International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-7 Issue-5, February 2018

Flood Frequency Analysis for Greater-Zab River

Salah AL- Dubai

Abstract— In this study, Flood Frequency Analysis at Greater-Zab was carried out using different distribution models such as Log-Normal type 3(LN3), Log-Pearson type 3(LP3) and Generalize Extreme value(GEV). The annual peak flow series of Zab River was used for this purpose. Using Kolmogorov and Anderson Darling tests, the fitness of the models was evaluated. Log-Normal Type 3 was found as the best model for estimation of floods (magnitude and return period for Greater-Zab River.

Index Terms— **Frequency Data Analysis, Greater-Zab, Annual flood series, Anderson Darling Test.**

I.INTRODUCTION

Flow prediction and observation are important issues in hydrological analysis, water resources management, reservoir operation, hydropower projects, water supply, etc (Al-Juboori, A.M., Guven, A., (2016)). In statistic, frequency is the number of times an event occurs. Frequency analysis is also an important area of hydrological studies that deals with the number of occurrences (frequency) and analysis measures of central tendency, dispersion and percentile. Frequency analysis usually deal with three types of measurement-measure of central tendency (mean, median and mode), measure of dispersion (standard deviation, variance and range) and a measure of percentile (quartiles, deciles and percentiles). Single random variable is dealt with frequency modeling as they are statistical method of modeling and known as univariate method. Hydrological data is analyzed by univariate frequency analysis, also this analysis can be used for peak discharge series, characteristics of rainfall (Danandeh Mehr, A. and Kahya, E. (2017)) and records of low flows (Danandeh Mehr, A. and Demirel, M.C. (2016)). The objective of univariate prediction is estimation of magnitudes or probabilities of randomized variables. Common assumptions of analytical frequencies is that the independent data is represented by hydrological data and extremes.i.e. uncorrelated data with adjacent observation. Another assumption is identical distribution of data, meaning that the same population gives all data as well as having the same statistical properties.

II.STUDY AREA AND DATA

The Great-Zab is a river with 400 km length. It goes through Turkey and Iraq; its level rises near Van lake to join Tigris in Iraq. This river's basin covers about 40300 km2, along the river journey it is provided by many tributaries, all streams depend on rainfall and snow melting. Due to that rivers level variates rapidly through the year. Fill length of the river divides into two parts, the bigger one is located within the Iraqi land with length of 300 km, the rive has an average discharge of 413 m3/s with maximum discharge recorded as 1320 m3/s while the second part will not be discussed. A series of flood discharges of Greater – Zab River were set up for a period of (74) years (1931 – 2004) as shown in the observation data.

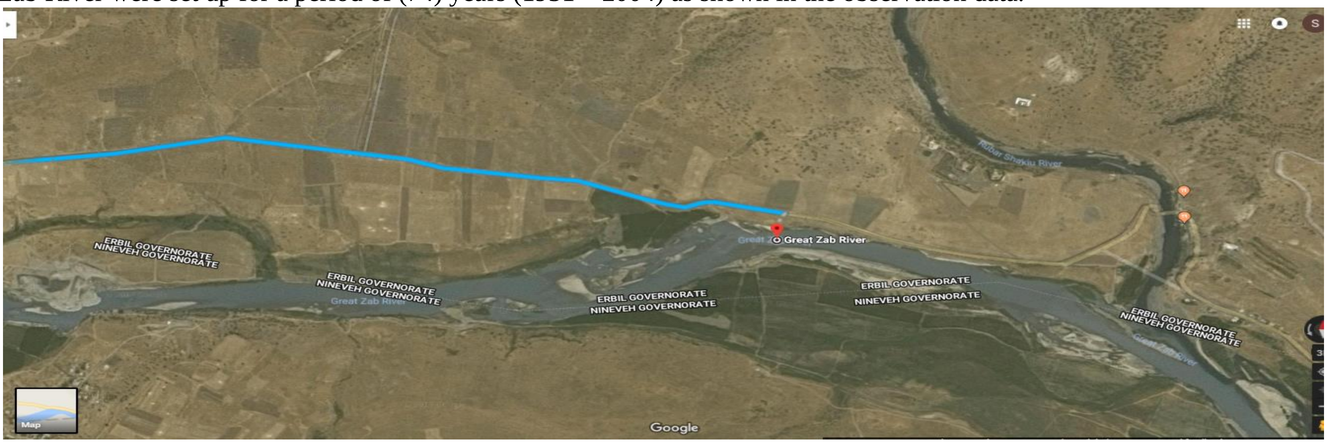
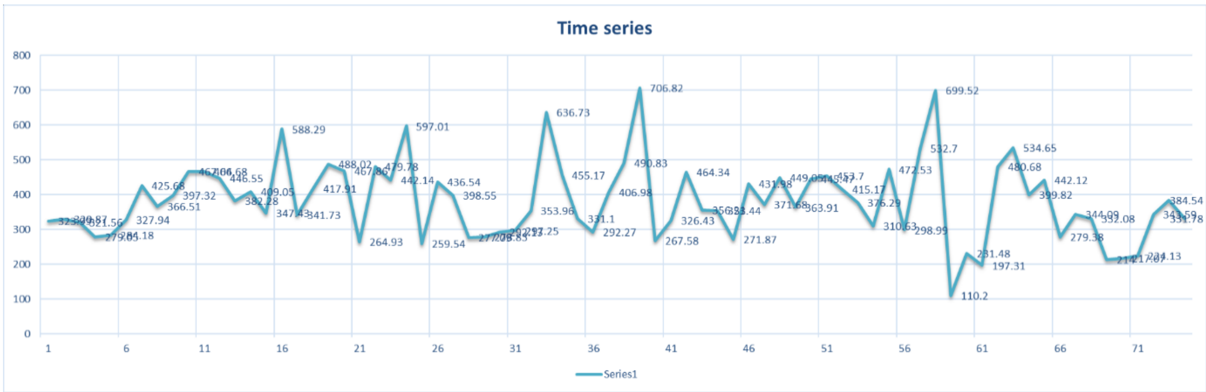


Figure 1 Great-Zab River

Manuscript published on 28 February 2018.
***Correspondence Author(s)**
Salah AL- Dubai, Near East University, Faculty of engineering, Near East Boulevard, 99138, Nicosia, North Cyprus (e-mail: saniisaabba86@gmail.com).



Graph 1 Maximum and minimum yearly stream

III.METHODOLOGY

A. *Frequency Analysis and Synthesis*

The most used procedure for the analysis of floods data in gagged area. Data of many types accepts this procedure since it is a general procedure, it is so popular and widely used. It is also used with flood data, and is known as flood frequency analysis. There are two basic groups of methods to estimate the maximum discharge rate, one of them is used on field when flow observations are available while the other is used when not. (McCuen, 1941).

B. *Return Period*

The return period also called the recurrence interval T_X is the period expressed in number of years in which the annual observation is expected to return. Consider a random variable *X*, with the outcome having a return period *T* given by x_T. Let p be the probability that $X \geq x_T$ in any observation, or $p = P(X \geq x_T)$ (McCuen,1941).

$$T = \frac{1}{p} \quad (1)$$

$$T = \frac{1}{P(X \geq x_T)} \quad (2)$$

This can also be written as

$$P(X \geq x_T) = \frac{1}{T} \quad (3)$$

IV.STATISTICAL DISTRIBUTIONS

A. *Distribution of Extreme Values*

Distribution of flood frequency analysis was proposed by Gumble, therefore Gumble's method is used when working on distribution analysis. The daily flow of 365 days was recorded and all values during that period were considered as extreme values, the values all together defined a flood. The largest annual value of recorded years will lead to an approach of a clearly stated modality of frequency distribution which can be summarized as theory of extreme values. Type 1 extremal distribution is modeled by a series of annual maximum flood (Todorovic & Rousselle, 1971).

B. *Log-Normal type 3 distribution:*

Reduced variable (x-y) logarithm of normal distribution is presented by three-parameters, where the lower boundary is indicated by a probability density distribution as shown below (Sangal & Asit, 1970) (Sangal & Asit,1970):

$$f(x) = \frac{\exp\left(-\frac{1}{2}\left(\frac{\ln(x-\gamma)-\mu}{\sigma}\right)\right)}{(x-\gamma)\sigma\sqrt{2\pi}} \quad (4)$$

Where

Ɣ, μ and σ are the three parameters

C. *log-Pearson type 3*

Log-Pearson type 3 is the mostly used for hydrological distribution in USA, it is a PDF, and it is normally accepted because of its usage flexibility in case of method of moment parameters estimates and usually give a good fitting for measured data, this type of analysis `and LP3 is a PDF, the fitting process for an LP3 curve with observed systematic data is the same with the normal and lognormal analysis (McCuen, 1941).

D. *Generalized extreme value distribution*

An extreme of natural phenomena is commonly modeled by Generalized-Extreme values distribution, where hydrologists consider it of great importance. The probability density distribution will be given as shown below (Hosking, Wallis& Wallis, 1985):

$$f(x) = \begin{cases} \frac{1}{\sigma}\exp(-(1+kz)^{-1/k})\,(1+\mathrm{kz})^{-1-\frac{1}{k}} & k \neq 0 \\ \frac{1}{\sigma}\exp(-z-exp(-z)) & k = 0 \end{cases} \quad (5)$$

Where,

k, σ, μ: parameters of General extreme values which represents shape, scale and location respectively.

V. TEST METHODS

A. *Kolmogorov – Smirnov test*

Kolmogorov – Smirnov test is different from the chi square test in that no parameters from the theoretical probability distributions need to be estimated from the observed data.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

Kolmogorov test is non-parametric test; it's Generally more efficient than chi – square test when the sample size is small.

In spite of this cautionary note, both the chi- square and Kolmogorov square tests are widely used in engineering applications (McCuen, 1993).
The Kolmogorov-Smirnov statistic (D) is based on the largest vertical difference between the theoretical and the empirical cumulative distribution Function.

$$D = max_{1\leq i\leq n}(F(x_i) - \frac{i-1}{n}, \frac{i}{n} - F(x_i)) \qquad (6)$$

B. Anderson darling test

Samples of data retrieved from a population having a certain distribution can be best tested by Anderson-darling test method. Critical values are calculated by Anderson-darling test which uses specific distribution method, where an advantage of allowing more sensitive test will be achieved but the disadvantage on the other hand is critical values are calculated for each distribution. Statics (A2) of Anderson-Darling can be defined as shown below (McCuen, 1993).

$$A^2 = n - \frac{1}{n}\sum_{i=1}^{n}(2i-1)\cdot[\ln F(X_i) + \ln(1 - F(X_{n-i+1}))] \quad (7)$$

VI.RESULTS AND DISCUSSIONS

Various distribution models are available within easy fit software, but only three types where chosen which are, Log-Normal 3, log-Pearson 3 and Generalized-Extreme value distribution, to compare between them and determining the must fit distribution, comparison related to discharge, probability, non-exceedance and the return period. Four samples of discharge were selected randomly and then it's probability and non-exceedance were found according to the three models. The result shows that there is significant difference between Generalized-Extreme value and Log-Normal, with a smooth different in result according to Log-Pearson 3 as shown in table 2 below:

Table 1probability of exceedance and non-exceedance

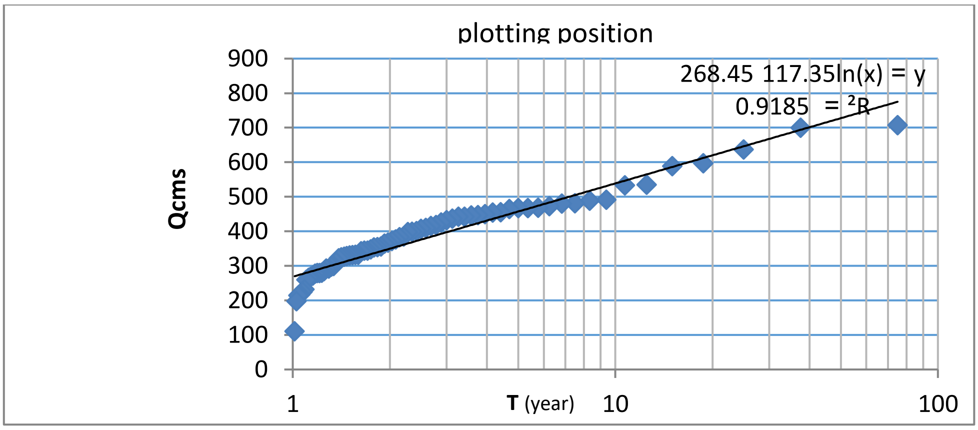
	LN 3		LP3		GEV	
Q (m^3/s)	P%	F%	P%	F%	P%	F%
636.73	1.959	98.041	1.008	98.992	2.177	97.023
453.7	24.397	75.603	25.959	74.041	24.216	75.784
409.05	37.737	62.263	39.807	60.193	37.062	62.938
347.43	54.954	40.046	61.175	38.825	59.085	40.915

Generalized-Extreme, Log- Pearson type 3 and Log – Normal type 3 were the three statistical models value distributions had been used for estimating flood magnitude for multiple return periods.

Table 2 Retain period and corresponding discharge

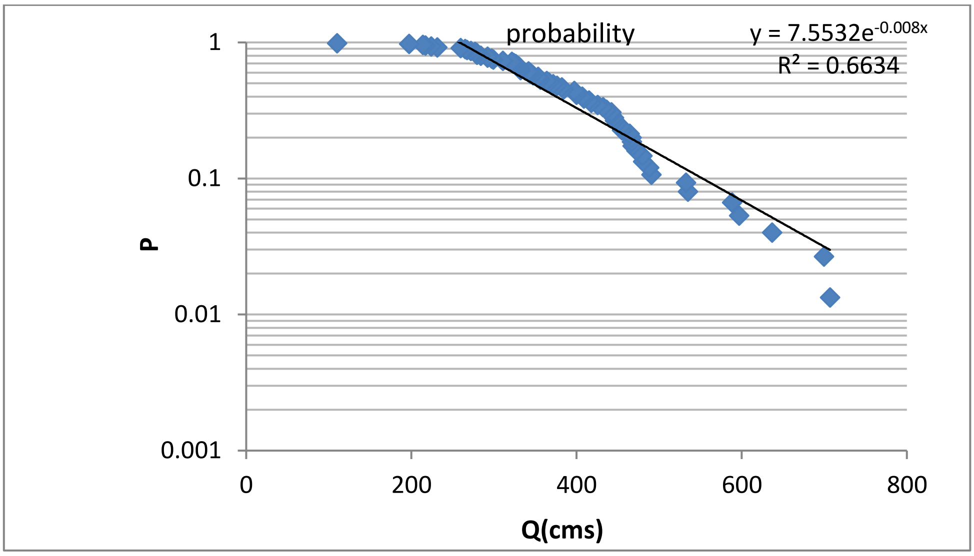
T	lognormal	log-person3	gen.extreme value
Year	Q m3/s	Q m3/s	Q m3/s
100	676.6	636	682.56
150	743.52	676.19	702.05
200	715.71	660.64	719.63
250	727.95	667.61	730.88

by comparing results between distribution models, it was found that in "log-normal 3" the value at 250 years which equals to 727.59 m^3/s is close to the value in "Generalized Extreme value" which equals to 730.88 m^3/s, on the other hand value in "log-Pearson 3" at 250 years equals to 667.61m^3/s
Logarithmic graph plotting method was used for the river discharge (m3/s), where return periods are plotted on the x-axis and discharge is plotted on the y-axis. The major importance of that is getting a straight line for the flood frequency result. The first graph gives the discharge at any return period and at the second graph we get the probability at any discharge.



Graph 2Discharge and retain period

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)



Graph 3 Probability and Discharge

A. Goodness of Fit

The software presents three goodness of fit tests, but two were used in this paper to select the must fit distribution for greater Zab river. Kolmogorov and Anderson darling tests gives accurate result were the distributions can be accepted or rejected according to the models used. In this paper the three statistical models were accepted. The Log-Normal type 3 could be regarded as the according to the values found as shown below:

Table 3 Goodness of fit test

Model type	Kolmogorov	Anderson darling	result
Log-normal 3	0.06531	0.29373	Accept
Generalized-Extreme value	0.06701	0.29307	Accept
Log-Pearson 3	0.07164	0.53281	Accept

VII.CONCLUSION

The research was conducted to determine the flood frequency analysis for a discharge data (1931-2004) for Greater-Zab river using 3 distribution function. The results indicated that LN 3, GEV, LP3 were found to perform the FFA sufficiency, but based on the goodness of fit methods applied, LN-3 was the best distribution model for the Greater-Zab river.

REFERENCES

1. McCuen, Richard H. (1941) Modeling Hydrologic Change, Statistical Method. Department of Civil Engineering University of Maryland, Lewis Publisher CRC Press LLC. (book 1)
2. McCuen, Richard H. (1993). Microcomputer Applications in Statistical Hydrology.Department of Civil Engineering University of Maryland, (PTR: Englewood Cliffs, New Jersey 07632)
3. Stephen,J, B., Dennis, P,L.,Courtney,L,B. (1975).Properties of the Three-Parameter Log Normal Probability Distribution. Departmentof Civil Engineering,Universityof Washington. Water Resources Res, Vol 11(2).
4. Sangal, B., P. and Asit, K., B. (1970). The3 -Parameter Lognormal Distribution and itsApplication in Hydrology. Inland Waters Branch and Policy and Planning Branch Department of Energy, Mines and Resources. Water Resources Res, Vol 6(2).
5. Todorovic, P., Rousselle, J. (1971). Some Problems of Flood Analysis.EngineeringResearchCenter, ColoradoState University. Water Resources Res, Vol 7(5).
6. J. R. M. Hosking, J. R. Wallis and E. F. Wood (1985). Estimation of the Generalizederalized Extreme- Value Distribution by the Method of Probability-Weighted Moments. Technometrics, VOL. 27, NO. 3
7. Danandeh Mehr, A. and Kahya, E. (2017). Climate change impacts on catchment-scale extreme rainfall variability: Case Study of Rize Province, Turkey. Journal of Hydrologic Engineering, 22(3), 05016037, 10.1061/(ASCE)HE.1943-5584.0001477.
8. Danandeh Mehr, A. and Demirel, M.C. (2016). On the calibration of multi-gene genetic programming to simulate low flows in the Moselle River. Uludağ University Journal of the Faculty of Engineering 21 (2), 365-376.
9. Al-Juboori, A.M., Guven, A., (2016). A stepwise model to predict monthly streamflow. J. Hydrol. 543, 283–292

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)