Journal of Sedimentary Environments
Published by Universidade do Estado do Rio de Janeiro
4 (4): 360-368. October-December, 2019
doi: 10.12957/jse.2019.46128

RESEARCH PAPER

EVALUATION OF THE BEST-FIT PROBABILITY OF DISTRIBUTION AND RETURN PERIODS OF RIVER DISCHARGE PEAKS. CASE STUDY: AWETU RIVER, JIMMA, ETHIOPIA

TOLERA ABDISA FEYISSA [1]* AND NASIR GEBI TUKURA[1]

1 Jimma University, Faculty of Civil and Environmental Engineering, Department of Hydraulic and Water Resources Engineering, Jimma, Ethiopia

* CORRESPONDING AUTHOR, toleraabdissa@yahoo.com

Received on 3 October 2019
Received in revised form on 20 October 2019
Accepted on 23 October 2019

Editor: *Maria Virginia Alves Martins, Universidade do Estado do Rio de Janeiro, Brazil*

Citation:
Feyissa, T.A., Tukura, N.G., 2019. Evaluation of the best-fit probability of distribution and return periods of river discharge peaks. Case Study: Awetu River, Jimma, Ethiopia. Journal of Sedimentary Environments, 4 (4): 361-368.

Abstract

The identification of the best distribution function is essential to estimate a river peak discharge or magnitude of river floods for management of watershed and ecosystems. However, inadequate estimation of the river peak discharge and floods magnitude may decrease the efficiency of water-resources management, resulting in soil erosion, landslides, environmental damage and ecosystem degradation. To overcome this problem in hydrology, different methods have been employed, applying a probability distribution.
In this study to determine the suitable probability of distribution for estimating the annual discharge series with different return periods, the annual mean and peak discharges of the Awetu River (Jimma, Ethiopia) over a 24 years' time period have been collected and used. After the homogeneity and consistency test, data were analyzed to predict extreme values and were applied in seven different probability distribution functions by using L-moment and easy fit methods. Then, three goodness of fit tests, Anderson-Darling (AD), Kolmogorov-Smirnov (KS), and Chi-Squared (x^2) tests, were used to select the best probability distribution function for the study area. The obtained results indicate that, Log-normal distribution function is the best-fit distribution to estimate the peak discharge recurrence of the Awetu River. The 5-year, 10-year, 25-year, 50-year, 100-year and 1000-year return periods of discharge were calculated for this river. The results of this study are useful for the development of more accurate models of flooding inundation and hazard analysis.

Keywords: River Discharge. Goodness of fit. Log Pearson Type III. Probability Distribution.

1. Introduction

The variability of precipitation and rivers floods has long been recognized as an important factor related to water resources use and development. In the past, this variableness has led to an extensive study of precipitation and river floods, especially with respect to their dependence on a large number of climatic and physiographic factors (Markovic, 1965). Due to improperly estimation of extreme runoff generated from upstream catchment area, large amounts of sediment are transported downstream, affecting the environment and the water ecosystem.

Sedimentation is a process by which soil particles are eroded and transported by running water or other transport agent and deposited in sedimentary basins and water bodies, such as reservoirs and rivers. It is a complex process that varies with watershed sediment yield, rate of transportation and mode of deposition (Ezugwu, 2013). Sediment deposition reduces the storage capacity and life span of reservoirs and contributing to increased flooding (Eroglu et al., 2010). Soil erosion adversely hinders the growth of plants, agricultural yields, water quality and recreation. It is a key cause of soil degradation as it occurs naturally on all lands (Bai et al., 2008; Li and Wei, 2011; Ding et al., 2015). Soil erosion, basically caused by water and wind, contributes to significant level of yearly soil loss.

Extreme environmental events, such as floods, rainstorms, strong winds, and droughts, have severe consequences on environment. Planning for water and climate issues such as waterworks design, reservoir management, pollution control and risk calculation all depends on knowing the frequency of extreme events (Einfalt, 1998). In hydrology, it is impossible to determine the time of occurrence of phenomena such as floods and

Journal of Sedimentary Environments
Published by Universidade do Estado do Rio de Janeiro
4 (4): 360-368. October-December, 2019
doi: 10.12957/jse.2019.46128

maximum river flows, but it is possible to investigate the occurrence of previous events and obtain the average probability of their occurrence. Calculation of the mean probability of occurrence or floods mean return periods can help to solve many problems. For example, in flood control projects it is possible to calculate the resulting average annual damage from flooding and also the design of structures such as dam spillway conducts, regarding the probability of flooding (Mahdavi, 2010).

Frequency analysis of extreme flood values, the magnitude of this phenomenon and its frequency also provide important information for determining risk and assessing reliability criteria in the design of structures. This analysis provides event frequency values that are greater than the original values calculated during the period of data record. This phenomenon can be defined using the concept of event return period (Hadian et al., 2011).

Proper assessment of flood frequency distribution is one of the main problems faced by hydrologists. This issue is very important because different distributions can produce significantly different estimates for the same return period (Coulson, 1991). In order to establish the appropriate probability distribution function, several investigations were previously performed (e.g., Cunanne, 1973; Stedinger, 1980; Stedinger et al., 1992; Alam and Khan, 2014).

In the study area, every year there are several floods of the Awetu River that cause damage to houses, farmland and so on. This work aims to obtain statistical distributions in discharge series with different return periods for the Awetu River. Maximum and average annual Awetu River flow discharges were collected over a period of twenty-five years and, after outlier test, Goodness of fit test, often used to select appropriate probability distribution for frequency analysis, was applied.

2. Description of study watershed

The Awetu River basin is located in South - West part of Ethiopia, in Oromia regional state, Jimma Zone, at about 360 km of Addis Ababa. Its watershed is one of the sub-basins of the Omo-Gibe River and is located in the highest portions of the Boye River sub-basin. Awetu River basin is located between 7°40'- 7°46' N latitudes and 36°46'- 36°54 E longitudes as shown in Figure 1. It covers a total drainage area of 15,975 km² in the Omo-Gibe River basin.

The mean annual rainfall of the study area is 1130.2 mm. At Awetu River basin high rainfall was recorded in May to September, whereas the lower rainfall was recorded in October to April in all stations. Among these 38.33% falls in a dry season.

3. Methodology

Monthly stream flow data for 24 years (1992-2016) were collected by the Ethiopian Ministry of Water irrigation and Energy, Hydrology Department (Appendix 1). Data were arranged on monthly and yearly basis and were treated statistically.

For selecting the best-fit probability distribution for a certain location, the choice of probability distribution models is important.

3.1 Selection of candidate probability distributions

Probability distributions are basic concepts in statistics. The results of statistical experiments and their probabilities of occurrence are linked by probability distributions. Discharge data from Awetu River were evaluated with five probability models to find the best-fit model.

The applied probability models include the Normal (N), Log-normal (LN), Log-Pearson type 3 (LP3), General extreme value and Gumbel (EVI) probability models.

3.1.1 Normal Distribution (N)

The Gaussian or N distribution is often applied in annual precipitation and runoff analysis (Markovic, 1965). The two moments mean μ and variance σ^2, are the parameters of the normal distribution.

The probability density function (pdf), f(x) and cumulative distribution function (cdf), F(x) for a normal random variable x are expressed as,

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} exp\left[-\frac{1}{2\sigma^2}(x-\mu^2)\right] \quad \textbf{(1)}$$

$$F(x) = \frac{1}{\sigma\sqrt{2\pi}} \int_{-\infty}^{\infty} \left(exp\left[-\frac{1}{2\sigma^2}(x-\mu^2)\right]\right) dx \textbf{(2)}$$

In the normal distribution, the maximum value of expected discharge (X_T) corresponding to any return period (T) can be calculated using Eq. (3):

$$X_T = \bar{X}(1 + C_v K_T) \quad (3)$$

Where X_T is the maximum value of expected rainfall, $\bar{X}$ is the mean, C_v is the coefficient of variation and K_T is the frequency factor, which depends on the return period and probability distribution. K_T is calculated using the following equation.

$$K_T = \frac{X_T - \mu}{\sigma} \quad \textbf{(4)}$$

The frequency factor (K_T) is the same as the standard normal variate 'z', which is calculated using Eq. (5).

$$Z = W - \frac{2.515517 + 0.802853w + 0.0110328w^2}{1 + 1.432788w + 0.189269w^2 + 0.001308w^2} \quad (5)$$

From Eq. (5), can be expressed as follows:

$$w = \left[ln\left\{\frac{1}{p^2}\right\}\right]^{\frac{1}{2}} (0 < p \le 0.50) \quad \textbf{(6)}$$

Where 'p' is the exceedance probability (P=1/T). When P > 0.5, *1 - P* is substituted for 'P' in eq. (6).

Journal of Sedimentary Environments
Published by Universidade do Estado do Rio de Janeiro
4 (4): 360-368. October-December, 2019
doi: 10.12957/jse.2019.46128

JSE
RESEARCH PAPER

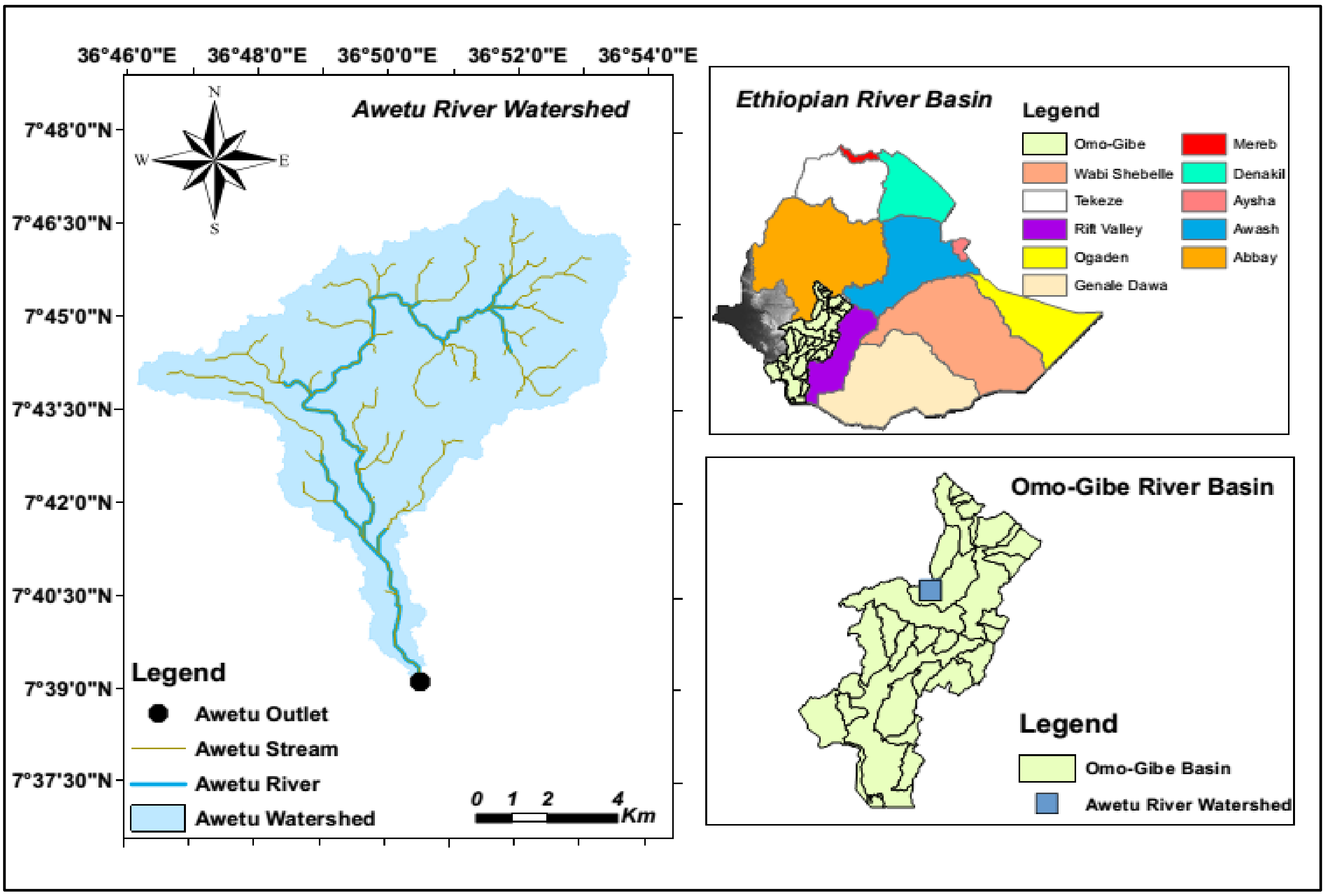

Fig. 1. Location map of the study area.

3.1.2 Log-Normal Distribution (LN)

The probability density function (pdf), *f*(x) and cumulative distribution function (cdf), *F(x)* of the 2-parameter Log-normal (LN2) are expressed as:

$$f(x) = \frac{1}{x\sigma_y\sqrt{2\pi}} exp\left[-\frac{1}{2\sigma_y{}^2}\left(\ln(x) - \mu_y\right)^2\right] \quad \textbf{(7)}$$

$$F(x) = \frac{1}{\sigma_y\sqrt{2\pi}}\int_0^x \left(\frac{1}{x} exp\left[-\frac{1}{2\sigma_y{}^2}\left(\ln(x) - \mu_y{}^2\right)\right]\right) dx \quad \textbf{(8)}$$

The log-normal distribution assumes that $Y = ln\ (X)$; therefore, the maximum value of expected discharge (X_T) corresponding to any return period (T) can be calculated using Eq. (9):

$$X_T = exp\ (Y_T) \qquad \textbf{(9)}$$

$$Y_T = \bar{Y}\left(1 + c_{vy}K_T\right)$$

$$K_T = \frac{Y_T - \mu_y}{\sigma_y}$$

Where $\bar{Y}$ and c_{vy} are the mean and coefficient of variation of Y, respectively. K_T is the frequency factor, which is the same as the standard normal variate and can be computed using Eq. (4).

3.1.3 Log-Pearson Type 3 (LP3)

The Log-Pearson Type 3 (LP3), another gamma family distribution, describes a random variable whose logarithm follows the P3 distribution. The probability density function (pdf), f(x) and cumulative distribution function (cdf), F(x) of the LP3 are expressed as:

$$f(x) = \frac{1}{|\alpha|\Gamma(\beta)}\left[\left(\frac{\ln(x) - \xi}{\alpha}\right)^{\beta-1}\right] exp\left[-\left(\frac{\ln(x) - \xi}{\alpha}\right)\right] \quad \textbf{(10)}$$

$$F(x) = \frac{1}{|\alpha|\Gamma(\beta)}\int_0^x \frac{1}{x}\left[\left(\frac{\ln(x)-\xi}{\alpha}\right)^{\beta-1}\right] exp\left[-\left(\frac{\ln(x)-\xi}{\alpha}\right)\right] dx \textbf{(11)}$$

In the log-Pearson type 3 distributions, the maximum value of expected discharge (X_T) corresponding to any return period (T) can be calculated using Eq. (12)

$$X_T = Antilog(X) \qquad \textbf{(12)}$$

$$Log(X) = \bar{X} + K_T S_d$$

$$K_T = \frac{2}{c_s}\left[\left\{\left(Z - \frac{c_s}{6}\right)\frac{c_s}{6} + 1\right\}^3 - 1\right]$$

Where $\bar{\boldsymbol{X}}$, $\boldsymbol{S_d}$ and $\boldsymbol{c_s}$ are the mean, standard deviation and coefficient of skewness of discharge data, respectively, and $\boldsymbol{K_T}$ is the frequency factor.

Journal of Sedimentary Environments
Published by Universidade do Estado do Rio de Janeiro
4 (4): 360-368. October-December, 2019
doi: 10.12957/jse.2019.46128

3.1.4 Gumbel Distribution

The extreme value type 1 distribution, also called the GUM distribution, is often used to represent a maximum process, for example the maximum rainfall or flood discharge, or the lowest stream flow or pollutant concentration. The pdf and cdf:

$$f(x) = \left(\frac{1}{\alpha}\right) exp\left[-\left(\frac{x-\beta}{\alpha}\right) - exp\left(-\left(\frac{x-\beta}{\alpha}\right)\right)\right] \quad \textbf{(13)}$$

$$F(x) = exp\left[-exp\left(-\frac{x-\beta}{\alpha}\right)\right]$$

$$\alpha = 0.7797\sigma, \quad \beta = \mu - 0.5772\alpha$$

Where α is the scale parameter and β is the location parameter for the GUM distribution.

The Gumbel distribution can be used to calculate the maximum value of expected discharge (X_T) corresponding to any return period (T) using Eq. (14):

$$X_T = \bar{X}(1 + C_v K_T) \quad \textbf{(14)}$$

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

Where $\bar{X}$ is the mean, C_v is the coefficient of variation and K_T is the frequency factor, which depends on return period (T) and probability distribution.

3.1.5 Generalized Extreme Value

A well-known three-parameter distribution for maxima is the GEV. In many European countries, such as Austria, Germany, Italy and Spain, the GEV distribution is recommended to provide the best-fit to flood data (Salinas et al., 2014). It includes a shape, ϰ, a scale, α and a location, ξ, and parameter. The parameters are estimated by L-moment estimators. The pdf and cdf are expressed as:

$$f(x) = \alpha^{-1}exp[-(1-k)y - exp(-y)] \textbf{(15)}$$

$$y = -k^{-1}\log\left\{1 - \frac{k(x-\xi)}{\alpha}\right\}, k \neq 0$$

$$y = \frac{x-\xi}{\alpha}, k = 0$$

$$F(x) = exp[-exp - y]$$

$$k = 7.8590c + 2.955c^2$$

Where,

$$c = \frac{2}{3+\tau_3} - \frac{\log 2}{\log 3}$$

$$\alpha = \frac{\lambda_2 k}{(1-2^{-k})\Gamma(1+k)}$$

$$\xi = \lambda_1 - \alpha\{1 - \Gamma(1+k)\}/k$$

With a range

$$-\infty < x < \xi + \frac{\alpha}{k}; if k\xi > 0;$$

$$-\infty < x < \infty; if k = 0$$

$$\xi + \frac{\alpha}{k} \leq x < \infty; if k = 0$$

Where τ_3 is the L-skewness of the distribution.

3.2 Selection of candidate parameter estimation methods

Having selected *a priori* probability distribution, the next step is to estimate the parameters required to fit the probability distribution to the selected data. A number of methods can be used for parameter estimation. In this study, the method of moments (MOM), the maximum likelihood estimates (MLE), and the L-moments are adopted since these are the most commonly adopted methods in previous studies. The L-moments method is considered in this study because it is less affected by extremes in the data series (Hosking, 1990) and can model a wide range of theoretical distributions.

3.2.1 Selection of candidate goodness-of-fit tests

The choice of a distribution is influenced by many factors, such as method of comparing the distributions, method of parameters estimation, and the availability of flood data. In this study, for evaluating the suitability of different probability distributions, following three goodness-of-fit tests are adopted: Kolmogorov–Smirnov test (KS); Anderson – Darling test (AD); and Chi-Squared (x^2) tests. The chosen distribution that best fits the maximum monthly flood amount is based on the minimum error indicated by all these three tests.

3.2.2 Return Period

One of the important objectives of frequency analysis is to calculate the recurrence interval or return period. If the variable (x) equal to or greater than an event of magnitude X_T, occurs once in T years, then the probability of occurrence P (X ≥ x) in a given year of the variable is:

$$P(x \geq x_T) = \frac{1}{T}, \qquad T = \frac{1}{1 - P(x \leq x_T)} \textbf{(16)}$$

4. Results and Discussion

The methodology presented above was applied to 24 years observational data taken by the Department of Hydrology, of Ministry of Water Resources, Ethiopia.

Based on the result of L moment diagram ratio drawn by skewness *versus* kurtosis and tests that provided lognormal distribution were selected among five distributions to estimate maximum or design flood of the Awetu River with respect to different return periods (Fig. 2).

Besides this, a diagnostic test was performed to validate the probability distribution function selected to fit the empirical frequency distribution of a given sample data by

Journal of Sedimentary Environments
Published by Universidade do Estado do Rio de Janeiro
4 (4): 360-368. October-December, 2019
doi: 10.12957/jse.2019.46128

the D-index test. According to the D-index test, the minimum value written in Table 1 shows that lognormal distribution is the best and validate function to provide the frequency analysis of the Awetu River. Also, Goodness of fit tests has done to calculate a test–statistics, which are used to analyze how well the data fits the given distribution and describe the differences between the observed data values, and the expected values. The Anderson-Darling (AD), Kolmogorov-Smirnov (KS), and Chi-Squared (X^2) tests were used for the goodness of fit tests in this report. To execute this goodness of fit tests, Easy Fit software was used. The values corresponding to each test are presented in Table 2.

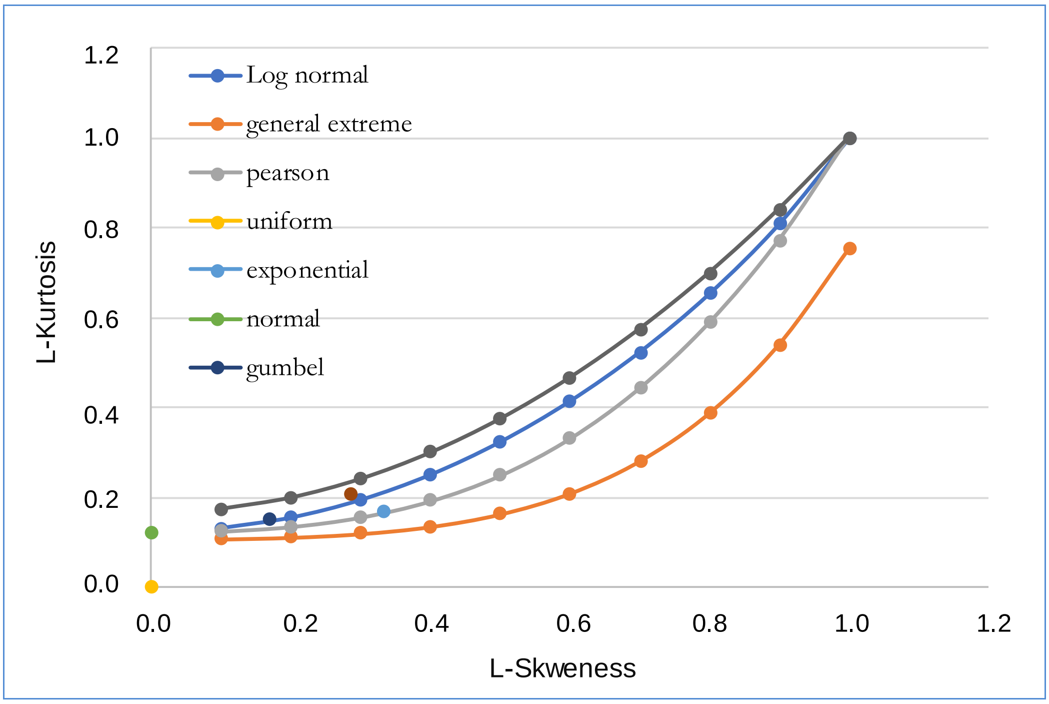

Fig. 2. L moment diagram ratio for selected of L moment diagram ratio

Tab. 1. D-index test result for selected probability distributions

Distribution Name	**Gumbel**	**Log Pearson Type III**	**Log Normal**	**Normal**
D-index value	5.08	3.422	3.31	3.33
Remark	4	3	1	2

Tab. 2. GOF value for selected probability distributions

No.	**Distribution**	**Kolmogorov-Smirnov**		**Chi-Squared**	
		Statistic	Rank	Statistic	Rank
1	Gen. Extreme Value	0.18825	3	5.9979	4
2	Gumbel	0.22437	4	4.1236	3
3	Log-Pearson 3	0.15574	2	3.0938	2
4	Lognormal	0.1419	1	1.9382	1
5	Normal	0.26772	5	7.9245	5

Journal of Sedimentary Environments
Published by Universidade do Estado do Rio de Janeiro
4 (4): 360-368. October-December, 2019
doi: 10.12957/jse.2019.46128

After all, the tests performed confirmed that the lognormal distribution function is the best fit, and the magnitude of the maximum floods corresponding to return periods of 5, 10, 25, 50, 100 and 1000 years was estimated, as shown in Table 3.

Conclusion

The estimation for the best fitting distribution for monthly flood data amount has been the main interest in several studies. In this work, several forms of distributions have been tested in order to find the best fitting distribution.

Different tests of goodness-of-fit have been attempted in several studies. In this study, the Log normal distribution function has been identified as the best fitting distribution for flood data in Awetu River, based on D-index value and goodness of fit (GOF) test. However, the flood data should be further analyzed and corrected for missing data, Historical data and Zero flood value. The study should be further extended to account for outliers existing in data.

Tab. 3. Discharge estimates using the best-fit distribution.

Return period (Years)	Y_m (mean) (m^3/s)	SD (standard deviation) (m^3/s)	K (frequency factor)	Z_T (m^3/s)	X_T (m^3/s)
5	1.002	0.37327	0.842	1.316293	20.7154
10	1.002	0.37327	1.282	1.480532	30.23654
25	1.002	0.37327	1.751	1.655596	45.24762
50	1.002	0.37327	2.054	1.768697	58.7079
100	1.002	0.37327	2.326	1.870226	74.16961
1000	1.002	0.37327	3.09	2.155404	143.0225

Based on this study, the Log normal distribution function should be considered the most suitable distribution for the analysis of monthly flood data of Awetu River.

This study should lead to the preparation of a flood return map for various return periods with application in the field of flood forecasting management. In addition, peak discharge estimation plays a great role in the design of hydraulic structures, determination of reservoir capacity, increase of agricultural productivity, and watershed and ecosystem management. In urban areas, it is essential to reduce overflow of drainage structures, for creating a buffer zone to protect the human life and property from flooding damage.

References

Alam, S., Khan, S.M., 2014. Statistical characterization of extreme hydrologic parameters for the peripheral river system of Dhaka City. Journal of Water Resources and Ocean Science 3, 30-37.

Bai, Z.G., Dent, D.L., Olsson, L., Schaep Man, M.E., 2008. Proxy global assessment of land degradation, Soil Use and Management, 24, 223-234. https://doi.org/10.1111/j.1475-2743.2008.00169.x

Cunanne, C., 1973. A particular comparison of annual maxima and partial duration series methods of flood frequency prediction J Hydrol 18:257–271.

Coulson, C.H., 1991. Manual of operational hydrology in B.C., 2ndedn B.C. Water Management Division, Hydrology Section, Ministry of Environment, Lands and Parks, BC, Canada.

Ding, L., Chen, K. L., Cheng, S. G., Wang, X., 2015. Water ecological carrying capacity of urban lakes in the context of rapid urbanization: A case study of East Lake in Wuhan. Physics and Chemistry of the Earth, Parts A/B/C, 89–90, 104–113.10.1016/j.pce.2015.08.004

Einfalt, T., 1998. Correction and preparation of continuously measured rain gauge data: a standard method in North Rhine-Westphalia, Water Science and Technology 37(11), 12-22.

Eroglu, H., Çakır, G., Sivrikaya, F., Akay, A. E., 2010. Using high resolution images and elevation data in classifying erosion risks of bare soil areas in the Hatila Valley Natural Protected Area, Turkey, Stoch. Env. Res. Risk A., 24, 699–704.

Ezugwu, C., 2013. Sediment Deposition in Nigeria Reservoirs: Impacts and Control Measures, Innovative Systems Design and Engineering, 4, 54–62.

Hadian, M. Habibnez Hadroshan, M., Omidvar, A., 2011. Evaluation of different statistical distributions in instantaneous peak discharges with different return periods in Tajen watershed 6th National science and watershed engineering conference, p. 1-8.

Hosking, J., 1990. L-moments: analysis and estimation of distributions using linear combinations of order statistics. J Roy Stat Soc B 52(105), 124.

Li, G.X., Wei, X., 2011. Soil erosion analysis of human influence on the controlled basin system of check dams in small watersheds of the Loess Plateau, China. Expert Systems with Applications 38, 4228–4233.

Mahdavi, M., 2010. Applied Hydrology, Vol. 2 Tehran University Press, 437 p.

Journal of Sedimentary Environments
Published by Universidade do Estado do Rio de Janeiro
4 (4): 360-368. October-December, 2019
doi: 10.12957/jse.2019.46128

Markovic, R.D., 1965. Probability Functions of Beet Fit to Distributions of Annual Precipitation and Runoff. Colorado state University, Hydrology Papers Nº 8.

Salinas, J.L., Castellarin, A., Kohnová, S., Kjeldsen, T.R., 2014. Regional parent flood frequency distributions in Europe, Part 2: Climate and scale controls. Hydrology and Earth System Sciences 18, 4391–4401.

Stedinger, J.R., 1980. Fitting lognormal distributions to hydrologic data Water Resources 16(3), 481–490.

Stedinger, J.R, Voge,l R.M., Foufoula-Georgiou, E., 1992. Frequency analysis of extreme events. In: Maidment, D.R. (ed) Handbook of Hydrology. McGraw-Hill, New York.

Journal of Sedimentary Environments
Published by Universidade do Estado do Rio de Janeiro
4 (4): 360-368. October-December, 2019
doi: 10.12957/jse.2019.46128

JSE
RESEARCH PAPER

Appendix 1. Monthly Awetu River Peak Discharge (m^3/s) from 1992 to 2016.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Max Discharge
1992	1.870	1.870	0.025	0.132	0.997	3.430	3.320	5.090	6.170	3.040	1.320	1.870	6.170
1993	0.607	0.158	0.241	0.796	1.580	0.132	5.530	7.990	6.040	4.970	1.870	1.860	7.990
1994	1.870	1.880	0.084	0.084	0.132	0.796	3.770	5.530	5.470	0.534	0.364	0.364	5.530
1995	0.184	0.132	0.184	0.271	0.301	6.440	7.240	7.520	6.900	1.710	0.956	0.108	7.520
1996	0.025	0.063	0.084	0.450	0.184	5.470	7.580	7.580	7.850	1.120	0.796	0.570	7.850
1997	0.063	0.084	0.570	0.132	0.570	2.460	5.910	7.580	7.720	3.320	1.120	0.643	7.720
1998	0.184	0.241	0.241	0.132	0.430	4.840	7.440	8.130	8.270	7.440	1.870	1.870	8.270
1999	0.084	0.039	0.374	5.287	1.312	7.222	17.465	8.231	13.950	5.789	1.067	1.846	17.465
2000	0.350	0.502	4.158	4.832	10.224	12.157	11.385	12.100	13.365	6.911	2.750	0.364	13.365
2001	0.149	0.410	0.968	2.952	13.296	16.424	20.418	17.500	26.451	4.070	0.508	0.315	26.451
2002	0.202	0.294	0.167	0.782	5.420	10.106	12.611	19.510	14.189	27.144	3.055	1.292	27.144
2003	0.528	1.210	0.600	6.997	20.543	17.730	8.052	5.717	9.153	3.993	1.357	0.256	20.543
2004	0.143	0.110	0.110	0.309	7.022	20.910	28.239	23.670	18.900	2.273	2.731	0.561	28.239
2005	0.095	0.081	0.147	0.631	1.648	1.841	6.358	7.395	20.330	5.351	0.320	0.327	20.330
2006	0.379	0.110	0.511	8.596	17.009	27.008	8.706	10.850	19.126	8.646	0.448	0.234	27.008
2007	0.568	0.098	0.882	1.616	5.000	20.066	15.677	4.629	4.751	38.181	19.928	16.530	38.181
2008	5.878	0.896	0.505	2.863	11.397	14.858	15.019	35.590	17.581	23.173	5.254	0.354	35.592
2009	0.107	0.074	0.105	1.289	3.250	5.091	5.007	8.900	4.826	8.692	1.293	0.260	8.900
2010	0.319	0.254	0.252	0.365	0.610	1.128	1.356	2.917	4.367	1.667	1.399	0.603	4.367
2011	0.213	0.187	0.194	0.296	0.331	0.831	3.932	3.648	2.386	5.277	0.438	0.200	5.277
2012	0.210	0.110	0.163	0.134	0.107	0.499	2.993	6.828	3.039	0.390	0.187	0.214	6.828
2013	0.211	0.101	0.160	0.477	0.126	1.319	2.088	0.892	1.348	0.595	0.175	0.124	2.088
2014	0.113	0.091	0.091	0.839	1.477	0.299	1.161	1.744	1.297	0.388	0.187	0.140	1.744
2015	0.217	0.111	0.131	0.507	1.967	0.889	6.030	3.562	9.159	2.152	0.267	0.151	9.159
2016	0.140	0.110	0.372	3.258	1.870	1.867	1.870	1.867	1.870	1.867	1.870	1.867	3.258