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Effect of Water on Flow Fluctuation in River Flow

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Abstract
River water fluctuations affect the amount of inundation that occurs. The study aims to obtain a cross-section of the river channel to drain runoff water so that the runoff due to maximum rainfall does not cause puddles. The Ketupak river flow cannot drain flow during the rainy season. Besides that, there is also a lot of sediment, garbage, stems and branches that interfere with the Ketupak river flow. Therefore, it is necessary to rearrange the river channel. From the results of calculations based on rainfall data, it is necessary to increase the cross-sectional area of the river.

Keywords:
Change in Cross-Sectional Area;
Channel Capacity;
Flow Rate;
River Fluctuation;

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INTRODUCTION

In recent years, water resources have become a hot topic in public discussion and reporting political problems that are always frenzied in this country. Various water resources disasters, ranging from annual floods or flash floods, collapsed reservoirs, landslides, seawater instrumentation, water level decline or drought, to peatland fires as if incessantly hitting and taking turns. In print media, this issue is always reported on the front page. Nature is no longer friendly to us caused of humanity's unfriendliness towards the environment. A system provides water to agricultural lands to meet the needs of plants so that these plants grow well [1][2].

However, along with the development of land functions following their needs, several events resulted in disasters. Part of the losses caused by improper land-use changes are flooding and erosion, which causes an increase in river bed sedimentation. One of the sedimentation causes is relatively high rainfall and unbalanced land use in the basin. In addition, river flow velocity affects the rate of sediment transport, especially floating sediments at the estuary of the Ketupak watershed. According to research results, 2008 stated that if the water discharge volume is high, the measured floating sediment also increases.

This study aims to get a river channel to drain runoff water so that runoff water due to maximum rainfall does not cause the inundation—formulation of the problem in this study. Observe the behaviour of Ketupak River in G2 Dwijaya Village, Tugumulyo District, Musi Rawas Regency during the rainy season. How big is the discharge of the Ketupak River during the rainy? The impact is caused by the release of the Ketupak River flow during the rainy season. The research location is shown based on the map source in Figure 1.

Figure 1. Research Location Map source

According to [3], irrigation management is all efforts to utilize irrigation water, including operation and maintenance, security, rehabilitation, and improvement of irrigation networks. The purpose of irrigation is to flow water in various ways and ways for farming, distributing it to several rice fields or fields Regularity, then discharged through the drainage canals or rivers regularly after use [4, 5, 6, 7].

Likewise, the surface water network, to meet the water needs in the agricultural area of the Tupak Water Irrigation Area, its water source comes from the Ketupak River. The current condition of the Ketupak River is very alarming due to misuse of land by carrying out illegal logging and dumping logged trees and twigs into the Ketupak River. Water drainage can be optimal if the condition of the Ketupak River can be maintained its beauty, with the physical maintenance efforts of the River Basin, which need more attention.

Indonesia has around 5,590 major rivers and 65,017 tributaries, with the total length of the main river reaching 94,573 Km. The entire watershed area (DAS) corresponding to 1,512,466 Km2 is located in 458 watersheds. As many as 60 are in severe critical conditions, 222 are critical, and 176 are potentially critical. It happened due to land use control which made the environmental buffer not function optimally. From the river management perspective, ten provincial crossing rivers currently need special attention due to pollution. In addition to the ten crossing rivers, there are still three strategic rivers that must be managed.

Ketupak River has a length of 18,424 M 'with the coverage area of Dwijaya Village, P2 Purwodadi Village, Tri Karya Village, Megang Sakti II Village. The rhombic river was normalized in 2013 along 3,812 m', in 2014 along 3,039 m', and in 2015 along 3,222 m', The remainder has not been normalized for 8,351 m'. As a result, Ketupak River has an initial existing with an average width of 5.75 m' with a depth of 1.96 m' and after normalization with an average width of 8 M' and a depth of 3 m'.

Rivers are formed naturally according to local area conditions' topography, geology, and hydrology. Hence, in its development, the demographic, the physical condition of the river. Indonesia has several topographic, geological and hydrological conditions throughout the region. The results of these conditions in several types of rivers, with their features and differ from one another. Types of rivers are divided into five rivers: tidal, non-tidal, dry, debris flow, and underground rivers.

A watershed (basin, drainage basin, catchment area, or watershed) indicates an area that contributes to the surface flow and valleys. The water that falls at each location within the boundary flows upstream of the watershed through tributaries of the main river until it finally exits through one outlet. The boundaries between watersheds are termed drainage divides. The outlet, or pour point, is the point on the surface at which water flows out of an area. It is the lowest point along the boundary of a watershed [8, 9, 10].

The Ketupak River has a Tupak Water Irrigation Area with a standard area of 778 Ha with a function area of 288 Ha. The flowing water is divided into three regions, namely Dwi Karya Village, Tugumulyo District, Tri Karya Village Purwodadi District, and Sinar Karya Village Purwodadi District. Water withdrawal buildings are located in Desa Dwijaya Tugumulyo Subdistrict.

METHOD

There are several calculations needed to design Flow Fluctuation in River Flow. These calculations include Normal Distribution, Normal Log Distribution, Pearson Log Type III Distribution, Gumbel Distribution, Flow Discharge Measurement, and Average Flow Speed. The explanation of some of these calculations is given below.

Normal Distribution

The normal distribution or the normal curve is also called the distribution in the calculation of plan rainfall according to the normal distribution method, having the following equation:

$$\overline{X}_T = X + K_T S \tag{1}$$

$$K_T = \frac{X_{T} - \vec{X}}{S} X + K_T S \tag{2}$$

Where:

XT = estimated value expected to occur with a T-annual return period

$\bar{X}$ = Average Value of variance count

S = standard deviation of the variate value

KT = frequency factor is a function of the opportunity or return period.

The KT frequency factor value is generally available in the table, called the variable reduced gauss table value, to simplify the calculation, as shown in the table in the appendix [6, 7, 8].

Normal Log Distribution

The data X is converted into logarithmic form Y = log X. If the random variable Y = log X is normally distributed, then X is said to follow the normal log distribution. For example, for a normal log distribution, the rainfall calculation plan uses the following equation:

$$\overline{Y}_T = Y + K_T S \tag{3}$$

$$K_T = \frac{Y_T - \overline{Y}}{S} \tag{4}$$

Where:

YT = estimated value expected to occur with a T-annual return period

$\bar{Y}$ = Average Value of variant count

S = standard deviation of the variate value, and

KT = frequency factor is a function of chance or return period and the type of mathematical model of opportunity distribution used to analyze reinforcement [11, 12, 13].

Pearson Log Type III Distribution

The statistical parameters required by the Pearson Log Type III Distribution illustrate the theoretical distribution following the following equation:

$$Log\ R_T = Log\ \bar{R}_I + KS \qquad (5)$$

$$Log\ \bar{R}_I = \frac{\sum_{i=1}^{n} Log R_i}{n} \qquad (6)$$

$$S = \frac{\sqrt{\sum_{i=I}^{n} (Log R_I - log\bar{R}_I)^2}}{n-1} \qquad (7)$$

$$Cs = \frac{n\sum_{i=1}^{n} (log\ R_i - log\overline{\bar{R}_I})^3}{(n-1)(n-2)S^3} \qquad (8)$$

$$K = Z + (Z^2+1)K + \frac{1}{3}(Z^3+6z)K^2 - (Z^2-1)K^3 + ZK^4 + \frac{1}{3}K^5 \qquad (9)$$

where Cs is an Asymmetric coefficient of data logarithm [8, 9, 10].

Distributing Gumbel

Calculation of rainfall plan according to the Gumbel method, has the following formulation:

$$\bar{X} = X + SK \qquad (10)$$

Where:
$\bar{X}$ = Sample average price
S = standard deviation (standard deviation) of the sample.
The K value (probability factor) for extreme prices of gambles can be expressed in the equation:

$$K_T = \frac{Ytr - Yn}{Sn} \qquad (11)$$

Where:

Yn = reduced mean depending on the number of samples / n data (table in appendix)

Sn = reduced standard deviation, which also depends on the number of samples/data n

Y_Tr = reduced variate, which can be calculated with the following equation

$$Y_{Tr} = -in\left\{-In\frac{T_r - 1}{T}\right\} \qquad (12)$$

Flow Discharge Measurement

The flow of a river given a is the amount of water flowing through the rivers at each unit of time, which is usually expressed in cubic meters per second (m^3/sec). With its distribution in space and time, River discharge is important information needed in water building planning and utilization of water resources. In the first case, the parameters measured are river cross-section, water level elevation and flow velocity [14].

Discharge measurements are carried out to get the wrong debit. Some discharge measurement methods are often used, both direct measurements and indirect measurements and the equipment used. For example, implementing river flowrate measurement is a direct way to use a flow meter.

The method for calculating flow discharges can be used in general formulas [15]:

$$Q = V \times A \tag{13}$$

Where:
Q = Flow rate (m^3/dt)
V = Average speed (m/dt)
A = River wet cross-sectional area (m^2).

Average Flow Speed

The average flow velocity in a wet section is obtained from the average velocity measurement from its depth point. The average flow velocity in a vertical is obtained from the measurement of the flow velocity of one, two or three points, the implementation of which depends on the flow conditions, depth of flow, width of the flow and available facilities [15]. Types of means of measuring the average flow velocity and calculated using the following formula:

a. One point flow velocity measurement, carried out at 0.6 depth (d) or 0.2 d from the surface of the water, with the following conditions:
   1. At 0.6 d, carried out if the water depth is less than 0.75 m.
   2. At 0.6 d from the surface of the water, also carried out to measure flood discharge if the measurement method at 0.2 d and 0.8 d cannot be carried out because the flow changes quickly so that the available time is relatively short.

$$\overline{V} = V\,0.6 \tag{15}$$

b. Measurement of two-point flow velocity, carried out at 0.2 d and 0.8 d from the surface of the water depth is more than 0.75 m.

$$\bar{V} = \frac{V\,0{,}2 + V\,0{,}8}{2} \tag{16}$$

c. Three-point flow velocity measurements, carried out at points 0.2 d, 0.6 d and 0.8 d from the water surface.

$$\bar{V} = \left[\left(\frac{V\,0{,}2 + V\,0{,}8}{2}\right) + V\,0{,}6\right] x\ \frac{1}{2} \tag{17}$$

Information:
V¯ is the average flow velocity at a vertical (m/s).; V0.2 is the flow velocity at the point 0.2 d, (m/s), V0,6 is the flow velocity at the point 0.6 d, (m/s).; V0.8 is the flow velocity at the point 0.8 d, (m/s).

RESULTS AND DISCUSSION

River Flow Discharge

The equation for the vertical velocity distribution in the river is obtained by measuring the velocity at several points on the river's vertical with the results listed in Table 1.

Table 1. Debit Calculation

Position	Depth (d)	Current Meter (m/det)	Average Discharge
P1	0.8	0.1	0.42
	0.2	0.2	
	0.8	0.2	
	0.2	0.3	
	0.8	0.1	
	0.2	0.1	
P2	0.6	0.1	0.31
	0.8	0.2	
	0.2	0.3	
	0.6	0.2	
P3	0.8	0.1	0.21
	0.2	0.1	
	0.8	0.1	
	0.2	0.1	
	0.6	0.1	
P4	0.6	0.1	0.18
	0.2	0.1	
	0.8	0.1	
	0.6	0.1	
P5	0.6	0.1	0.21
	0.8	0.1	
	0.2	0.2	
	0.6	0.2	

River Cross Section

Based on the actual measurements at the study site, and Existing cross-sectional area of each point was obtained. Figure 2 illustrates the Existing Condition of the Ketupak River at each point. The Wet Section of the Ketupak River is shown in Figure 3. The Cross-Sectional Area of River Existing is listed in Table 2.

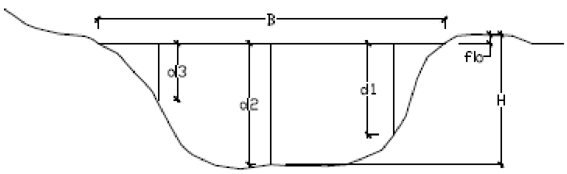

Figure 2. Existing Condition of the Ketupak River

Where:
B = width of river cross-section
d = water level
Ht = height of river embankment

Table 2. Cross-Sectional Area of River Existing

No.	Measurement point code	Top Width (B) (m)	Bottom Width b) (m)	Embankment height (Ht) (m)
1	P1	7	5	2.5
2	P2	5	4	1.8
3	P3	6.8	5	1.8
4	P4	6.2	4.5	2.15
5	P5	6.8	4.7	2.1
6	P6	6.5	4	2.2
7	P7	7.5	5.5	1.85
8	P8	7.2	5.5	1.7
9	P9	5	4	1.6
10	P10	6.5	4	2.15

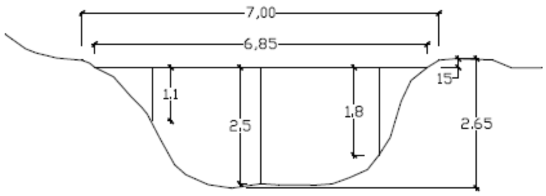

Figure 3. Wet Section of the Ketupak River

Source [1] Spacious Pias 3 =

$$A3 = \frac{W1 + W2 + W3}{3} B$$

$$A3 = \frac{1.1 + 2.5 + 1.8}{3} 6.85$$

$$A3 = 12.33 \text{ m}^2$$

The calculation of water discharge in the river is intended to determine the effectiveness of the river. Based on the results of measurements in the field during the rainy season, the water debit from each channel is as follows. The method for calculating flow discharges can be used in general formulas [16].

Table 3. Channel Wet Cross Section Area (A)

No.	Measurement point code	Large A (m^2)	Average Speed (m/det)	Results (Q) (m^3/det)
1	P1	12.33	0.42	5.220
2	P2	7.112	0.42	3.058
3	P3	8.951	0.42	3.849
4	P4	9.082	0.42	3.905
5	P5	10.080	0.42	4.334
6	P6	9.652	0.42	4.150
7	P7	10.001	0.42	4.300
8	P8	8.364	0.42	3.596
9	P9	3.852	0.42	1.656
10	P10	7.305	0.42	3.141

Examples of channel flow calculation calculations in Table 3 are as follows:

$$Q = V \text{ x } A \tag{18}$$

Where :
Q = Flow rate (m^3/dt)
V = Average speed (m/dt)
A = Wet cross-sectional area of the river (m^2)
V = 0.42 m/dt (current meter)
A = 12.33 m^2 (wet cross section of the river)
Q = 0.42 x 12.33 = 5.220 m^3/det

The data in Table 3 is obtained from the measurement data in field A, as calculated in (18)

Rainfall Intensity Analysis (I)

The intensity of the rain is the height or depth of the rainwater unity of time. The condition happened is because the rainfall has a plan. Table 4 shows data of recapitulation of maximum plan rainfall analysis

Table 4. Recapitulation of Maximum Plan Rainfall Analysis

No.	Measurement point code	Top Width A (m^3/det)	Rainfall (m^3/det)	Qp (m^3/det)
1	P1	5.220	0.719	5.94
2	P2	2.987	0.719	3.71
3	P3	3.760	0.719	4.48
4	P4	3.815	0.719	4.53
5	P5	4.234	0.719	4.95
6	P6	4.054	0.719	4.77
7	P7	4.200	0.719	4.92
8	P8	3.513	0.719	4.23
9	P9	1.618	0.719	2.34
10	P10	3.068	0.719	3.79

Qp = Q existing + Q Rainfall
= 5.22 + 0.719 = 5.94 m^3/det

Change in Cross-sectional Area

From the analysis of the calculation of the channel, it is found that the channel dimensions are not sufficient to float all planned channel debits (Q = 5.22 m^3/det ≤ Qp = 5,94 m^3/det).

Calculation of River Normalization (Dredging) Using Trapezoid-Shaped Cross-section

For example, data of calculation as described here is listed in Table 5. The table shows the cross-sectional area of river channels before normalized (A). However, Table 6 describe the river basin wet cross-sectional area after normalization (A). Figure 4 shows the River Wet Cross Section After Normalization (A). In addition, Figure 5 shows the River Basin Wet Cross-sectional Area after Normalization (A)

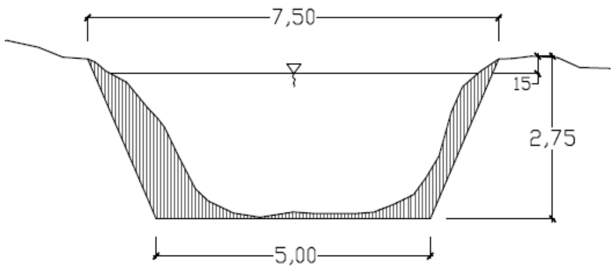

Figure 4. River Wet Cross Section After Normalization (A)

Normalized Wet cross section area of the channel
(A) = ½ (A + B) x Ht = ½ (7.5+ 5) x 2.75= 15.63 m^2

Table 5. Cross-sectional Area of River Channels Before Normalized (A)

No.	Measurement point code	A (m)	B (m)	Ht (m)	Cross-sectional area (m^2)
1	P1	7.5	5	2.5	15.63
2	P2	6.5	4.5	2.5	13.75
3	P3	7.5	5	2.5	15.63
4	P4	7.5	5	2.5	15.63
5	P5	7.5	6	2.5	16.88
6	P6	7	6	2.5	16.25
7	P7	7.5	6	2.5	16.88
8	P8	7	5.5	2.5	15.63
9	P9	6	4.5	2	10.50
10	P10	6.5	5	2.5	14.375

Table 6. River Basin Wet Cross-sectional Area after Normalization (A)

No.	Measurement point code	Cross-sectional area (m^2)	Current meter m/det	Normalization (m^3/det)
1	P1	15.63	0.42	6.61
2	P2	13.75	0.42	5.775
3	P3	15.63	0.42	6.563
4	P4	15.63	0.42	6.563
5	P5	16.88	0.42	7.088
6	P6	16.25	0.42	6.825
7	P7	16.88	0.42	7.088
8	P8	15.63	0.42	6.563
9	P9	10.50	0.42	4.41
10	P10	14.375	0.420	6.0375

$Q = V \times A$
$Q = 0.42 \times 15.63$
$Q = 6.61$ m^3/det.
So, to meet the $Q = 5.94$ m^3/sec, it is necessary to increase the cross-sectional area of the river from 12.33 m^2 to 15.63 m^2 so that a Q of 5.94 m^3/sec is obtained.

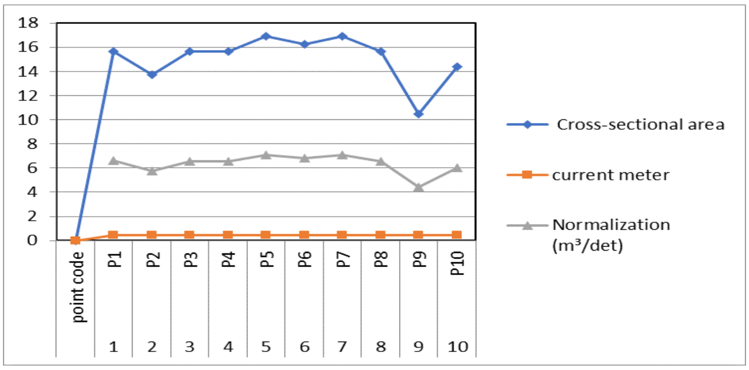

Figure 5. River Basin Wet Cross-sectional Area after Normalization (A)

CONCLUSION

Fluctuations in river water impact the amount of inundation that occurs. The Ketupak river flow cannot drain flow during the rainy season. Besides, there is a lot of sediment, garbage, stems, and branches that obstruct the flow of the Ketupak river. As a result, the river channel must be rearranged. In addition, the river's cross-sectional area must be increased based on the results of calculations based on rainfall data.

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