Asian Journal of Applied Science and Technology (AJAST)
(Open Access Quarterly International Journal) Volume 2, Issue 1, Pages 13-27, 2018

Estimation of Design Flood with Four Frequency Analysis Distributions

Ery Suhartanto[1], Lily Montarcih Limantara[1], Dina Noviadriana[2], Febri Iman Harta[2] and Dwi Aryani K[2]

[1]*Lecturer on the Department of Water Resources, Faculty of Engineering, University of Brawijaya, Jl. MT Haryono No. 167 Malang 65145, East Java of Indonesia.*
[2]*Doctoral Program on the Department of Water Resources, Faculty of Engineering, University of Brawijaya, Jl. MT Haryono No. 167 Malang 65145, East Java of Indonesia*

Article Received: 21 September 2017 *Article Accepted: 23 December2017* *Article Published: 07 January 2018*

ABSTRACT

The Lesti sub-watershed has the complex enough of problem related with the area damage, erosion, landslide, the fluctuation of river discharge and sedimentation is high enough. The solution which can be carried out to prevent the problem is by the accurate design, development, and the controlling of water structure accurately. However, the accuracy can be reached by the optimum accuracy in analyses including the hydrological analysis in it. One of the important hydrological analyses is to calculate the design flood. This study intends to analyze the design flood by using the four frequency analysis distribution. The methodology consist of analyzing the flood frequency by using the distributions of Normal, Log Normal, Log Pearson Type III, and Gumbel. The result is hoped can support the accurate project design of water resources structures.

Keywords: Design Flood, Frequency Analysis, Normal, Log-Normal, Gumbel-Weibull and Log Pearson-III.

1. INTRODUCTION

Frequency analysis is generally used in hydrology for the possibility of discharge extremes, mainly for low flow or high flow [1]. .The application of the frequency analysis methods has been widely recognized by the numerous researchers in the field. There are several kinds of frequency analysis distribution that have been successfully applied to the hydrological data [2]. Some of the extreme value probability distributions are usually used for hydrological analysis such as Normal Distribution, Log-Normal Distribution, Gumbel-Weibull Distribution, and Log Perason Type III Distribution [3].

Flood frequency analysis is the important parameter to determine the extend od flooding for the different of return period [4]. Generally, the instantaneous peak discharge of river at the various recorded location are taken from long term data [5] and the maximum flood of each year is extracted. Then the data is processed for the outliers and consistency test. The outliers is those the data points which departs significantly from the trend of the remaining data [6]. The consistency of data is evaluated with the help of t-test (t-statistics) [7]. Estimation of design flood are routinely required by water resources engineering purposes. The design flood is required for the planning and operation measures, the structural design, and the safety and risk analysis of the existing structures [8]. The conventional approaches for estimating the design flood are the flood frequency analysis. Hosking [9] and Hosking and Wallis [10] have provided the estimation of design floods based on the regional frequency analysis. However, Moon and Lall [11] used the nonparametric kernel estimator for reliable flood frequencies estimation analysis.

The Lesti sub-watershed is located in the Malang regency and it is as the priority sub-watershed in the upstream Brantas watershed. The Lesti sub-watershed has the complex enough of problem related with the area damage, erosion, landslide, the fluctuation of river discharge and sedimentation is high enough. In the last few years, the condition is changed regarding to the land use change, geographical condition of the upstream area where is part of

Asian Journal of Applied Science and Technology (AJAST)
(Open Access Quarterly International Journal) Volume 2, Issue 1, Pages 13-27, 2018

them is as mountainous, the global climate change, and the dangerous level of natural disaster in the Lesti sub-watershed is high enough.

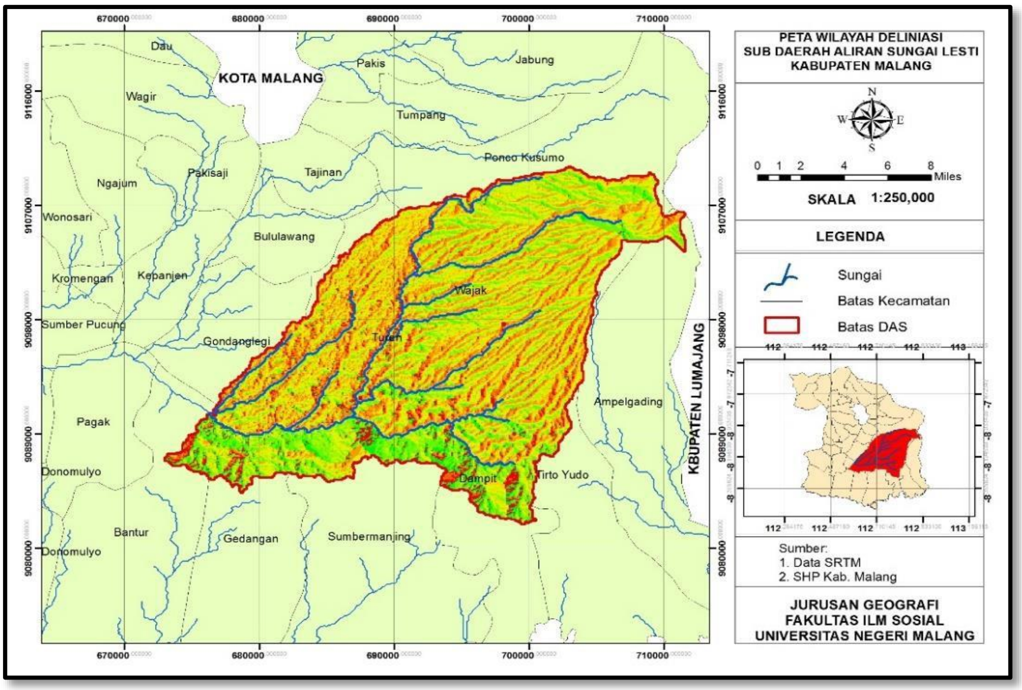
The solution to prevent the problem is by well design, development, and controlling the water structure accurately. However, the accuracy can be reached by the optimum accuracy in analyses including the hydrological analysis in it. One of the important hydrological analysis is to calculate the design flood. Therefore, the analysis of design flood is very necessary to be carried out including the testing of goodness of fit for evaluating the suitable probability distribution which is used in the frequency analysis. In additional, this evaluation is also to know the suitable water recorder as the reference of flooding recorder.

2. MATERIALS AND METHODS

2.1. Study location

Lesti sub-watershed is located on the south longest of 8°02’50’’- 8°12’10’’ and east longest of 112° 42’58’’-112°56’21’’. This area is on the Malang regency and has the heterogenic characteristic of the basic physical condition. The delineation of the research area uses the ecological boundary such as the division of the upstream Lesti sub-watershed which is remained by the Brantas watershed determination institution.

The condition of river network is known that the Lesti sub-watershed has the river arbitrary with the tree shaped which the affluent connects to the main river. The pattern shows that part of the area is homogeny. It indicates that there is happened the concentration of water surface in this area. However, this condition will cause the ability of water absorption in the soil is relatively small so it will be frequently happened the flooding and there is the water concentration (flooding) in some area. Map of the study location is presented as in the Figure 1.



 Online ISSN: 2456-883X Impact Factor: 1.805 Website: www.ajast.net

2.2. Data collecting

The secondary data are needed for this study. The secondary data are the data which is obtained from some sources which can be responsible to the truth. The secondary data which are needed in this study is as follow:

1. The daily rainfall data from the Poncokusumo station (2007-2016)

2. The daily rainfall data from the Dampit station (2007-2016)

3. The daily discharge data from the Tawangrejeni water recorder (2007-2016)

2.3. Steps of study

The steps of study are as follow:

1. To analyze the design flood by using the methods of Normal, Log Normal, Log Perason Type III. And Gumbel.

2. To carry out the testing of goodness of fit by using the methods of smirnov-kolmogorof and chi-square.

2.4. Normal distribution

The Normal distribution or Normal curve is also mentioned as the Gauss distribution. The formula for calculating the estimation value with the return period of T (Xt) is as follow:

$$X_T = \overline{X} + K_T S \quad (1)$$

Where,

XT : estimation of value which is hoped to be happened by the return period of T

X : mean

S : deviation standard

KT : factor of frequency which is as the function of probability or return period and as the type of mathematical modeling of the probability distribution that is used for the probability analysis

2.5. Log Normal distribution

The formula of Log Normal distribution is the same as the Normal distribution, but the data have to be transformed into log.

$$X_T = \overline{X} + K_T S \quad (2)$$

Where,

XT : estimation of value which is hoped to be happened by the return period of T)in the log)

X : mean (in the log)

S : deviation standard (in the log)

KT : factor of frequency which is as the function of probability or return period and as the type of mathematical modeling of the probability distribution that is used for the probability analysis

2.6. Log Pearson Type III distribution

To use the Log Pearson Type III, the data have to be transformed into the Log form. The formula of Log Pearson Type III with the return period of T (Xt) is as follow:

$$\text{Log } X_T = \text{Log } X + K.s \quad (3)$$

Where,

Log X_T : estimation of value (in the Log from) which is hoped to be happened by the return period of T

X : mean (in the Log form)

S : deviation standard (in the log form)

K_T : factor of frequency which is as the function of probability or return period and as the type of mathematical modeling of the probability distribution that is used for the probability analysis

2.7. Gumbel distribution

The formula of the Gumbel distribution that is used for estimating the value which is hoped to be happened with the return period of T(Xt) is as follow:

$$Xt = \overline{X} + \frac{(Y_t - Y_n)}{S_n} \times Sx \quad (4)$$

Where,

Xt = design rainfall in the return period of T year (mm)

X = mean rainfall of the observed result

Yt = reduced variate that is as the Gumbel parameter for the return period of T year

Yn = reduced mean that is as the function of the data number= f(n)

Sn = reduced deviation standard that is as the function of the data number = f(n)

Sx = deviation standard

3. RESULTS AND DISCUSSIONS

3.1. Analysis of discharge data

In the hydrological analysis, the data of Automatic Water Level Recorder (AWLR) is obtained from the Tawangrejeni station which consists of disxharge data on the period from 2007 until 2016. Table 1 presents the maximum discharge of Tawangrejeni AWLR.

Table 1. Maximum discharge data of Tawangrejeni AWLR

No.	Year	Discharge (m^3/s)
1	2007	514.4
2	2008	202.5
3	2009	254.7
4	2010	85.8
5	2011	127.9
6	2012	175.3
7	2013	86.5
8	2014	81.5
9	2015	72.3
10	2016	63.2

Source: own study

3.2. Analysis by using the Normal Distribution

Analysis by using the Normal distribution uses the formula as follow:

$$X_T = \overline{X} + K_T S \tag{5}$$

The data preparation is presented as in the Table 2, however the result of design flood by using the Normal distribution is presented as in the Table 3.

Table 2. Data preparation for Normal distribution analysis

No	year	Q max (m^3/s)
1	2016	63.25
2	2015	72.34
3	2014	81.47
4	2010	85.79
5	2013	86.50
6	2011	127.85
7	2012	175.29
8	2008	202.54
9	2009	254.67
10	2007	514.42
Mean		166.4
Deviation standard		138.0

Source: own study

Table 3. Result of design flood by using the Normal distribution

Tr (year)	P (%)	z	Q design (m^3/s)
1.01	0.990	-2.33	155.09
5	0.200	0.84	282.32
10	0.100	1.28	343.03
25	0.040	1.71	402.14
50	0.020	2.05	449.28
100	0.010	2.33	487.92
200	0.005	2.58	522.41
500	0.002	2.88	563.81
1000	0.001	3.09	592.79

Source: own study

Explanation: Tr = return period; P = probability; Z = parameter in Normal distribution; Q = discharge

3.3. Analysis by using the Log Normal distribution

If y = log x, so the analysis by using the Log Normal distribution can be carried out by using the formula of the Normal distribution. The data preparation for the Log Normal distribution is presented as in the Table 4, however, the result of design flood by using the Log Normal distribution is presented as in the Table 5.

Table 4. Data preparation for Log Normal analysis

No	year	Q Max (m^3/s)	Log Q
1	2016	63.25	1.80
2	2015	72.34	1.86
3	2014	81.47	1.91
4	2010	85.79	1.93
5	2013	86.50	1.94

6	2011	127.85	2.11
7	2012	175.29	2.24
8	2008	202.54	2.31
9	2009	254.67	2.41
10	2007	514.42	2.71
Mean		166.41	2.12
Deviation standard		137.99	0.29

Source: own study

Table 5. Result of design flood by using the Log Normal distribution

Tr (year)	P (%)	P(z)	z	Log Q	Q design (m^3/s)
1.01	99	0.010	-2.33	1.44	27.74
5	20	0.800	0.84	2.37	232.41
10	10	0.900	1.28	2.49	312.17
25	4	0.960	1.71	2.62	416.03
50	2	0.980	2.05	2.72	523.15
100	1	0.990	2.33	2.80	631.20
200	0.5	0.995	2.58	2.87	746.41
500	0.2	0.998	2.88	2.96	912.73
1000	0.1	0.999	3.09	3.02	1050.75

Source: own study, Explanation: Tr = return period; P = probability; Q = discharge

3.4. Analysis by using the Log Pearson Type III

If y = log x, so the analysis by using Log Pearson III distribution can be carried out by transforming the data into Log form and then to analyze it by using the formula of Log Pearson III. The data preparation for the Log Pearson III distribution is presented as in the Table 6, however, the result of design flood by using the Log Pearson III distribution is presented as in the Table 7.

Table 6. Data preparation for the Log Pearson Type III distribution

No	year	Q Max (m^3/s)	Log Q
1	2016	63.2	1.80
2	2015	72.3	1.86
3	2014	81.5	1.91
4	2010	85.8	1.93
5	2013	86.5	1.94
6	2011	127.9	2.11
7	2012	175.3	2.24
8	2008	202.5	2.31
9	2009	254.7	2.41
10	2007	514.4	2.71
Mean Log Q			2.12
Cs Log Q			0.92
Deviation standard of Log Q			0.29

Source: own study

Table 7. Result of design flood by using the Log Pearson Type III distribution

Tr (year)	P (%)	K	Log Q	Q design (m^3/s)
1.01	99	-1.648	1.64	43.81
2	50	-0.151	2.08	119.61
5	20	0.767	2.35	221.34
10	10	1.339	2.51	324.80
25	4	2.022	2.71	513.43
50	2	2.505	2.85	709.85
100	1	2.968	2.99	967.89
200	0.5	3.415	3.12	1306.80
500	0.2	3.791	3.23	1681.78
1000	0.1	4.418	3.41	2560.76

Source: own study

Explanation: Tr = return period; P = probability; k = coefficient of frequency; Q= discharge

3.5. Analysis by using the Gumbel distribution

By using the Gumbel distribution, the data preparation for Gumbel distribution is presented as in the Table 8, however, the result of design flood by using the Gumbel distribution is presented as in the Table 9.

Table 8. Data preparation for Gumbel distribution

No	Year	Q Max (m^3/s)
1	2016	63.2
2	2015	72.3
3	2014	81.5
4	2010	85.8
5	2013	86.5
6	2011	127.9
7	2012	175.3
8	2008	202.5
9	2009	254.7
10	2007	514.4
Mean		166.41
Deviation standard		137.99
N		10
Sn (from Gumbel table)		0.950
Yn (from Gumbel table)		0.459

Source: own study

Table 9. Result of design flood by using the Gumbel distribution

Tr (year)	P (%)	Yt	K	Q design (m^3/s)
1.01	99	-1.529	-2.094	-122.54
2	50	0.367	-0.098	152.94
5	20	1.500	1.096	317.64

10	10	2.250	1.886	426.68
20	5	2.970	2.644	531.28
25	4	3.199	2.885	564.46
50	2	3.902	3.625	666.67
100	1	4.600	4.361	768.13
200	0.5	5.296	5.093	869.21
500	0.2	6.214	6.060	1002.58
1000	0.1	6.907	6.790	1103.37

Sumber : Hasil perhitungan

Explanation: Tr = return period; P = probability; k = coefficient of frequency; Q= discharge; Yt = reduced variate

3.6. Testing of goodness of fit by using Smirnov Kolmogorov test

Testing of goodness of fit by using Smirnov-Kolmogorof test is carried out by comparing the probability of every variant between the empirical and theoretical probability and then the maximum deviation is compared with the deviation of table [12].

If the Δ max (D max) on the probability paper is less than Δ critic (Dcr) for a level of significance and the number of certain variant, so it can be concluded that the deviation which is happened is caused by the accidental error. The steps for carrying out the test are as follow:

a. To rank the data (from small to big or big to small) and to calculate the probability each of the data as the empirical probability.

b. To determine the value each of the theoretical probability

c. To find the maximum deviation between the empirical and theoretical probability.

d. Then, the maximum deviation is compared with the critical value with a level of significant from the Smirnov-Kolmogorof' table.

Testing of goodness of the Smirnov-Kolmogorof test is for evaluating the frequency analysis by using the Normal distribution, the Log Normal distribution, the Log Pearson Type III distribution, and the Gumbel distribution. The results are presented each on the Table 10, 11, 12, and 13.

Table 10. Smirnov-Kolmogorov test for the Normal distribution

No	Year	Q Max (m^3/s)	Pe	K	Pr	Pt	D [Pt-Pe]
1	2016	63.25	0.091	-0.748	0.774	0.226	0.135
2	2015	72.34	0.182	-0.682	0.755	0.245	0.063
3	2014	81.47	0.273	-0.616	0.733	0.267	0.006
4	2010	85.79	0.364	-0.584	0.722	0.278	0.085
5	2013	86.50	0.455	-0.579	0.720	0.280	0.175

6	2011	127.85	0.545	-0.279	0.610	0.390	0.155
7	2012	175.29	0.636	0.064	0.474	0.526	0.111
8	2008	202.54	0.727	0.262	0.396	0.604	0.123
9	2009	254.67	0.818	0.640	0.260	0.740	0.078
10	2007	514.42	0.909	2.522	0.006	0.994	0.085

Source: own study

Explanation: Pe = empirical probability; Pt = theoretical probability; D = deviation

Table 11. Smirnov-Kolmogorov test for the Log Normal distribution

No	year	Q Max (m^3/s)	Log Q	Pe	K	Pr	Pt	D [Pt-Pe]
1	2016	63.25	1.801	0.091	-1.101	0.860	0.140	0.049
2	2015	72.34	1.859	0.182	-0.901	0.814	0.186	0.004
3	2014	81.47	1.911	0.273	-0.723	0.767	0.233	0.040
4	2010	85.79	1.933	0.364	-0.646	0.744	0.256	0.107
5	2013	86.50	1.937	0.455	-0.634	0.739	0.261	0.194
6	2011	127.85	2.107	0.545	-0.051	0.520	0.480	0.066
7	2012	175.29	2.244	0.636	0.419	0.337	0.663	0.026
8	2008	202.54	2.307	0.727	0.635	0.262	0.738	0.011
9	2009	254.67	2.406	0.818	0.976	0.169	0.831	0.013
10	2007	514.42	2.711	0.909	2.025	0.022	0.978	0.069

Source: own study

Explanation: Pe = empirical probability; Pt = theoretical probability; D = deviation

Table 12. Smirnov-Kolmogorov test for the Log Pearson Type III distribution

No	Year	Q Max (m^3/s)	Pe	Log Q	K	Pr	Pt	D [Pt-Pe]
1	2016	63.25	0.091	1.801	-1.101	0.885	0.115	0.024
2	2015	72.34	0.182	1.859	-0.901	0.816	0.184	0.002
3	2014	81.47	0.273	1.911	-0.723	0.744	0.256	0.017
4	2010	85.79	0.364	1.933	-0.646	0.712	0.288	0.075
5	2013	86.50	0.455	1.937	-0.634	0.706	0.294	0.161
6	2011	127.85	0.545	2.107	-0.051	0.468	0.532	0.013
7	2012	175.29	0.636	2.244	0.419	0.314	0.686	0.050
8	2008	202.54	0.727	2.307	0.635	0.243	0.757	0.029
9	2009	254.67	0.818	2.406	0.976	0.163	0.837	0.018
10	2007	514.42	0.909	2.711	2.025	0.040	0.960	0.051

Source: own study, Explanation: Pe = empirical probability; Pt = theoretical probability; D = deviation

Table 13. Smirnov-Kolmogorov test for the Gumbel distribution

No	Year	Q Max (m^3/s)	P	K	Yt	Tr	Pr	D [1-Pr-Pe]
1	2016	63.25	0.091	-0.748	-0.251	1.382	0.723	0.186
2	2015	72.34	0.182	-0.682	-0.188	1.427	0.701	0.117
3	2014	81.47	0.273	-0.616	-0.125	1.475	0.678	0.049

4	2010	85.79	0.364	-0.584	-0.096	1.499	0.667	0.031
5	2013	86.50	0.455	-0.579	-0.091	1.503	0.665	0.120
6	2011	127.85	0.545	-0.279	0.194	1.782	0.561	0.107
7	2012	175.29	0.636	0.064	0.520	2.232	0.448	0.084
8	2008	202.54	0.727	0.262	0.708	2.570	0.389	0.116
9	2009	254.67	0.818	0.640	1.067	3.434	0.291	0.109
10	2007	514.42	0.909	2.522	2.854	17.864	0.056	0.035

Source: own study

Explanation: Pe = empirical probability; Pt = theoretical probability; D = deviation

3.7. Testing of goodness of fit by using the Chi- Square distribution

Test of chi square distribution evaluates the difference between the sample data and the probability distribution. The formula of chi square is as follow:

$$X^2 = \sum_{i=1}^{N} \frac{(Oi-Ei)^2}{Ei} \quad (6)$$

where X2 = chi-square calculated value; Ei = frequency that is hoped regarding to the class division; Oi= frequency on the same class; N = number of class. The value of Ei can be found with the formula as follow:

$$Ei = \frac{n}{N} \quad (7)$$

Where, n = number of N = number of class.

Testing of goodness of fit by using chi square distribution test for evaluating the frequency analysis by using the Normal distribution, the Log Normal distribution, the Log Pearson Type III distribution, and the Gumbel distribution. The results are presented each on the Table 14, 15, 16, and 17

Table 14. Chi-Square test for the Normal distribution

No.	P (%)	Tr (year)	Mean	Deviation Standard	K	Q (m^3/s)
1	20	5.00	166.412	137.985	0.840	282.320
2	40	2.50	166.412	137.985	0.250	200.909
3	60	1.67	166.412	137.985	-0.254	131.399
4	80	1.25	166.412	137.985	-0.840	50.505

Interval of class			Of	Ef	$(Ef-Of)^2$/Ef
0.000	-	50.505	0.00	2.00	2.00
50.506	-	131.399	6.00	2.00	8.00
131.400	-	200.909	1.00	2.00	0.50
200.910	-	282.320	2.00	2.00	0.00
282.321	-	~	1.00	2.00	0.50
Total			10	10	11.00

Chi-square calculated value = 11.00

α (%) = 5%

degree of freedom (g) = 2 = k-h-1 h =2

Chi-square critic = 5.99 non accepted

Source: own study

Table 15. Chi-Square test for the Log Normal distribution

Interval pf class			Of	Ef	(Ef-Of)2/Ef
0.000	-	75.334	2.00	2.00	0.00
75.334	-	111.615	3.00	2.00	0.50
111.615	-	156.468	1.00	2.00	0.50
156.468	-	232.405	2.00	2.00	0.00
232.405	-	~	2.00	2.00	0.00
Total			10	10	1.00

No.	P (%)	Tr (year)	Mean	Deviation standard	K	Log Q (m^3/s)	Q (m^3/s)
1	20	5.00	2.122	0.291	0.840	2.366	232.405
2	40	2.50	2.122	0.291	0.250	2.194	156.468
3	60	1.67	2.122	0.291	-0.254	2.048	111.615
4	80	1.25	2.122	0.291	-0.840	1.877	75.334

Chi-square calculated value = 1.00

α (%) = 5%

degree of freedom (g) = 2 = k-h-1 h =2

Chi-square ctritic = 5.99 accepted

Table 16. Chi-Square test for the Log Pearson Type III distribution

No.	P (%)	Mean	Deviation standard	Cs	K	Q	
						Log	(m^3/s)
1	20	2.122	0.291	0.916	0.787	2.351	224.295
2	40	2.122	0.291	0.916	0.164	2.169	147.695
3	60	2.122	0.291	0.916	-0.391	2.008	101.782
4	80	2.122	0.291	0.916	-0.879	1.866	73.407

Interval of class			Of	Ef	(Ef-Of)2/Ef
0.00	-	73.407	2.00	2.00	0.00
73.407	-	101.782	3.00	2.00	0.50
101.782	-	147.695	1.00	2.00	0.50
147.695	-	224.295	2.00	2.00	0.00
224.295	-	~	2.00	2.00	0.00
Total			10	10	1.00

Chi-square calculated value = 1.00

α (%) = 5%

degree of freedom (g) = 2 = k-h-1 h =2

Chi-square critic = 5.99 accepted

Source: own study

Table 17. Chi-Square test for the Gumbel distribution

No.	P (%)	Mean	Deviation standard	Tr (year)	Yt	K	Q (m^3/s)
1	20	166.412	137.985	5	1.500	1.096	317.641
2	40	166.412	137.985	2.5	0.672	0.224	197.295
3	60	166.412	137.985	1.67	0.087	-0.392	112.390
4	80	166.412	137.985	1.25	-0.476	-0.985	30.536

Interval of class			Of	Ef	(Ef-Of)2/Ef
0.000	-	30.536	0.00	2.00	2.00
30.536	-	112.390	5.00	2.00	4.50
112.390	-	197.295	2.00	2.00	0.00
197.295	-	317.641	2.00	2.00	0.00
317.641	-	~	1.00	2.00	0.50
Total			10	10	7.00

Chi-square calculated value = 7.00

α (%) = 5%

degree of freedom (g) = 2 = k-h-1 h =2

Chi-square critic = 5.99 non accepted

Yn = 0.459

Sn = 0.950

Source: own study

4. CONCLUSION

Based on the statistical analysis result as above which includes the Normal distribution, the Log Normal distribution, the Log Pearson Type III distribution, and the Gumbel distribution, it can be concluded that the rainfall data from 2007 until 2016 due to the four distributions can be accepted regarding to the Smirnov-Kolmogorof test. However, based on the chi square test, the Normal distribution and the Gumbel distribution are not accepted. Table 18 presents the recapitulation of test results.

Table 18. The recapitulation of test results for every distribution

No	Distribution	Smirnov-Kolmogorov test			Chi-Square test		
		Δ D Max	Δ D critic	Decision	X^2 calculation	X^2 critic	Decision
1	Normal	0.175	0.410	Accepted	11.000	5.991	Non accepted
2	Log Normal	0.194	0.410	Accepted	1.000	5.991	Accepted
3	Log Pearson III	0.161	0.410	Accepted	1.000	5.991	Accepted
4	Gumbel	0.186	0.410	Accepted	7.000	5.991	Non accepted

Source: own study

Based on the result as above, it can be selected the Log Pearson Type III distribution as the suitable distribution for the Lesti sub-watershed. It is due to the result which indicates that the Log Pearson Type III is accepted for the two testing of goodness of fit and has the minimum deviation.

REFERENCES

[1] Radevski, I; Gorin, S; Dimitrovska, O; Milevski, I, Apostolovska, B; Taleska, M; and Zlatanoski, V. 2016. Estimation of maximum annual discharges by frequency analysis with four probability distribution in case of non-homogeneous time series (Kazani Karst Spring in Republic of Macedonia). Acta Carsalogica, 45(3): 253-262, Postoina.

[2] Selaman, O.S.; Said, S; and F.J. Putuhena. 2007. Flood frequency analysis for Sarawak using Weibull, Gringorten and L-Moments formula. Journal-The Institution of Engineers, 68(1): 43-52.

[3] Guru, N. and R. Jha. 2015. Flood frequency analysis for Tel sub-basin of Mahanadi River, India using Weibull, Gringorten and L-moments formula. International Journal of Innovative Research and Creative Technology, 1(2): 220-223.

[4] US Water Resources Council (USWRC). 1981. Guidennes for determining flood flow frequency. Bulletin No. 17B, Washington, pp. 16-30.

[5] Ahmad, I; Z., Ahmad.; and S.A.,Ahmad. 2012. Flood frequencies to Soan Valley. Pakistan Journal of Sciences, 64(1): 1-6.

[6] Chow, V.T.; D.R., Maidment; and W. Larry. 1988. Applied hydrology. Mc. Graw Hill Book Company, New York, USA, pp 380-405.

[7] Kpttegoda, N.T. 1980. Stochastic water resources technology. The Macmillan Press Ltd, pp. 38-46.

[8] Hyun-Han Kwon; Young-Il Moon; and Abedalraszq, F. Khalil. 2007. Nonparametric Monte Carlo simulation for flood frequency curve derivation: an application to a Korean watershed. Journal of the Amaericam Water Resources Association, 43(5): Biological Sciences Database, 1316-1328.

[9] Hosking, J.R,M. 1990. L-Moment – analysis and estimation of distribution using linear-combination of order-statistics. Journal of the Royal Statistical Society SeriesB-Methodological, 52(1): 271-281.

[10] Hosking, J.R.M. and J.R. Wallis. 1993. Some statistics useful in regional frequency analysis. Water Resources Research, 29(2); 271-0181.

[11] Moon, Y.I. and U. Lall. 1994. Kernel quantile function estimator for flood frequency analysis. Water Resources research, 30(110; 3096-3100.

[12] Soewarno 1995. Hidrologi aplikasi metode statistik untuk analisa data [Statistical method of hydrological application for data analysis]. Jilid I. Bandung. Nova pp. 269.