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Generation Of Intensity Duration Frequency Curves For Different Return Period Using Short Duration Rainfall For Manvi Taluk Raichur District Karnataka

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ABSTRACT

The estimation of rainfall intensity is commonly required for the design of hydraulic and water resources engineering control structures. The intensity-duration-frequency (IDF) relationship is a mathematical relationship between the rainfall intensity, the duration and the return period. The present study aimed the derivation of IDF curves of Manvi Taluk of Raichur District using four Rain gauge Station with rain gauge stations with 19 years of rainfall data (1998 to 2016). The Normal Distribution, Log Normal Distribution, Gumbel distribution techniques are used to derived the rainfall intensity values of 2,5,10,15,30,60,120,720,1440 minutes of rainfall duration with different return period. The short duration IDF using daily rainfall data are presented, which is input for water resources projects.

Key words: Gumbel Distribution, Intensity Duration Frequency (IDF), Log Normal Distribution, Normal Distribution, Rainfall Duration, Return Period, Rainfall Intensity.

INTRODUCTION

Rainfall is an important component in the hydrologic cycle. Quantification of rainfall is needed for planning and designing of various water resource projects. Quantification of rainfall is generally done using isopluvial maps and intensity-duration-frequency (IDF) curves (Chow et al., 1988). The IDF relationship is a mathematical relationship between the rainfall intensity i, the duration d, and the return period T. (Eman, 2011).

IDF stands for Intensity-Duration-Frequency. Rainfall intensity is defined as the ratio of the total amount of rain (rainfall depth) falling during a given period to the duration of the period It is expressed in depth units per unit time, usually as mm per hour . The period of time over which rainfall is measured is called duration. The number of times, during a specified period of years, that precipitation of a certain magnitude or greater occurs or will occur at a station is called frequency. (FAO, 2012).

The IDF-relationships give an idea about the frequency or return period of a mean rainfall intensity or rainfall volume that can be expected within a certain period, i.e. the storm duration. In this sense the storm duration is an artificial parameter that can comprise any part of a rainfall event.

The scope of this study was to predict rainfall depth and intensity for the stations using the data of 1998 to 2014 spread in Manvi Taluk by using Normal, Log Normal and gumbel distribution. For the distribution giving the best results, short duration IDF curves and equations were derived for the station having maximum rainfall depth for various short durations and standard return periods,

2 MATERIALS AND METHODS

2.1 Study Area

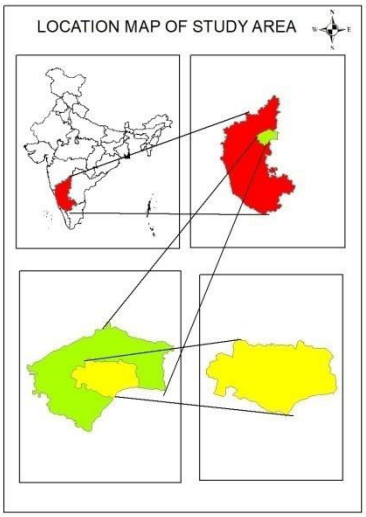


Fig 1 Location Map of Study Area

The Study area Manvi Taluk Of Raichur District, Karnataka is located between 76^0 38' 22.19" E to 77^0 16'22.43" E and 15^0 50'40.16" to 16^0 13"16.25" N. Four rainguage data station namely Manvi, Kallur, Kavatal and Sirwar has been taken From 1998 to 2016. The average mean daily temperature varies from 24 to 39.8^0C respectively. The impact of climate change is likely to have serious influence on agriculture and water sector.

2.2 Methodology

Fig 2 Methodology adopted for IDF curves

Data collection – Daily rainfall data for stations for the years 1998 to 2016

↓

Estimation of Missing rainfall values by Normal Ratio Method) Px = 1/M [P1 + P2 + ….. + Pm]

↓

The maximum 24 hour rainfall data for each year was selected

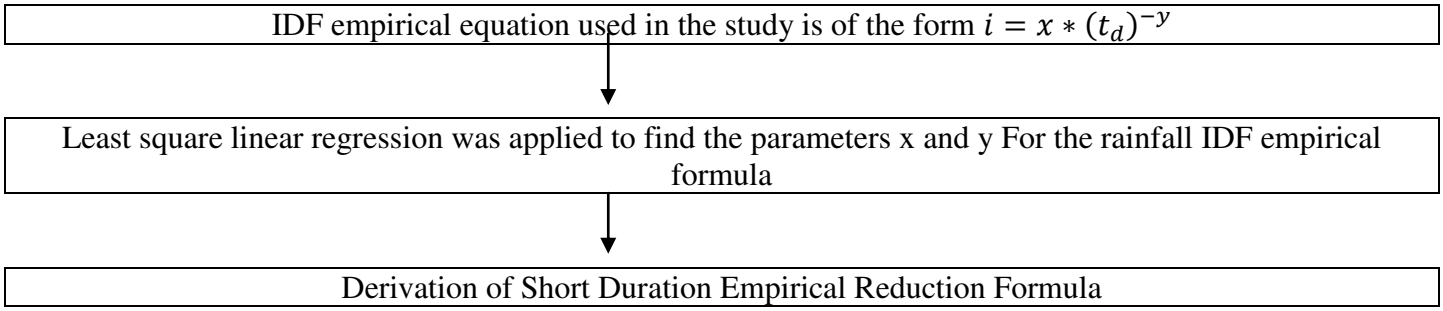
↓

Maximum short duration rainfall for various return periods are calculated using Normal, Log normal and Gumbels Distribution

↓

The rainfall intensity I is obtained from the equation $I = \frac{P_t}{t_d}$

↓



3 Results and Discussions

3.1 Estimation of Short Duration Rainfall

Indian Meteorological Department (IMD) use an empirical reduction formula (Equation 3.1) 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)

$$P_t = P_{24}\left(\frac{t}{24}\right)^{\frac{1}{3}} \qquad (3.1)$$

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 Manvi station is tabulated in Table 1.
Similarly short duration rainfall for station Sirwar, Kallur and Kavatal is calculated mean and standard deviation is determined.

3.2 Frequency Analysis using Frequency Factor

The magnitude of x_T of a hydrologic event may be represented as the mean μ plus the departure x_T of the variate from the mean i.e., $x_T = \mu + \Delta x_T$ (Chow et al, 1988). The departure may be taken as equal to the product of σ and a frequency factor K_T are functions of the return period and the type of distribution to be used in the analysis. The above equation may be expressed as $x_T = \mu + k_T\sigma$which may be approximated by$x_T = \bar{x} + k_T s$. (Chow et al, 1988)

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	60	9.085591	11.44715	13.10371	16.50964	20.80084	26.20741	47.62203	60
1999	100	15.14265	19.07858	21.83951	27.51606	34.66806	43.67902	79.37005	100
2000	112	16.95977	21.36801	24.46025	30.81799	38.82823	48.92051	88.89446	112
2001	73.4	11.11471	14.00368	16.0302	20.19679	25.44636	32.0604	58.25762	73.4
2002	51	7.722752	9.730078	11.13815	14.03319	17.68071	22.2763	40.47873	51
2003	110	16.65692	20.98644	24.02346	30.26767	38.13487	48.04693	87.30706	110
2004	65	9.842723	12.40108	14.19568	17.88544	22.53424	28.39137	51.59053	65
2005	155	23.47111	29.5718	33.85124	42.64989	53.7355	67.70249	123.0236	155
2006	66	9.99415	12.59187	14.41408	18.1606	22.88092	28.82816	52.38423	66
2007	90	13.62839	17.17073	19.65556	24.76445	31.20126	39.31112	71.43305	90
2008	55	8.328458	10.49322	12.01173	15.13383	19.06744	24.02346	43.65353	55
2009	220	33.31383	41.97288	48.04693	60.53533	76.26974	96.09385	174.6141	220
2010	130	19.68545	24.80216	28.39137	35.77088	45.06848	56.78273	103.1811	130
2011	35	5.299928	6.677504	7.643829	9.630621	12.13382	15.28766	27.77952	35
2012	73	11.05414	13.92737	15.94284	20.08672	25.30769	31.88569	57.94014	73
2013	67	10.14558	12.78265	14.63247	18.43576	23.2276	29.26495	53.17794	67
2014	46.5	7.041333	8.871541	10.15537	12.79497	16.12065	20.31075	36.90707	46.5
2015	82.6	12.50783	15.75891	18.03944	22.72827	28.63582	36.07887	65.55966	82.6
2016	47.7	7.223045	9.100484	10.41745	13.12516	16.53667	20.83489	37.85952	47.7

Table1 Short duration rainfall for manvi

3.3 Normal Distribution

Table 2 Estimation of maximum rainfall intensity for various return period by normal distribution for Manvi station

Normal Distribution	**Return period T (years)**		**2**		**5**		**10**		**25**	
Duration in minutes	Mean	Standard Deviation	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	13.06412 33	6.785815 124	17.7562 43	213.0749	18.4122 96	220.9475	18.6009 4126	223.2113	18.7063 25	224.4759
10	16.45979 68	8.549608 415	22.3715 091	134.2291	23.1980 85	139.1885	23.4357 6431	140.6146	23.5685 397	141.4112
15	18.8417	9.78685	25.608	102.43	26.555	106.22	26.8272	107.30	26.979	107.9

	513	1996	968	59	161	06	353	89	2251	169
30	23.7391191	12.33066084	32.2652778	64.53056	33.457406	66.91481	33.80019847	67.6004	33.9916936	67.98339
60	29.9094158	15.53565915	40.6517027	40.6517	42.15369	42.15369	42.58558154	42.58558	42.8268503	42.82685
120	37.6835026	19.57370399	51.2179359	25.60897	53.110322	26.55516	53.65447061	26.82724	53.9584502	26.97923
720	68.4754685	35.5677806	93.0691661	7.755764	96.507859	8.042322	97.49664344	8.12472	98.0490111	8.170751
1440	86.2736842	44.81259548	117.259801	4.885825	121.59228	5.066345	122.8380734	5.118253	123.534013	5.147251

Table 2 Continued

Normal Distribution	**Return period T (years)**		**50**		**75**		**100**	
Duration in minutes	Mean	Standard Deviation	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)
5	13.0641233	6.785815124	18.7401862	224.8822	18.75131492	225.0158	18.75681143	225.0817
10	16.4597968	8.549608415	23.6112023	141.6672	23.62522363	141.7513	23.63214881	141.7929
15	18.8417513	9.786851996	27.0280615	108.1122	27.04411194	108.1764	27.05203929	108.2082
30	23.7391191	12.33066084	34.0532236	68.10645	34.07344591	68.14689	34.08343375	68.16687
60	29.9094158	15.53565915	42.9043733	42.90437	42.92985175	42.92985	42.94243563	42.94244
120	37.6835026	19.57370399	54.056123	27.02806	54.08822389	27.04411	54.10407859	27.05204
720	68.4754685	35.5677806	98.2264943	8.185541	98.28482546	8.190402	98.31363536	8.192803
1440	86.2736842	44.81259548	123.757628	5.156568	123.8311205	5.15963	123.8674187	5.161142

Table 3 Estimation of maximum rainfall intensity for various return period by normal distribution for Sirwar raingauge station

Normal Distribution	**Return period T (years)**		**2**		**5**		**10**		**25**	
Duration in minutes	Mean	Standard Deviation	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	11.70526955	6.401247661	16.13147625	**193.577715**	16.75034888	**201.004187**	16.92830356	**203.139643**	17.02771494	16.1314762 5
10	14.74774499	9.232208998	21.13144822	**126.7886893**	22.02401819	**132.144109**	22.2806736	**133.684042**	22.42404981	21.1314482 2
15	16.88194248	11.63185445	24.92490456	**99.69961825**	26.04947225	**104.197889**	26.3728378	**105.491351**	26.5534805	24.9249045 6
30	21.26991469	12.33066084	29.79607344	**59.59214688**	30.98820173	**61.976 4035**	31.3309941	**62.661 9882**	31.52248927	29.7960734 4
60	26.79841325	14.65521828	36.93191048	**36.931 91048**	38.34877699	**38.348 777**	38.75619205	**38.756 1921**	38.98378759	36.9319104 8
120	33.76388496	18.464418	46.53129143	**23.265 64571**	48.31643136	**24.158 2157**	48.82974218	**24.414 8711**	49.11649459	46.5312914 3
720	61.35305066	33.55207418	84.55296787	**7.0460 80656**	87.7967824	**7.3163 9853**	88.72953006	**7.3941 2751**	89.25059377	84.5529678 7
1440	77.3	42.27296452	106.530064	**4.4387 52669**	110.6170143	**4.6090 4226**	111.7922027	**4.6580 0844**	112.4487018	106.530064

Table 3 Continued

Normal Distribution	**Return period T (years)**		**50**		**75**		**100**	
Duration in minutes	Mean	Standard Deviation	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)
5	11.70526955	6.401247661	17.05965716	204.715886	17.07015521	204.841863	17.07534022	204.904083
10	14.747744	9.2322089	22.47011	134.820	22.4852	134.911	22.492737	134.956

	99	98	853	711	5935	556	44	425
15	16.88194248	11.63185445	26.61152346	106.446094	26.6305997	106.522399	26.6400215	106.560086
30	21.26991469	12.33066084	31.58401926	63.1680385	31.60424155	63.2084831	31.61422938	63.2284588
60	26.79841325	14.65521828	39.05691713	39.0569171	39.08095169	39.0809517	39.09282242	39.0928224
120	33.76388496	18.464418	49.20863204	24.604316	49.23891368	24.6194568	49.25386986	24.6269349
720	61.35305066	33.55207418	89.41801862	7.45150155	89.47304402	7.456087	89.50022121	7.45835177
1440	77.3	42.27296452	112.6596439	4.69415183	112.7289716	4.69704048	112.7632127	4.69846719

Table 4 Estimation of maximum rainfall intensity for various return period by normal distribution for Kavata1 raingauge station

Normal Distribution	**Return period T (years)**		**2**		**5**		**10**		**25**	
Duration in minutes	Mean	Standard Deviation	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	12.57635705	9.135156312	18.8929657	226.7156	19.776153	237.3138	20.030109 93	240.3613	20.1719789	242.0637
10	15.84526 56	11.50959875	23.8036928	142.8222	24.916441	149.4986	25.236407 61	151.4184	25.4151517	152.4909
15	18.13828 91	13.17519283	27.248408	108.9936	28.522186	114.0887	28.888455 96	115.5538	29.0930667	116.3723
30	22.85281 23	16.59970279	34.3308428	68.66169	35.935702	71.8714	36.397173 77	72.79435	36.6549672	73.30993
60	28.79273 92	20.91431496	43.2541515	43.25415	45.276147	45.27615	45.857565 39	45.85757	46.1823647	46.18236
120	36.27657 82	26.35038567	54.4968159	27.24841	57.044371	28.52219	57.776911 93	28.88846	58.1861334	29.09307
720	65.91891 74	47.88182842	99.0272864	8.252274	103.6565	8.638042	104.98761 65	8.748968	105.731221	8.810935
1440	83.05263 16	60.32732354	124.766563	5.198607	130.59901	5.441625	132.27610 79	5.511504	133.212991	5.550541

Table 4 Continued

Normal Distribution	Return period T (years)		50		75		100	
Duration in minutes	Mean	Standard Deviation	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)
5	12.5763705	9.135156312	20.2175633	242.6108	20.232545	242.7905	20.23994447	242.8793
10	15.8452656	11.50959875	25.4725846	152.8355	25.49146032	152.9488	25.50078309	153.0047
15	18.1382891	13.17519283	29.1588109	116.6352	29.18041824	116.7217	29.19109014	116.7644
30	22.8528123	16.59970279	36.7377997	73.4756	36.76502318	73.53005	36.77846894	73.55694
60	28.7927392	20.91431496	46.2867271	46.2867 3	46.32103266	46.32103	46.33796672	46.33797
120	36.2765782	26.35038567	58.3176218	29.15881	58.36083647	29.18042	58.38218028	29.19109
720	65.9189174	47.88182842	105.970152	8.830846	106.0486778	8.83739	106.087462	8.840622
1440	83.0526316	60.32732354	133.514025	5.563084	133.6129614	5.567207	133.6618266	5.569243

Table 5 Estimation of maximum rainfall intensity for various return period by normal distribution for Kallur raingauge station

Normal Distribution	Return period T (years)		2		5		10		25	
Duration in minutes	Mean	Standard Deviation	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	9.73227114	3.380661639	12.0698634	144.8384	12.396706	148.7605	12.4906882	149.8883	12.5431899	150.5183
10	12.2619178	4.259375281	15.2071054	91.24263	15.618902	93.71341	15.7373 1246	94.42387	15.8034606	94.82076
15	14.0363826	4.875764298	17.4077786	69.63111	17.879167	71.51667	18.0147 1371	72.05885	18.0904343	72.36174
30	17.6847339	6.143078073	21.9324266	43.86485	22.526339	45.05268	22.6971 1701	45.39423	22.792519	45.58504

60	22.2813685	7.739793375	27.633126	27.63313	28.381409	28.38141	28.59657549	28.59658	28.7167745	28.71677
120	28.0727652	9.751528595	34.8155571	17.40778	35.758335	17.87917	36.02942741	18.01471	36.1808687	18.09043
720	51.0115997	17.71970342	63.2640658	5.272005	64.977207	5.414767	65.46985145	5.455818	65.7450015	5.47875
1440	64.2705882	22.32542734	79.7077282	3.321155	81.866151	3.41109	82.48679742	3.43695	82.8335113	3.451396

Table 5 Continued

Normal Distribution	**Return period T (years)**		**50**		**75**		**100**	
Duration in minutes	Mean	Standard Deviation	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)	Rainfall Depth(mm)	Rainfall Intensity (mm/hr)
5	9.73227114	3.380661639	12.5600594	150.7207	12.56560366	150.7872	12.568342	150.8201
10	12.2619178	4.259375281	15.8247148	94.94829	15.83170022	94.9902	15.83515031	95.0109
15	14.0363826	4.875764298	18.1147644	72.45906	18.12276064	72.49104	18.12671001	72.50684
30	17.6847339	6.143078073	22.823173	45.64635	22.83324762	45.6665	22.83822351	45.67645
60	22.2813685	7.739793375	28.755396	28.7554	28.76808931	28.76809	28.77435854	28.77436
120	28.0727652	9.751528595	36.2295288	18.11476	36.24552129	18.12276	36.25342002	18.12671
720	51.0115997	17.71970342	65.8334228	5.486119	65.86248313	5.48854	65.87683609	5.489736
1440	64.2705882	22.32542734	82.9449152	3.456038	82.98152889	3.457564	82.99961248	3.458317

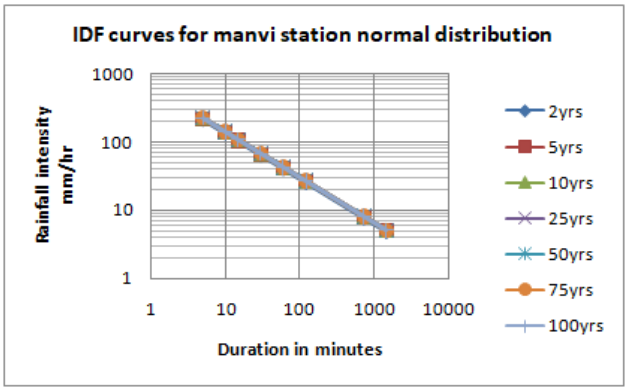


Fig 3: IDF for Manvi by Normal Distribution

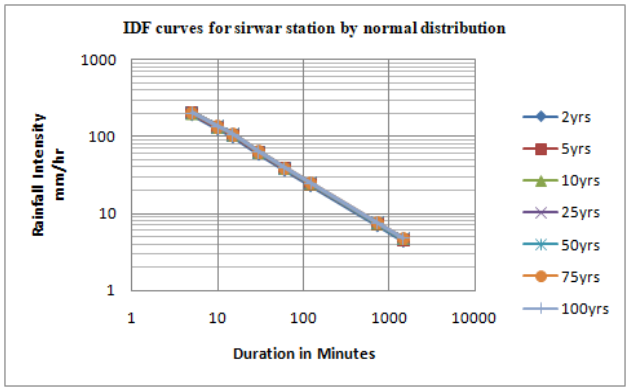


Fig 4: IDF for Sirwar by Normal Distribution

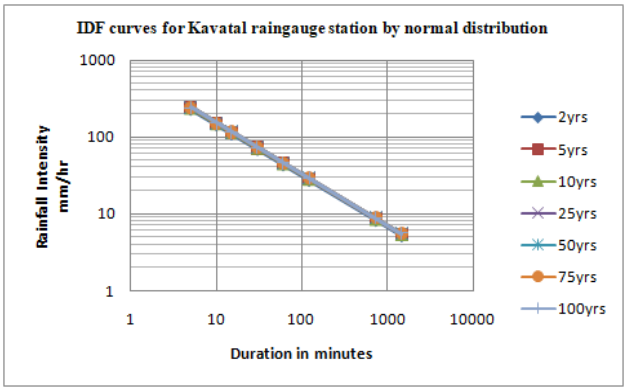


Fig 5: IDF for Kavatal by Normal Distribution

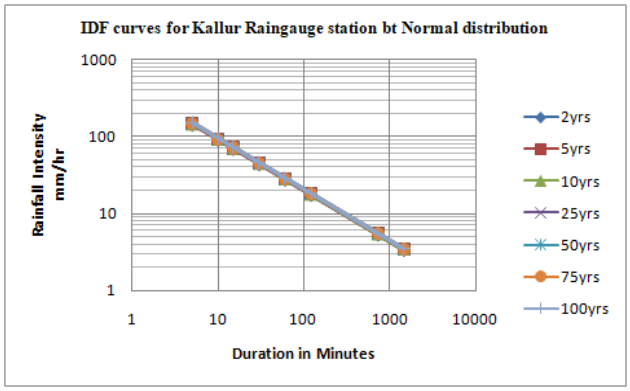


Fig 6: IDF for Kallur by Normal Distribution

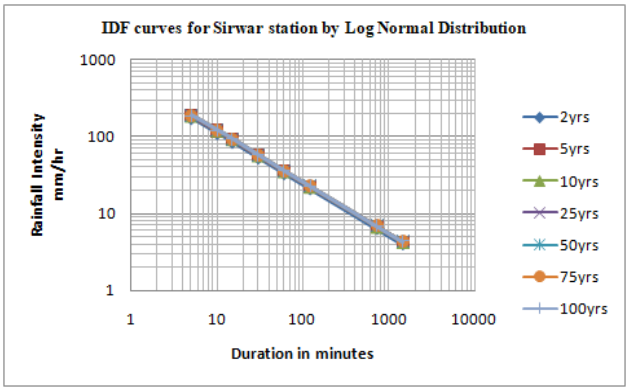


Fig 7: IDF for Sirwar by Log Normal Distribution

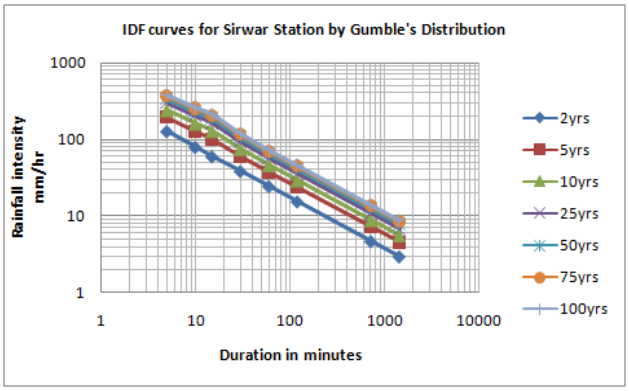


Fig 8: IDF for Sirwar by Gumble's Distribution

Table 6 Estimation of maximum rainfall intensity for various return period by log normal distribution for Manvi 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	16.254653	195.0558	17.04113	204.4936	17.27425	207.2909	17.40586	208.8703	17.44836	209.3803	17.462348	209.5482	17.46926	209.6311
10	20.47962	122.8777	21.47052	128.8231	21.76423	130.5854	21.93005	131.5803	21.9836	131.9016	22.001224	132.0073	22.00994	132.0596
15	23.443297	93.77319	24.5776	98.31039	24.91381	99.65523	25.10362	100.4145	25.16492	100.6597	25.185098	100.7404	25.19507	100.7803
30	29.536703	59.07341	30.96583	61.93166	31.38943	62.77886	31.62858	63.25716	31.70581	63.41162	31.731235	63.46247	31.7438	63.4876
60	37.213914	37.21391	39.0145	39.0145	39.5482	39.5482	39.84952	39.84952	39.94682	39.94682	39.97885	39.97885	39.99468	39.99468
120	46.886594	23.4433	49.15519	24.5776	49.82761	24.91381	50.20724	25.10362	50.32984	25.16492	50.370195	25.1851	50.39014	25.19507
720	85.198596	7.099883	89.32092	7.44341	90.54278	7.545232	91.23262	7.602718	91.45539	7.621282	91.528719	7.627393	91.56496	7.630413
1440	107.3435	4.472646	112.5373	4.689054	114.0768	4.753198	114.9459	4.789412	115.2266	4.801107	115.31896	4.804957	115.3646	4.806859

3.4 Log Normal Distribution

Table 7 Estimation of maximum rainfall intensity for various return period by log normal distribution for kavatal 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(	Rainfall	Rainfall Depth(	Rainfall	Rainfall Depth(	Rainfall	Rainfall Depth(	Rainfall	Rainfall Depth(	Rainfall	Rainfall Depth(	Rainfall	Rainfall Depth(	Rainfall

	mm)	Intensity (mm/hr)	mm)	Intensity (mm/hr)	mm)	Intensity (mm/hr)	mm)	Intensity (mm/hr)	mm)	Intensity (mm/hr)	mm)	Intensity (mm/hr)	mm)	Intensity (mm/hr)
5	15.959541	191.5145	16.99618	203.9542	17.30654	207.6785	17.48238	209.7886	17.53926	210.4711	17.557994	210.6959	17.56725	210.8071
10	20.107802	120.6468	21.41389	128.4834	21.80492	130.8295	22.02647	132.1588	22.09813	132.5888	22.121731	132.7304	22.1334	132.8004
15	23.017672	92.07069	24.51277	98.05109	24.96039	99.84156	25.21399	100.856	25.29602	101.1841	25.323044	101.2922	25.3364	101.3456
30	29.00045	58.0009	30.88416	61.76831	31.44812	62.89624	31.76764	63.53528	31.87099	63.74199	31.905036	63.81007	31.92186	63.84372
60	36.538277	36.53828	38.9116	38.9116	39.62215	39.62215	40.02472	40.02472	40.15494	40.15494	40.197826	40.19783	40.21903	40.21903
120	46.035345	23.01767	49.02554	24.51277	49.92078	24.96039	50.42799	25.21399	50.59205	25.29602	50.646087	25.32304	50.6728	25.3364
720	83.651773	6.970981	89.08533	7.423777	90.71208	7.55934	91.63373	7.636144	91.93186	7.660988	92.030048	7.669171	92.07858	7.673215
1440	105.39463	4.391443	112.2405	4.676687	114.2901	4.762086	115.4513	4.810469	115.8269	4.82612	115.95059	4.831275	116.0117	4.833823

Table 8 Estimation of maximum rainfall intensity for various return period by log normal distribution for kallur 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	11.610031	139.3204	11.99513	143.9416	12.10822	145.2986	12.17185	146.0622	12.19237	146.3084	12.199118	146.3894	12.20245	146.4294
10	14.627752	87.76651	15.11295	90.67771	15.25543	91.53255	15.3356	92.0136	15.36145	92.1687	15.369956	92.21973	15.37416	92.24495

15	16.744585	66.97834	17.3	69.2	17.46309	69.85236	17.55487	70.21947	17.58446	70.33784	17.594196	70.37678	17.59901	70.39603
30	21.096855	42.19371	21.79663	43.59327	22.00212	44.00423	22.11775	44.2355	22.15503	44.31006	22.167297	44.33459	22.17336	44.34672
60	26.580372	26.58037	27.46204	27.46204	27.72093	27.72093	27.86662	27.86662	27.91359	27.91359	27.929045	27.92904	27.93668	27.93668
120	33.48917	16.74458	34.6	17.3	34.92618	17.46309	35.10974	17.55487	35.16892	17.58446	35.188391	17.5942	35.19801	17.59901
720	60.85386	5.071155	62.87237	5.239364	63.46509	5.288757	63.79862	5.316552	63.90617	5.325514	63.94155	5.328463	63.95903	5.329919
1440	76.671059	3.194627	79.21422	3.300593	79.961	3.331708	80.38123	3.349218	80.51672	3.354864	80.561305	3.356721	80.58333	3.357639

Table 9 Estimation of maximum rainfall intensity for various return period by log normal distribution for Sirwar 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	14.627555	175.5307	15.36912	184.4294	15.58923	187.0707	15.71356	188.5627	15.75372	189.0446	15.766939	189.2033	15.77347	189.2817
10	18.60389	111.6233	19.66744	118.0047	19.98437	119.9062	20.16363	120.9818	20.22158	121.3295	20.240654	121.4439	20.25008	121.5005
15	21.391184	85.56473	22.71982	90.87928	23.11692	92.46769	23.34177	93.36708	23.41448	93.65792	23.438427	93.75371	23.45026	93.80105
30	26.698814	53.39763	28.12502	56.25004	28.54905	57.09809	28.7887	57.5774	28.86613	57.73226	28.891622	57.78324	28.90422	57.80844
60	33.488786	33.48879	35.18654	35.18654	35.69047	35.69047	35.97512	35.97512	36.06706	36.06706	36.097328	36.09733	36.11229	36.11229

120	42.193226	21.09661	44.33226	22.16613	44.96718	22.48359	45.32581	22.6629	45.44165	22.72082	45.479783	22.73989	45.49863	22.74932
720	76.670178	6.389182	80.55707	6.713089	81.71078	6.809232	82.36246	6.863538	82.57295	6.881079	82.642251	6.886854	82.6765	6.889708
1440	96.598373	4.024932	101.4955	4.228981	102.9491	4.289547	103.7702	4.323758	104.0354	4.334808	104.12271	4.338446	104.1659	4.340244

3.4 Gumbel's Distribution

Table 10 Estimation of maximum rainfall intensity for various return period by Gumbel's distribution for Manvi 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	11.94884	143.3861	17.97517	215.7021	21.92114	263.0537	26.94032	323.2838	30.66383	367.966	32.82808	393.937	34.35985	412.3183
10	15.05462	90.32774	22.64734	135.8841	27.61896	165.7138	33.94274	203.6565	38.63409	231.8045	41.36087	248.1652	43.29079	259.7447
15	17.23323	68.93292	25.92472	103.6989	31.61579	126.4632	38.85471	155.4189	44.22496	176.8998	47.34635	189.3854	49.55555	198.2222
30	21.71251	43.42502	32.6631	65.3262	39.8334	79.66681	48.95387	97.90775	55.71996	111.4399	59.65266	119.3053	62.43608	124.8722
60	27.35605	27.35605	41.15293	41.15293	50.18695	50.18695	61.67802	61.67802	70.20275	70.20275	75.15765	75.15765	78.66453	78.66453
120	34.46646	17.23323	51.84944	25.92472	63.23159	31.61579	77.70943	38.85471	88.44992	44.22496	94.6927	47.34635	99.1111	49.55555
720	62.62971	5.219143	94.21668	7.85139	114.8994	9.574952	141.2074	11.76728	160.7242	13.39368	172.0681	14.339	180.0968	15.00807
1440	78.90849	3.287854	118.7056	4.946066	144.7642	6.031842	177.9102	7.412924	202.4998	8.43749	216.7922	9.033007	226.9078	9.454491

Table 11 Estimation of maximum rainfall intensity for various return period by Gumble's distribution for Sirwar 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	11.94884	143.3861	17.97517	215.7021	21.92114	263.0537	26.94032	323.2838	30.66383	367.966	32.82808	393.937	34.35985	412.3183
10	15.05462	90.32774	22.64734	135.8841	27.61896	165.7138	33.94274	203.6565	38.63409	231.8045	41.36087	248.1652	43.29079	259.7447
15	17.23323	68.93292	25.92472	103.6989	31.61579	126.4632	38.85471	155.4189	44.22496	176.8998	47.34635	189.3854	49.55555	198.2222
30	21.71251	43.42502	32.6631	65.3262	39.8334	79.66681	48.95387	97.90775	55.71996	111.4399	59.65266	119.3053	62.43608	124.8722
60	27.35605	27.35605	41.15293	41.15293	50.18695	50.18695	61.67802	61.67802	70.20275	70.20275	75.15765	75.15765	78.66453	78.66453
120	34.46646	17.23323	51.84944	25.92472	63.23159	31.61579	77.70943	38.85471	88.44992	44.22496	94.6927	47.34635	99.1111	49.55555
720	62.62971	5.219143	94.21668	7.85139	114.8994	9.574952	141.2074	11.76728	160.7242	13.39368	172.0681	14.339	180.0968	15.00807
1440	78.90849	3.287854	118.7056	4.946066	144.7642	6.031842	177.9102	7.412924	202.4998	8.43749	216.7922	9.033007	226.9078	9.454491

Table 12 Estimation of maximum rainfall intensity for various return period by Gumbel's distribution for Kavatal 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	11.07496	132.8995	19.18769	230.2523	24.4998	293.9976	31.25669	375.0803	36.26934	435.2321	39.18288	470.1946	41.24497	494.9397
10	13.9536	83.72161	24.17502	145.0501	30.86788	185.2073	39.38104	236.2863	45.69659	274.1796	49.36743	296.2046	51.96551	311.7931
15	15.97288	63.8915	27.67348	110.6939	35.33488	141.3395	45.08001	180.32	52.30951	209.238	56.51157	226.0463	59.48562	237.9425
30	20.12456	40.24912	34.8664	69.73279	44.51916	89.03832	56.79726	113.5945	65.90585	131.8117	71.20011	142.4002	74.94719	149.8944
60	25.35536	25.35536	43.92891	43.92891	56.09062	56.09062	71.56006	71.56006	83.03617	83.03617	89.70652	89.70652	94.42754	94.42754
120	31.94575	15.97288	55.34695	27.67348	70.66976	35.33488	90.16002	45.08001	104.619	52.30951	113.0231	56.51157	118.9712	59.48562
720	58.04928	4.83744	100.5721	8.381007	128.4155	10.70129	163.8316	13.65264	190.1054	15.84211	205.3767	17.11472	216.1851	18.01543
1440	73.13751	3.047396	126.7129	5.279704	161.7934	6.74139	206.4149	8.600622	239.5178	9.979906	258.7584	10.7816	272.3762	11.34901

Table 13 Estimation of maximum rainfall intensity for various return period by Gumbel's distribution for Kallur 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/h	Rainfall Depth(mm)	Rainfall Intensity (mm/h	Rainfall Depth(mm)	Rainfall Intensity (mm/h	Rainfall Depth(mm)	Rainfall Intensity (mm/h	Rainfall Depth(mm)	Rainfall Intensity (mm/h	Rainfall Depth(mm)	Rainfall Intensity (mm/h	Rainfall Depth(mm)	Rainfall Intensity (mm/h

		r)		r)		r)		r)		r)		r)		r)
5	9.176641	110.1197	12.17893	146.1472	14.14479	169.7375	16.64533	199.7439	18.50037	222.0044	19.57858	234.9 43	20.34171	244.1005
10	11.56187	69.3712	15.34452	92.06715	17.82136	106.9282	20.97184	125.831	23.30905	139.8543	24.66752	148.0051	25.62899	153.774
15	13.23502	52.9401	17.56508	70.26034	20.40035	81.60141	24.00675	96.02699	26.68218	106.7287	28.23724	112.949	29.33786	117.3514
30	16.67509	33.35017	22.13062	44.26124	25.70283	51.40566	30.24661	60.49321	33.61744	67.23488	35.5767	71.15339	36.96338	73.92676
60	21.00929	21.00929	27.88283	27.88283	32.38354	32.38354	38.10834	38.10834	42.35532	42.35532	44.82383	44.82383	46.57094	46.57094
120	26.47005	13.23502	35.13017	17.56508	40.8007	20.40035	48.0135	24.00675	53.36436	26.68218	56.47448	28.23724	58.67571	29.33786
720	48.09927	4.008273	63.83575	5.319646	74.1398	6.178316	87.24631	7.270526	96.96947	8.08079	102.6209	8.551746	106.6208	8.88507
1440	60.60128	2.525054	80.42801	3.351167	93.41029	3.892096	109.9235	4.580144	122.1739	5.090578	129.2943	5.387262	134.3338	5.597243

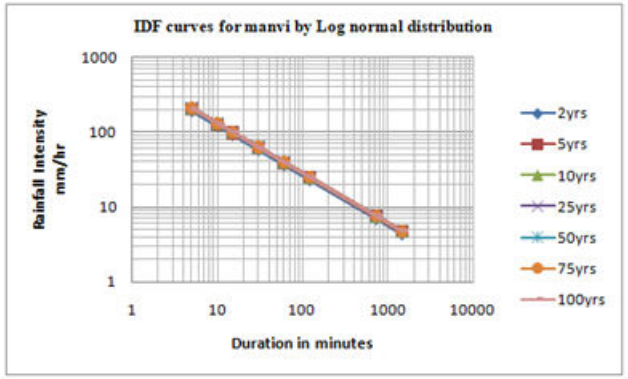


Fig 9: IDF for Manvi by Log Normal Distribution

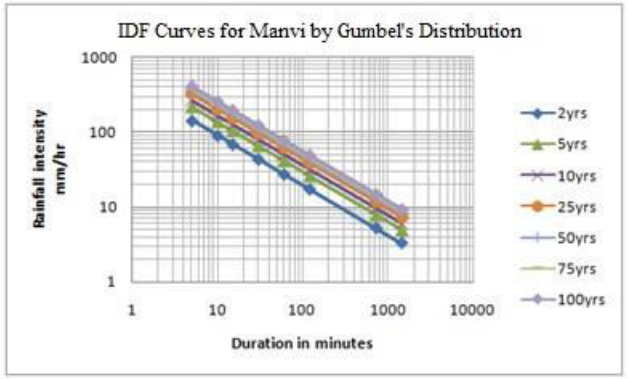


Fig 10: IDF for Manvi by Gumbel's Distribution

Table 14 : RAINFALL IDF EMPIRICAL EQUATION FOR RESPECTIVE RETURN PERIOD							
Station	Return Period (T) years	Normal Distribution $i = \square * (\square_{\square})^{-\square}$		Log Normal Distribution $i = \square * (\square_{\square})^{-\square}$		Gumbel Distribution $i = \square * (\square_{\square})^{-\square}$	
		x	y	x	y	x	y
Manvi	2	623	0.66	570.3	0.66	419.2	0.66
	5	646	0.66	597.9	0.66	630.7	0.66
	10	652.6	0.66	606.1	0.66	769.1	0.66
	25	656.3	0.66	610.7	0.66	945.2	0.66
	50	657.5	0.66	612.2	0.66	1075	0.66
	75	657.9	0.66	612.7	0.66	1151	0.66
	100	658.1	0.66	612.9	0.66	1205	0.66
Sirwar	2	589.6	0.67	517.9	0.67	368.1	0.67
	5	614.6	0.67	547.7	0.67	597.9	0.67
	10	621.8	0.67	556.5	0.67	748.3	0.67
	25	625.8	0.67	561.6	0.67	939.4	0.67
	50	627.1	0.67	563.2	0.67	1081	0.67
	75	627.5	0.67	563.7	0.67	1163	0.68
	100	627.7	0.67	564	0.67	1221	0.68
Kavatal	2	662.9	0.66	559.9	0.66	388.6	0.66
	5	693.9	0.66	596.3	0.66	673.2	0.66
	10	702.8	0.66	607.2	0.66	859.6	0.66
	25	707.8	0.66	613.4	0.66	1096	0.66
	50	709.4	0.66	615.4	0.66	1272	0.66
	75	709.9	0.66	616	0.66	1374	0.66
	100	710.1	0.66	616.4	0.66	1447	0.66
Kallur	2	423.5	0.66	407.3	0.66	321.9	0.66
	5	434.9	0.66	420.8	0.66	427.3	0.66
	10	438.2	0.66	424.8	0.66	496.3	0.66
	25	440.1	0.66	427	0.66	584	0.66
	50	440.7	0.66	427.8	0.66	649.1	0.66
	75	440.9	0.66	428	0.66	686.9	0.66
	100	441	0.66	428.1	0.66	713.7	0.66

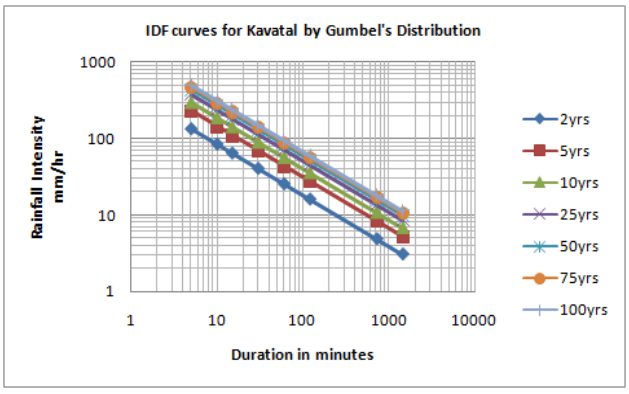


Fig 11: IDF for Kavatal by Gumbel's Distribution

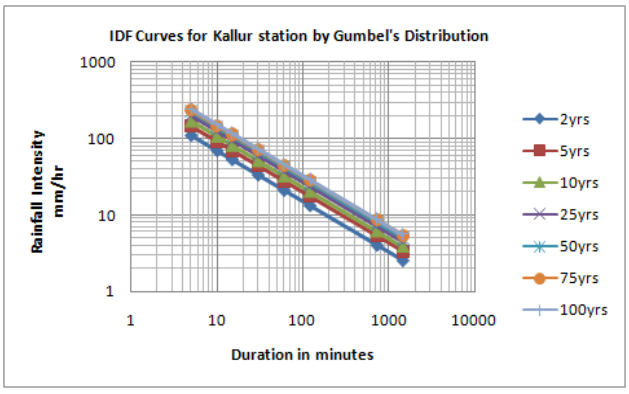


Fig 12: IDF for Kallur by Gumbel's Distribution

CONCLUSIONS

This study will help in planning and designing of any water resources project. Rainfall Intensity, Duration and Frequency relationship for Manvi, Sirwar, Kavatal and Kallur raingauge stations using short duration rainfall data has been generated. Various 'x' and 'y' parameter values for return periods of 2, 5, 10, 25, 50, 75 and 100 years have been derived from which rainfall intensity for a given duration of a rainfall event can be easily calculated. The results computed can be utilized for developing surface drain network for recharging ground water.

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