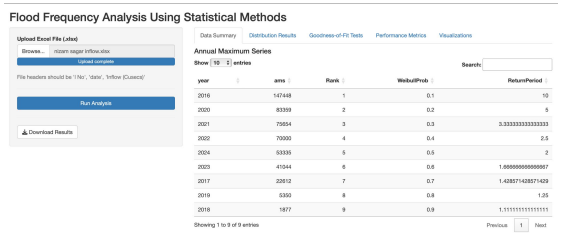
FLOOD FREQUENCY ANALYSIS USING STATISTICAL METHODS

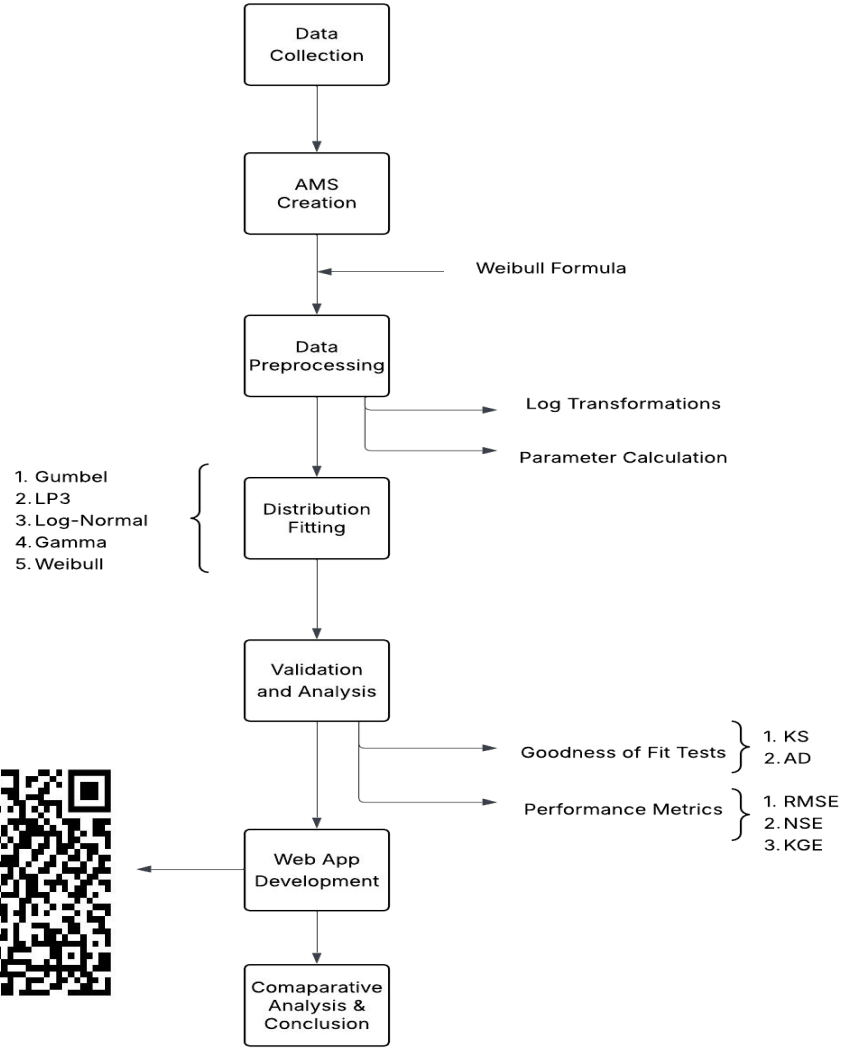
CE F321
Engineering Hydrology

Methodology and Tools

year	ams	Rank	WeibullProb	ReturnPeriod
2016	147448	1	0.1	10
2020	83359	2	0.2	5
2021	75654	3	0.3	3.333333333333333
2022	70000	4	0.4	2.5
2024	53335	5	0.5	2
2023	41044	6	0.6	1.666666666666667
2017	22612	7	0.7	1.428571428571429
2019	5350	8	0.8	1.25
2018	1877	9	0.9	1.111111111111111

$$P = \frac{m}{n+1}$$





Distribution Results

T	Gumbel_MLE	Gumbel_Manual	LogNormal_Manual	LogNormal_MLE	LP3_MLE	Weibull_MLE	Gamma_MLE
2	47,964.65	49,470.45	31,703.30	31,703.30	42,574.23	40,842.60	38,907.47
5	89,748.35	103,730.24	105,356.61	98,363.38	74,265.39	88,566.05	89,364.91
10	116,080.70	139,654.93	197,373.59	177,774.25	94,965.12	123,078.98	127,372.16
25	147,907.27	185,045.89	385,491.02	334,169.83	136,377.42	167,441.66	177,514.55
50	170,518.90	218,719.49	594,051.33	502,384.14	194,021.14	200,302.37	215,398.82
100	192,155.71	252,144.45	876,506.31	724,946.02	301,029.17	232,691.30	253,255.54
200	212,941.86	285,447.45	1,251,296.01	1,014,071.73	513,676.03	264,685.39	291,091.57

Observations

1. Manual Gumbel predicted 34% higher discharge than MLE at T=200.

2. Manual Log-Normal estimates double the value of MLE at T=200.

3. LP3 discharge triples between T=50 and 200.

4. At T=50, Gamma and Weibull differ by only ~7.5%.

Inferences

1. MLE to reduce human bias

2. Multi-model ensembles

3. Validation of the use of LP3 distribution

Goodness of Fit Results

Distribution	KS_Statistic	KS_PValue	AD_Statistic	AD_PValue
Gamma	0.1856	0.8629	0.3724	0.8727
Gumbel	0.1321	0.991	0.1979	0.9917
Log-Normal	0.2428	0.5832	0.6356	0.6103
Weibull	0.1685	0.9248	0.3797	0.8656

Observations

1. Gumbel shows lowest KS-statistic and highest p-values.

2. Log-Normal shows highest KS-statistic and lowest p-values.

3. Gamma and Weibull show intermediate statistics with comparable values.

4. All distributions have p-values above 0.05 threshold.

Inferences

1. Gumbel distribution should be prioritised.

2. Importance of extreme value prediction accuracy

3. Gumbel > Weibull > Gamma > Log-Normal

4. Strong justification for use of Gumbel

Performance Metrics Results

Distribution	RMSE	NSE	KGE
Gumbel (MME)	8780.18	0.958	0.9575
Gumbel (MLE)	12032.41	0.9212	0.7968
Log-Normal (MME)	22519.84	0.7239	0.6309
Log-Normal (MLE)	17697.5	0.8295	0.7658
LP3	20106.53	0.7799	0.5863
Gamma (MLE)	12024.44	0.9213	0.8254
Weibull (MLE)	12245.4	0.9184	0.8013

Observations

1. Gumbel shows lowest RMSE and highest NSE and KGE.

2. Log-Normal shows highest RMSE and lowest NSE.

3. For same distributions, difference in MME and MLE is substantial.

4. LP3 shows high RMSE yet moderate NSE with the lowest KGE.

Inferences

1. Gumbel distribution should be the primary choice.

2. Prioritise MME approach.

3. Gumbel(MME) > Gumbel(MLE) ≈Gamma (MLE) ≈ Weibull(MLE) > Log-Normal(MLE) > LP3 > Log-Normal(MME)

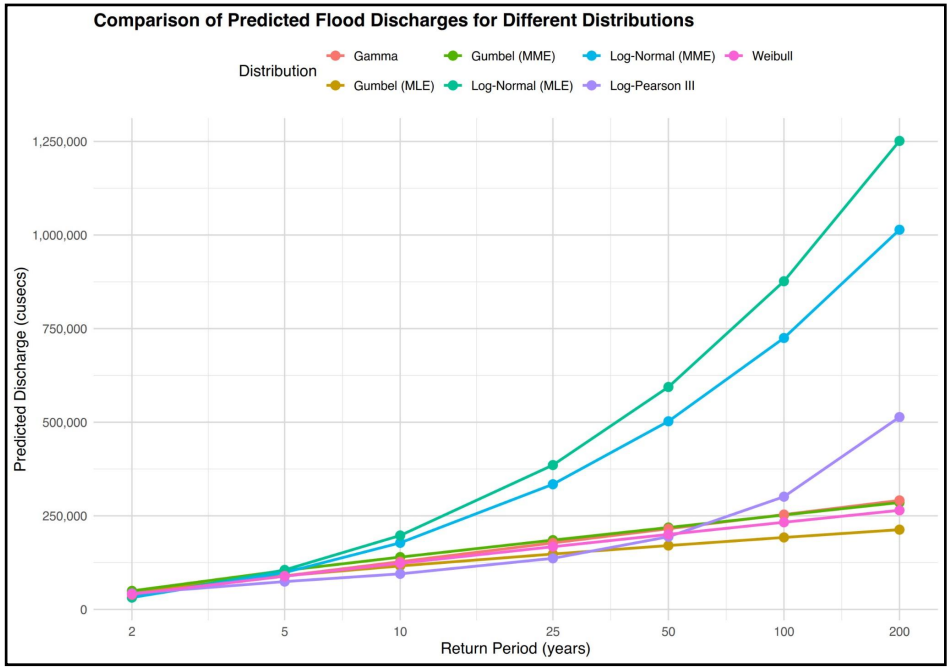
Comparative Analysis & Conclusion

1. ***Optimal Model:*** Gumbel MME outperforms all distributions with lowest RMSE (8,780.18), highest NSE (0.958) and KGE (0.9575), validated by KS/AD p-values >0.99.

2. ***Critical Divergence:*** 5x higher discharge estimates at T=200 (Log-Normal: 1,251,296 vs Gumbel: 285,447) – impacts infrastructure costs (₹2,800Cr vs ₹14,200Cr.

3. ***MME > MLE:*** Method of Moments Estimation yields more reliable predictions than MLE for Gumbel in this watershed.

4. ***Recommendation:*** Mandatory multi-model analysis for >50-year events to balance statistical validity and engineering practicality.



THANK YOU!