Plant Archives Volume 20 No. 1, 2020 pp. 2392-2398 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

AN ANALYSIS OF SEASONAL RAINFALL DATA FOR CENTER AND SOUTH IRAQ USING HYDROLOGICAL STATISTICS

Iman A. Hameed

Department of Soil and Water Resources, College of Agriculture, AL Qasem Green University, Hilla, Iraq.

Abstract

The amount of rainfall is a key role in renewing natural water resources. Which is the component of the Hydrological Cycle. The research title the rainfall analysis depending on the rainfall season for five metrological station in Iraq for period (1988-2017) (Baghdad, Hilla, Najaf, Karbala and Diwaniya). By choosing the theoretical distribution (Mathematical Model) that features data values. The suitable for the theoretical distribution of the data distribution was evaluated through statistical tests. An attempt is made to fit three of the available theoretical distributions *i.e*. The Normal, Gamma and Log-Normal distributions. These three distribution apply to quarterly data during comparison of the value Chi-square calculated with standard value that is available from its tables at a 95% confidence level.

Key words: Rainfall, Hydrological, statistics.

Introduction

The rain is the main source of water, Water is the vital element of any process in life and there is no alternative to it, So the study of the nature of the climate, especially rainfall of climate important is factor of Hydrology in terms of knowledge of quantity, intensity and distribution, especially in Arid and Semi-arid areas. In particular, its importance in all areas of life, as it is main pillar of various field such as agriculture, industry and others. Crops that depend on water supply from natural sources and through Irrigation in low-lying areas depend on the rainfall pattern. It is therefore necessary to predict precipitation from previous records of hydrological data using statistical analysis frequency or likelihood of distribution helps to identify extreme events from floods droughts and severe storms with a number of occurrences that can be expected to occur again. The study of change, variability and the probability of rainfall is important for water resources management planning and agriculture planning, In studying climate change and environmental studies, estimating the discharge of rivers, runoff and all activities. The aim of research is to analyze quarterly rainfall data for five metrological stations (Baghdad, Hilla, Najaf, Karbala and Diwaniya), Which has been adopted on the amount of fat rains and limits its fall (from 1-October to 31-May) By choosing the theoretical distribution (Mathematical model) that features data values for the quarter rainfall by evaluating the theoretical distribution of the use of statistical tests. There are many literature review adopted by the statistical approach to the data analysis of the data and these studies that approach the current research methodology (Omran *et al*., 2014) have been used to analyze the annual rainfall data recorded for some metrological stations in Iraq (Hussein, 2014) also has analyzed the annual rainfall data for the Holy Karbala basin and the application of seven of theoretical possibilities and their appropriateness. (G. Arvind *et al*., 2017) Statistical analysis of annual, quarterly and monthly rainfall data for 30 years as a case study in India.

Materials and Methods

Study area

The study area is located in center and south of Iraq. (Fig. 1), which is within the two regional areas as the east and seeded area of the western plateau. Most of their parts are not so for from the mean see level (m.s.l.). (Table 1) shows the location of each station relative to longitude, latitude and altitude of the station relative to mean see level. The region is characterized by the prevalence of desert climate and the widening of the thermal range between night and day during the summer and winter seasons.

Table 1: Location Metrological station of the study area.

Station	Longitude (degree)	Latitude (degree)	Altitude (m)
Baghdad	44.40	33.3	32
Hilla	44.45	32.45	27
Najaf	44.32	31.95	33
Karbala	44.05	32.57	29
Diwaniya	44.95	31.95	20

Mathematical Model and Methodology

The rainy season in Iraq starts from (1-October to 31-May) and five meteorological stations for the period (1988-2017). The monthly rainfall data for meteorological stations were obtained from (The Iraqi General Meteorological and meteorological Agency) the fall duration of registration. As the increase period of time increases the accuracy of the possible result as being approaching or exceeding one at least one climate cycle of any passage of the study of the previous hydrological accidents. It shows that the recorded recording period is 30 years, but it loses some of its recordings, as shown in (Table 2). The total seasonal rainfall of the selected stations and the missing data cannot be completed according to the known methods for the lock of monthly rainfall data for most nearby and nearby stations for the

Fig. 1: Location map of the study area.

Table 2: Seasonal Rainfall and Some Statistical Values in all station.

Season	Seasonal Rainfall at Baghdad St.	Seasonal Rainfall at Hilla St.	Seasonal Rainfall at Diwaniya St.	Seasonal Rainfall at Najaf St.	Seasonal Rainfall at Kerbala St.
1988-1989	139.201	180.1	132.101	132.603	110.3
1989-1990	140.802	70	50.002	39.302	84.503
1990-1991	(M)	(M)	77.103	(M)	(M)
1991-1992	71.5	49.4	59.601	66.9	45.4
1992-1993	220.3	190.9	236.9	223.4	173.8
1993-1994	89.3	64.301	71.401	57.8	27.902
1994-1995	156.3	167.2	203.601	156.6	160.001
1995-1996	110.102	123.102	118.801	99	125.201
1996-1997	36.601	19.6	50.102	33.1	48.3
1997-1998	173.1	180.4	176.402	197.602	162.4
1998-1999	55.801	43.801	61.201	30.702	23.703
1999-2000	62.401	40.901	142.302	31.5	36.802
2000-2001	106.9	129.9	200.601	94.3	99.401
2001-2002	84.201	96.7	167.502	68	79.9
2002-2003	(M)	(M)	(M)	(M)	(M)
2003-2004	(M)	163.202	144.703	84.301	81.101
2004-2005	(M)	103.4	78.701	75.601	99.401
2005-2006	141.403	112.4	112.001	125.302	65.401
2006-2007	125.9	95.501	56.3	97.102	74.4
2007-2008	37.603	43.502	42.203	36.102	49.501
2008-2009	52.201	41.501	37.402	91.401	46.101
2009-2010	94.7	89.7	65.6	67.4	93.5
2010-2011	121.101	97.201	83.802	74.8	96.502
2011-2012	29.301	15.901	18.302	10.201	20.401
2012-2013	263.602	152.3	148.601	90.802	125.902
2013-2014	278.101	226.401	143.401	184.501	206.701
2014-2015	73.2	72.2	52.9	42.7	59.102
2015-2016	219.4	206	169.701	183.301	232.2
2016-2017	100.502	96.001	38.701	57.801	70.602
Sum	2983.523	2871.515	2939.938	2452.124	2498.428
Mean	119.341	106.352	104.998	90.819	92.534
St. dev.	68.630	59.671	59.907	56.490	55.336
Skew	0.894	0.364	0.532	0.896	0.952

same period. Therefore, the number of data varies from station to station according to the years of loss and this may be within the limits allowed for the completion of such a study.

The software was used in dealing with the data to complete the study including (Microsoft Excel) to find

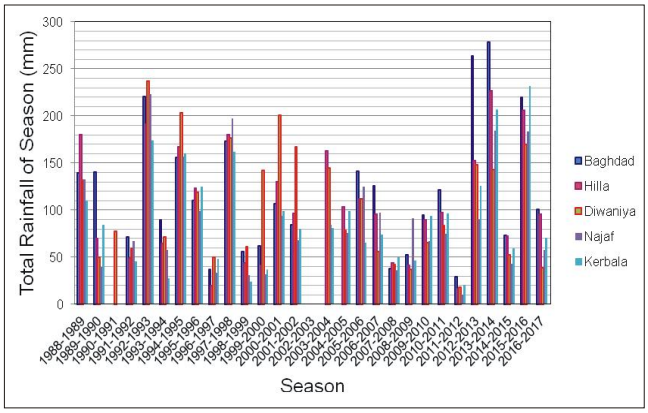

Fig. 2: Seasonal Rainfall for all station.

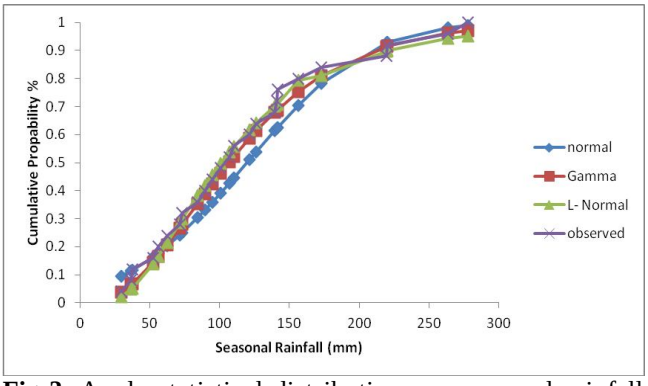

Fig. 3: Apply statistical distributions on seasonal rainfall values for the period (1988-2017) (Station : Baghdad).

Table 3: Statistical distribution and their function.

Statistical Distribution	Probability density function f(x)	Cumulative probability F(x)	Statistical parameters	Range
Normal	$f(x)=\frac{1}{\sigma\sqrt{2\pi}}\exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right)$	$F(x)=\frac{1}{\sigma\sqrt{2\pi}}\int_{-\infty}^{\infty}\exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right)dx$	$\mu,\quad \sigma^2$	$-\infty \le x \le \infty$
Log-normal	$f(x)=\frac{1}{x\sigma_y\sqrt{2\pi}}\exp\left(-\frac{(y-\mu_y)^2}{2\sigma_y{}^2}\right)$	$F(x)=\frac{1}{\sigma_y\sqrt{2\pi}}\int_0^{x_i}\frac{1}{x}\exp\left(-\frac{(y-\mu_y)^2}{2\sigma_y{}^2}\right)dx$	$\mu_y,\quad \sigma_y{}^2$	$-\infty \le y \le \infty$
Gamma	$f(x)=\left(\frac{x}{\beta}\right)^{\gamma-1}\frac{e^{-\left(\frac{x}{\beta}\right)}}{\beta(\gamma)}$	$F(x)=\frac{\int_0^x\left(\frac{t}{\beta}\right)^{\gamma-1}e^{-\left(\frac{t}{\beta}\right)}}{\beta(\gamma)}dt$	$\gamma=\left(\frac{\mu}{s}\right)^2,\ \beta=\frac{s^2}{\mu}$	$0 \le x \le \infty$

the distribution function cumulative F(x) of the three distributions after calculating the statistical parameters for each distribution and the data were analyzed according to the most common distributions such as (The Normal, Gamma and Log-Normal distributions). And their suitability after selecting the Goodness of fit by using chi-square to choose the best and most convenient data. Shown the (Table 3) statistical distribution and function are used in analyzed (Viessman *et al*., 2003).

Table 4: Calculations of probabilities by using method of moments (Station: Baghdad).

Observed	L-Normal	Gamma	Normal	Rank (m)	Total rainfall (mm)
F(x)%	F(x)%	F(x)%	F(x)%		
0.04	0.021	0.038	0.095	1	29.301
0.08	0.048	0.065	0.114	2	36.601
0.12	0.052	0.069	0.117	3	37.603
0.16	0.139	0.144	0.164	4	52.201
0.20	0.165	0.166	0.177	5	55.801
0.24	0.214	0.207	0.203	6	62.401
0.28	0.285	0.267	0.243	7	71.5
0.32	0.298	0.279	0.251	8	73.2
0.36	0.382	0.354	0.304	9	84.201
0.40	0.419	0.388	0.331	10	89.3
0.44	0.457	0.424	0.360	11	94.7
0.48	0.496	0.462	0.392	12	100.502
0.52	0.537	0.503	0.428	13	106.9
0.56	0.556	0.522	0.446	14	110.102
0.60	0.617	0.586	0.510	15	121.101
0.64	0.641	0.613	0.538	16	125.9
0.68	0.700	0.679	0.614	17	139.201
0.72	0.707	0.686	0.623	18	140.802
0.76	0.709	0.689	0.626	19	141.403
0.80	0.763	0.752	0.705	20	156.3
0.84	0.811	0.810	0.783	21	173.1
0.88	0.898	0.913	0.928	22	219.4
0.92	0.900	0.915	0.929	23	220.3
0.96	0.942	0.961	0.982	24	263.602
1.00	0.952	0.971	0.990	25	278.101

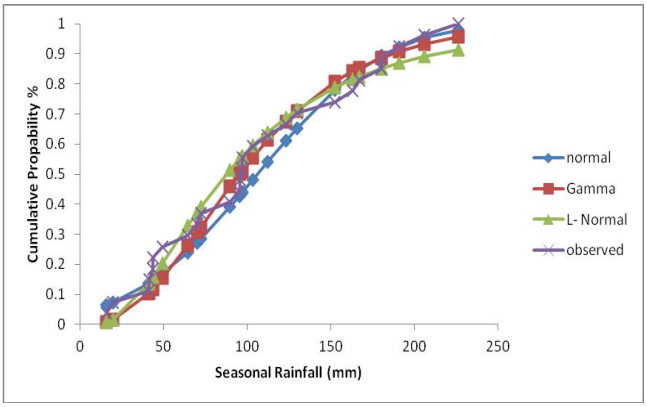

Fig. 4: Apply statistical distributions on seasonal rainfall values for the period (1988-2017) (Station :Hilla).

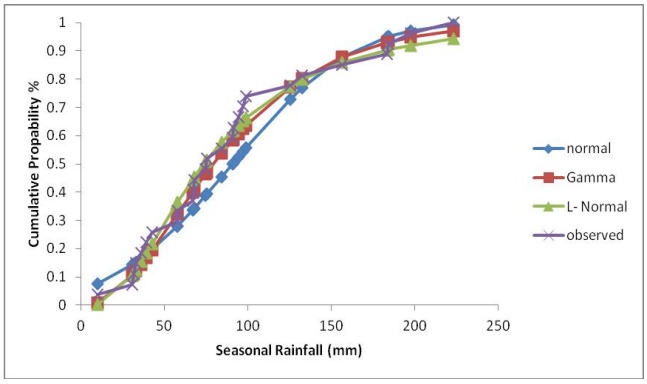

Fig. 5: Apply statistical distributions on seasonal rainfall values for the period (1988-2017) (Station :Najaf).

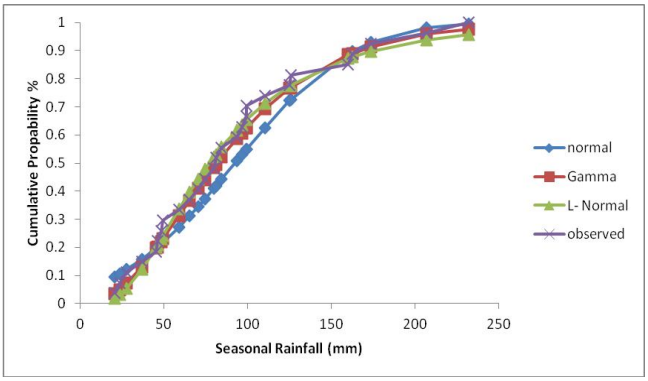

Fig. 6: Apply statistical distributions on seasonal rainfall values for the period (1988-2017) (Station :Karbala).

1. Testing the goodness of fit

The goodness of fit test of probability distributions can be obtained by comparing the theoretical values with the sample values of the relative frequency function or the cumulative frequency function. The Chi-square test as any relative to the relative frequency function is:

$$X_c^2 = \sum_{i=1}^{m} \frac{n[f_s(x_i) - p(x_i)]^2}{p(x_i)} \quad \ldots\ldots\ldots\ldots\ldots \quad (1)$$

Whereas: m : Number of Intervals.

$nf_s(x_i)$: The number of observed the phenomenon occurred in the sample within the interval i.

$np(x_i)$: The number of expected occurrences within the same interval.

The value of Chi- square computed is compared with the standard value obtained from the tables of the Chi-square.

The Chi-square distribution by degrees of freedom

Table 5: Calculations of probabilities by using method of moments (Station: Hilla).

Observed	L-Normal	Gamma	Normal	Rank (m)	Total rainfall (mm)
F(x)%	F(x)%	F(x)%	F(x)%		
0.037	0.007	0.009	0.065	1	15.901
0.074	0.016	0.016	0.073	2	19.6
0.111	0.136	0.102	0.136	3	40.901
0.148	0.141	0.105	0.139	4	41.501
0.185	0.157	0.117	0.146	5	43.502
0.222	0.159	0.119	0.147	6	43.801
0.259	0.205	0.155	0.170	7	49.4
0.296	0.328	0.263	0.240	8	64.301
0.333	0.373	0.307	0.271	9	70
0.370	0.390	0.324	0.284	10	72.2
0.407	0.513	0.458	0.390	11	89.7
0.444	0.549	0.500	0.428	12	95.501
0.481	0.552	0.504	0.431	13	96.001
0.518	0.556	0.509	0.436	14	96.7
0.555	0.559	0.512	0.439	15	97.201
0.592	0.594	0.555	0.480	16	103.4
0.629	0.640	0.613	0.540	17	112.4
0.666	0.688	0.675	0.611	18	123.102
0.703	0.714	0.710	0.653	19	129.9
0.740	0.787	0.806	0.779	20	152.3
0.777	0.815	0.842	0.830	21	163.202
0.814	0.824	0.854	0.846	22	167.2
0.851	0.850	0.886	0.892	23	180.1
0.888	0.851	0.887	0.893	24	180.4
0.925	0.869	0.909	0.922	25	190.9
0.962	0.891	0.933	0.953	26	206
0.999	0.914	0.957	0.978	27	226.401

Table 6: Calculations of probabilities by using method of moments (Station: Najaf).

Observed	L-Normal	Gamma	Normal	Rank (m)	Total rainfall (mm)
F(x)%	F(x)%	F(x)%	F(x)%		
0.037	0.002	0.009	0.077	1	10.201
0.074	0.105	0.105	0.144	2	30.702
0.111	0.112	0.110	0.147	3	31.5
0.148	0.126	0.121	0.153	4	33.1
0.185	0.154	0.143	0.166	5	36.102
0.222	0.184	0.168	0.181	6	39.302
0.259	0.217	0.195	0.197	7	42.7
0.296	0.363	0.323	0.279	8	57.8
0.333	0.363	0.323	0.279	9	57.801
0.370	0.444	0.400	0.336	10	66.9
0.407	0.448	0.404	0.339	11	67.4
0.444	0.453	0.409	0.343	12	68
0.481	0.507	0.464	0.388	13	74.8
0.518	0.513	0.470	0.394	14	75.601
0.555	0.575	0.537	0.454	15	84.301
0.592	0.616	0.583	0.500	16	90.802
0.629	0.620	0.587	0.504	17	91.401
0.666	0.636	0.606	0.525	18	94.3
0.703	0.652	0.624	0.544	19	97.102
0.740	0.662	0.636	0.558	20	99
0.777	0.775	0.773	0.729	21	125.302
0.814	0.798	0.803	0.770	22	132.603
0.851	0.858	0.877	0.878	23	156.6
0.888	0.903	0.930	0.949	24	183.301
0.925	0.904	0.931	0.951	25	184.501
0.962	0.920	0.948	0.971	26	197.602
0.999	0.943	0.971	0.991	27	223.4

v is the distribution of the sum of squares of v of independent standard natural variables (z_i).

$$x_v^2 = \sum_{i=1}^{v} Z_i^2 \quad \ldots\ldots\ldots\ldots\ldots \quad (2)$$

To test Chi-square :

$$v = m - p - 1 \quad \ldots\ldots\ldots\ldots \quad (3)$$

Whereas: p: Number of parameters distribution standards used in the data application.

The level confidence level is selected for the test and symbolizes him (1- α) whereas α :Movement level (5% usually take). Then extracted value of the $x_{v,1-\alpha}^2$ from the tables. The selected distribution applies to the data acceptable in the case of being $x_c^2 < x_{v,1-\alpha}^2$ (Hussein, 2017).

Results and Discussion

Research result, which used the statistical methods

Table 7: Calculations of probabilities by using method of moments (Station: Karbala).

Observed	L-Normal	Gamma	Normal	Rank (m)	Total rainfall (mm)
F(x)%	F(x)%	F(x)%	F(x)%		
0.037	0.018	0.035	0.096	1	20.401
0.074	0.032	0.050	0.107	2	23.703
0.111	0.055	0.072	0.121	3	27.902
0.148	0.123	0.130	0.157	4	36.802
0.185	0.202	0.197	0.197	5	45.4
0.222	0.209	0.202	0.201	6	46.101
0.259	0.231	0.220	0.212	7	48.3
0.296	0.243	0.230	0.218	8	49.501
0.333	0.337	0.312	0.273	9	59.102
0.370	0.397	366	0.312	10	65.401
0.407	0.444	0.410	0.346	11	70.602
0.444	0.477	0.441	0.372	12	74.4
0.481	0.521	0.485	0.410	13	79.9
0.518	0.530	0.495	0.418	14	81.101
0.555	0.556	0.521	0.442	15	84.503
0.592	0.618	0.586	0.507	16	93.5
0.629	0.636	0.607	0.529	17	96.502
0.666	0.654	0.626	0.549	18	99.401
0.703	0.654	0.626	0.549	19	99.401
0.740	0.712	0.692	0.626	20	110.3
0.777	0.775	0.767	0.723	21	125.201
0.814	0.778	0.770	0.727	22	125.902
0.851	0.873	0.885	0.889	23	160.001
0.888	0.878	0.890	0.897	24	162.4
0.925	0.898	0.914	0.929	25	173.8
0.962	0.939	0.959	0.980	26	206.701
0.999	0.958	0.977	0.994	27	232.2

that rely on the Mathematical foundations to derive the characteristics of the population to rely on the characteristics of the random sample taken from it. The amount of seasonal rainfall is low and fluctuating almost no more than 300 mm in all climatic stations. The rainfall varies according to the spatial and time changes in each station. Through the (Fig. 2) shows that the highest amount

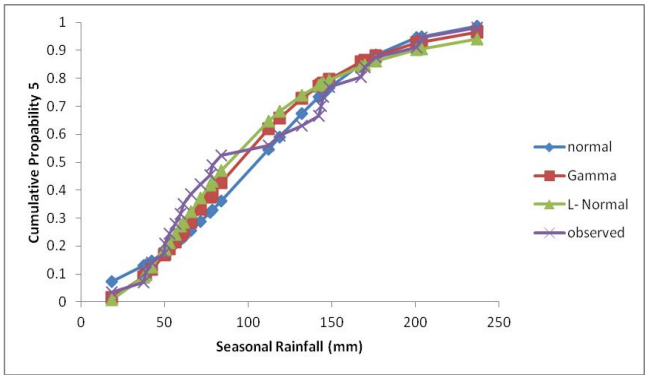

Fig. 7: Apply statistical distributions on seasonal rainfall values for the period (1988-2017) (Station :Diwaniya).

Table 8: Calculations of probabilities by using method of moments (Station: Diwaniya).

Observed	L-Normal	Gamma	Normal	Rank (m)	Total rainfall (mm)
F(x)%	F(x)%	F(x)%	F(x)%		
0.035	0.007	0.015	0.074	1	18.302
0.070	0.090	0.090	0.130	2	37.402
0.105	0.099	0.097	0.134	3	38.701
0.140	0.125	0.118	0.147	4	42.203
0.175	0.188	0.169	0.179	5	50.002
0.210	0.189	0.170	0.180	6	50.102
0.245	0.213	0.190	0.192	7	52.9
0.280	0.242	0.215	0.203	8	56.3
0.315	0.271	0.239	0.224	9	59.601
0.350	0.285	0.252	0.232	10	61.201
0.385	0.323	0.285	0.255	11	65.6
0.420	0.372	0.331	0.287	12	71.401
0.455	0.419	0.375	0.321	13	77.103
0.490	0.431	0.387	0.330	14	78.701
0.525	0.470	0.426	0.362	15	83.802
0.560	0.648	0.620	0.547	16	112.001
0.595	0.682	0.659	0.591	17	118.801
0.630	0.739	0.728	0.675	18	132.101
0.665	0.775	0.773	0.733	19	142.302
0.700	0.779	0.777	0.739	20	143.401
0.735	0.783	0.782	0.746	21	144.703
0.770	0.795	0.797	0.767	22	148.601
0.805	0.844	0.858	0.852	23	167.502
0840	0.849	0.864	0.860	24	169.701
0.875	0.863	0.881	0.883	25	176.402
0.910	0.902	0.927	0.945	26	200.601
0.945	0.906	0.931	0.950	27	203.601
0.980	0.940	0.966	0.986	28	236.9

Table 9: Parameters values of the best fitted distributions of seasonal rainfall depths (mm) for five stations.

Distribution type		Shape parameter	Scale parameter	Location parameter
Normal	Baghdad	-	σ= 68.630	μ=119.341
	Hilla	-	σ= 59.671	μ=106.352
	Najaf	-	σ= 59.490	μ=90.819
	Karbala	-	σ= 55.336	μ=92.534
	Diwaniya	-	σ= 59.907	μ=104.998
Gamma	Baghdad	γ=3.024	β=39.467	-
	Hilla	γ=3.177	β=33.480	-
	Najaf	γ=2.585	β=35.137	-
	Karbala	γ=2.796	β=33.091	-
	Diwaniya	γ=3.072	β=34.180	-
Log-normal	Baghdad	-	σ_{Lnx}= 0.609	μ_{Lnx}=4.616
	Hilla	-	σ_{Lnx}= 0.695	μ_{Lnx}=4.473
	Najaf	-	σ_{Lnx}= 0.701	μ_{Lnx}=4.302
	Karbala	-	σ_{Lnx}=0.638	μ_{Lnx}=4.347
	Diwaniya	-	σ_{Lnx}=0.637	μ_{Lnx}=4.476

Table 10: Chi-Square index for all the stations that are used in the paper and with confidence level equal 95%.

Stations	v	Theo. Chi-Sq.	Normal	Gamma	Log-Normal
			Obs. Chi-Sq	Obs. Chi-Sq	Obs. Chi-Sq
Baghdad	4	9.49	4.780	4.209	5.85
Hilla	7	14.07	7.615	7.804	7.768
Najaf	3	7.81	2.248	1.601	1.811
Karbala	5	11.07	3.690	1.934	3.083
Diwaniya	7	14.07	10.995	6.948	7.769

of rainfall in the (2013-2014) season for Baghdad and Hilla station, While the Diwaniya and Najaf station were the highest value in the (1992-1993) season and the Karbala station was the top of the rainy season (2015-2016). As we note through a (Table 2) some statistical parameters of the calculation of the Arithmetic mean, standard deviation and skewness accountable for all the area of station. The results of the statistical analysis of seasonal rainfall data for all stations after the application of the three statistical distributions of the Normal, Gamma and Log-Normal distributions of data for the period (1988-2017). As we note in the tables from 4 to 8 using the computer program to find the cumulative distribution function F(x) of the three distributions after the account of the statistical parameters for each distribution as indicated by the (Table 9) (Nist/ Sematech, 2003). These distribution were tested with Chi-square the calculated values were showed with (Table 10) and compared to critical values at a 95% confidence (Walpol and Myers, 1978). Note of the 3 to 7 forms distributions functions curves with of the observations. The x-axis represents the quantity rainfall season with y- axis represents cumulative probability.

Conclusion

The Probability distributions that have been used in this study for the seasonal rains are the normal distribution, log-normal distribution and gamma distribution. The hypothesis of all distributions applies to the seasonal rain data by testing these distributions in Chi-square. The calculated values at Baghdad station were 4.780 in the normal distribution, 5.85 in the log- normal distribution and 4.209 in the Gamma distribution and compare with critical values of 9.49 at a 95% confidence level. The calculated values at Hilla station were 7.615 in the normal distribution, 7.768 in the log- normal distribution and 7.804 in the Gamma distribution and compare with critical values of 14.07 at a 95% confidence level. The calculated values at Najaf station were 2.248 in the normal distribution, 1.811 in the log- normal distribution and 1.601 in the Gamma distribution and compare with critical values of 7.81 at a 95% confidence level. The calculated values at Karbala station were 3.690 in the normal distribution, 3.083 in the log- normal distribution and 1.934 in the Gamma distribution and compare with critical values of 11.07 at a 95% confidence level. The calculated values at Diwaniya station were 10.995 in the normal distribution, 7.769 in the log- normal distribution and 6.948 in the Gamma distribution and compare with critical values of 14.07 at a 95% confidence level. From this we conclude that the distributions hypothesis applies to the seasonal rainfall data and cannot be rejected at 95% confidence level.

References

Arvind, G. *et al*., (2017). "Statistical Analysis of 30 years Rainfall Data: A Case Study", Earth and Environmental Science 80 012067.

Hussein, Ayad Kadhum (2014). "Best Distribution and Plotting Positions of Annual Rainfall in the Catchment of Holy Karbala in Iraq", *Uni. Of Kufa / College of Engineering Structure and water Resources Eng. Department*, **22:** 894-906.

Hussein, M.H. (2017). "Basics and applications of hydrology".

NIST/ SEMATECH (2003). e-Handbook of statistical methods hHp, / www.it1 nist.gov/div 898/ handbook/,(accessed 4 October 2003).

Mohammed, R.J. (2018). The Spatial Variability of Some Chemical Properties of Gypsiferous Soils by Using Gis. *International Journal of Agricultural and Statistical Sciences*., **14(1):** 303-312.

Mohammed, R.J., S.M.A. Kadhim and D.F. Hassan (2019). Thermodynamic Parameters of Well Water in Babylon Governorate of Iraq. *Plant Archives.*, **19:** 1097-1104.

Omran, Z.A. and S.T. AL-Bazzaz (2014). "Statistical Analysis of Rainfall Ecords of some Iraqi Etiorological Stations", *Jou. of Babylon Uni. / Engineering Sciences.*, **22:** 67-77.

Viessman, Warren and Gary L. Lewis (2003). " Introduction to Hydrology", 5th ed. Pearson Education, Inc. upper saddle river, NJ 07458.

Walpale, R.E. and R.H. Myers (1978). " Probability and Statistics for Engineers and Scientists" 2nd ed., Macmillan publishing Co., N.Y., USA.