Normalizing the river of Cisangkuy to reduce the flood risk in the future

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Abstract. The rapid population growth has made residential land more widespread, causing the surface water runoff getting bigger and coupled with the narrowing of the river cross-section by sediment so that the river's capacity is no longer able to accommodate the existing flood discharge. This study aims to reduce the risk of flooding in the Cisangkuy river. Modeling was carried out using HEC-RAS 2D. Modeling results in the existing conditions show that water has flowed into the residential area. Handling in the form of normalization of the Cisangkuy River as an appropriate alternative for reducing flood risk. After normalization, there was a decrease in the water level in the upper reaches of the Cisangkuy river from an altitude of 672.13 masl to 667.85 masl and in the middle of the Cisangkuy river it fell +3.3 meters. which was originally from an altitude of 668.57 masl to 665.21 masl. The improvement of the Cisangkuy River has had a significant impact on the flow of the Cisangkuy tributary and the urban drainage system around the area. So that the Cisangkuy River can accommodate the discharge and the risk of urban flooding can be reduced. With this risk reduction, flooding that has an impact on the social, economic, and health sectors can be controlled and can be focused on future urban problems.

1. Introduction

Future development in climate makes us more disappointed in some study cases. Climate change and its impacts are some of the dangerous threats that are facing the world today. Most developing countries are very vulnerable to the effects of climate change because of their economic circumstances. Therefore, they are often unable to implement adaptation strategies to reduce climate-related impacts [1]. The risk of flooding will increase in many regions of the world due to climate change and increase exposure to the economy. This implies that sufficient flood insurance schemes are needed to adapt to an increase in flood risk and to minimize welfare losses for communities in flood-prone areas [2]. Building an infrastructure for disaster management needs an expensive cost. In another study, it was explained that the purpose of the reservoir is not only as a flood basin but also as a reservoir of clean water to save costs and more functions [3]. In 2008, the Government of Indonesia developed a risk assessment approach to climate change adaptation plans [4]. The effects of climate change, land, and also human changes on flooding are related to the risk of flooding [5] [6]. And it is proven in developing countries [7]. A comprehensive flood disaster management strategy is needed to reduce flood vulnerability [8]. Indonesia is the fourth most populous country in the world and is expected to be significantly affected in a longer period [9]. The case study in the Cisangkuy River Basin which is located in the Bandung district and crosses a thriving urban city. Besides the economy
and the growing population, incidents of flooding in the river as well as sanitation in residential residents also often occur in the rainy season. Flood risks can be reduced at various stages of the integrated disaster management process. Traditionally, technical measures are needed for flood prevention, while other risks are managed by emergency actions that are triggered by estimation [10]. This study aims to reduce the risk of flooding in the Cisangkuy river.

2. Methods and material

2.1. Study location

This research will be focused on the Cisangkuy watershed due to the availability of data. Cisangkuy watershed is located at 107° 28' - 108° 03' East Longitude and 7° 00' - 7° 13' South Latitude, administratively located in Bandung Regency. The Cisangkuy watershed has an area of 28,236 hectares and is geographically located at an altitude of 657 meters up to 2,340 meters above sea level. Morphologically the Cisangkuy watershed has contours that vary from the plains to the mountains. The Cisangkuy watershed is part of the upstream Citarum watershed located in the southern part of Bandung Regency. The phenomenon of flooding always occurs in the downstream areas of the Cisangkuy watershed, such as housing and industrial areas, Dayeuhkolot [11]. The inability of the river to accommodate runoff is one of the causes of flooding, especially in high rainfall intensity [12].

2.2. Flood modelling

The methodology that is used is by determining the planned flood discharge due to climate change with CMIP5 rain inputs. The next modeling uses the 2D HEC-RAS application to determine the extent and height of flood inundation. HEC-RAS is used to manage flood risk management strategies [13], and also can be used to mitigation [14]. GIS is used to determine the area of inundation and inundation height. The integration of the two applications provides various information to the user. The calculation of disaster risk will be carried out after modeling the HEC-RAS. The result of the modeling is used to process of determining strategic steps to reduce the risk of the disaster. The basis for creating a hydrodynamic model can be using topographic maps, orthophotograph images, and digital field models (DTM). Inundated areas can be identified and also used to calculate the potential damage due to flooding. The results achieved are used to explore technical adaptation. When the results of the modeling are visualized, it is effective for decision making regarding the proposed flood protection structure for the area under study.

2.3. Flood risk reduction scenario

There are various ways to decrease flood risk by the government and surrounding communities, with various costs, effectiveness, and time characteristics, which can be applied before a flood occurs. Permanent structures, such as dikes, dams, and pumping stations, are most often used to avoid flooding. Preventive steps used to reduce flooding, or to reduce the risk of flooding by increasing the level of limited time (such as building temporary dikes, strengthening existing dikes with sandbags, or repairing drainage channels). There are some choices available, so we are trying to integrate flood control infrastructure. Handling requires higher costs, so a gradual project is being worked on and integrated.

2.4. Flow chart of research

For more detail process is described in this flow chart below:
3. Results and discussion

3.1. Rainfall intensity
This rainfall intensity calculation uses the Dr. Mononobe’s method assuming that the average rainfall in Indonesia by lasts 6 hours, the complete rain distribution calculation table using the Mononobe method can be seen in Table 1 below:

| t (hour) | Rt  | Net Rainfall (Rn, mm) | Return Period (Year) |
|---------|-----|-----------------------|-----------------------|
|         |     | 2                     | 5                     | 10 | 20 | 25 | 50 |
| 1       | 55.032% | 38.411               | 46.169               | 52.893 | 59.539 | 63.169 | 72.181 |
| 2       | 14.304% | 5.494                 | 6.604                | 7.566 | 8.516 | 9.036 | 10.325 |
| 3       | 10.034% | 3.854                 | 4.633                | 5.307 | 5.974 | 6.338 | 7.243 |
| 4       | 7.988%  | 3.068                 | 3.688                | 4.225 | 4.756 | 5.046 | 5.766 |
| 5       | 6.746%  | 2.591                 | 3.114                | 3.568 | 4.016 | 4.261 | 4.869 |
| 6       | 5.896%  | 2.265                 | 2.722                | 3.119 | 3.511 | 3.725 | 4.256 |

3.2. Rainfall distribution using ABM method
The Alternating Block Method is a simple way to create a hyetograph plan from a rain intensity curve. Hyetograph plan produced by this method is rain that occurs in n series of consecutive time intervals with duration Δt = 1 hour during time P = I x Δt. For certain return periods, the rainfall intensity is obtained from the IDF curve at each time duration Δt, 2Δt, 3Δt, 4Δt, 5Δt, and 6Δt.

The amount of rain is obtained from the rainfall intensity times the duration of the rain. The rain increase is sorted back into a time series with maximum rainfall intensity in the middle of the rain duration and the remaining blocks are arranged with the smallest rain value located at the beginning of the rain duration.
Table 2. Summary of rainfall distribution using ABM method

| t  | 2 Yr | 5 Yr | 10 Yr | 25 Yr | 50 Yr |
|----|------|------|-------|-------|-------|
| 1  | 0.000| 0.000| 0.000 | 0.000 | 0.000 |
| 2  | 0.682| 0.820| 0.939 | 1.122 | 1.282 |
| 3  | 21.138| 25.408| 29.108| 34.763| 39.723|
| 4  | 0.711| 0.854| 0.979 | 1.169 | 1.335 |
| 5  | 0.634| 0.762| 0.873 | 1.043 | 1.191 |
| 6  | 0.574| 0.690| 0.790 | 0.944 | 1.078 |

3.3. Nakayasu synthetic unit hydrograph
Calculating Synthetic Unit Hydrograph in Cisangkuy watershed use these following parameter:
- Watershed Area (A) = 189,057 km²
- Length of Cisangkuy river (L) = 33,855 km
- Effective Rainfall (Ro) = 1.0 mm
- Hydrograph coefficient (α) = 2
  - α = 2 (in ordinary watershed)

![HSS Nakayasu Cisangkuy River](image)

**Figure 2.** HSS Nakayasu Cisangkuy river

3.4. Hydraulic modeling in Cisangkuy river (current condition)
The current condition of the Cisangkuy river is no longer able to accommodate the existing flood discharge and causes overflowing of the Cisangkuy river and causes the surrounding area to be submerged. The following are the results of hydraulic modeling of the existing Cisangkuy river channel using HEC-RAS software.
Figure 3. Flood inundation of Cisangkuy river

Figure 4. Long section Cisangkuy river current condition
In this study, flood control planning uses river normalization. The planned flow improvement plan is to do a narrow river cross-section repairing. The shape of the river cross-section is adjusted to the existing flood discharge conditions.

After normalizing the channel by changing the cross-section dimensions of the Cisangkuy river channel according to the existing flood discharge, the elevation of the Cisangkuy river water level during the flood with a 25-year return period has decreased and the flood has been overcome.

Figure 5. Cross section Cisangkuy river

![Cross section Cisangkuy river](image)

Figure 6. Flood inundation of Cisangkuy river after section improvement

![Flood inundation of Cisangkuy river](image)
4. Conclusions
Floods and risks that occur due to these disasters that occur in urban areas are increasingly important issues especially in developing countries such as Indonesia. Predictions with the worst-case scenario are important with an adaptive risk management approach. The results of the 2D HEC-RAS modeling show that water has run out into the neighborhoods of residents. Normalization of the Cisangkuy river is an alternative for flood management. After normalization, there was a decrease in water level in the upper reaches of the Cisangkuy river, which was originally from an altitude of 672.13 meters above sea level to 667.85 meters above sea level and in the middle of the Cisangkuy river down by + 3.3 meters, which from 668.57 to 665.21 meters above sea level. The improvement of the Cisangkuy river has a significant impact on the drainage of the Cisangkuy tributaries and the urban drainage system that drains its wastewater into the Cisangkuy river. So that the Cisangkuy river has been able to accommodate the existing discharge and urban flooding can be handled. Further research can be sought for disaster mitigation and management in terms of zoning in disaster-prone areas and human security engineering to deal with disasters that cannot be accurately predicted.
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