International Journal of Scientific Research in Science and Technology
Print ISSN: 2395-6011 | Online ISSN: 2395-602X (www.ijsrst.com)
doi : https://doi.org/10.32628/IJSRST1229649

Flood Control of Kupang River, Pekalongan

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Article Info
Volume 9, Issue 6
Page Number : 516-520

Publication Issue
November-December-2022

Article History
Accepted : 01 Dec 2022
Published : 15 Dec 2022

ABSTRACT
The local community in Pekalongan suffered financial losses as a result of the Kupang River flood. To control floods in the Kupang watershed, this research aims to identify the most effective way to lower the discharge that flows downstream due to heavy rainfall. HEC-HMS modeling was used to analyze flood discharge. The result from an analysis of flood discharge in the existing conditions downstream of the Kupang River with a 100-year returns period is 641.6 m³/s. This study will include 9 locations of the potential reservoir as flood control that will be simulated using small dams and dry dams. The discharge analysis results from modeling a small dam can reduce the discharge by 261.9 m³/s, or 40.8%. On the other hand, the dry dam simulation can reduce flood discharge by 406 m³/s, or 64.8%. According to the analysis's results, using a dry dam to reduce the amount of water that is discharged into the upstream watershed is the most efficient way to manage floods. As a result, the dry dam method is ideal for controlling floods from the Kupang upstream watershed.

Keywords: Flood, HEC-HMS, Dry dam, Small dam

I. INTRODUCTION

Flooding is a common issue in regions of Indonesia, particularly in densely populated areas, such as cities. The damages that can be incurred are rather enormous, both in terms of material and human losses, thus it is understandable that the problem of flooding requires urgent attention [1].

Some of the activities carried out to control flooding in the Kupang watershed include installing parapets and raising embankments at the Loji river (Kupang River's downstream), and study of the motion weir in the lower reaches of the Loji river.

Several developed countries have made innovations in flood control by using dry dams, for example, the Masudagawai Dam in Japan, and Miami's Conservancy District Ohio Dam in the United States [2]. A dry dam is located in a riverbed and water is made to flow continuously through an outlet positioned at roughly the same level as the riverbed so that no water is retained under normal situations. Sediment and fish also are able to pass through [3].

There hasn't been any mention of using dry dams to reduce flood output in the studies that have been done so far in the Kupang River. Therefore, the purpose of this study was to evaluate the efficiency of dry dams in preventing flooding along the Kupang River.

II. METHODS AND MATERIAL

A. *Material*

This research begins by collecting the necessary data as material for flood analysis in the Kupang watershed. The data used in this study include:

- Rainfall data. Rainfall data is in the form of daily rainfall data with a minimum length of 10 years for each rain station for flood discharge analysis, and hourly rainfall data for model calibration.
- Observation discharge data.
- Land use map.
- Soil-type map.
- Topographic maps.

B. *Hydrological analysis*

The steps in analyzing the discharge in the Kupang River are as follows:

1) Set the catchment area. The catchment area is determined by connecting the ridges surrounding a river or tributary with the help of a contour map using AutoCad.

2) Calculation of regional rainfall. This analysis uses the Thiessen method. Based on the relative areas of each measuring station in the Thiessen polygon network, this method uses a graphical technique to determine station rainfall weights [4].

3) Determine the rainfall using the normal distribution method, Log normal, Log person III, and Gumbel. that distribution is then evaluated on the results of the rain calculation obtained from the four methods using the Chi-square test and Smirnov Kolmogorov.

C. *Analysis of existing flood discharge, the addition of small dams and dry dams*

Flood discharge analysis in this study used hec-hms software with the Soil Conservation Service (SCS) dimensionless synthetic unit hydrograph method. The hec-hms modeling process is performed by the requirements of the research. The components inputted in the HEC-HMS simulation are as follows:

1) Basin model: contains the area of the catchment area with the selected loss method and transform method.
2) Meteorologic models: to determine the precipitation method
3) Control specification: the start and end times of running the simulation.
4) Time-Series Data: results of analysis of design rainfall with the return period used.

In this analysis, the discharge to be calculated is the existing flood discharges, flood discharges after small dam simulations, and flood discharges after dry dam simulations. Existing discharge is discharge with a certain return period that passes through the existing wet section. Small dams are any earth or concrete dams less than 15 meters in height, and with a low to moderate hazard potential [5]. While the dry dam is simulated with a small dam that has several outlets installed at the bottom of the dam.

III. RESULTS AND DISCUSSION

Use a map consisting of the contours of the area and the rivers that flow within it to determine the boundaries of a catchment area. The Kupang River catchment area has an area of 220 km^2. The following Fig. 1 is the result of determining the watershed with a red line.

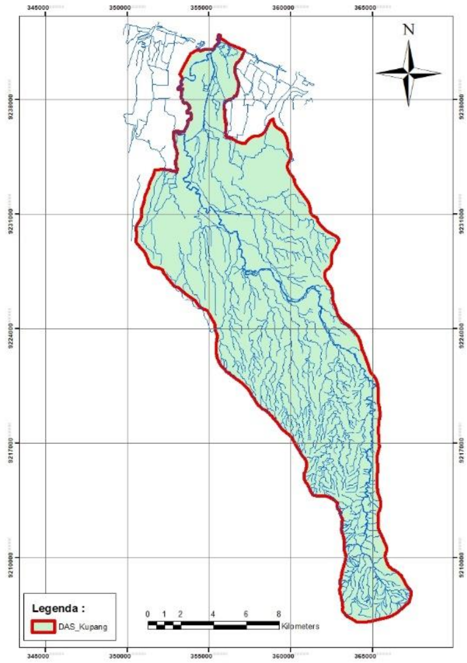

Fig 1. Kupang river's catchment area

The average daily maximum rainfall of the watershed is calculated using the Thiessen Polygon Method, taking into account the area of influence of each observation point. This analysis is intended to determine the average maximum daily rainfall that occurs in the catchment area by multiplying the maximum daily rainfall data obtained from rain gauge stations, with the weight of influence of each rain gauge station. From the average daily maximum rainfall of the stations compared, the one with the highest average daily maximum rainfall value is taken as the rainfall in the Kupang catchment area.

Maximum daily rainfall data is then tested using four distributions there are Gumbel, Log Normal, Pearson III log, and normal distribution. Based on the results of calculating the statistical parameters of the planned rainfall with various distribution methods, then the distribution that is closest to or matches the existing data is selected. From the results of the analysis, it was found that the statistical parameters that met the requirements were the normal distribution with the magnitude of the rainfall return period as shown in Table 1.

Table 1. Return period of Kupang CA

No	Return Periode (Years)	Rainfall Intensity (mm)
1	2	95
2	5	129
3	10	157
4	20	187
5	25	191
6	50	233
7	100	273
8	200	319
9	500	390
10	1000	452

In this study, researchers will do two simulations to reduce flood discharge, with small dams and dry dams. The two simulations will be compared with the existing conditions so that it can be seen how much these models can reduce flooding. From the topographic map, several potential locations for the reservoir are made based on the contour in the form of a basin. Determining the location of a reservoir must take into account several factors, namely a sufficient basin to hold water, especially in locations where the geotechnical conditions do not allow water to pass so that only a small amount of water is lost. Nine potential reservoir locations can be used for research. The locations of these reservoirs can be seen in Table 2.

Table 2. Potensial of Reservoir in Kupang CA

No	Reservoir	Catchmen Area
1	Reservoir-Hulu	27.18
2	Reservoir-Tengah	35.13
3	Reservoir-Hilir	62.17
4	Reservoir-1	10.07
5	Reservoir-2	11.96

6	Reservoir-3	19.59
7	Reservoir-4	14.96
8	Reservoir-5	1.26
9	Reservoir-6	11.96

With the potential location of the reservoir above, small dams and dry dams modeling are analyzed using the HEC-HMS model (fig 2). In this modeling, the return period used is the 100-year return period for small dam and dry dam simulations.

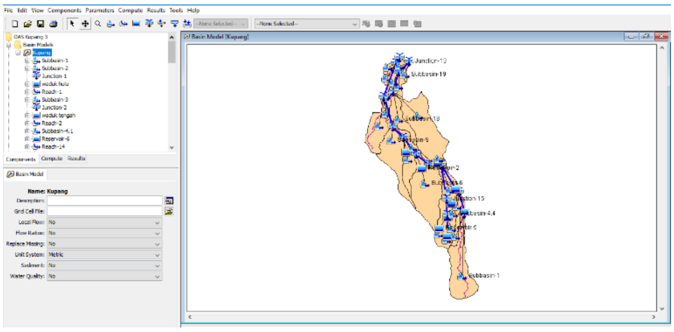

Figure 2: HEC-HMS model

When modeling the reservoir in HEC-HMS, storage capacity data is required. The data on storage capacity is needed for inputting each reservoir for example data for the Reservoir-hilir as seen in table 3. To find out the efficient reservoir height using the graph contains the relationship between elevation-volume (fig. 3). The intersection between the volume and elevation lines is the efficient weir height.

Table 3. Storage capacity of the Reservoir-hilir

No	Contour	Catchment Area	Cumulative Volume
	(m)	(km²)	10^6 (m³)
1	145	0.01	0.00
2	150	0.02	0.64
3	155	0.04	2.00
4	160	0.06	4.34
5	165	0.09	8.06
6	170	0.13	13.64
7	175	0.18	21.35
8	180	0.25	32.08
9	185	0.35	47.14

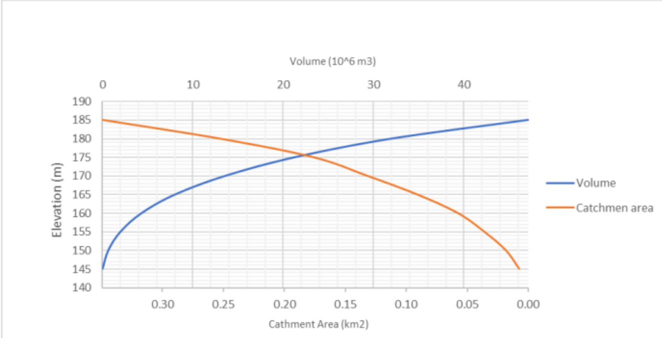

Figure 3: Reservoir-storage curve Reservoir-hilir

After modeling, it is known that the maximum discharge existing of the Kupang River is 641.6 m³/second as well as the results of small dams and dry dams as shown in table 4.

Table 4. Discharge summary table

Information	Discharge 100 th (m³/s)		
	Existing	Small Dam	Dry Dam
Downstream of the Kupang River	641.6	379.7	225.6

The output of the HEC-HMS is also obtained by the flood hydrograph as shown in Figure 4. Based on the graph, when the existing conditions the flood discharge with a peak of 641.6 m³/s occurs for 10 hours. Then if a small dam is simulated, the peak discharge which was originally 641.6 m³/s will decrease to 379.7 m³/s with a longer time of 13 hours. Whereas if it is simulated using a dry dam, the peak discharge will be 225.6 m³/s with a time of 23 hours.

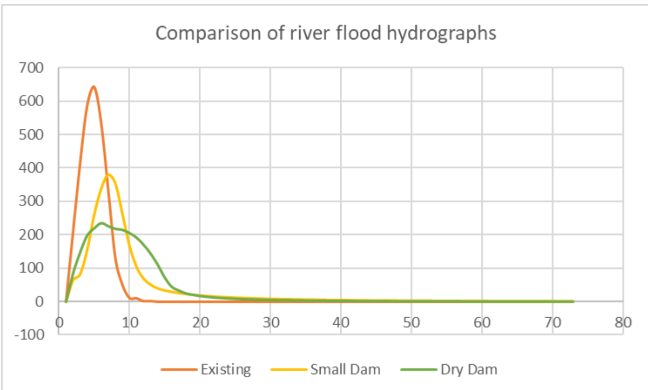

Figure 4: flood hydrographs

From the results of the analysis, it is known that the addition of a small dam can reduce maximum flood discharge by 261.9 m^3/s or 40.8 %, and using a dry dam can reduce the maximum flood discharge by 416 m^3/s or 64.8% as seen in table 5.

Table 5. Flood discharge reduction table

Information	Small Dam		Dry Dam	
	(m^3/s)	(%)	(m^3/s)	(%)
Downstream of the Kupang River	261.9	40.8	416	64.8

IV. CONCLUSION

Flood control of the Kupang River can be done by reducing the discharge in the reservoir in the upstream watershed. The reservoir modeling can be in the form of a small dam or a dry dam. The flood discharge of the Kupang River obtained using the HEC-HMS in the existing conditions is 641.6 m^3/s. With the small dam plan, the discharge obtained is 379.7 m^3/s, so the amount of reduced flooding can be calculated at 261.9 m3/sec or 40.8 percent. Meanwhile, with the Dry Dam Plan, the flood discharge was obtained at 225.6 m^3/s, so the amount of reduced flooding can be calculated at 416 m^3/s or 64.8 percent. Based on the results of the research that has been done, it is necessary to conduct further research on the morphology of the Kupang river due to the existence of a dry dam, and analysis of sedimentation and erosion as operational costs for maintaining the dry dam.

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Cite this article as :

Jehandyah Erma Pahlevari, "Flood Control of Kupang River, Pekalongan", International Journal of Scientific Research in Science and Technology (IJSRST), Online ISSN : 2395-602X, Print ISSN : 2395-6011, Volume 9 Issue 6, pp. 516-520, November-December 2022. Available at doi : https://doi.org/10.32628/IJSRST1229649

Journal URL : https://ijsrst.com/IJSRST1229649