

IDF Curve Patterns for Flood Control of Air Lakitan river of Musi Rawas Regency

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IDF Curve Patterns for Flood Control of Air Lakitan river of Musi Rawas Regency

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Abstract. The problem of flooding in a Watershed (Basin) or region is caused by natural conditions, such as relatively high rainfall, sloping topographic conditions and tidal influences. Human behaviour is often also the cause of flooding problems, such as the location of settlements that are in the river borders or industries that dump waste directly into river bodies. Besides the problem of flooding can also be caused by a not well-organized river/drainage system or lack of maintenance of an existing river/drainage system. Furthermore, social problems include increasing demands for the availability of new and good residential environmental infrastructure.

To overcome the problems as described above, before an activity such as build in a left/right inspection road planning, is need analysis rainfall data and make patterns of Intensity Duration Frequency (IDF) Curve to an analysis of hydraulics in determining flood discharge plans. The results showed that the discharge of river capacity of Air Lakitan river was 482.74 m³/seconds, so the river is unable to hold water flow.

1. Introduction

Musi Rawas Regency has ± 254 rivers covering large rivers and small rivers, with the Air Lakitan River Watershed, Semangus Watershed, Kelingi Watershed and Musi Watershed. Besides having potential utilization, these rivers also have the potential for water damage, namely flood. With the collection of river discharge and profile data in Musi Rawas Regency, it will facilitate the Public Works Cipta Karya, Spatial Planning and Irrigation Agency to utilize and control the river so that problems caused by the river can be minimized.

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Besides the problem of flooding can also be caused by a not well-organized river/drainage system or lack of maintenance of an existing river/drainage system. Furthermore, social problems include increasing demands for the availability of new and good residential environmental infrastructure.

To overcome the problems as described above, an activity that results in a left / right inspection road planning, reclamation and installation of river talud in Musi Rawas Regency in an integrated manner both structurally and non-structurally, as well as an urgent program output to be carried out.

Thus, a benefit will be obtained from efforts to overcome the causes of flooding caused by local natural conditions/conditions, for example, by utilizing retarding ponds and spatial planning.

Based on Law no. 7 of 2004 concerning Water Resources that it is necessary to have appropriate activities for flood management patterns in accordance with conditions on the ground and the habits of the local community. In article 51 paragraph (1) it is necessary to immediately disseminate correctly to various groups, especially in the regions that flood control is prioritized on prevention activities or non-physical (non-structural) activities besides physical activities. This is a priority approach to flood control patterns.

2. Theory and Hypotheses

2.1. River flow

The river channel in the watershed is categorized as a "mainstream". It has a relatively sloping and long base slope because the leading causes are upper erosion sedimentation, river bends and local geological conditions. The condition of the river channel in Musi Rawas Regency is still relatively good, meaning that whatever the flow capacity that will enter the trough is still able to be accommodated, even some river channels can function as river transportation channels. However, there are some river segments that function as fish ponds, and this is very disturbing in the flow movement. Rising riverbed causes a decrease in flow capacity and flooding. Some residential areas will also be flooded due to overflow from river banks. For this reason, it is necessary to confirm from the local government regarding the regulation of river channel functions with precise regulations. In some places, there is damage to river basins and cliffs, especially at river bends because river basins have relatively large tree branches and this will disrupt the flow in the river and will be a factor in the flow capacity.

2.2. Problems and Causes of Flooding

Flooding in the river of Musi Rawas Regency which occurred several years ago is a flood event caused by overflowing of the river in Musi Rawas Regency, which inundates residential areas. The average inundation height was almost 1.00 meters, and the length of inundation was two days (results of interviews with residents). In addition to the river that functions as the mainstream, there are also small rivers that function as collector and conveyor drain from both the road inlet and other residential areas. It is indicated that these small rivers that do not function when it rains where the storage capacity is not able to drain the rainwater into rivers in Musi Rawas Regency.

Of course, with the flooding, all facilities and infrastructure in the Musi Rawas Regency were disrupted, including houses that could not be used due to flooding, public health was disrupted by the emergence of various diseases including schools being forced to be temporarily closed and total mobility and paralysis of transportation including the economy unable to walk as usual does not include loss of property including many lost and dead livestock. Rainfall is quite high with duration / length of rain 1-3 hours and small rivers or natural drainage channels that have not all been carried out revitalization following conventional design so that it will add to the problem of flooding because the overflow of water from natural drainage / small rivers overflows and fills all low basins as well as carrying sediment into the drainage channel that has not been arranged and into the river in Musi Rawas Regency as the "mainstream" earlier.

The problem of flooding is the problem of losses incurred, so the effort to overcome flooding is an effort to reduce losses to the smallest possible extent. Even so, there are several ways to overcome the loss of handling events and their effects so that the losses incurred can be reduced as little as possible. So the purpose of flood mitigation activities (flood loss and management) is to reduce losses due to flooding because it realizes that it is not possible to eliminate floods.

Another cause is the management of forest functions which, if the control program is not followed and adjusted to the existing land use plan and transparent regulations, then the change in the function of protected forests to productive forests is one of the causes of flooding. Besides regulating the river/drainage system, especially the border area of the river, the disposal of industrial waste, especially oil that is not controlled and the absence of an active role of the community in terms of land use is the cause of flooding.

Often there is a misperception in the community that if a flood control building has been created, certain areas will be free from flooding though every building is designed with specific planning parameters. He is only able to withstand certain conditions in accordance with the parameters of the planning because it is not understood then the misperception arises that they can build anything.

2.3. Losses Due to Flooding

Inundations that occur due to river flooding in Musi Rawas Regency, especially on both sides of the river have developed into residential areas. This will be a problem that affects many aspects including economic, social, health and aesthetics. The losses incurred both direct and indirect losses, economically reviewed, some can be calculated, but some are difficult to calculate. When it comes to genes

3. Research Methods

3.1. Regional Planning Description

Considering that the river in Musi Rawas Regency is the main river (mainstream) which, among other things, aims to maintain the capacity of the riverbed, and pay attention to the following factors:

1. The planning area is classified as a slightly bumpy area.
2. The topography of the area which is relatively flat and partly marshy is in the form of a basin or depression.
3. Geologically the soil is sedimentary soil with reduced carrying capacity and a large permeability of $1.09 \times 10^{-3} \text{ kg / cm}^3$.

3.2. Location and Area of Planning

The planning area is technically located in Musi Rawas Regency with coverage of discharge measurement data along the Air Lakit River, Kelingi River, Semangus River and Musi River. Based on the hydrological analysis and hydraulics analysis, if necessary, river system design includes strengthening river banks with river or concrete construction, wire gabions or crib buildings, river normalization and making river/left/ right inspection roads.

3.3. Return Period

Re-determination period based on how:

3.3.1. Empirical Method

Observation data of past events to predict future events with the same magnitude. Opportunities for extreme events in the "N" year will be repeated in the next "n" year expressed by:

$$P(N, n) = n / N + n \quad (3.1)$$

3.3.2. Risk Analysis

The risk of failure from the planned building is a risk analysis stated in the equation:

$$R = 1 - \{1 - 1/T\}^n \quad (3.2)$$

with:

R = The probability that $Q \geq Q_t$ happens at least once in n year.

3.3.3. Hydro-economic analysis

This analysis is a super-impose of "Risk Cost" and "Capital Cost."

3.4. Hydrology

Considering the availability of hydrometric data is not yet available properly, then as a basis for hydrological calculations used rain data. The rain data used is the rain data from the recording of several stations in the planning area and has quite long data, from 1990 to 2008. The average rainfall value is taken from the maximum monthly rainfall data. For estimating rainfall, a frequency analysis is used by reviewing the distribution that is commonly used.

3.4.1. Estimated Rain Plan

a. Over one year

Estimated rainfall plans are carried out by frequency analysis of annual maximum rainfall data (annual series). There are some statistics in the distribution, and which are commonly used in frequency analysis there are 4 (four) types, namely:

- 1). Normal
- 2). Gumbel type I
- 3). Normal log 2 parameters
- 4). Pearson type III logs

Each distribution has unique statistical characteristics. By calculating the statistical parameters of the analyzed data set, it can be estimated which distribution is suitable for that data set. The intended statistical parameters are as follows:

$$X = \frac{\sum xi}{n} \quad (3.3)$$

$$S = \sqrt{\frac{(xi - xr)^2}{(n - 1)}} \quad (3.4)$$

$$Cs = \frac{n}{(n - 1)(n - 2)S^3} \sum (xi - xr)^3 \quad (3.5)$$

$$Cv = \frac{n}{(n - 1)(n - 2)(n - 3)S^4} \sum (xi - xr)^4 \quad (3.6)$$

with:

xr = mean value

S = standard deposit (standard deviation)

Cs = Skewness coefficient

Cv = coefficient of kurtosis (curtosis coefficient)

xi = rain data

n = amount of data

As for the unique statistical nature of each distribution, it can be explained as follows:

1). Normal distribution

Characteristics: $C_s = 0$

Probability $P(x-S) = 15.87\%$

$P(x) = 50.00\%$

$P(x+S) = 84.14\%$

The possibility of variates that are at intervals $x - S$ and $x + S = 68.27\%$ and those that are at intervals $x - 2S$ and $x + 2S = 95.44\%$.

2). Normal log distribution (2 parameters)

Characteristics: $C_s = 3 C_v$

C_s are always positive

Probability line equation: $x(t) = x + K$

With $x(t)$ = depth of rain with the return period t (years) K = Frequency factor

3). Gumbel type I distribution

Characteristics: $C_s = 1.3960 C_v$

$C_k = 5.4002$

Probability line equation:

$$X(t) = x + \frac{\sigma}{\sigma n} (y - y_n) \quad (3.7)$$

with: Y = reduced variated

y_n and δn = The mean value and standard deviation of reduced variated.)

4). Log Pearson type III distribution

The statistical data do not approach the characteristics of the three previous distributions.

The rain data is transformed into its natural logarithmic value so that the values of x_i change to $\ln x_i$. Then calculate the average value, standard deviation and the skewness coefficient as follows:

$$\bar{\ln x} = \frac{\sum_{i=1}^n \ln x_i}{n} \quad (3.8)$$

$$S = \sqrt{\frac{\sum_{i=1}^n (\ln x_i - \bar{\ln x})^2}{(n-1)}} \quad (3.9)$$

$$C_s = \frac{n}{(n-1)(n-2)S^3} \sum_{i=1}^n (\ln x_i - \bar{\ln x})^3 \quad (3.10)$$

probability equation:

$$\ln x(t) = \overline{\ln x} + K S \quad (3.11)$$

K is the frequency factor

4. Result and Discussion

4.1. River flow

The river channel in the watershed is categorized as a "mainstream". It has a relatively sloping and long base slope because the leading causes are upper erosion sedimentation, river bends and local geological conditions. The condition of the river channel in Musi Rawas Regency is still relatively good, meaning that whatever the flow capacity that will enter the trough is still able to be accommodated, even some river channels can function as river transportation channels. However, some river segments function as fish ponds, and this is very disturbing in the flow movement. Rising riverbed causes a decrease in flow capacity and flooding. Some residential areas will also be flooded due to overflow from river banks. For this reason, it is necessary to confirm from the local government regarding the regulation of river channel functions with precise regulations. In some places, there is damage to river basins and cliffs, especially at river bends because river basins have relatively large tree branches and this will disrupt the flow in the river and will be a factor in the flow capacity.

Estimated rainfall plans are carried out by frequency analysis of annual maximum rainfall data (annual series). There are several statistics in the distribution, and which are commonly used in frequency analysis there are 4 (four) types, namely: 1). Normal; 2). Gumbel type I; 3). Standard log 2 parameters; and 4). Pearson type III logs

Each distribution has unique statistical characteristics. By calculating the statistical parameters of the analyzed data set, it can be estimated which distribution is suitable for that data set. The intended statistical parameters as a result of value design rainfall are as follows:

Table 4.1. Value of Design Rainfall with every Return Period

Results of Rainfall analysis				
Return Period	Rainfall Frequency Analysis (mm)			
	Normal	Log Normal	Log Pearson Type III	Gumbel
5	542,304	139,711	486,191	557,249
10	593,813	153,019	561,098	643,347
25	642,982	166,901	678,243	752,121
50	683,956	179,428	782,738	832,816
100	716,735	190,123	903,333	912,926

Resources: analysis result, 2019

4.2. IDF Curve

After analyzing the daily rainfall from the available rainfall data, we obtain the curvature of the rainfall curve with a variety of return periods of 2, 5, 10, 15, 20, 50 and 100 years as shown in figure 4.1.

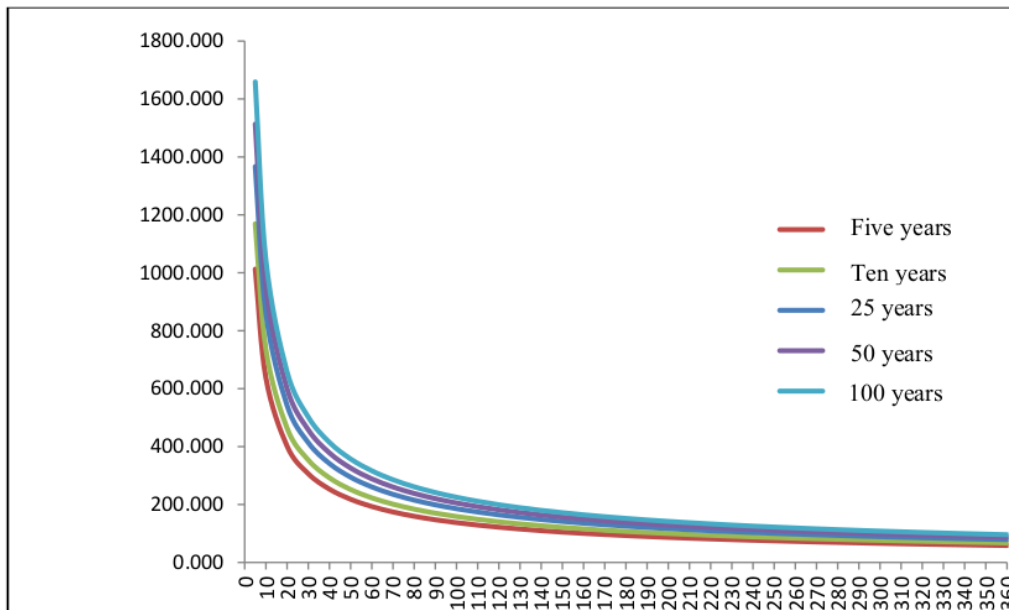


Figure. 4.1. IDF curve patterns Air Lakitan river

4.3. River flow capacity according to Regime Theory

Based on regime theory, the flow capacity in the Air Lakitan river is as follows

Table 4.2. River capacity (Regime theory)

No	Item		Lakitan river
1	D ₅₀ (average diameter)	mm	0,50
		inchi	0,02
2	h (water level)	ft	12,00
		M	3,66
3	f (silt factor)		1,12
4	U (velocity)	ft/sec	4,22
		m/sec	1,29
Field data			
5	A (wet area)	ft ²	4.039,29
		m ²	375,26
6	P (wet width)	ft	348,42
		M	106,20
7	R (hydraulic radius)		11,59
8	<i>Q (bankfull)</i>	ft ³ /sec	17.047,96
		m ³ /sec	482,74

No	Item		Lakitan river
9	I (river slope) river regime		0,00013
10	I (river slope) measured in the field		0,00035
11	<i>Conclusion of river slope</i>		Upstream eroded and downstream buried
12	<i>Flood discharge (Q_{100})</i>	m^3/sec	1.391,01
13	<i>Conclusions of riverbed</i>		Riverbed is not able
14	<i>The remaining capacity need to be accommodated</i>	m^3/sec	908,27
15	<i>Action required</i>		Hold water upstream or create a flood embankment

Source: analysis result, 2019

4.4. River capacity according to of strickler formula

From the investigation of Air Lakitan river capacity based on the strickler's formula, the obtained solar water assembly capacity is as follows.

Table 4.3. River capacity (stricklers)

No	Item		Air Lakitan river
1	h (water level)	m	
2	b (width)	m	
3	Slope m		
4	A (wet area)	m ²	256,76
5	P (wet width)	m	65,91
6	R (hydraulic radius)	m/m	3,90
7	n (Manning's coefficient)		0,023
8	I (river slope)		0,00010
9	U (velocity) based on Manning's n	m/sec	1,05
10	<i>Q (bankfull)</i>	<i>m³/sec</i>	<i>270,61</i>
11	<i>Flood discharge (Q₁₀₀)</i>	<i>m³/sec</i>	<i>1.076,59</i>
12	Conclusion riverbed		Riverbed is not able
13	Remaining capacity not to be accommodated	<i>m³/sec</i>	<i>805,98</i>

Source: analysis results, 2019

5. Conclusion

IDF rainfall curve is a preliminary data analysis that is very important in determining the capacity of the river. Based on the results of rainfall analysis of 100 year return period was chosen in the study of Air Lakitan river.

From the calculation of river capacity based on the regime theory, the water river capacity of the assembled river water is 482.74 m³/sec smaller than the results of the calculation of the planned flood discharge which is 1,391.01 m³/sec. That means the riverbed is not able to accommodate the existing discharge.

Based on the calculation of the capacity using the strickler's formula, the capacity of Air Lakitan river of 270.61 m³/sec. A means that the tributary river can not accommodate the existing discharge.

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