Strategy in river flood control

N Nurdiyanto*
Faculty of Civil Engineering Swadaya Gunung Jati University Cirebon, Indonesia

*nurdiyanto@unswagati.ac.id

Abstract. In February 2018, there was a flood due to the overflow of the Cisanggarung River, one of the affected areas is the population in Ciledug Sub-district, Cirebon, West Java, Indonesia. The purpose of this research is to control the flood of the Cisanggarung River. This study analyzes the amount of water flow that flows in the river crossing capacity. The method used is floods routing from rainfall data using Nakayashu hydrological analysis. The results of the analysis show that the amount of discharge for river capacity is 658 m$^3$/s, while the flood discharge is 784 m$^3$/s, so the river capacity cannot accommodate water. The solution is to floods control by building embankments and normalizing river flow from existing waste. With plans to build embankments and normalize the river, the river capacity becomes 940 m$^3$/s.

1. Introduction

The main causes of the disaster are as a result of human intervention such as reduced land as a water catchment area and decreased environmental carrying capacity to preserve the function and benefits of water resources due to uncontrolled forest destruction, lack of maintenance of flood control and river channel control, sediment deposition, drainage system which does not work and rainfall exceeds normal limits. Flood is a natural phenomenon because of the high rainfall and insufficient capacity of water bodies (rivers or drainage channels) to accommodate and drain water [1]. Flooding has not become a problem if it does not interfere with activities and cause harm to human life, but if it has fallen victim to both property and soul, then it must be addressed immediately. So that it is necessary to have flood plain management to reduce losses [2].

Novan in study Ciberes River flood mitigation analysis in Cirebon District explained that high rainfall caused the river flood [3]. The flood control efforts of the Ciberes River were carried out by normalizing the river. The problem of flood that occurred in the Cisanggarung River caused the embankment to break down and inundate settlements, especially in the District of Ciledug, Cirebon. Rainfall is quite high, the condition of the banks is full of plants and garbage, thereby reducing the capacity of the river.

Some previous studies stated that flood prevention can be done by improving the Watershed Area. Coordination activities among collaborating stakeholders help to deal with flooding problems institutionally [4]. Research conducted by Andina, found that flood water overflowing can be overcome by making river dikes. The purpose of this research is to control the flood of the Cisanggarung River. This study is to find out planned flood discharge, analyze the capacity of river flow and flood prevention.
2. Methodology

2.1. Data and object
Cisanggarung River flood that occurred in February 2018 struck residents around Ciledug Wetan Village, Ciledug District, Cirebon. The amount of water discharge at the flood location is 924 m³/s. Maximum rainfall analysis in the study area is carried out using rainfall recording data on existing hydrometry networks, namely rainfall data in 1999 until 2018.

![Flood conditions in Ciledug Wetan village.](image1)

Hydraulic performed to determine the capacity of the existing river flow water profile is figure below:

![Existing river cross section.](image2)

2.2. Data analysis technique
The method used in the calculation of the average rainfall area of the watershed is Polygon Thiessen method. The Polygon Thiessen method takes into account the weight of each station that represents the area around it. In an area within the watershed it is assumed that the rain is the same as that at the nearest station, so that the recorded rain on a station represents that area. Nakayasu has investigated unit hydrographs in several rivers in Japan. The results of the research are formulated with the following equations and calculation stages: Existing data for processing including R24 rainfall in mm, river length (L) in km, catchment area (A) in km² and hourly of distribution of effective rainfall.
2.3. Strategy flood control
Sosrodarsono and Masateru stated that embankments are one of the main and important buildings in an effort to protect the lives and property of people against puddles caused by floods and storms [5]. The cross section and embankment sections can be seen in the following figure:

Integrated watershed management is one of the most effective methods in flood control. In general, the watershed management in question includes:

- Terraces
- Reforestation
- Land use control
- Waterway planting
- Flood storage system
- Control of damage water

3. Result and discussion

3.1. Analysis of maximum rainfall
Maximum rainfall analysis in the study area is carried out using rainfall recording data on existing hydrometry networks, namely rainfall data in 1999 until 2018. Results of rainfall analysis using the Gumbel method can be seen in the table below:
Table 1. Rainfall of Gumbel method.

| Return Period (year) | Rainfall (mm) |
|----------------------|---------------|
| 2                    | 92.80         |
| 5                    | 114.82        |
| 10                   | 129.41        |
| 25                   | 147.84        |
| 50                   | 161.51        |
| 100                  | 175.08        |

3.2. Analysis of flood discharge
Using with formula synthetic unit hydrograph analysis from Nakayasu, obtained the following results is table and figure below:

Table 2. Flood discharge of Nakayasu method.

| Return Period (year) | Discharge Q (m³/s) |
|----------------------|--------------------|
| 2                    | 491.95             |
| 5                    | 668.62             |
| 10                   | 783.81             |
| 25                   | 929.40             |
| 50                   | 1037.38            |
| 100                  | 1144.63            |

Figure 5. Graphic flood discharge of Nakayasu method.

3.3. River hydraulic analysis
From the existing condition data obtained:

- a. Slope : 0.007
- b. Manning Coefficient : 0.022
- c. Width : 20 m
- d. High water level : 4 m
- e. Slope stability : 1: 2
To determine the capacity of the river in the existing conditions can be calculated by the following formula:

\[ Q = A \times V \]

where:
- \( Q \) = discharge, \( m^3/s \)
- \( A \) = area, \( m^2 \)
- \( V \) = velocity, \( m/s \)

The calculation results show that the amount of existing discharge is 658 \( m^3/s \).

Flood control strategies are carried out by structural and nonstructural efforts. Structurally it is carried out by normalization and construction of embankments. Normalization is carried out on the banks of the Cisanggarung River which is near to the final waste disposal site up to the downstream along the 300 m residential area. Normalization channel capacity is designed with size:

- Slope: 0.007
- Manning coefficient: 0.022
- Width: 20 m
- High water level: 5 m
- Slope Stability: 1:2

Then the amount of normal discharge capacity with 1 m high embankment is 940 \( m^3/s \). For the nonstructurally, the effort made is: cleaning garbage on the river, reforestation in the upper of the Cisanggarung watershed, evacuation of residents when affected by floods, law enforcement and institutional and community empowerment.

Figure 6. Plan for river embankment.

With the construction of a 1-meter high embankment, the flood water surface in the Cisanggarung River will be at the water level limit of 5 meters from the bottom.

4. Conclusion
Flood control strategies, especially floods in the Cisanggarung River in Ciledug Wetan Village, Ciledug District, Cirebon were carried out by structural method with normalization of the river channel at the study location from a depth of 4 meters to 5 meters, and a 300 m river embankment. The amount of flood discharge with a return period of 10 years after normalization is 940 \( m^3/s \). And then nonstructural method with cleaning up garbage on river banks, reforestation in the upper Cisanggarung watershed, evacuation of residents when affected by floods, law enforcement, institutional and community empowerment.

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