EVALUATION OF FLOOD MITIGATION PLAN FOR CIBALIGO RIVER, CIMahi CITY, WEST JAVA PROVINCE

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ABSTRACT: Cibaligo river is one of the major rivers that flow in Cimahi city. During the rainy season, the river is often causing a flood, especially in Melong sub-districts. Several mitigation alternatives have been prepared by the Government of Cimahi City, such as normalization of the river, and construct retention pond. This research is aimed to simulate the mitigation plan hydraulically to examine the effectiveness of the plan alternative. The simulation was done using HEC-RAS software for existing conditions and the condition with mitigation alternatives. The input for simulation collected from 3 nearest climatological stations, whereas SRTM, SPOT 6, and Cimahi City land used map used as a physical condition data input of catchment. A topographical survey was done to measure both cross and long sections of the river and used as simulation input of existing conditions. Two dimensional HEC-RAS simulation applied for each mitigation alternatives such as river normalization, construction of detention pond, and combination of both river normalization and retention pond. The simulation shows that the construction of 125 000 m3 retention ponds has a minimal effect. The combination of both river normalization and construction of ±315.000 m3 retention pond can prevent the area from inundation only for 2 years rainfall period; therefore, other mitigation plans have to be prepared to prevent the area from the flood.

Keywords: Cibaligo, Flood, HEC-RAS, Normalization, Retention pond.

1. INTRODUCTION

As most of the urban areas in a developing country where population growth and land used changes gone very fast, Cimahi city is prone to flood problem, moreover when there are five river flows through the area. One of the rivers is the Cibaligo river, which is also known to some people as the Cilember river. During the rainy season, the river often caused a flood in a residential area, especially in the Melong sub-district. On 10th November 2017, the overflow affects the TOL Road, which crossed by the river [1]. The recent flood happened on 1st November 2019 (Fig. 1.) Two primary causal factors of the problem are the land used changes in the upstream area and the reduction of river capacity. The land-use changes in the upstream area were due to the development of the residential and industrial zone, which are difficult to be avoided, and almost impossible to be restored to its natural condition. The river capacity continuously reduced due to the sedimentation resulting from upstream erosion and the narrowed river cross-section caused by illegal occupancy of the riverbank by the resident [2].

To cope with those flood problems, the Government of Cimahi City has a plan to increase river capacity by normalizing the river and build a retention pond to restrain the runoff during high river flow rate. The choice to normalize the river and construct a retention pond taken to resolve the problem as soon as possible. To ensure the effectiveness of the plan, a hydraulic simulation using HEC-RAS, validate the result.

Fig. 1. Cibaligo Flood 1st November 2019
2. STUDY AREA

The study area located in Cimahi City, West Java Province. The Cibaligo river flows from north to south across Cimahi city. The catchment area of the river cover 14.3 Km² [Fig.2.]. The point of interest in this research is in the Melong sub-district, where the floods often occur in a residential area and affect the Tol Road [Fig. 3].

Fig. 2 Cibaligo Catchment Area.

3. DATA AND METHODS

Rainfall data collected from three nearby climatological stations; they are St. Husein, St. Cipeusing, and St. Dago Pakar. The data collected for a period of the year 2008 to 2017. As seen in Table 1, the average maximum daily rainfall was calculated using the arithmetic mean method. Based on the average rainfall data, frequency distribution was analyzed using the Gumbel Distribution method, Pearson Log Type III Distribution, Normal Log Distribution, and Normal Distribution [3].

The rain frequency distribution was tested using the Chi-Square and Smirnov-Kolmogorov method. The discharge flow was calculated using the Rational Method, applying The frequency distribution, which meets Chi-Square and Smirnov-Kolmogorov criteria.

Table 1 Maximum Daily Rainfall

| No | Year | St. Husein | St. Cipeusing | St. Dago Pakar | Average (mm) |
|----|------|------------|---------------|---------------|-------------|
| 1  | 2008 | 72         | 48            | 80            | 66.667      |
| 2  | 2009 | 105        | 37            | 73            | 71.667      |
| 3  | 2010 | 113.4      | 29            | 104           | 82.133      |
| 4  | 2011 | 57.4       | 88            | 43            | 62.800      |
| 5  | 2012 | 67.6       | 50            | 70            | 62.533      |
| 6  | 2013 | 140        | 30            | 95            | 88.333      |
| 7  | 2014 | 149        | 73            | 79            | 100.333     |
| 8  | 2015 | 135.5      | 83            | 85            | 101.167     |
| 9  | 2016 | 102        | 83            | 86            | 90.333      |
| 10 | 2017 | 62         | 79            | 187           | 109.333     |

The discharge of Cobaligo River was calculated based on the effective rainfall. The effective rainfall is apart of the rain that discharged into the river. Effective rain is equal to the total rain that falls on the catchment minus the loss of water (infiltrate and evaporate). The amount of effective rainfall in the catchment depends on rainfall intensity, land topography, tillage system, and plant growth rate [4]. The effective rainfall is then used to calculate the hourly rain distribution using the Alternating Block Method (ABM) method. The Alternating Block Method (ABM) is a simple way to make a hyetograph plan from the IDF curve [5]. The flood discharge is then calculated using the HSS Nakayasu method [6].

The river simulation was carried out using the 2D-HEC-RAS software. The software used in several rivers and hydrological studies in Indonesia [7], [8]. The model requires topographical data, which in this study, the SRTM format [Fig.4] used as a data resource [9]. The drainage cross-section data obtained from the result of a direct field survey while the river normalization data and the dimension of retention pond data collected from the Cimahi City Government [10].
4. RESULT AND DISCUSSIONS

Based on the output of the data suitability test using the Chi-Square and Smirnov-Kolmogorov methods, only Pearson Type III Log Distribution meets the requirements [Table 2]. The result of rainfall distribution calculations shown in the resume [Table 3].

![Fig 4. Contour Map in SRTM Format.](image)

### Table 2. Suitability Test

| No | Distribution Methods | Criteria | Result | Conclusion |
|----|----------------------|----------|--------|------------|
| 1  | Gumbel               | Cs = 1.1936 | 0.089 | Not Suitable |
| 2  | Normal               | Cs = 5.4002 | 2.568 | Not Suitable |
| 3  | Log                   | Cs = 0 | 0.089 | Not Suitable |
| 4  | Log                   | Cs = 3 | 2.568 | Not Suitable |
| 5  | Log                   | Cs = Cv^2 + 6Cv^3 + 15v^4 | -0.105 | Not Suitable |
| 6  | Log                   | Pearson III | None | -0.105 | Suitable |

![Fig.5. Rainfall Intensity Curve.](image)

### Table 3. Rainfall Distribution

| No | Return Periods | Probability Distribution |
|----|----------------|--------------------------|
| 1  | 2              | Gumbel 80.136, Normal 83.530 | 82.035, Pearson II 82.339 |
| 2  | 5              | Gumbel 101.602, Normal 97.879 | 97.669, Pearson II 97.795 |
| 3  | 20             | Gumbel 115.101, Normal 105.305 | 107.013, Pearson II 106.779 |
| 4  | 25             | Gumbel 130.841, Normal 112.712 | 116.688, Pearson II 117.112 |
| 5  | 50             | Gumbel 144.806, Normal 118.549 | 125.569, Pearson II 124.283 |
| 6  | 100            | Gumbel 157.345, Normal 123.332 | 133.086, Pearson II 139.830 |

![Fig.6 Hydrograph HSS Nakayatsu](image)

The flood discharge was calculated using the Nakayasu method, the Nakayasu method. As shown in Figure 6, that the maximum discharge for two years return period was noted 50 m3/sec with a duration of 2 hours, whereas for five years return period, the maximum discharge is 50 m3/sec for 2 hours rain.
sections resulted from field survey was used as an input. The cross-sectional nodes presented in Figure 7 and the river long section presented in Figure 8.

The HEC-RAS simulation shows that even for two years rainfall return period, the overflow occurred in some areas [Fig. 9]. The simulation also shows the inundated area in the downstream area near TOL Road. The total inundation area for two years and five years of rainfall periods are 93 009 m² and 99.341 m² consecutively [Fig. 10, Fig. 11]. The water depth in the inundation area was varied from 20 to 50 cm for two years return periods, and 25 to 60 cm for five year return periods.

Fig. 7 Cross sectional Nodes

Fig. 8 Existing River Long Section

Fig. 9 Simulation of Existing Condition (2 Year Return Period)

Fig. 10 Inundated area Existing Condition for 2 Years Return Period.

Fig. 11 Inundated area Existing Condition for 5 Years Return Period.
The second simulation was carried out for condition with 125,000 m³ retention pond, which located beside the Tol Road [Fig. 12] and the cross-section presented in Figure 13.

Fig. 12 Location of Retention Pond.

Fig. 13 Cross Section of 125 000 m³ Retention Pond

The simulation result shows that the 125 000 m³ retention pond gives a minimal impact on the inundated area [Fig. 14 and Fig 15]. The reduction of the inundation area was insignificant, whereas the water depth reduces by 2 to 8 cm.

Fig. 14 Simulation with 125 000 m³ Retention Pond for 2 year Return Period.

The third simulation condition was normalization of the river and construction of ±315,000 m³ retention pond. The third simulation result shows that for a two year return period, the inundation area was significantly reduced [Fig 16]. No inundated area shows in two years return periods simulation, but for five years return period, an area of 27 000 m² inundated with a water depth varied from 20 to 40 cm [Fig. 17].

Fig. 15 Simulation with 125 000 m³ Retention Pond for 5 year Return Period

5. CONCLUSION

Based on the simulation result using two-dimensional HEC-RAS software for the existing condition of the river, the flood occurs every year. Constructing a 120 000 m³ retention pond gives a minimal impact to both inundation area and water depth. River normalization and construction of 315 000 m³ only sufficient to prevent the Melong sub-district from two year return period flood, whereas for five years return period inundation area still occurs. To increase the effectiveness of flood mitigation, water conservation, such as the construction of infiltration well in the upstream
region, must be promoted.

![Fig. 16 Simulation with 315,000 m³ Retention Pond for 2 year Return Period.](image1)

![Fig. 17 Simulation with 315,000 m³ Retention Pond for 5 year Return Period.](image2)

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