EEET ECOLOGICAL ENGINEERING & ENVIRONMENTAL TECHNOLOGY

Ecological Engineering & Environmental Technology 2024, 25(7), 22–33
https://doi.org/10.12912/27197050/187924
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Received: 2024.04.15
Accepted: 2024.05.15
Published: 2024.05.01

Examining Uncertainties in Intensity-Duration-Frequency Curves for Babylon City: A Comprehensive Analysis

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ABSTRACT

Rains are one of the complementary components of the hydrological cycle, so engineers must be able to determine as much as possible in order to design facilities dealing with the assembly, transportation and storage of rains.. The objective of this research is to comprehensive analysis the data of the depth of annual rainfall (mm) of the Babylon Station for the purpose of finding the characteristics of the distributions of observed frequency. In this paper data of annual rainfall depth (mm) by taking maximum value from one year's data as well as the rate of data values for one year from 1991 to 2021 for one stock station in Iraq, Babylon for the purpose of creating the characteristics of the distribution of observed frequency. An attempt was made to fit three of the available theoretical distributions, the Normal, Log Normal and Gamma distributions. The Chi-Square, Kolmogorov-Smirnov and Anderson-Darling indices examined for the purpose of comparing theoretical distributions with viewed distributions. Gumbel's extreme value distribution, the Normal and the Log Normal distribution were used to know the suitability of the data and for the periods of 5, 10, 15 and 50 years. In the remainder of this research, grants of intensity-duration-frequency (IDF) curves of the rainfall were obtained and repeated for the rainfall of the Babylon observation station for 15, 30 and 60 minutes.

Keywords: data analysis, forecasting, IDF, normal distribution, log normal distribution, gamma distribution.

INTRODUCTION

The intensity-duration-frequency curve (IDF) is a tool used in the design of hydraulic structures such as drainage networks, bridges and road channels. Engineers help estimate extreme rainfall levels by analysing their frequency for different periods. This is done through a technique called frequency analysis (FA), which involves the installation of a possible distribution of recorded rainfall intensity. Using this approach, engineers can determine. Appropriate design standards to ensure the resilience of structures to extreme weather conditions (Gu et al., 2022). The study estimated the likelihood of an event every 100 years for groups of maximum annual measurements of rainfall collected from rain gauges in southeastern Arizona using different distributions and frequency methods. Normal distribution can be used successfully to fit a straight line through the highest data points for periods ranging from 5 to 120 minutes. The installation of rainfall data through thunderstorms through mathematical or visual methods may lead to errors in estimating the depths of rainfall for 100 years, with the possibility of overestimating the mathematical composition. These schemes continue to be analyzed by researchers interested in climate and hydrological risks (Reder et al., 2022).

Precipitation is an important aspect of water resources that must be accurately measured. Hydrological models require accurate estimates of average rainfall (Omran et al., 2014). Extreme rainfall events pose challenges to society's human and economic impact and require analysis of a multidisciplinary approach. To build hydraulic structures that manage rainwater runoff, it is necessary to collect data on the amount of heavy rain over different time periods. This information is usually represented by the severity, duration and frequency relationship (Miller et al., 2022). Babylon is located in central Iraq, along the Babylon branch of the Euphrates River, about 100 km south of Baghdad. The population of Babylon governorate is about 3,000,000, with an annual growth rate of about 3%. The city of Babylon is located as the provincial capital next to the old city of Babylon and close to the historic towns of Borceba and Quich. The city of Babylon covers an area of 5,116 km^2, primarily characterized by agricultural activities. The area benefits from extensive irrigation facilitated by the Babylon Canal, enabling the cultivation of varied crops, fruits and textiles (Figure 1). The river flows through the city centre, surrounded by palm trees and other arid plants, effectively mitigating the harmful effects of dust and desert winds. The size of the annual peak floods was obtained in 152 representative locations totaling 6,728 years of water and forestry management. The value of the 50 year design flood using three obtained distributions (Log Pearson type III, Generalized extreme value, and Extreme value type I distributions), statistical analysis confirms that the distribution of Log Pearson type III distribution user estimates traditional moments. Gumbel distribution is commonly used to represent different time periods of the annual maximum precipitation within a unique FA framework. This method assumes that different duration is independent and often includes simplifications, which many authors and services used to create IDF curves for extreme rainfall (Chow et al., 1988). Annual maximum rainfall is estimated for one day and two to five consecutive days of different return periods from 2 to 100 years in In Banswara, Rajasthan, India, researchers used three probability distributions (normal, log normal, and Gamma) to analyze the data and determine the best fit. They compared distributions using the value of the Chi box and performed frequency analysis using the frequency factor. Results revealed that the normal distribution function was best suited to predict rainfall patterns for one, two and three consecutive days. On the other hand, the most suitable Gamma distribution function was offered for four and five consecutive days (Campos et al., 2020).

In another study in the City of London, researchers developed IDF curves for three different weather scenarios: historic, wet and dry. They used rainfall data collected by the Canadian Meteorological Service from 1943 to 2001. Rainfall data were collected for different periods, ranging from 5 minutes to 24 hours. The researchers extracted the extreme values for each duration of the time series data and installed them in the

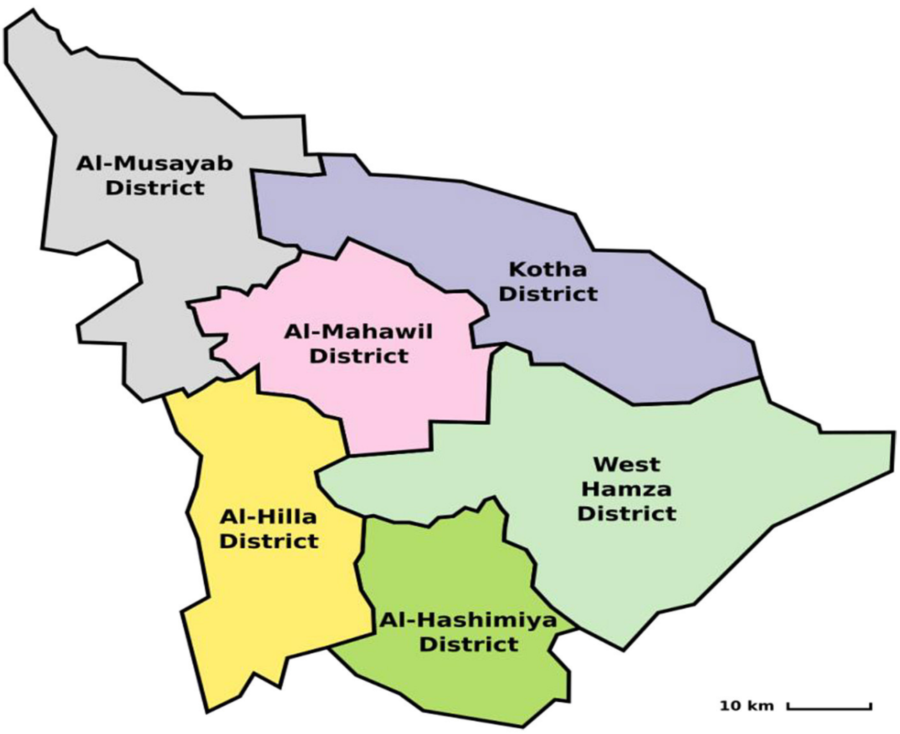

Figure 1. The studied zone location

distribution of the maximum value of Gumbel. This analysis is critical for assessing the availability of water for agriculture, industry and other human activities, as rainfall acts as a vital factor in these sectors. Understanding how rainfall is distributed in time and space is vital for the state's economy. Rather than relying solely on summary statistics, knowing the actual distribution of rainfall greatly enhances various applications of rainfall data. Researchers conducted several studies to explore different ways to represent real rainfall patterns for specific purposes (Silva et al., 2021).

Extreme rainfall events are occasional, and understanding their intensity and frequency is important for long-term planning and for public safety (Alam et al., 2021). However, due to limited records and the need infer the distribution at a location without observations, it is difficult to evaluate the possibility of extreme events (Cooley et al., 2007). Heavy precipitation events caused several devastating floods in North America. The most destructive was the 1993 flooding in the upper Mississippi river, which caused an estimated $18 billion in damage (Salam et al., 2021). Changes in rainfall patterns afect many sectors of a country such as agriculture, economy, and disaster management (Fang et al., 2019).

The amount of rainfall received over an area is an important factor in assessing the amount of water available to meet the various demands of agriculture, industry, and other human activities. Therefore, the study of the distribution of rainfall in time and space is very important for the welfare of the national economy. Many applications of rainfall data are enhanced by a knowledge of the actual distribution of rainfall rather than relying on simple summary statistics. There is a large number of studies investigating the use of particular distributions to represent the actual rainfall patterns (Abdullah and Al-Mazroui, 1998). Information on quantiles of extreme rainfall of various durations is needed in the hydraulic design of structures that control storm runoff, such as flood detention reservoirs, sewer systems etc. Such information is usually expressed as a relationship between IDF of extreme rainfall (Bara et al., 2009). Previous research in the field of runoff prediction models for hydraulic structures has underscored the critical role of accurate forecasting in effective water resource management. While existing studies have provided valuable insights into various modeling approaches and their applications, there remains a notable gap in the literature regarding the comparative evaluation of these models under different scenarios and conditions. Specifically, the lack of comprehensive assessments that consider the performance of multiple models across diverse precipitation patterns, time periods, and hydraulic structures limits our understanding of their effectiveness and robustness. The purpose of the current study is to address this gap by conducting a systematic comparison of runoff prediction models for hydraulic structures. By evaluating the performance of these models under varying precipitation regimes, time scales, and hydraulic configurations, this research aims to provide a comprehensive analysis of their strengths and limitations. Through this comparative study, we seek to identify the most suitable models for different scenarios, thereby enhancing the accuracy and reliability of runoff forecasts in practical applications. In doing so, this research contributes to the scientific literature by offering valuable insights into the selection and optimization of runoff prediction models for hydraulic structures. By filling the existing gap in knowledge through a rigorous comparative analysis, this study aims to advance the field and provide guidance for improved water resource management practices.

DATA FITTING FOR THE PROBABILTY DISTRIBUTION

With regards to this method, parameters of a statistical model are commonly estimated from a sample with either method of moments estimators, or maximum likelihood estimators. Then the values of parameters are substituted into the chosen probability distribution function to solve it and get the probability (U.S. Army Corps of Engineers, 1994). There are many reasonable probability distributions (Frequency analysis models) which are used in statistical analysis. In this paper four probability distributions are used, i.e., Normal, Log Normal, and Gamma distributions. All the parameters of the selected distributions are estimated by the method of moments and maximum likelihood. All statistical distributions and their functions that were analyzed in this paper are shown in Table 1.

Table 2 and 3 presents estimates of probabilities using the moments method for all selected distributions at Babylon Station to the max value and value average of data, while Figure 2 and 3 depicts the frequency curve for Normal distribution (using moments and maximum likelihood methods) at Babylon Station as well as for maximum and modified.

Table 1. Statistical distributions and their functions

Statistical distributions	Functions
Normal distribution	$f(x) = \frac{1}{\sqrt{2\pi\sigma^2}} exp(\frac{-(x-\mu)^2}{2\sigma^2})$
Log normal distribution	$f(x) = \frac{1}{\sqrt{2\pi\sigma^2{}_x}} exp\left(-\frac{(log\, x - \mu_y)^2}{2\sigma^2{}_y}\right)$
Gamma distribution	$f(x) = \frac{\lambda^\beta x^{(\beta-1)} e^{-\lambda_x}}{\Gamma(\beta)}$

FIT TESTS

Appropriate test quality provides objective procedures to determine whether The presumed theoretical distribution provides a sufficient description of what has been observed insufficient model, such tests serve only to reject an insufficient model; They can't prove The model is correct. Three types of tests apply to a wide range of tests, So the distributions in this paper are considered: Chi-square, Kolmogorov-Smirnov and Anderson-Darling tests (Shlef et al., 2022). These tests are applied to all distributions used in this paper.

Kolmogorov-Smirnov index

Kolmogorov-Smirnov (K-S) test is based on statistical Measures cumulative scheme deviation from presumption Cumulative distribution function (Montgomery et al., 2003). Results of K-S index are shown in Table 4, 5. The tests showed that the results success in all tests.

Chi-square index

Chi-squared statistic depends on determining the number of histogram categories in which data will be compiled, and there is no rule that gives correctness number for use (Vose, 2010). The Chi-square test statistic is computed from the relationship:

$$\chi^2 = \sum_{i=1}^{k} \frac{(o_i - E_i)^2}{E_i} \quad (1)$$

where: χ^2 is Chi-square test, O_i is the observed and E_i is the expected number of observation in the *ith* class interval (based on the probability distribution being tested). The value of Chi-square is determined from published χ^2 tables with degrees of

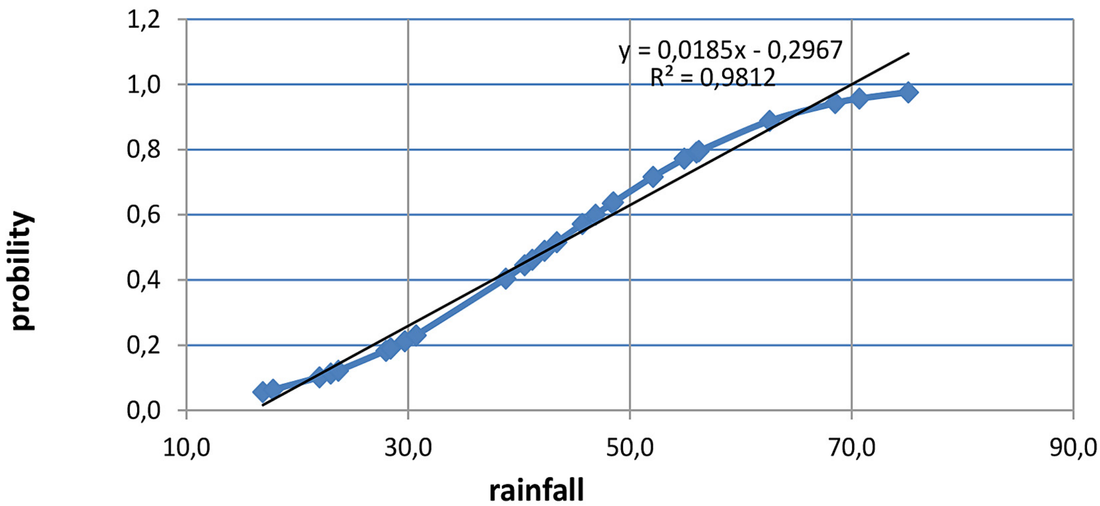

Figure 2. Frequency curve with respect to the normal dis. (moments method) for Babylon Station. For maximum data value

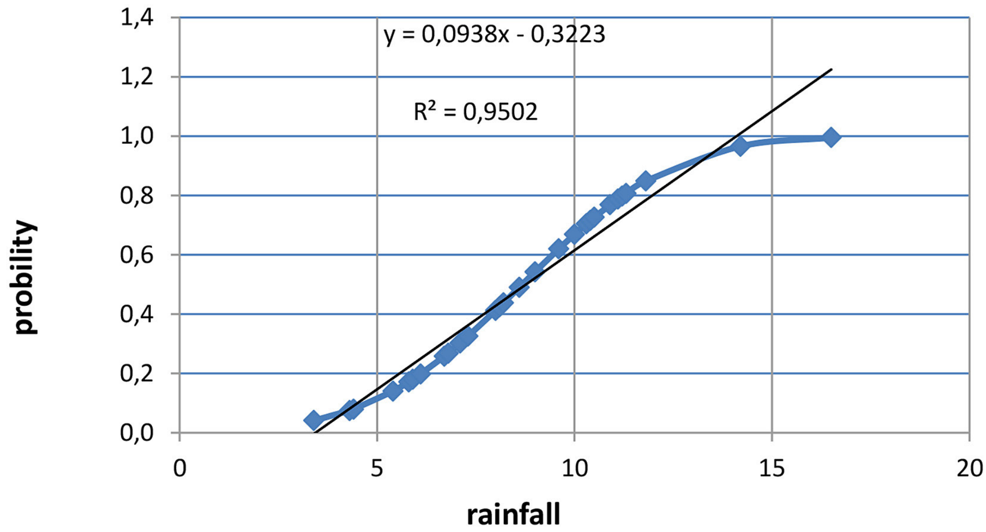

Figure 3. Frequency curve with respect to the normal dis. (moments method) for Babylon Station. For average data value

Table 2. Estimations of probabilities by using moments method (Station: Babylon), Iraqi Meteorological Office in Baghdad, Iraq (for max rainfall)

Max rainfall (mm)	Ln(χ)	Rank(m)	Normal F(x) %	Log normal F(x) %	Gamma F(x) %
16.9	2.83	1	5.670	0.986	2.441
17.8	2.88	2	6.326	1.421	3.091
22.0	3.09	3	10.193	5.274	7.599
23.0	3.14	4	11.327	6.698	9.047
23.7	3.17	5	12.173	7.817	10.149
28.0	3.33	6	18.331	16.682	18.330
28.4	3.35	7	18.985	17.653	19.198
28.4	3.35	8	18.985	17.653	19.198
29.7	3.39	9	21.221	20.963	22.138
30.7	3.42	10	23.041	23.631	24.500
38.8	3.66	11	40.471	46.599	45.205
40.5	3.70	12	44.551	51.218	49.546
41.2	3.72	13	46.251	53.063	51.303
42.3	3.74	14	48.935	55.886	54.017
43.4	3.77	15	51.623	58.607	56.667
45.7	3.82	16	57.206	63.946	61.962
46.9	3.85	17	60.070	66.534	64.577
48.4	3.88	18	63.573	69.573	67.693
48.5	3.88	19	63.803	69.768	67.894
52.1	3.95	20	71.695	76.154	74.603
54.9	4.01	21	77.198	80.310	79.086
56.0	4.03	22	79.183	81.763	80.675
56.2	4.03	23	79.532	82.016	80.953
56.2	4.03	24	79.532	82.016	80.953
62.6	4.14	25	88.824	88.638	88.316
68.5	4.23	26	94.280	92.660	92.829
70.7	4.26	27	95.669	93.777	94.072
75.1	4.32	28	97.632	95.539	95.998

Table 3. Estimations of probabilities by using moments method (Station: Babylon), Iraqi Meteorological Office in Baghdad, Iraq (for average rainfall)

Average rainfall (mm)	Ln(χ)	Rank(m)	Normal F(x) %	Log normal F(x) %	Gamma F(x) %
3.4	1.22	1	4.108	0.498	1.414
4.3	1.46	2	7.470	2.962	4.709
4.4	1.48	3	7.946	3.447	5.251
5.4	1.69	4	14.025	11.190	12.830
5.8	1.76	5	17.172	15.714	16.917
5.9	1.77	6	18.025	16.953	18.022
6.1	1.81	7	19.807	19.545	20.323
6.7	1.90	8	25.759	28.027	27.830
6.8	1.92	9	26.834	29.513	29.151
7.1	1.96	10	30.188	34.036	33.196
7.3	1.99	11	32.524	37.078	35.942
8	2.08	12	41.199	47.589	45.636
8.1	2.09	13	42.486	49.045	47.008
8.2	2.10	14	43.781	50.485	48.373
8.6	2.15	15	49.014	56.050	53.726
9	2.20	16	54.264	61.254	58.853
9.6	2.26	17	61.974	68.288	65.985
10	2.30	18	66.881	72.436	70.309
10.3	2.33	19	70.384	75.263	73.308
10.4	2.34	20	71.513	76.152	74.261
10.5	2.35	21	72.621	77.015	75.189
10.9	2.39	22	76.828	80.214	78.667
11.1	2.41	23	78.788	81.668	80.264
11.2	2.42	24	79.731	82.360	81.028
11.3	2.42	25	80.648	83.029	81.770
11.8	2.47	26	84.844	86.052	85.146
14.2	2.65	27	96.567	94.815	95.040
16.5	2.80	28	99.504	98.071	98.502

freedom at the 5% level of significance (Reich et al., 1982). Results of Chi-Square index are shown in Table 6, 7. The tests showed that the results success in all tests.

Anderson-Darling index

Anderson-Darling normality test is a type of statistical test which is used to check whether the range of tested data overlaps with the theoretical range and thus confirm or deny hypotheses made earlier and gives more weight to the tails than does the K-S test, This has the advantage of allowing a more sensitive test and the disadvantage that critical values must be calculated for each distribution, measures how well the data follow a given distribution. For a specific data set and distribution, the more appropriate the distribution of data, the smaller the statistic (Jäntschi, Bolboacă 2018). The Anderson-Darling test statistic is computed from the relationship:

$$AD = -n - \frac{1}{n}\sum_{i=1}^{n}(2i-1)[\ln(F_i) + \ln(1-F_{n-i+1})] \quad (2)$$

where: AD is Anderson-Darling test, F is the cumulative distribution function of the specified distribution and n is the number of elements in the sample. Results of A-D index are shown in Table 8, 9. The tests showed that the results success in all tests when significance α = 0.05.

ESTIMATION IDF CURVES FOR RAINFALL

The intensity of rainfall at different intervals and frequency as IDF curves that are important

Table 4. The values of Kolmogorov-Smirnov index for Babylon station and with confidence level equal 95% (for max likelihood)

Station	n	Theo. d.	Obs. d.					
Babylon	28	0.246	Normal dis.		Lognormal dis.		Gamma dis.	
			Moments	Max. likelihood	Moments	Max. likelihood	Moments	Max. likelihood
			0.12674	0.12674	0.12083	0.08441	0.11214	0.09539

Table 5. The values of Kolmogorov-Smirnov index for Babylon station and with confidence level equal 95%. (for average likelihood)

Station	n	Theo. d.	Obs. d.					
Babylon	28	0.246	Normal dis.		Lognormal dis.		Gamma dis.	
			Moments	Max. likelihood	Moments	Max. likelihood	Moments	Max. likelihood
			0.08638	0.08638	0.07267	0.08768	0.07711	0.08512

Table 6. Chi-Square index for the station that are used in the paper (for max likelihood)

Station	√	Theo. chi-sq.	Obs. chi-sq.					
Babylon			Normal dis		Lognormal dis.		Gamma dis.	
			Moments	Max. likelihood	Moments	Max. likelihood	Moments	Max. likelihood
	4	9.49	6.2421	6.2421	8.3985	6.4483	6.2935	5.7759

Table 7. Chi-Square index for the station that are used in the paper (for average likelihood)

Station	√	Theo. chi-sq.	Obs.chi-sq.					
Babylon			Normal dis		Lognormal dis.		Gamma dis.	
			Moments	Max. likelihood	Moments	Max. likelihood	Moments	Max. likelihood
	4	9.49	0.9167	0.9167	5.1546	3.5883	2.6048	2.1925

Table 8. Anderson–Darling index for the station that are used in the paper (for max likelihood)

Station	AD critical	Obs. Anderson-Darling		
Babylon			Moments	Max. likelihood
	0.704	Normal dis	0.30824	0.30824
	0.795	Lognormal dis.	0.75417	0.49488
	0.752	Gamma dis.	0.43301	0.35579

Table 9. Anderson–Darling index for the station that are used in the paper (for average likelihood)

Station	AD critical		Obs. Anderson-Darling	
Babylon			Moments	Max. likelihood
	0.704	Normal dis	0.24199	0.24199
	0.795	Lognormal dis.	0.40448	0.32532
	0.752	Gamma dis.	0.23733	0.23373

for design, planning and operation of water resources projects, so as to protect the project from Floods and water use in agriculture, dams and others by collecting them in reservoirs (Betül, 2005).The analysis of intensity, duration and frequency begins with the collection of different records Extensions. After data collection, annual extremes are extracted from the register for Every time. Then the extreme annual data fits into the distribution of possibilities to rainfall is estimated. In this study Gumbel extreme value distribution, the Normal distribution and Log Normal distribution are used to fit annual severe rainfall data.

Normal distribution

The form of probability distribution may be written as follows:

$$x_t = \mu + K_t \sigma \quad (3)$$

where: represents the magnitude of the T – year event, μ and σ are the mean and standard deviation of the annual maximum series, and is a frequency factor depending on the return period T or probability of non exceedence P_t which can be calculated from generated uniform random numbers ($0 < p < 1$), that is the frequency factor for normal distribution can be expressed from Equation 4 (Erto et al., 2011):

$$z = w - \frac{2.515517 + 0.802853w + 0.010328w^2}{1 + 1.432788w + 0.189269w^2 + 0.001308w^3} \quad (4)$$

where: $Z = K_t$

$$w = [\ln(\frac{1}{p^2})]^{\frac{1}{2}} \; [0 < p < 0.5] \quad (5)$$

where: $p > 0.5$; $1 - p$ is substituted for p in Equation 5, p = exceedence probability

Alternatively the frequency factor is computed by using tables. This gives the value of K_t depends on skew coefficient ($Cs = 0$) with different return periods. When the value of K_t is computed then it is substituted in Equation 3 to obtain the value of extreme rainfall intensity (Krishnamoorthy, 2006).

Gumbel distribution

The frequency factor is applicable to many probability distributions used in hydrologic frequency analysis, for the Gumbel distribution K_t is obtained from Equation 6 (Prodanovic et al., 2007).

$$K_t = -\frac{\sqrt{6}}{\pi}\left\{0.5772 + ln\left[ln\left(\frac{T}{T-1}\right)\right]\right\} \quad (6)$$

Table 10 shows the values of intensities by using Gumbel distribution for Babylon station. Figure 4 shows IDF curves for Babylon station that are used in this paper for Gumbel distribution.

Log normal distribution

The frequency factor value in Log Normal distribution is calculated in the same way as Normal distribution, but the severe rainfall intensity value depends on the data logarithm. This value is then used in Equation 7 The answer in the discussion and the results to obtain the value of extreme rainfall intensity.

$$y_t = \bar{y} + K_t S_y \quad (7)$$

where: is represents the magnitude of the T-year event, and are the mean and standard deviation of the annual maximum series for the logarithms of the data (Table 11, 12) (Ginos, 2009).

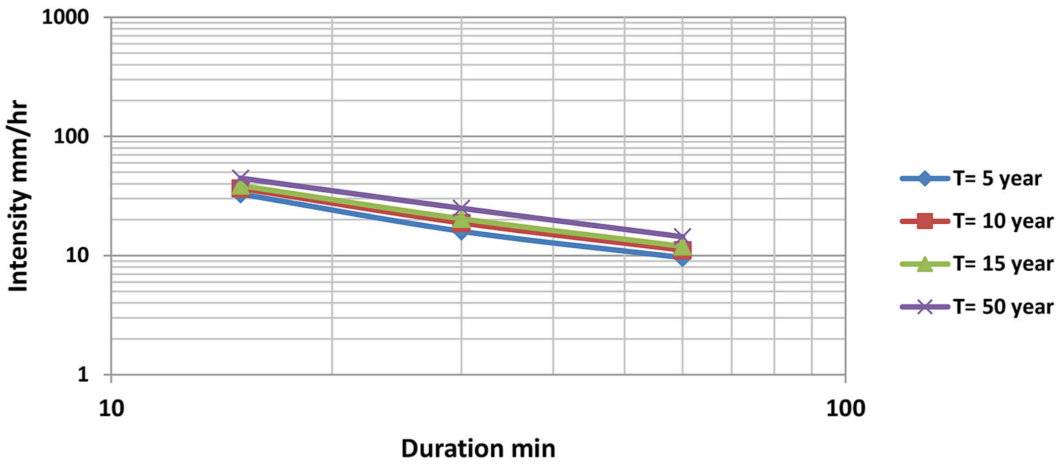

Figure 4. IDF Curve for babylon station (Gumbel distribution)

Table 10. Results for Babylon station (Gumbel distribution).

Duration (min)	Intensity (mm/hr)			
	5 year	10 year	15 year	50 year
15	32.88	36.56	38.63	44.64
30	15.98	18.78	20.36	24.93
60	9.6	11.1	11.94	14.38

Table 11. Results for babylon station (normal distribution)

Duration (min)	Intensity (mm/hr)			
	5 year	10 year	15 year	50 year
15	33.64	36.41	37.77	41.26
30	16.56	18.67	19.71	22.36
60	9.91	11.04	11.59	13.01

Table 12. Results for Babylon station (log normal distribution)

Duration (min)	Intensity (mm/hr)			
	5 year	10 year	15 year	50 year
15	33.58	37.18	39.08	44.41
30	16.36	19.45	21.18	26.32
60	10.10	11.89	12.88	15.80

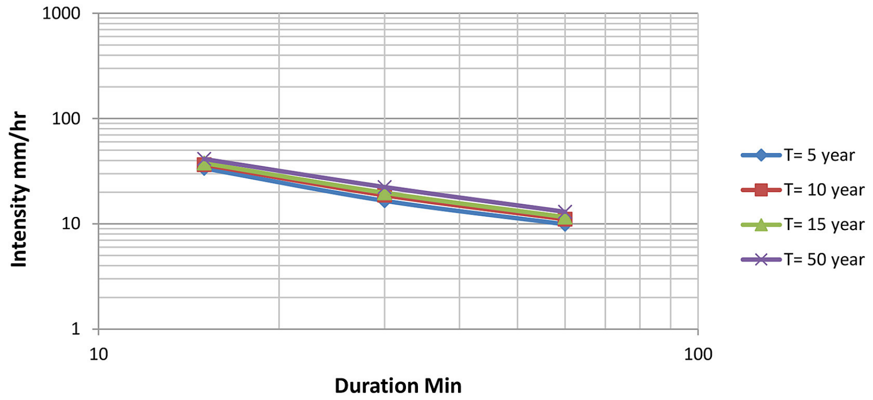

Figure 5. IDF Curve for Babylon station (normal distribution)

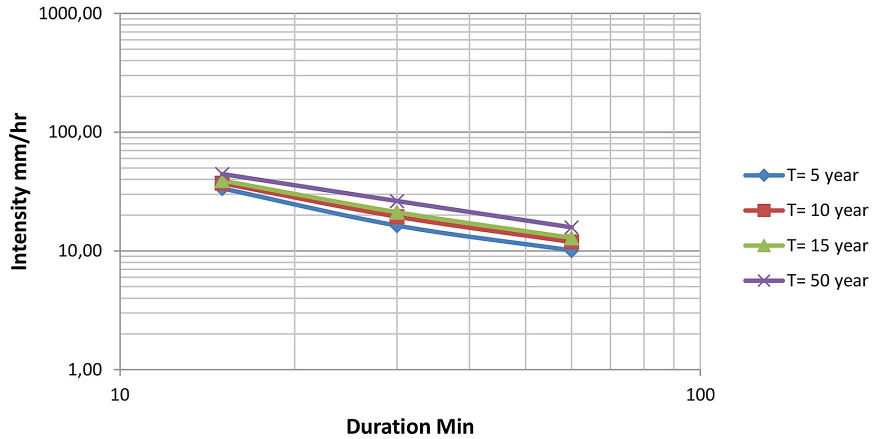

Figure 6. IDF Curve for Babylon station (log normal distribution)

RESULTS AND DISCUSSIONS

In this paper three probability distributions are used, i.e., normal, log normal, and gamma distributions. These distributions are applied to the data of rainfall depth for max data and average data for one selected station in Iraq, namely, Babylon. Moments and maximum likelihood methods are used to estimate the parameters of the selected distributions. For the purpose of testing the suitability of the theoretical distributions to the data, three goodness of fit test are used: the chi-square, Kolmogorov-Smirnov, and Anderson-Darling. The results of Chi-Square index are as follows:

1. The Normal distribution is acceptable for Babylon station by using both the moments and maximum likelihood methods.
2. The Log Normal distribution is acceptable for Babylon station by using the two methods of estimation (moments and maximum likelihood).
3. Gamma distribution is acceptable for Babylon station by using the two methods (moments and maximum likelihood).

The results of the Kolomogrov-Smirnov index show that Babylon station is acceptable for the Three distributions by using the two methods (moments and maximum likelihood). The results of the Anderson-Darling index show that Babylon station is acceptable for the Three distributions by using the two methods (moments and maximum likelihood), because the critical value is greater than the resulting value, that is, we accept the zero hypothesis. The results for the three statistical tests are shown in Table 13 and 14.

The IDF curves for the Babylon station in Iraq is constructed by using Gumbel extreme value distribution, the normal, and log normal distributions. the results show that for Babylon station (15, 30, and 60 min. durations) the normal distribution is better than the Gumbel extreme value and the log normal distributions, due to the small differences in the IDF curve in the normal distribution from the Gumbel and log normal, the Normal distribution is better. When comparing the distributions used to examine and test Babylon Station's total rainfall data in research

Table 13. Summary of results for the three indices. For the best distribution and the best method of maximum values of data

Stations	Chi-square index		K-S index		A-D index	
	Success dis.	Estimation method	Success dis.	Estimation method	Success dis.	Estimation method
Babylon	Gamma	(M.L)	Log normal	(M.L)	Normal	(M. and M.L)

Table 14. Summary of results for the three indices. For the best distribution and the best method of average values of data

Stations	Chi-square index		K-S index		A-D index	
	Success dis.	Estimation method	Success dis.	Estimation method	Success dis.	Estimation method
Babylon	Normal	(M. and M.L)	Log Normal	(M)	Gamma	(M.L)

Table 15. The values of Kolmogorov-Smirnov index for Babylon station and with confidence level equal 95% (for total data)

Station	Theo. d.	Obs. d.					
		Normal dis.		Lognormal dis.		Gamma dis.	
Babylon	0.246	Moments	Max. likelihood	Moments	Max. likelihood	Moments	Max. likelihood
		0.09177	0.09177	0.11010	0.07683	0.07378	0.08618

Table 16. Chi-square index for the station that are used in the paper (for total data)

Station	Theo. chi-sq.	Obs. chi-sq.					
		Normal dis		Lognormal dis.		Gamma dis.	
Babylon	11.071	Moments	Max. likelihood	Moments	Max. likelihood	Moments	Max. likelihood
		8.6359	8.6359	9.2920	9.5757	8.6257	8.3928

Table 17. Anderson–Darling index for the station that are used in the paper (for total data)

Station	AD critical	Obs. Anderson-Darling		
Babylon			Moments	Max. likelihood
	0.704	Normal dis	0.27105	0.27105
	0.795	Lognormal dis.	0.62566	0.27404
	0.752	Gamma dis.	0.19938	0.21900

Table 18. Summary of results for the three indices. For the best distribution and the best method of total values of data

Stations	Chi-square index		K-S index		A-D index	
	Success dis.	Estimation method	Success dis.	Estimation method	Success dis.	Estimation method
Babylon	Gamma	(M.L)	Gamma	(M)	Gamma	(M)

(Mizhir et al., 2024) accepted under publication), where the results of the three tests are as shown in Tables 15, 16, 17 as well as which are better than the distributions as shown in Table 18, where we compare with the research through which the highest data values and data rate are shown in the results of the study presented in the previous tables. The gamma distribution was the best for the Kolomogrov-Smirnov test and Anderson-Darling test in a Moments method while the Chi-square test was the best gamma distribution in a Max. Likelihood method when we took the total data. Whereas the best distribution and the best method of tests when we take the max data values and the average data was in Table 13 and 14.

CONCLUSION

This research provides an overview of the way in which rainfall is estimated in Iraq. Since the different climatic conditions and terrain from one region to the other, a rainfall relationship must be obtained for a different duration and return periods ranging from (5 to 50) years, to be used in hydraulic projects. This research presents the IDF curves and an empirical formula to estimate the rainfall intensity at Babylon city The IDF curves were built for the Babylon station in Iraq using the Gumbel maximum value distribution and Normal and Log Normal distributions. IDF was drawn as shown in Figures 4 to 6 using Excel, the results showed that for Babylon Station (15, 30 and 60 minutes). Normal distribution is better than the maximum value of Gumbel and Log Normal since differences in drawing for Normal distribution are minimal. But using the Kolmogorov-Smirnov index, Chi-square and Anderson-Darling for the three distributions, the results showed that Babylon Station had succeeded in all tests. The results showed a high correlation coefficient for all formulas as well as the lowe errors, this indicates that these formulas are good for estimating the intensity of rainfall for the study area for return periods from 5 to 50 years. recommended that the new IDF curves should be reviewed or updated every 4–5 years because of climate change. It is not possible to determine exactly distribution between them. Further studies are recommended when more information and data are available to verify the results obtained and update the IDF curves. This study aims to improve precipitation forecasting by comparing the accuracy of prediction of the different models associated with analysis of the optimal degradation forecasting method. The results showed that Normal distribution had the lowest differences in the graphic if is the best distribution of gamma distribution and Log Normal. Future research can explore the application of this model in different regions and scenarios to further verify its effectiveness.

This revised conclusion summarizes the results of the study and highlights Normal distribution compared to other models. It also proposes future research directions to further verify the model's effectiveness.

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