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Evaluation of the Most Appropriate Statistical Distribution for Monthly Rainfall Prediction in the Zarrineh River Watershed

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Abstract: *Statistical distribution of rainfall in a geographic area and the potential positive and negative effects of the most fundamental issues in environmental planning and optimization of rainfall is true. Accordingly, to calculate of this parameter in the various return periods and its spatial variation, statistical analysis and selection of appropriate distribution is essential. In this research to obtain the best statistical distributions to estimate monthly rainfall, monthly rainfall data from 6 meteorological stations West Azerbaijan province named Sariqamish, Pole Miandoab Zarrineh River, Qareh Papaq, Shahid Kazemi dam, Shahin Dezh and Nezam Abad were collected during the 30-year statistical periods (1989 to 2018). This study was designed to find the best-fit probability distribution of monthly rainfall in the Zarrineh river watershed at Iran using six probability distributions: Normal, 2 Parameter Log Normal, 3 Parameter Log Normal, Pearson Type 3, Log Pearson Type 3 and Gumbel distribution. The randomness of the data was tested with Run Test method and then with all kinds of statistical distributions the relevant SMADA software that is based on the Method of Moments were fitted. Finally, the best distribution by using statistical indicators root mean square error (RMSE) and the mean absolute error (MAE) was determined for all meteorological stations. The results showed that monthly rainfall data of Pole Miandoab Zarrineh River and Sariqamish stations with the 3 Parameter Log Normal distribution, Qareh Papaq and Shahid Kazemi dam stations with the Pearson Type III distribution, Shahin Dezh station with the Gumble Type I Extremal distribution and the Nezam Abad station with the 2 Parameter Log Normal distribution indicate the most fitting and compliance. Normal distribution was found to be the distribution to gives the unsuitable estimate of monthly rainfall data among six others. The results of this study by providing an optimized method to estimate rainfall and hence the sustainability of water resources of the watershed to be used by decision makers and researchers.*

Keywords: *Monthly rainfall, Zarrineh river, SMADA, RMSE, MAE.*

INTRODUCTION

The aspects of human life are somehow influenced by the processes of climate and the changes that govern it, and this effect is seen in various fields of human life such as agriculture, economics and industry, transportation, and so on. Therefore, the use of scientific and precise methods for analyzing climate and weather characteristics is essential affair, and the results obtained can be used to optimize costs and facilities. Drought is an integral part of climate change, and it can occur in any geographic region. The probability distribution function is an effective and efficient tool for a comprehensive description of all hydrological and meteorological variables. In hydrological investigations, we try to fit appropriate probabilistic functions into data that are experimentally measured and recorded and the best function that matches the data is chosen as the probability distribution function, to obtain the value of the variable for each certain probability. By fitting the appropriate statistical distribution of the rainfall variable, to a great extent its behavior can be identified. On the other hand, an appropriate distribution function can be a suitable alternative in condition the absence of statistical data. Many researchers in Iran and other countries have to analyze the rainfall data. Statistical methods and software are available for such analyzes, including the SMADA software that many researchers have used. Husak et al. (2007) used of the gamma distribution to represent monthly rainfall in Africa for drought monitoring applications. The results showed that gamma distribution is appropriate for almost 98% of the locations in all months. The techniques and results presented in this study provide a foundation for use of the gamma distribution to generate drivers for various rain related models. These models are used as decision support tools for the management of water and agricultural resources as well as food reserves by providing decision makers with ways to evaluate the likelihood of various rainfall accumulations and assess different scenarios in Africa. Mayooran and Laheetharan (2014) identified the best fit probability distribution of annual maximum rainfall in Colombo district. The results showed that Log pearson type III and Burr (4P) were found as the best fit probability model for the annual and first inter monsoon season period of study, respectively. Alghazali and Alawadi (2014) used of the three statistical distributions (Normal, Gamma and Weibull) were fitted to thirteen Iraqi stations of monthly rainfall observations: Mosul, Kirkuk, Khanaqin, Ramadi, Baghdad, Karbala, Hilla, Najaf, Diwaniya, Samawa, Nasiriyah, Amara and Basrah for the period (1970-2010) for all stations except Ramadi (1981-2010) and Hilla (1980-2010). The results showed that Gamma distribution was suitable for five stations which were Ramadi, Baghdad, Hilla, Najaf and Samawa stations while, Normal and Weibull distributions were not suitable for any station. Alam et al. (2018) determined the best-fit probability distributions in the case of maximum monthly rainfall using 30 years of data (1984–2013) from 35 locations in Bangladesh by using different statistical analysis and distribution types. The results showed that Generalized Extreme Value, Pearson type 3 and Log-Pearson type 3 distributions showed the largest number of best-fit results. Among the best score results, Generalized Extreme Value yielded the best-fit for 36% of the stations and Pearson type 3 and Log-Pearson type 3 each yielded the best-fit for 26% of the stations. Amini and Haidari (2016) evaluated of the statistical distribution fitness of rainfall prediction in the Karun Murghab watershed. In this research, annual rainfall data from "Gard" station was examined using SMADA and HYFA softwares. The results showed that Normal distribution was found to be the distribution to gives the reasonable estimate of rainfall data among six others. Khudri and Sadia (2013) determined of the best fit probability distribution for annual extreme precipitation in Bangladesh. Gamma, normal, lognormal, Pearson, generalized extreme value, Weibull and different forms of these distributions were assessed. Results exhibited that the generalized extreme value and generalized gamma (4P) distribution have occupied 50% of the total stations, while no other distribution ranked consistently best in different stations. Kalita et al. (2017) evaluated the probability distribution of rainfall and discharge of Kulsi river basin. For evaluation of observed and expected values Weibull's plotting position Gumbel, Log Pearson and Log normal probability distribution functions were fitted. The results found showed that the Log Pearson and Log Normal were the best fit probability distribution for determination of annual one-day maximum rainfall and discharge for different return periods respectively. Bhavyashree and Bhattacharyya (2018) investigated the probability distributions for rainfall analysis of Karnataka, India. Around 20 different probability distributions were used to evaluate the best fit for maximum daily rainfall (mm). The results showed that Log logistic (3P), Gen gamma (4P), Dagum (3P,4P), Gamma (2P), Pearson 5(3P), Weibull (3P), Johnson SB (4P) were found to be the best fit for different districts of the state. Bermudez et al. (2017) investigated the probability distributions of Philippine daily rainfall data.

The results showed that Gamma distribution is a suitable fit for the daily up to the ten-day cumulative rainfall data. Sukrutha et al. (2018) assessmented the probability distributions of some selected Indian cities monthly rainfall data. For evaluation of observed and expected values Normal, Lognormal, Gamma, Inverse Gaussian, GEV, Gumbel, Beta, Weibull and Fisher probability distribution functions were fitted. The results showed that for most of the cities, generalized extreme value distribution or inverse Gaussian distribution most adequately fits the observed data. Ye et al. (2018) investigated the probability distributions of daily precipitation at the point and catchment scales in the United States. The results showed that kappa distribution best describes the distribution of wet-day precipitation at the point scale, whereas the performance of two parameter gamma and Pearson Type-III distributions are comparable for wet-day precipitation at the catchment scale, with Pearson Type-III generally providing the improved goodness of fit over two parameter gamma. Al-Suhili and Khanbilvardi (2014) investigated the frequency analysis of the monthly rainfall data at Sulaimania region, Iraq. The distributions models fitted are of Normal, Log-normal, Wiebull, Exponential and Two Parameters Gamma type. The results showed that Gamma, Exponential and Weibull distributions were found as the best fits for the three stations respectively for the overall models, while for the monthly models different distribution type was found as the best fit for each month and each station, however the Gamma distributions was found to have the highest percent of best fit. The purpose of this study is to determine the most suitable statistical distribution for predicting monthly rainfall in the Zarrineh River watershed.

Materials and Methods

Introducing the study Zarrineh River watershed

The Zarrineh River is a river in Kurdistan and West Azarbaijan Provinces, Iran (Karimi et al, 2014). It is 302 km long, arising in the Zagros Mountains of Kurdistan Province south of Saqqez, where it is also known as the Jaqatoo River (Rafferty, 2011). The river continues north and slightly west past the cities of Shahin Dezh, Kashavar and Miandoab and into Lake Urmia. Although it is perennial, unlike many of the streams in the Urmia Basin, its flow is still markedly seasonal with a discharge into Lake Urmia ranging from 500 cubic metres (0.41 acre·ft) per second to only 10 cubic metres (0.0081 acre·ft) per second at the end of the dry season (Karimi et al, 2014). In this research, a part of the Zarrineh River watershed located in West Azarbaijan province (located in North West of Iran), from downstream of Bukan dam (Shahid Kazemi dam) up to Urmia lake (near to 140 km), has been investigated. Figure 1 shows the location of West Azerbaijan province (The part where the color is green) in Iran country.The white section near the West Azarbaijan province in Figure 1 shows the Lake Urmia. Figure 2 shows the position of meteorological stations that have been studied in the Zarrineh River watershed located in the West Azarbaijan province.

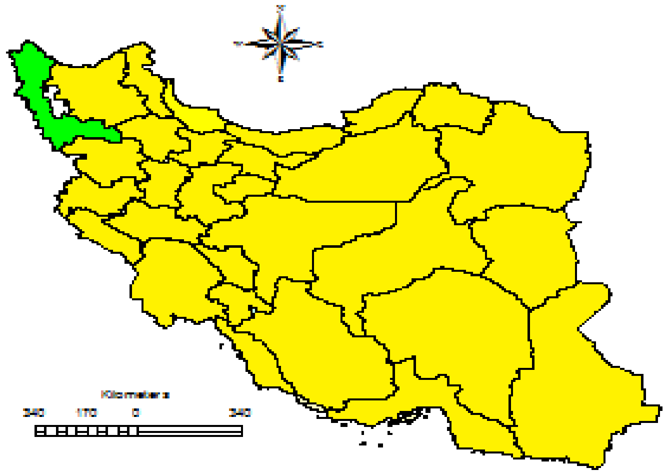

Figure 1. Location of West Azerbaijan province in Iran country

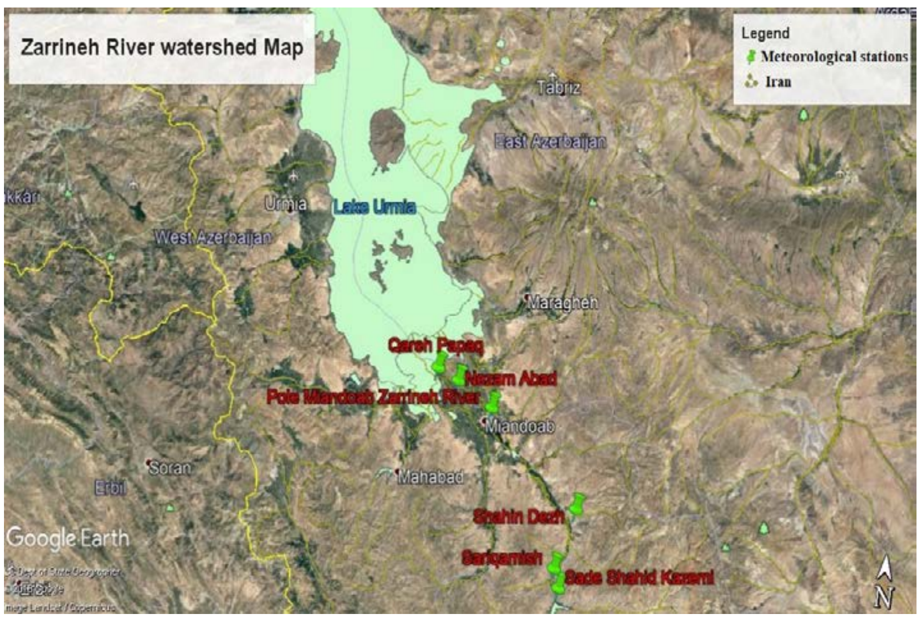

Figure 2. The position of meteorological stations in the Zarrineh River watershed

Used data

Monthly rainfall data of meteorological stations in the Zarrineh River watershed from Iran Water Resources Management Company was prepared. Considering different criteria for selecting stations, having long-term statistics and little incomplete statistics, six meteorological stations within the same period of 30 years (1989-2018) were selected. The characteristics of the selected stations in the Zarrineh River watershed are presented in Table (1). Data were analyzed by SPSS software using Run Test method and their homogeneity was investigated.

Table 1: Specifications of Meteorological stations in the Zarrineh River watershed

Station name	Longitude	Latitude	Metres above sea level	UTM_X	UTM_Y
Sariqamish	46-29-26	36-29-01	1391	633518	4038435
Pole Miandoab Zarrineh River	46-07-08	36-58-28	1295	599592	4092413

Qareh Papaq	45-50-56	37-04-44	1277	575444	4103749
Shahid Kazemi dam	46-31-14	36-25-19	1431	636319	4031624
Shahin Dezh	46-33-47	36-41-09	1373	639663	4060969
Nezam Abad	45-57-00	37-02-47	1285	584480	4100249

Introducing SMADA Software

SMADA software is a hydrology software by Dr. Ron Eaglin was designed in 1992 at the university of Florida and includes several subprograms. Each subprogram can be run independently. The ability of this software to provide flood hydrograph, hydrograph routing, flood in reservoir, sewer system design, correlation analysis, pollution modeling and climate analysis capabilities (Ahmadpari et al., 2017). The climatic analysis of this software is a distrib 2.0 statistical distribution that can be used to determine the appropriate statistical distribution, probability of the event and return period of a phenomenon. Distributions of Normal, 2 Parameter Log Normal, 3 Parameter Log Normal, Pearson Type III, Log Pearson Type III and Gumble Type I Extremal are the distributions available in this software. In this study observational data of monthly rainfall of all meteorological stations located in the Zarrineh River watershed was given to SMADA software and with distributions available in the SMADA software, monthly rainfall data for all stations was predicted and then, with the help of statistical indicators, the most appropriate distribution was determined for each month and for each station.

Statistical indicators

In this study, for the comparison of the results of different statistical distributions, the root mean square error (RMSE) and mean absolute error (MAE) were used. The RMSE value indicates how much the predictions have estimated the measurements more or less and the MAE value represents the accuracy of the method and the mean value of the error., the more these indicators are closer to zero (the difference between the predicted and measured values is lower), the better. Relationships with the statistical indicators are as follows: Equation 1 and 2.

$$\text{RMSE} = [\frac{\sum_{i=1}^{n}(\text{P}-\text{O})^2}{n}]^{1/2} \qquad (1)$$

$$\text{MAE} = \frac{\sum_{i=1}^{n}|(P-O)|}{n} \qquad (2)$$

In the above relations, p is the predicted value, o the observed value and n is the number of data.

Results and Discussion

Figures 3 to 8 rainfall intensity (millimeter per month) in different months (mean 30 years) for all stations is shown. According to Figures 3 to 8, it can be said that the minimum rainfall for all stations occurred in August. According to Figures 3 to 8, it can be said that the maximum rainfall for 4 stations (Sariqamish, Pole Miandoab Zarrineh River, Shahid Kazemi dam, Shahin Dezh) occurred in November. The maximum rainfall occurred at the Qareh Papaq Station in April. The months of May and November are the most rainfall months of the year at the Nezam Abad Station. The results of the Run Test for various months of the all stations indicate the homogeneity of all data is confirmed.

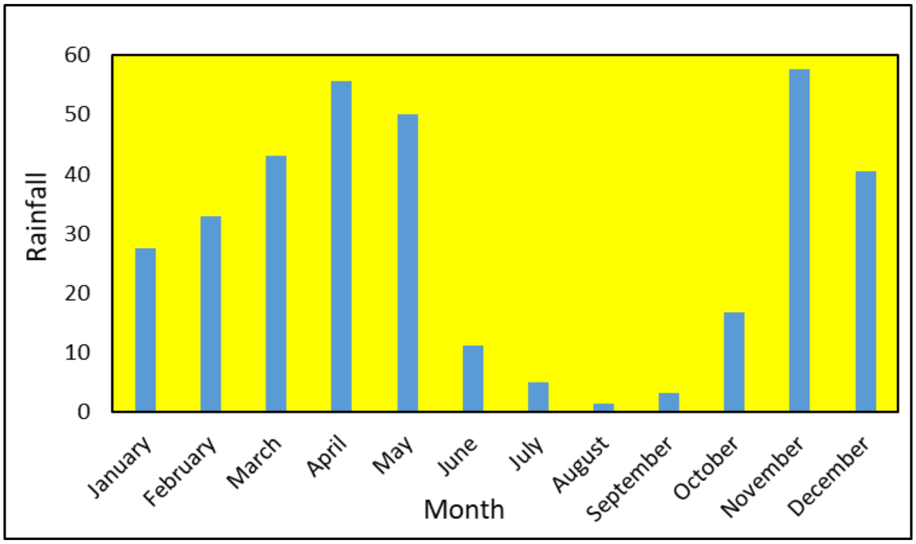

Figure 3. Monthly rainfall chart of Sariqamish station

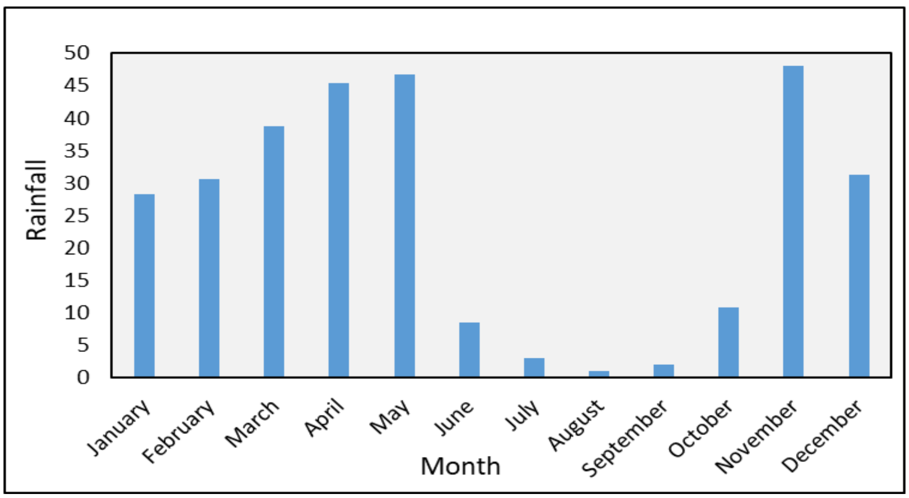

Figure 4. Monthly rainfall chart of Pole Miandoab Zarrineh River station

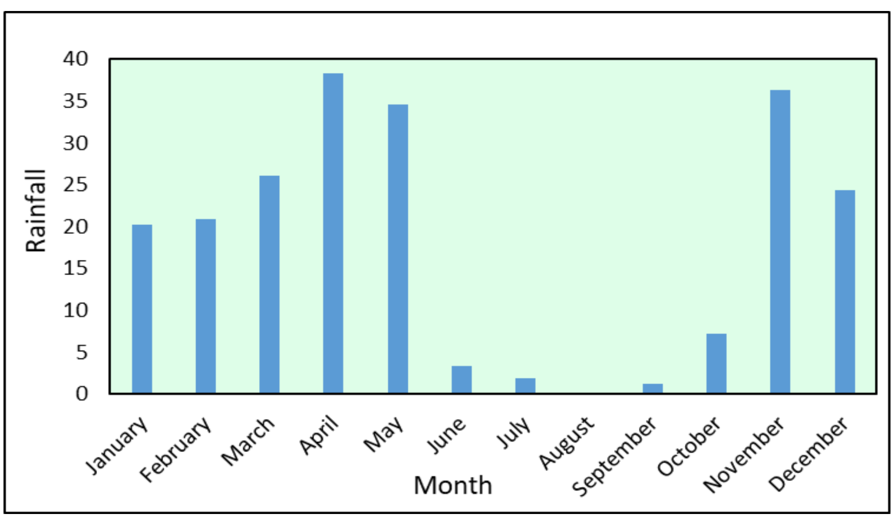

Figure 5. Monthly rainfall chart of Qareh Papaq station

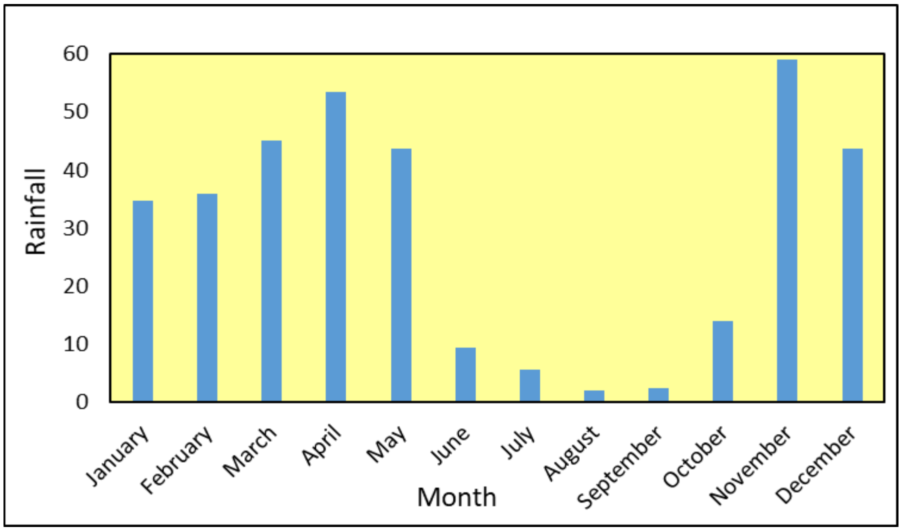

Figure 6. Monthly rainfall chart of Shahid Kazemi dam station

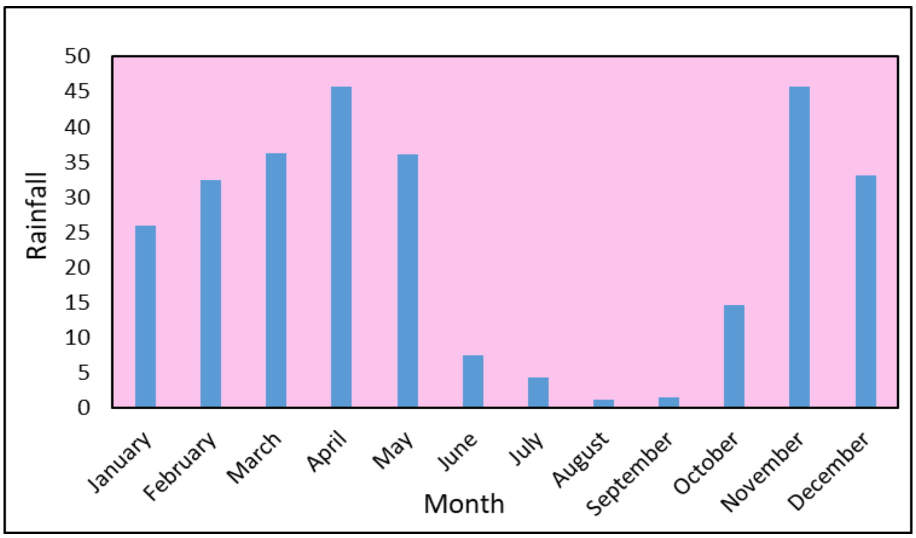

Figure 7. Monthly rainfall chart of Shahin Dezh station

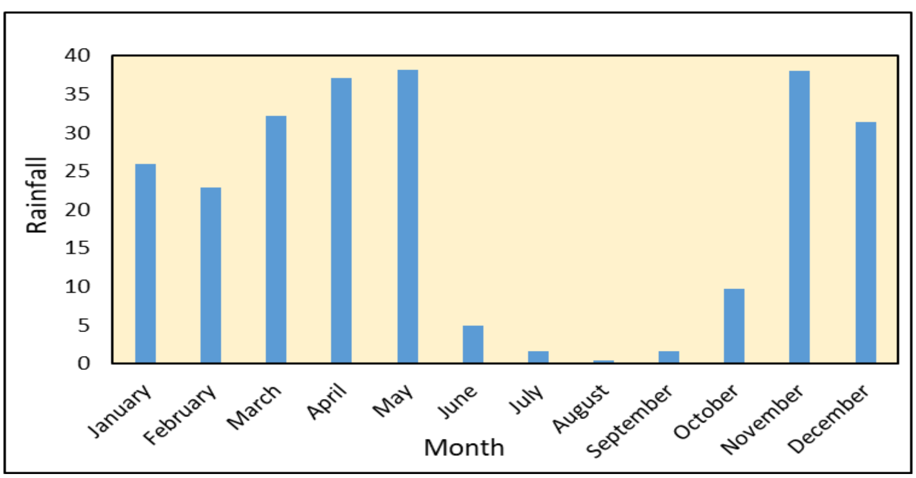

Figure 8. Monthly rainfall chart of Nezam Abad station

In tables 2 to 7, the values of statistical indicators RMSE and MAE for the different distributions are presented at the six meteorological stations studied. Tables 2 to 7 show that the Normal distribution is the most inappropriate statistical distribution for predicting monthly rainfall in the Zarrineh River watershed. This result is consistent with the results of Alghazali and Alawadi (2014). Bagherzadeh Somarin et al (2016) investigated the frequency analysis of maximum daily rainfall in Nouran Chay basin in the Ardabil Province. Generally, due to the survey of the maximum rainfall data, Normal distribution function, in terms of the Goodness of fit tests, indicated the lowest adaptation to predict the maximum daily rainfall for different return periods. Also, the results of this study do not match the results of Amini and Haidari (2016). Tables 2 and 3 show that in the stations Pole Miandoab Zarrineh River and Sariqamish, the 3 Parameter Log Normal distribution is the most appropriate distribution for all months of the year in the statistical period studied. This result is consistent with the results of some researchers. For example, Ahmadpour et al (2017) investigated of the frequency analysis of maximum daily rainfall in various climates of Iran the data of 40 synoptic rain gauges collected in 40 years period i.e., 1973 to 2012 were used. The results showed that the suitable distribution for 29 stations is three-parameter lognormal, for five stations is two-parameter gamma, for two stations is two-parameter lognormal, for four stations is extreme value type I or Gumbel. Tables 4 and 5 show that in the stations Qareh Papaq and Shahid Kazemi dam, the Pearson Type III distribution is the most appropriate distribution for all months of the year in the statistical period studied. This result is consistent with the results of some researchers. For example, the Hamidi Machekposhti and Sedghi (2019) investigated of the best fit probability distribution for annual rainfall in Karkheh River at Iran. The results showed that the Log Pearson Type 3 and then Pearson Type 3 distributions were found to be the best-fit probability distribution at the Jelogir Majin and Pole Zal rainfall gauging station. Table 6 show that in the Shahin Dezh station, the Gumble Type I Extremal distribution is the most appropriate distribution for all months of the year in the statistical period studied. This result is consistent with the results of some researchers. For example, Maryanaji and Abbasi (2017) investigated of the best fit probability distribution for daily precipitation in Hamedan province at Iran. The results showed that the Gumble Type I Extremal distribution is a suitable fit for daily rainfall data in Hamedan province. Table 7 show that in the Nezam Abad station, the 2 Parameter Log Normal distribution is the most appropriate distribution for all months of the year in the statistical period studied. This result is consistent with the results of some researchers. For example, Sharma and Singh (2010) analysed of the rainfall data to identify the best fit probability distribution for 37 years in the Pantnagar, India. The lognormal and gamma distribution were found as the best fit probability distribution for the annual and monsoon season period of study, respectively.

Table 2. Results of statistical indicators according to millimeters for different distributions in the Sariqamish station

Distributions	Normal		2 Parameter Log Normal		3 Parameter Log Normal		Pearson Type III		Log Pearson Type III		Gumble Type I Extremal	
Indicators / Month	RMSE	MAE	RMSE	MAE	RMSE	MAE	RMSE	MAE	RMSE	MAE	RMSE	MAE
January	0.772	0.662	0.565	0.470	0.225	0.210	0.275	0.233	0.601	0.532	0.333	0.264
February	0.718	0.810	0.345	0.404	0.248	0.267	0.288	0.363	0.518	0.564	0.558	0.592
March	0.669	0.750	0.471	0.542	0.239	0.259	0.542	0.577	0.404	0.458	0.247	0.348
April	0.346	0.412	0.277	0.289	0.252	0.266	0.273	0.285	0.256	0.271	0.261	0.277
May	0.476	0.542	0.407	0.419	0.323	0.368	0.382	0.396	0.366	0.411	0.401	0.417
June	0.862	0.752	0.655	0.56	0.315	0.3	0.365	0.323	0.691	0.622	0.423	0.354
July	0.898	0.99	0.525	0.584	0.428	0.447	0.468	0.543	0.698	0.744	0.738	0.772

August	0.809	0.89	0.611	0.682	0.379	0.399	0.682	0.717	0.544	0.598	0.387	0.488
September	0.536	0.602	0.467	0.479	0.442	0.456	0.463	0.475	0.446	0.461	0.451	0.467
October	0.596	0.662	0.527	0.539	0.443	0.488	0.502	0.516	0.486	0.531	0.521	0.537
November	0.832	0.722	0.625	0.53	0.285	0.27	0.335	0.293	0.661	0.592	0.393	0.324
December	0.726	0.792	0.657	0.669	0.573	0.618	0.632	0.646	0.616	0.661	0.651	0.667

Table 3. Results of statistical indicators according to millimeters for different distributions in the Pole Miandoab Zarrineh River station

Distributions	Normal		2 Parameter Log Normal		3 Parameter Log Normal		Pearson Type III		Log Pearson Type III		Gumble Type I Extremal	
Indicators / Month	RMSE	MAE	RMSE	MAE	RMSE	MAE	RMSE	MAE	RMSE	MAE	RMSE	MAE
January	0.932	0.822	0.725	0.63	0.385	0.37	0.435	0.393	0.761	0.692	0.493	0.424
February	0.638	0.73	0.265	0.324	0.168	0.187	0.208	0.283	0.438	0.484	0.478	0.512
March	0.779	0.86	0.581	0.652	0.349	0.369	0.652	0.687	0.514	0.568	0.357	0.458
April	0.479	0.442	0.456	0.463	0.475	0.446	0.461	0.451	0.467	0.669	0.632	0.646
May	0.736	0.802	0.667	0.679	0.583	0.628	0.642	0.656	0.626	0.671	0.661	0.677
June	0.742	0.632	0.535	0.44	0.195	0.18	0.245	0.203	0.571	0.502	0.303	0.234
July	0.748	0.84	0.375	0.434	0.278	0.297	0.318	0.393	0.548	0.594	0.588	0.622
August	0.639	0.72	0.441	0.512	0.209	0.229	0.512	0.547	0.374	0.428	0.217	0.318
September	0.626	0.692	0.557	0.569	0.532	0.546	0.553	0.565	0.536	0.551	0.541	0.557
October	0.656	0.722	0.587	0.599	0.503	0.548	0.562	0.576	0.546	0.591	0.581	0.597
November	0.702	0.592	0.495	0.4	0.155	0.14	0.205	0.163	0.531	0.462	0.263	0.194
December	0.646	0.712	0.577	0.589	0.493	0.538	0.552	0.566	0.536	0.581	0.571	0.587

Table 4. Results of statistical indicators according to millimeters for different distributions in the Qareh Papaq station

Distributions	Normal		2 Parameter Log Normal		3 Parameter Log Normal		Pearson Type III		Log Pearson Type III		Gumble Type I Extremal	
Indicators / Month	RMSE	MAE	RMSE	MAE	RMSE	MAE	RMSE	MAE	RMSE	MAE	RMSE	MAE
January	0.662	0.552	0.455	0.36	0.165	0.123	0.115	0.1	0.491	0.422	0.223	0.154
February	0.638	0.73	0.265	0.324	0.208	0.283	0.168	0.187	0.438	0.484	0.478	0.512
March	0.629	0.71	0.431	0.502	0.502	0.537	0.199	0.219	0.364	0.418	0.207	0.308
April	0.454	0.52	0.385	0.397	0.381	0.393	0.36	0.374	0.364	0.379	0.369	0.385
May	0.566	0.632	0.497	0.509	0.472	0.486	0.413	0.458	0.456	0.501	0.491	0.507
June	0.732	0.622	0.525	0.43	0.235	0.193	0.185	0.17	0.561	0.492	0.293	0.224
July	0.705	0.595	0.498	0.403	0.208	0.166	0.158	0.143	0.534	0.465	0.266	0.197
August	0.633	0.714	0.435	0.506	0.506	0.541	0.203	0.223	0.368	0.422	0.211	0.312
September	0.603	0.669	0.534	0.546	0.53	0.542	0.509	0.523	0.513	0.528	0.518	0.534

October	0.679	0.745	0.61	0.622	0.585	0.599	0.526	0.571	0.569	0.614	0.604	0.62
November	0.664	0.554	0.457	0.362	0.167	0.125	0.117	0.102	0.493	0.424	0.225	0.156
December	0.662	0.728	0.593	0.605	0.568	0.582	0.509	0.554	0.552	0.597	0.587	0.603

Table 5. Results of statistical indicators according to millimeters for different distributions in the Shahid Kazemi dam station

Distributions	Normal		2 Parameter Log Normal		3 Parameter Log Normal		Pearson Type III		Log Pearson Type III		Gumble Type I Extremal	
Indicators / Month	RMSE	MAE	RMSE	MAE	RMSE	MAE	RMSE	MAE	RMSE	MAE	RMSE	MAE
January	0.592	0.482	0.385	0.29	0.095	0.053	0.045	0.03	0.421	0.352	0.153	0.084
February	0.543	0.635	0.17	0.229	0.113	0.188	0.073	0.092	0.343	0.389	0.383	0.417
March	0.531	0.612	0.333	0.404	0.404	0.439	0.101	0.121	0.266	0.32	0.109	0.21
April	0.424	0.436	0.42	0.432	0.399	0.413	0.403	0.418	0.408	0.424	0.571	0.583
May	0.526	0.592	0.457	0.469	0.432	0.446	0.373	0.418	0.416	0.461	0.451	0.467
June	0.667	0.557	0.46	0.365	0.17	0.128	0.12	0.105	0.496	0.427	0.228	0.159
July	0.648	0.74	0.275	0.334	0.218	0.293	0.178	0.197	0.448	0.494	0.488	0.522
August	0.596	0.677	0.398	0.469	0.469	0.504	0.166	0.186	0.331	0.385	0.174	0.275
September	0.692	0.557	0.569	0.553	0.565	0.532	0.546	0.536	0.551	0.541	0.557	0.782
October	0.666	0.732	0.597	0.609	0.572	0.586	0.513	0.558	0.556	0.601	0.591	0.607
November	0.594	0.484	0.387	0.292	0.097	0.055	0.047	0.032	0.423	0.354	0.155	0.086
December	0.577	0.643	0.508	0.52	0.483	0.497	0.424	0.469	0.467	0.512	0.502	0.518

Table 6. Results of statistical indicators according to millimeters for different distributions in the Shahin Dezh station

Distributions	Normal		2 Parameter Log Normal		3 Parameter Log Normal		Pearson Type III		Log Pearson Type III		Gumble Type I Extremal	
Indicators / Month	RMSE	MAE	RMSE	MAE	RMSE	MAE	RMSE	MAE	RMSE	MAE	RMSE	MAE
January	0.61	0.5	0.403	0.308	0.113	0.071	0.439	0.37	0.171	0.102	0.063	0.048
February	0.592	0.684	0.219	0.278	0.162	0.237	0.392	0.438	0.432	0.466	0.122	0.141
March	0.558	0.639	0.36	0.431	0.431	0.466	0.293	0.347	0.136	0.237	0.128	0.148
April	0.516	0.582	0.447	0.459	0.443	0.455	0.426	0.441	0.431	0.447	0.422	0.436
May	0.665	0.731	0.596	0.608	0.571	0.585	0.555	0.6	0.59	0.606	0.512	0.557
June	0.699	0.589	0.492	0.397	0.202	0.16	0.528	0.459	0.26	0.191	0.152	0.137
July	0.69	0.782	0.317	0.376	0.26	0.335	0.49	0.536	0.53	0.564	0.22	0.239
August	0.628	0.709	0.43	0.501	0.501	0.536	0.363	0.417	0.206	0.307	0.198	0.218
September	0.427	0.493	0.358	0.37	0.354	0.366	0.337	0.352	0.342	0.358	0.333	0.347
October	0.45	0.516	0.381	0.393	0.356	0.37	0.34	0.385	0.375	0.391	0.297	0.342
November	0.663	0.553	0.456	0.361	0.166	0.124	0.492	0.423	0.224	0.155	0.116	0.101

December	0.593	0.659	0.524	0.536	0.499	0.513	0.483	0.528	0.518	0.534	0.44	0.485

Table 7. Results of statistical indicators according to millimeters for different distributions in the Nezam Abad station

Distributions	Normal		2 Parameter Log Normal		3 Parameter Log Normal		Pearson Type III		Log Pearson Type III		Gumble Type I Extremal	
Indicators / Month	RMSE	MAE	RMSE	MAE	RMSE	MAE	RMSE	MAE	RMSE	MAE	RMSE	MAE
January	0.628	0.518	0.081	0.066	0.131	0.089	0.457	0.388	0.189	0.12	0.421	0.326
February	0.559	0.651	0.089	0.108	0.129	0.204	0.359	0.405	0.399	0.433	0.186	0.245
March	0.537	0.618	0.107	0.127	0.41	0.445	0.272	0.326	0.115	0.216	0.339	0.41
April	0.507	0.573	0.413	0.427	0.434	0.446	0.417	0.432	0.422	0.438	0.438	0.45
May	0.416	0.482	0.263	0.308	0.322	0.336	0.306	0.351	0.341	0.357	0.347	0.359
June	0.664	0.554	0.117	0.102	0.167	0.125	0.493	0.424	0.225	0.156	0.457	0.362
July	0.709	0.801	0.239	0.258	0.279	0.354	0.509	0.555	0.549	0.583	0.336	0.395
August	0.622	0.703	0.192	0.212	0.495	0.53	0.357	0.411	0.2	0.301	0.424	0.495
September	0.59	0.656	0.496	0.51	0.517	0.529	0.5	0.515	0.505	0.521	0.521	0.533
October	0.724	0.79	0.571	0.616	0.63	0.644	0.614	0.659	0.649	0.665	0.655	0.667
November	0.653	0.543	0.106	0.091	0.156	0.114	0.482	0.413	0.214	0.145	0.446	0.351
December	0.578	0.644	0.425	0.47	0.484	0.498	0.468	0.513	0.503	0.519	0.509	0.521

Conclusion

Any planning and design in watersheds should be based on the analysis of hydrology and meteorological data related to that watershed. The results obtained from the selection of the most appropriate fitted distribution on monthly rainfall data in the Zarrineh River watershed show that rainfall phenomenon in this watershed do not follow a single distribution, and different stations in the watershed are a function of different statistical distributions. It can also be said that in the Zarrineh River watershed there is a rainfall variation within a year, but this has not caused a variety of statistical distributions within a year. From the results of this research, it can be said that the spatial scale plays an important role in determining the type of probable distribution of rainfall data and provides the arena for obtaining the appropriate information bases for designing and managing water resources in different parts of the Zarrineh River watershed. Therefore, due to the variation of climatic conditions in the Zarrineh River watershed, it is not possible to use a statistical distribution to analyze rainfall, prediction and drought evaluation, and it will add to the necessity of applying indicators based on the appropriate statistical distribution for each station. Because only then will the assessment and monitoring of a phenomenon such as drought lead to precise and practical results. According to various indicators of climate for drought monitoring or rainfall prediction, it is better to predict rainfall with a point of view and to determine the percentage and amount of droughts for watershed analysis of the geostatistical methods.

References

1. Ahmadpari, H., Hashemi Garmdareh, SE., & Shokuhi, A. (2017). Determining the most suitable statistical distribution for predicting annual average discharge with different return periods (case study: 6 hydrometric stations in Gilan province). Journal of Rainwater Catchment Systems, 5(1), 61-69.

2. Ahmadpour, A., Fathian, H., Haghighatjoo, P. (2017). Frequency Analysis of Maximum Daily Rainfall in various Climates of Iran. Journal of Water Science & Engineering, 7(16), 49-60.
3. Alam, M., Emura, K., Farnham, C., & Yuan, J. (2018). Best-fit probability distributions and return periods for maximum monthly rainfall in Bangladesh. Climate, 6(1), 1-16.
4. Alghazali, N. O., & Alawadi, D. A. (2014). Fitting statistical distributions of monthly rainfall for some Iraqi stations. Civil and Environmental Research, 6(6), 40-46.
5. Al-Suhili, R. H., & Khanbilvardi, R. (2014). Frequency analysis of the monthly rainfall data at Sulaimania Region, Iraq. American Journal of Engineering Research, 3(5), 212-222.
6. Amini, A., & Haidari, F. (2016). Evaluation of the statistical distribution fitness of rainfall prediction in the Karun Murghab Watershed. The 2nd international conference and the 5th national conference on urban development based on new technologies, Islamic Azad University Sanandaj Branch, Iran.
7. Bagherzadeh Somarin, B., Zeynali, B., & Fazeli, A. (2016). Frequency analysis of Maximum daily rainfall in Nouran Chay basin in the Ardabil Province, The 1st International Conference of Iranian Natural Hazards and Environmental Crises, Strategies and Challenges, Ardabil, Iran.
8. Bermudez, V. A. B., Abilgos, A. B. B., Cuaresma, D. C. N., & Rabajante, J. F. (2017). Probability distribution of Philippine daily rainfall data. Preprints (www.preprints.org), 1-15.
9. Bhavyashree, S., & Bhattacharyya, B. (2018). Fitting probability distributions for rainfall analysis of Karnataka, India. International Journal of Current Microbiology and Applied Sciences, 7(3), 1498-1506.
10. Hamidi Machekposhti, K., & Sedghi, H. (2019). Determination of the Best Fit Probability Distribution for Annual Rainfall in Karkheh River at Iran, World Academy of Science, Engineering and Technology International Journal of Environmental and Ecological Engineering, 13(2), 1-7.
11. Husak, G. J., Michaelsen, J., & Funk, C. (2007). Use of the gamma distribution to represent monthly rainfall in Africa for drought monitoring applications. International journal of Climatology, 27(7), 935-944.
12. Kalita, A., Bormudoi, A., & Saikia, M.D. (2017). Probability distribution of rainfall and discharge of Kulsi river basin. International Journal of Engineering and Advanced Technology(TM), 6(4), 31-37.
13. Karimi, S., Yasi, M., Cox, J. P., & Eslamian, S. (2014). Environmental flows. Handbook of Engineering Hydrology: Environmental Hydrology and Water Management, 85.
14. Khudri, M. M., & Sadia, F. (2013). Determination of the best fit probability distribution for annual extreme precipitation in Bangladesh. European Journal of Scientific Research, 103(3), 391-404.
15. Maryanaji, Z., Abbasi, H. (2017). Zoning of the Occurrence Probability of maximum daily precipitation in Hamedan Province. Scientific- Research Quarterly of Geographical Data (SEPEHR), 25(100), 89-96.
16. Mayooran, T., & Laheetharan, A. (2014). The statistical distribution of annual maximum rainfall in Colombo district. Sri Lankan Journal of Applied Statistics, 15(2), 1765-1784.
17. Rafferty, J.P. (2011). "Appendix A: Notable Smaller Lakes of the World: Lake Urmia". Lakes and Wetlands, New York: Britannica Educational Publishing, 204–205.
18. Sharma, M. A., & Singh, J. B. (2010). Use of probability distribution in rainfall analysis. New York Science Journal, 3(9), 40-49.
19. Sukrutha, A., Dyuthi, S. R., & Desai, S. (2018). Multimodel response assessment for monthly rainfall distribution in some selected Indian cities using best-fit probability as a tool. Applied water science, 8(145), 1-10.
20. Ye, L., Hanson, L. S., Ding, P., Wang, D., & Vogel, R. M. (2018). The probability distribution of daily precipitation at the point and catchment scales in the United States. Hydrology and Earth System Sciences, 22(12), 6519-6531.