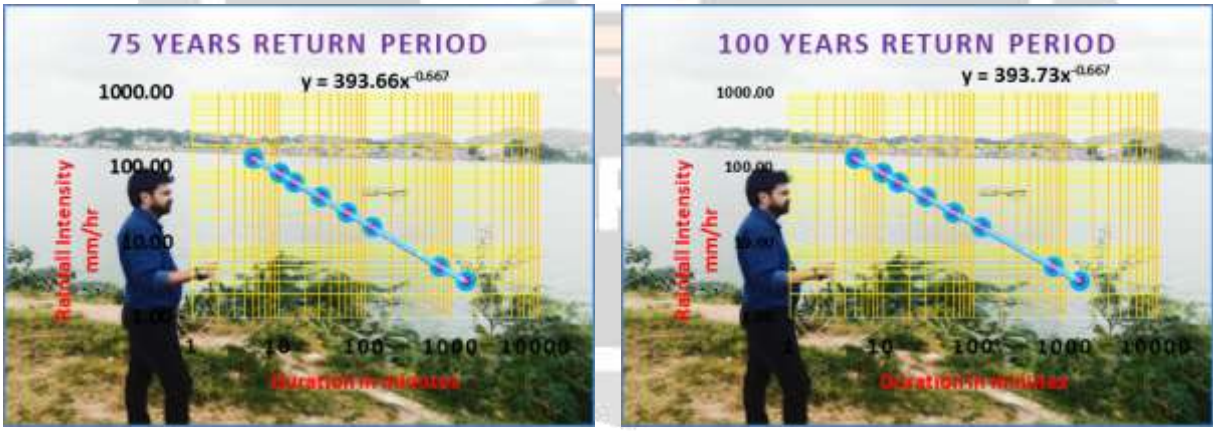
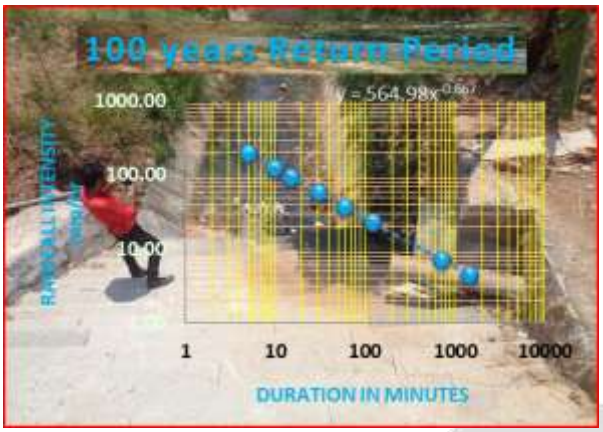
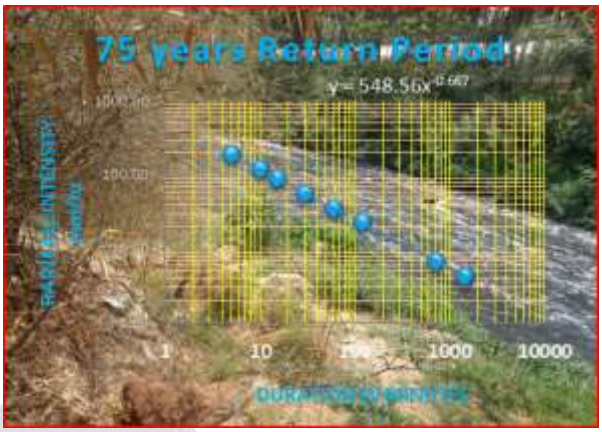
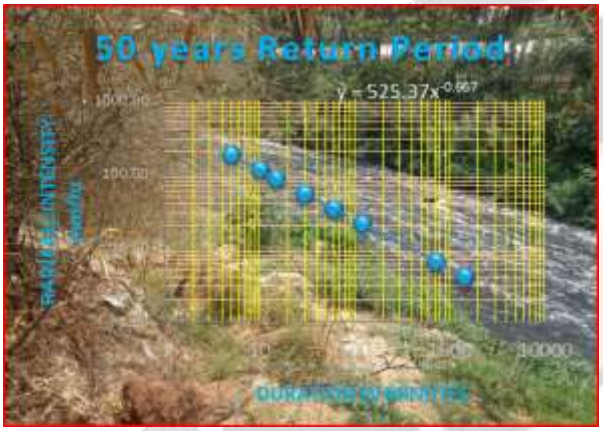
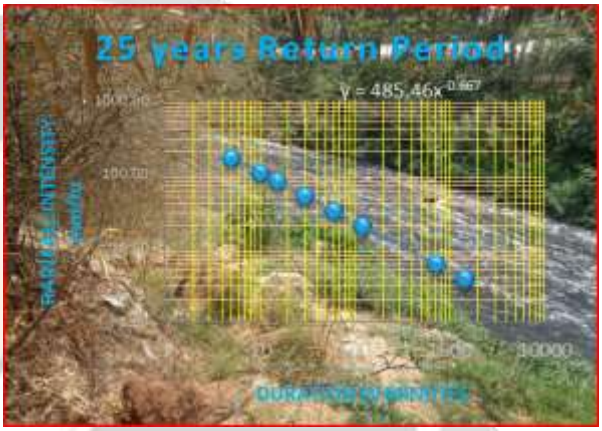


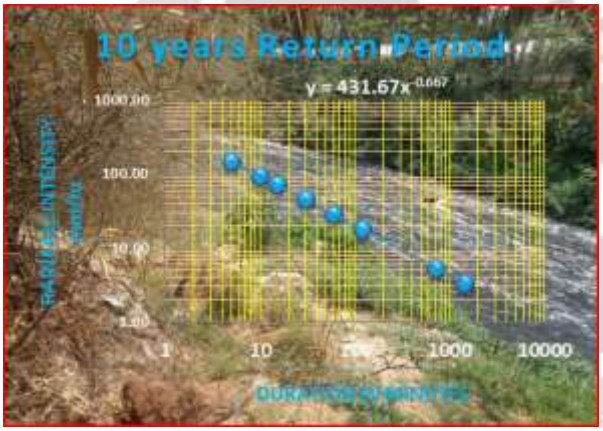
Figure 13 IDF Curves for Different Return Period Using Gumbel's Distribution for Bindganole station

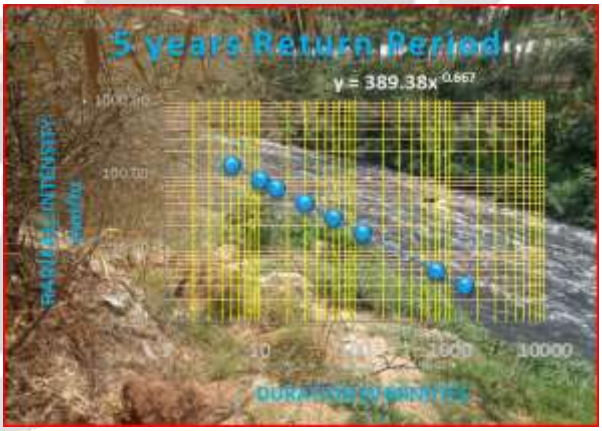

100 years Return Period
y = 564.98x^-0.667
1000.00
100.00
10.00
1
10
100
1000
10000
DURATION IN MINUTES


75 years Return Period
y = 548.56x^-0.667
1000
10000


50 years Return Period
y = 525.37x^-0.667


25 years Return Period
y = 485.46x^-0.667


10 years Return Period
y = 431.67x^-0.667
1000.00
100.00
10.00
1.00
1
10
1000
10000


5 years Return Period
y = 389.38x^-0.667


2 years Return Period
DURATION IN MINUTES

Figure 14 IDF Curves for Different Return Period Using Pearson TYPE III Distribution for Bindganole station

IV CONCLUSIONS

The present work shows a methodology for the evaluation of the IDF curves from daily rainfall data. In particular, to obtain durations shorter than 24 hours, Four different models of disaggregation were applied to the historical data available for Three raingauge stations of Mandya: Srirangapatna, Kikkere and Bindganarole. Among the various available probability distribution functions Log_ Normal distribution had the best approximation of rainfall intensity for various return periods. Short-duration rainfall is critical for the small catchments and urban drainage systems.

There is always a shortage of short-duration rainfall data as it requires automatic rain gauges to record such data. On the contrary, daily rainfall values are generally available due to the use of cheap manual instruments.
These IDF equations will help to estimate the rainfall intensity for any specific return period in a short time and more easily. The results computed can be utilized for developing surface drain network for recharging ground water.

References

1. Bell F. C., 1969, "Generalized rainfall-duration-frequency relationship", ASCE J. Hydraulic Eng., 95, 311–327.
2. Bernard, M. M., (1932), "Formulas for rainfall intensities of long durations". Trans. ASCE 6:592 - 624.
3. Bhaskar, N. R.; Parida, B. P.; Nayak, A. K. 1997. Flood Estimation for Ungauged Catchments Using the GIUH. *Journal of Water Resources Planning and Management., ASCE* 123(4): 228-238.
4. Chow V.T., D.R. Maidment and L.W.Mays, 1988, "Applied Hydrology", McGraw- Hill, Chapter 10 – Probability, Risk and Uncertainty Analysis for Hydrologic and Hydraulic Design: 361 – 398.
5. M. M. Rashid, 1 S. B. Faruque and 2 J. B. Alam 2012, "Modeling of Short Duration Rainfall Intensity Duration Frequency (SDRIDF) Equation for Sylhet City in Bangladesh.
6. Mohammed Badiuddin Parvez, M Inayathulla "Generation Of Intensity Duration Frequency Curves For Different Return Period Using Short Duration Rainfall For Manvi Taluk Raichur District Karnataka", International Research Journal of Engineering and Management Studies (IRJEMS), Volume: 03 Issue: 04 | April -2019.
7. Mohammed Badiuddin Parvez, M Inayathulla "Prioritization Of Subwatersheds of Cauvery Region Based on Morphometric Analysis Using GIS", International Journal for Research in Engineering Application & Management (IJREAM), Volume: 05 Issue: 01, April -2019. 4.
8. Mohammed Badiuddin Parvez, M Inayathulla "Modelling of Short Duration Isopluvial Map For Raichur District Karnataka", International Journal for Science and Advance Research in Technology (IJSART), Volume: 05 Issue: 4, April -2019.
9. Mohammed Badiuddin Parvez, and M .Inayathulla. "Morphometry, Hypsometry Analysis and Runoff Estimation of Aam Talab Watershed Raichur, Karnataka" International Journal Of Advance Research And Innovative Ideas In Education Volume 5 Issue 3 2019 Page 1713-1727
10. Mohammed Badiuddin Parvez, and M Inayathulla. "Generation of Short Duration Isohyetal Maps For Raichur District Karnataka" International Journal Of Advance Research And Innovative Ideas In Education Volume 5 Issue 2 2019 Page 3234-3242
11. Mohammed Badiuddin Parvez, and M Inayathulla. " Derivation Of Intensity Duration Frequency Curves Using Short Duration Rainfall For Yermarus Raingauge Station Raichur District Karnataka" International Journal of Innovative Research in Technology Volume 6 Issue 2 July 2019 Page 1-7
12. Mohammed Badiuddin Parvez, Chalapathi K and M Inayathulla. " Geomorphological Analysis of Two Mini-Watersheds in Raichur City Karnataka" International Research Journal of Engineering and Technology (IRJET) Volume 6 Issue 6 June 2019 Page 2896-2901

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