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Designed Rain Analysis of Various Times Using the Gumbel Method in The Babak River Flow Area, West Lombok District

Muhamad Yamin[1]*, Zamah Sari[2]
Universitas Qamarul Huda Badaruddin Bagu
Corresponding Author: Muhamad Yamin yaminmuhamad446@gmail.com

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ABSTRACT

The Babak River is located in Bagu Village which is part of the Administrative Region of Pringgarata District, Central Lombok Regency, which is one of the areas where river flooding and drainage systems frequently occur. In analyzing the planned flood discharge of the Babak river by evaluating several parameters including daily maximum rainfall, planned rainfall, effective rainfall, planned flood unit hydrograph. The purpose of the planned flood discharge analysis is to evaluate the magnitude of the planned flood discharge at various return periods. Based on the background, the problem formulation in this research is to find out the magnitude of the base flow in the river basin and the magnitude of the planned flood discharge at various return periods of T years. After analyzing the rainfall data obtained at the BMKG (Meteorology and Geophysics Agency) West Lombok Regency office, the rainfall plan for various return periods using the Gumbel method is as follows: 2 years = 444,687; 5 years = 477,295; 10 years = 498.909 mm; 20 years = 519.342 mm; 25 years = 526.192 mm; 50 years = 546.424 mm; 100 years = 566.542 mm. Based on the Babak Watershed Characteristics data and data analysis, it was obtained that the base flow discharge in the Babak Weir River Gebong River area, Central Lombok Regency was = 5,289 m^3/sec

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INTRODUCTION

Floods attract attention because they can affect human life and cause disaster/loss for communities around the river environment. The occurrence of overflow can be differentiated into several types, namely the discharge is too large or the river's drainage capacity is reduced. This can occur due to natural phenomena or due to carelessness in human activities in developing/managing rivers for various purposes. Along with the rate of growth and development of society, especially those who live and carry out activities around flood plains, the problems caused by floods are increasing from time to time and require attention and efforts to overcome them properly.

Gebong Dam is located in Bagu Village, which is part of the Administrative Area of Pringgarata District, Central Lombok Regency, which is one of the areas where river flooding and drainage systems often occur. (Anonymous, 2007).

In analyzing the design flood discharge of the Babak river by evaluating several parameters, including maximum daily rainfall, design rainfall, effective rainfall, design flood unit hydrograph. The purpose of the design flood discharge analysis is to evaluate the magnitude of the design flood discharge at various return periods of 2, 5, 10, 20, 25, 50, 100 years.

Various ways of structures being built to anticipate flooding can be obtained by determining the planned flood discharge as a basis for determining hydraulic structure designs such as spillway capacity.

Problem Formulation

Based on the background stated above, the problem formulation in this research is: what is the amount of base flow in the Babak Watershed, West Lombok Regency? And what is the magnitude of the design flood discharge at various return periods (2, 5, 10, 20, 25, 50, 100 years).

LITERATURE REVIEW

General

A river basin (DAS) is an area bounded (surrounded) by a height line where any water that falls on the ground surface will be channeled through an outlet. The components in a watershed system can generally be divided into 3 groups, namely input components, namely rainfall, output components, namely flow discharge and pollution/sediment, and process components, namely humans, vegetation, soil, climate and topography. Every component in a watershed must be managed in order to achieve the goals we want.

The aim of watershed management is to manage natural resources rationally so that they can be utilized optimally and sustainably so that good water management conditions can be obtained. Meanwhile, sustainable development is the use and management of natural resources for the benefit of humans today while ensuring the continued use of natural resources for future generations (Ratna, 2014).

Geographical Characteristics

Geographical characteristics are characteristics or features of a region that are seen from the reality that exists on the face of the earth or the position of that region in the world compared to the position of other regions. Geographical location is also determined by astronomical, geological, physiographic and socio-cultural locations.

a) Astronomical location is the location of an area in terms of latitude and longitude.
b) Geological location is the location of an area as seen from the rock structure in the earth's crust. The geological location can be seen from several aspects, namely geological formations, rock conditions, and mountain paths.
c) Physiographic location is the location of a place based on its physical aspects, such as latitude and longitude, its position with other areas, rocks in the earth, relief of the earth's surface and its relationship with the sea.
d) Social location is the location of a place based on the social and cultural conditions of the area concerned.

Base Flow

Baseflow is water flow that occurs underground or output from groundwater equipment which is produced from vertical percolation of water through the soil profile into groundwater, and is supported by slow flow from the zone of aeration on sloping areas. In this case, Base Flow is an important process in the hydrological cycle, the process of forming Base Flow starts from sea water, rivers, reservoirs and lakes evaporating (evaporation). Plus, evaporated vegetation (transpiration) rises upwards and gathers into clouds. Due to changes in temperature, the water that has become clouds then changes again into water droplets or rain which then falls to the earth. Some water that falls or rain falls directly into the sea, rivers, reservoirs and lakes, some also falls on plants and some falls into the ground where all the water that falls or rain will end up in the sea, rivers, lakes and reservoir. In this case, Base Flow is rainwater that falls into the ground, where this rainwater enters through the ground surface, because a lot of water enters the ground so that flow occurs in the ground or Base Flow.

Watershed

By definition, a river basin (DAS) is an area bounded (surrounded) by a height line where any water that falls to the ground surface will be channeled through an outlet. The components in a watershed system can generally be divided into 3 groups, namely input components, namely rainfall, output components, namely flow discharge and pollution/sediment, and process components, namely humans, vegetation, soil, climate and topography. Every component in a watershed must be managed in order to achieve the goals we want. The aim of watershed management is to manage natural resources rationally so that they can be utilized optimally and sustainably so that good water management conditions can be obtained. Meanwhile, sustainable development is the use and management of natural resources for the benefit of humans today while ensuring the continued use of natural resources for future generations.

River watersheds are determined using topographic maps equipped with contour lines. For this purpose, topographic maps at a scale of 1:50,000 can be used. Contour lines are studied to determine the direction of surface runoff. Runoff occurs from that position and moves towards the lowest location in a direction perpendicular to the contour line. The area bounded by the line connecting the highest points is called the watershed. Figure 2.1 shows an example of a watershed form. The image also shows a cross-section along the perimeter of the watershed. The line surrounding the watershed is the highest point. Rainwater that falls within the watershed will flow into the main river concerned, while water that falls outside the watershed will flow into other rivers next to it.

METHODOLOGY

1. Dispersion Measurement

This research is a case study using rainfall data for 5 years, namely 2019-2023. Next, an analysis of the average rainfall in the Babak watershed, climatological data obtained from the relevant agencies was carried out. The type of data used in research is data obtained from secondary data, namely data obtained from various existing sources, and literature studies, various literature such as books, research journals, scientific articles, as well as testing standards, as well as data results of observations and measurements at the research location, including field data, location photos and other matters relating to the required data sourced from weir officials.

Data Analysis

a. Measurement of Dispression
Standard Devision (Sd)

$$\mathrm{Sd} = \sqrt{\frac{\sum(Xi - Xr)^2}{n-1}}$$

b. Skewness Coefficient (Ck)

$$\mathrm{Cs} = \frac{n\sum(Xi - Xr)^3}{(n-1)(n-2)Sd^3}$$

c. Kurtosis Coefficient (Ck)

$$\mathrm{Ck} = \frac{n\sum(Xi - Xr)^4}{(n-1)(n-2)xSd^4}$$

d. Coefficient of Variation (Cv)

$$Cv = \frac{Sd}{Xr}$$

2. Selecting the Type of Rain Distribution

By following the appropriate distribution pattern, the planned rainfall is then calculated using several repeated methods that will be used to obtain the planned flood discharge. In statistics, several types of distribution are known, one of which is widely used in hydrology: the Normal Distribution Method. In hydrological analysis the normal distribution is widely used to analyze rainfall frequency, statistical analysis of annual rainfall distribution, annual average discharge. The normal distribution or normal curve is also called the Gaussian distribution:

$$\mathrm{Xt} = \overline{Xr}\ x\ kxS$$

Where:
Xt = planned rainfall (mm/hr)
Xr= average maximum rainfall (mm/hr)
S = frequency factor

Table 1. Coefficient Values for Normal Distribution

Return Period (year)					
2	5	10	25	50	100
0,00	0,84	1,28	1,71	2,05	2,33

Source: Ir C.D Soemarto, 1999

a. Gumbel Method

Calculate the standard deviation of rainfall data recorded at the local rain station using the following formula:

$$\text{Sd} = \sqrt{\frac{\sum_{i=1}^{n}(Xi - Xr)^2}{n-1}}$$

Where;

Sd = Standard deviation
Xi = Rainfall
Xr = Average Rainfall
n = Number of data

Calculate the frequency factor (K) value from rainfall data recorded at the local rain station using the following formula.

$$\text{K} = \frac{Yt - Yn}{Sn}$$

Calculate rain using an annual return period plan with the following formula.

$$\text{Xt} = Xr + (K.Sd)$$

Where;

Xt = Annual rainfall plan
K = Frequency factor
Xr = Average Rainfall
Sd = Standard deviation

Tabel 2. Reduced Mean (Yn)

n	0	1	2	3	4	5	6	7	8	9
10	0.4952	0.4996	0.5035	0.507	0.51	0.5128	0.5157	0.5181	0.5202	0.522
20	0.5236	0.5252	0.5268	0.5283	0.5296	0.53	0.582	0.5882	0.5343	0.5353
30	0.5363	0.5371	0.538	0.5388	0.5396	0.54	0.541	0.5418	0.5424	0.543
40	0.5463	0.5442	0.5448	0.5453	0.5458	0.5468	0.5468	0.5473	0.5477	0.5481
50	0.5485	0.5489	0.5493	0.5497	0.5501	0.5504	0.5508	0.5511	0.5515	0.5518
60	0.5521	0.5524	0.5527	0.553	0.5533	0.5535	0.5538	0.554	0.5543	0.5545
70	0.5548	0.555	0.5552	0.5555	0.5557	0.5559	0.5561	0.5563	0.5565	0.5567
80	0.5569	0.557	0.5572	0.5574	0.5576	0.5578	0.558	0.5581	0.5583	0.5585
90	0.5586	0.5587	0.5589	0.5591	0.5592	0.5593	0.5595	0.5596	0.8898	0.5599
100	0.56									

Source: Ir C.D Soemarto, 1999

Tabel 3. Reduced Standard Deviasi (Sn)

n	0	1	2	3	4	5	6	7	8	9
10	0.9496	0.9676	0.9833	0.9971	1.0095	1.0206	1.0316	1.0411	1.0493	1.0565
20	1.0628	1.0696	1.0754	1.0811	1.0864	1.0915	1.0961	1.1004	1.1047	1.108
30	1.1124	1.1159	1.1193	1.226	1.226	1.1255	1.1285	1.1313	1.1363	1.1388
40	1.1413	1.1436	1.1458	1.148	1.1499	1.1519	1.1538	1.1557	1.1574	1.159
50	1.1607	1.1623	1.1638	1.1658	1.1667	1.1681	1.1696	1.1708	1.1721	1.1734
		1.1759	1.177	1.1782	1.1793	1.1803	1.1814	1.1824	1.1834	1.1844
		1.1863	1.1873	1.1881	1.189	1.1898	1.1906	1.1915	1.1923	1.193
		1.1945	1.1953	1.1959	1.1967	1.1973	1.198	1.1987	1.1994	1.2001
		1.2013	1.2026	1.2032	1.2038	1.2044	1.2046	1.2049	1.2055	1.206

Source: Ir C.D Soemarto, 1999

Tabel 4. Reduced Variate (Yt)

No	PeriodeUlang	ReducedVariate
1	2	0.3665
2	5	1.4999
3	10	2.2502
4	20	2.9606
5	25	3.1985
6	50	3.9019
7	100	4.6001
8	200	5.2960
9	500	6.2140
10	1000	6.9190
11	5000	8.8390
12	10000	9.9210

Source: Ir C.D Soemarto, 1999

3. Base Flow

Base flow is the part of rainfall that experiences infiltration and percolation into groundwater reservoirs and out of rivers as spring seepage. Base flow is presented as follows (Viera Wim Andiese, 2012).

$$QB = 0{,}4751 \; x \; A^{0{,}6444} x \; D^{0{,}9430}$$

Where:

QB = Base Flow (m3/sec)
A = area (km2)
D = Drain network density, (km/km2)

RESEARCH RESULT

Hydrological Analysis

1. Rainfall Frequency Analysis

There are several types of distribution that can be used to determine the amount of planned rainfall, such as the Gumbel distribution, Log Person Type III, Log Normal and several other methods. This method must be tested which can be used in the calculations. This test involves measuring depression.

To calculate the design debit for various return periods, use the Gumbel method.

2. Dispersion Measurement

Not all hydrological values are located or equal to the average value, but there may be values that are greater or less than the average value. The magnitude is carried out by measurement, namely through parametric calculations for (Xi–X), $(Xi–X)^2$, $(Xi–X)^3$, $(Xi–X)^4$ first.

Where :

Xi = Amount of rainfall in the watershed (mm)

X = Average regional maximum rainfall (mm)

Types of able se measurements include the following:

1. Standard Deviation (Sd)

$$\mathrm{Sd} = \sqrt{\frac{\sum_{i=1}^{n}(Xi - Xr)^2}{n-1}}$$

Where :

Sx = Standard deviation

Xi = Average rainfall

Xr = Average price

2. Skewness Coefficient (Ck)

$$\mathrm{Cs} = \frac{n\sum(Xi - Xr)^3}{(n-1)(n-2)Sd^3}$$

3. Kurtosis Coefficient (Ck)

$$\mathrm{Ck} = \frac{n\sum(Xi - Xr)^4}{(n-1)(n-2)xSd^4}$$

4. Coefficient of Variation (Cv)

$$Cv = \frac{Sd}{Xr}$$

The calculation requires several parameters which are presented in table 5 below:

Table 5. Pringgarata Station Annual Rainfall Data

Year	Month												Rmak
	1	2	3	4	5	6	7	8	9	10	11	12	R24
2019	351	134	326	244	22	22	0	4	12	-	75	366	366
2020	185	200	472	452	220	9	21	49	21	331	241	208	472
2021	253	221	184	182	84	285	13	22	80	214	401	480	480
2022	148	369	240	149	168	148	30	73	106	487	496	510	510
2023	191	415	220	224	74	10	56	1	5	18	338	300	415

Source: BMKG Kediri

Depression Calculation

After getting the average rainfall from influential stations in the river basin, it is then analyzed statistically to obtain a distribution pattern that matches the existing average rainfall distribution. For this reason, the average price is calculated. (Table 4.2).

Table 6. Results of Normal Statistical Calculation of Gebong Irrigation Rainfall

Xi	Xi-X	Xi-X^2	Xi-X^3	Xi-X^4
366	-82,6	6822,76	-563560	46550054
472	23,4	547,56	12812,9	299822
480	31,4	985,96	30959,14	972117,1
510	61,4	3769,96	231475,5	14212598
415	-33,6	1128,96	-37933,1	1274551
X = 2243 N = 5 Xr = 448,6		**13255,2**	**-326245**	**63309142**

Source: Analysis results

After analyzing the rainfall data, it was obtained:
Standard Deviation (Sd) = 28,78
Skewness Coefficient (Ck) = 5,70
Kurtosis Coefficient (Ck) = 0,08
Coefficient of Variation (Cv) = 0.06

Gumbel Method Rainfall Analysis

To determine the magnitude of the planned flood discharge that will occur on the Babak River, the maximum possible daily rainfall is first sought. The method used in calculating maximum rainfall is the Gumbel method.

The Gumbel distribution is used for maximum data analysis, for example for flood frequency analysis.

The Gumbel distribution has a coefficient of skewness or Cs = 1.139 and a coefficient of kurtosis or Ck < 4.002.

The steps for calculating planned rainfall using the Gumbel Method are as follows:

Table 7. Gumbel Method Distribution Calculation

Xi	Xi-X	Xi-X^2	Xi-X^3	Xi-X^4
366	-82,6	6822,76	-563560	46550054
472	23,4	547,56	12812,9	299822
480	31,4	985,96	30959,14	972117,1
510	61,4	3769,96	231475,5	14212598
415	-33,6	1128,96	-37933,1	1274551
X = 2243 n = 5 Xr = 448,6		**13255,2**	**-326245**	**63309142**

Source: Analysis Results

Table 8. Results of Planned Precipitation Analysis for Each Return Period T Year

Tr (Thn)	Xr (mm)	Yt	Yn	Sn	K	Sx (mm)	X_{Tr}
1	2	3	4	5	6=3-4/5	7	8
2	448,6	0,366	0,512	1,020	-0,136	28,78	444,687
5	448,6	1,499	0,512	1,020	0,997	28,78	477,295
10	448,6	2,250	0,512	1,020	1,748	28,78	498,909
20	448,6	2,960	0,512	1,020	2,458	28,78	519,342
25	448,6	3,198	0,512	1,020	2,696	28,78	526,192
50	448,6	3,901	0,512	1,020	3,399	28,78	546,424
100	448,6	4,600	0,512	1,020	4,098	28,78	566,542

Source: Analysis results

Base Flow Calculation Base Flow (QB)

The watershed data is known as follows:

River Basin Area (A) : 259 km^2

River Length) : 55 km

Length of river along level (L') : 75 km

a. Network density (D)

D = L'/A

= 76 / 259

= 0.289

b. Base flow base flow (QB)

QB = 0.4751 * A0.6444 * D0.9430

= 0.475 * 259.6444 * 0.2890.9430

= 0.475 * 35.903* 0.310

= 5.289 m3 /sec

DISCUSSION

After observing and analyzing data at the research location in the Babak river basin, a watershed with an area of 259 km2, there was a fluctuation in discharge during the rainy season, this was due to sedimentation in the area upstream of the weir, which every day if material such as sand was not taken by the mining community, then The function of the weir as a building that can raise and store water for irrigation purposes, etc., cannot function optimally. If left unchecked, this will also have an impact on farmer production. To maintain water balance in the weir, the government must carry out regular maintenance.

CONCLUSIONS AND RECOMMENDATIONS

After analyzing the rainfall data obtained at the BMKG (Meteorology and Geophysics Agency) West Lombok Regency office, the rainfall plan for various return periods using the Gumbel method is as follows: 2 years = 444,687; 5 years = 477,295; 10 years = 498.909 mm; 20 years = 519.342 mm; 25 years = 526.192 mm; 50 years = 546.424 mm; 100 years = 566.542 mm. Based on the Babak Watershed Characteristics data and data analysis, it was obtained that the base flow discharge in the Babak Weir River Gebong River area, Central Lombok Regency was = 5,289 m^3/sec

ADVANCED RESEARCH

This research is certainly not perfect and there are still many shortcomings, this is because the rainfall data analyzed is only data from the last 5 years, in order to get maximum and more thorough results, longer rainfall recording data is needed. It is recommended for further research to improve it.

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REFERENCES

Kevin Alvaisha Matondang, Abu, Asep, Ganda, Yasin, Nario, 2014. Base Flow. Jakarta: STTP-PLN.

National Standardization Agency. 2004. Indonesian National Standards (SNI). RSNIT-02- 2004. Procedures for Calculating Planned Flood Discharge. Indonesian Standardization Council: Jakarta.

National Standardization Agency. 2016. Indonesian National Standards (SNI). SNI 2415- 2016. Procedures for Calculating Planned Flood Discharge. Indonesian Standardization Council: Jakarta.

Ratna Oktavia Budiono, 2014. Estimation of Maximum Possible Rainfall in River Watersheds in Situbondo Regency Using the Hersfield Method. Jember: Jember University.

Soemarto, C.D. 1999. Engineering Hydrology, II Edition. Jakarta: Erlangga

Sri Harto Br, 2000, Hydrology. Theory, Problem-Solution, Nafiri Off-set, Yogyakarta

Suyono Sosrodarsono, 2019, Directorate General of Water, Department of Public Works and Electrical Power, PT. Pradnya Pramika, Jakarta