Research Article

Flood Impact Reduction Study By Applying Rainwater Harvesting In De Marrakesh Residential

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Abstract: Flood is a natural phenomenon that can threaten the existence of human life, especially during the rainy season. In addition, the increasing need for residential facilities has an impact on changing land functions in an area that was originally an infiltration area to become a residential area. De Marrakesh Residential which has a land area of ± 117.025 m^2 is a residential area located in the Kecamatan Rancasari of Bandung City. In terms of flood prevention, this residential area already has a retention pond and pumps that drains water into the Cipamokolan river. But in reality there are still puddles that inundate the residential area of De Marrakesh. To deal with this, a flood impact reduction study was carried out by applying rainwater harvesting. In this study, the analysis carried out is the calculation of the planned rainfall, the selection of the type of rain distribution, the calculation of the volume of rainfall, and the estimated calculation of the volume of rainfall that can be captured. From the results of the analysis and calculations, the application of rainwater harvesting can reduce the impact of flooding that occurs in De Marrakesh Residential.

Keywords : Flood, Retention Pond, Rainwater Harvesting

1. Introduction

Flood is a natural phenomenon that can threaten the existence of human life, especially during the rainy season. The flood was triggered by a decrease in an absorption area in catchment areas due to increasing population, activities and land requirements, so that happens interventions in urban activities on conservation areas and green open spaces [1].

De Marrakesh Residential which has a land area of ± 117.025 m^2 is a residential area located in the Kecamatan Rancasari of Bandung City. In terms of flood prevention, this residential area already has a retention pond and pumps that drains water into the Cipamokolan river. But in reality there are still puddles that inundate the residential area of De Marrakesh. To deal with this, a flood impact reduction study was carried out by applying rainwater harvesting. This study can be used as a reference in reducing the impact of flooding so as to minimize the potential for flooding in that location.

Figure 1. De Marrakesh Residential Borderline

Figure 2. Retention Pond And Pumps At De Marrakesh Residential

2. Literature review

2.1. Rainfall Volume

To get the volume of rainwater that falls in an area, it can be calculated by multiplying the height of the rainfall, catchment area and the runoff coefficient.

V = Rt x A x C

where :

V = Rainwater volume (m^3)

Rt = Rainfall height (mm)

A = Catchment area (m^2)

C = Runoff coefficient

2.2. Retention Pond And Pump

The retention pond serves to temporarily store rainwater in an area so that the peak flood discharge can be reduced. The percentage of flood reduction depends on the characteristics of the flood hydrograph, the volume of the retention pond and other building constructions. The area used for reservoirs is usually in the lowlands or marshes. With good land use planning and implementation, reservoirs can be used for residential.

The dimensions of the reservoir are based on the volume of water due to rain for a predetermined t minutes, meaning that if the rain has reached t minutes, then the pump must have been operated until the water level in the reservoir reaches the maximum limit. To anticipate that the storage pond does not overflow its capacity, the officers who operate the pump must always be ready when it rains. An area with a lower elevation than sea level and flood water level in the river causes the area cannot be served by gravity drainage system. Then the area needs to be equipped with a pumping station. This pump serves to help remove water from the flood reservoir or directly from the drainage channel when water cannot flow gravity [2].

2.3 Rainwater Harvesting

The main components of rainwater harvesting are; catchment area (roof), gutter and distribution pipe (downpipe) and rainwater storage tank [3].

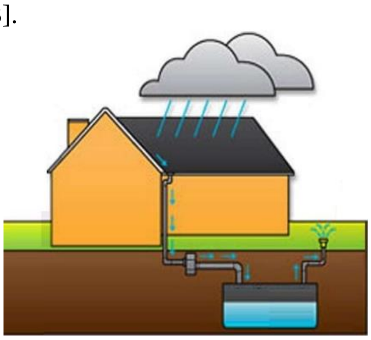

Figure 3. Rainwater Harvesting System

To get the available volume of rainwater that can be harvested, it can be calculated by multiplying the rainfall, catchment area and the runoff coefficient [4].

Reff = Rt x A x C

where :

Reff = Potential rainfall (Liter)

Rt = Rainfall (mm)

A = Catchment area (m^2)

C = Runoff coefficient

3. Methodology

The process of completing this research can be explained as follows:

1. Preparatory work

Preparatory work includes the preparation of a work planner and work approach methods. In this preparation stage, the collection and evaluation of existing secondary data is also carried out.

2. Field Survey

The main activity at this stage is to collect field data to meet the main needs for flood analysis purposes. The field survey includes Survey of areas causing flooding and existing drainage and Mapping survey.

3. Analysis

The scope of this activity includes analysis of rainfall volume on an area and rainfall volume that can absorbed by rainwater harvesting in the area.

4. Conclusions and Suggestions

This last activity was carried out in order to provide a picture that is easier to understand from the calculation data that has been done previously.

4. Analysis and discussion

4.1. Rainfall Data

Rainfall data that used in this study comes from one of the closest rainfall recording stations with an observation period of 12 years (2007-2018). The maximum annual rainfall data can be seen in the following table.

Table 1. Annual Maximum Daily Rainfall Data

No	Year	Maximum Rainfall (mm/day)
1	2007	69.5
2	2008	61.9
3	2009	88.9
4	2010	122.9
5	2011	73.5
6	2012	83.0
7	2013	68.4
8	2014	145.0
9	2015	114.3
10	2016	111.0
11	2017	71.5
12	2018	85.2

4.2. Catchment Area

In conducting a study of the water system at the activity location, the main thing that needs to be considered is the direction of surface runoff at the activity location and the surrounding catchment areas for the study location.

De Marrakesh Residential has a land area of ± 117.025 m^2. Within the residential area there are 3 flowing channels and to the right and left of the De Marrakesh Residential there are 2 large rivers. Based on the results of field surveys can be seen that not all rainfall in the residential area of De Marrakesh flow into the retention pond that located in the southeast. So that in this study the watershed used for the calculation of the volume of rainwater is the area near the retention pond, which is 78.699 m^2.

Figure 4. Catchment Area (Area In Red)

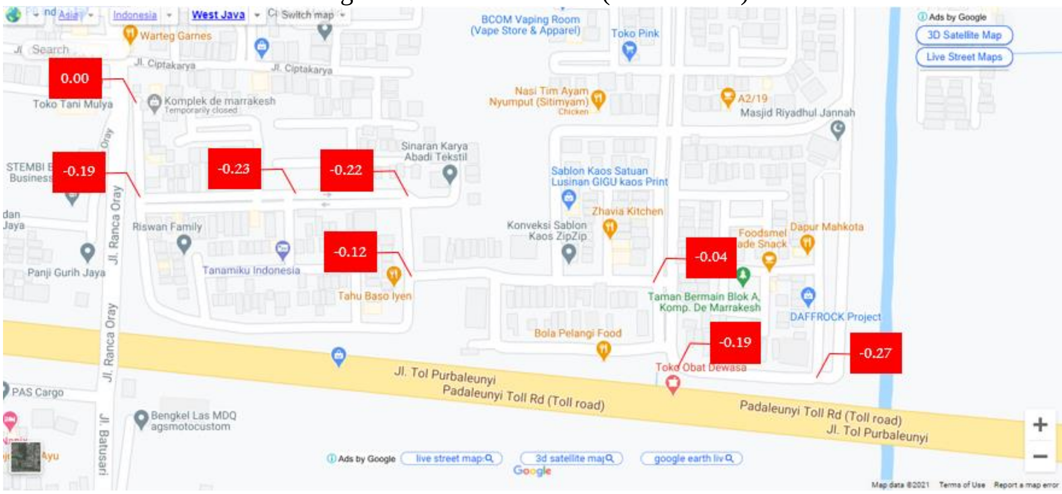

Figure 5. Differences in Land Altitude on the Road

4.3. Rainfall Analysis

Based on the hydrological data that has been collected, a planned rainfall analysis is then carried out, where the planned rainfall can be taken for several return periods. The maximum rainfall calculation is carried out by several methods, namely; Normal Method, Log Normal Method, Gumbel Method, and Log Pearson III Method. The calculated value of the planned rainfall from each method has a different value, so it must be tested for its suitability with the characteristics of each type of distribution. This is done by reviewing the statistical parameter boundary requirements of each distribution. Determination of the distribution type can be seen from the statistical parameters of field observation data, namely the values of Cs and Ck [5, 6]. Parameter testing was carried out using the Chi-square and Kolmogorov - Smirnov methods. Resume of rainfall distribution test calculations with each frequency distribution analysis method can be seen in the following table.

Table 2. Resume of Frequency Analysis Results Test

T	Rainfall characteristics (mm/day) according to the probability			
Return Period	NORMAL	LOG-NORMAL	GUMBEL	LOG-PEARSON III
1.1	57.830	62.299	62.557	63.569
2.	91.258	88.139	86.973	85.984
5.	113.211	110.695	110.025	109.525
10.	124.686	124.697	125.287	126.157
20.	134.163	137.586	139.926	142.929
50.	144.828	153.692	158.876	165.979
100.	151.939	165.464	173.076	184.379
1,000.	171.864	203.480	219.997	253.598

From the calculation results, it is concluded that all probability distributions meet the calculation of the frequency test. However, the fit test provides a minimum difference for the Log-Pearson III distribution. Therefore, for the calculation of the volume of rainfall at the study location, the results of the frequency analysis for the Log-Pearson III distribution are selected with the planned rainfall amount as shown in the following table.

Table 3. Rainfall Plan

Return Period (year)	Rainfall Plan (mm/day)
1.1	63.57
2.	85.98
5.	109.53
10.	126.16
20.	142.93
50.	165.98
100.	184.38
1,000.	253.60

4.5. Volume Analysis

Determination of the height of the planned rainfall using the Log-Pearson III method resulted in a 1 year return period rainfall plan of 63.57 mm. The volume of 1 year return period rainfall that falls in the residential area of De Marrakesh can be calculated as follows.

Rainfall Volume

Vr = Rt x A

Vr = 0.06 x 78,699

Vr = 5,002.79 m^3

Land use De Marrakesh Residential is a high density housing with a density level of 40 houses / ha (total ± 500 houses), so the runoff coefficient value is 0.8. So that the inundation volume is as follows.

Inundation volume

V = Rt x A x C

V = 0.06 x 78,699 x 0.8

V = 4,002.23 m^3

Based on field measurements, it can be seen that the dimensions of the retention pond are as follows.

Length = 140 m

Width = 4.3 m

Height = 3.0 m

So that the volume of the retention pond is equal to 1,806.0 m^3.

From these calculations it can be seen that the volume of rainwater that cannot be accommodated by the retention pond is 2,196.23 m^3. To minimize the impact of flooding due to rainwater that is not collected by the retention pond, the rainwater harvesting method can be used. If 200 houses use the rainwater harvesting method by making water storage tanks with dimensions of 2 m length, 2 m width and 1 m depth with a volume of 4 m^3, then this rainwater harvesting method can accommodate 800 m^3 of rainwater. Thus the remaining uncontained rainwater is 1,396.23 m^3 or in other words it can reduce the impact of inundation by 36.43%.

The application of the rainwater harvesting method is expected to be an alternative in minimizing the impact of flooding and reducing the performance load of existing pumps in the retention pond.

5. Conclusions and reccomendations

Based on the results of the analysis that has been done, the following can be seen:

1. The volume of rainwater with a 1 year return period that falls in the residential area of De Marrakesh is 5,002.79 m^3.
2. The volume of inundation with a 1 year return period that occurred in the De Marrakesh Residential was 4,002.23 m^3.
3. The volume of rainwater that cannot be accommodated by the retention pond is 2,196.23 m^3.
4. The application of the rainwater harvesting method can reduce the impact of inundation by 36.43%.

6. Acknowledge

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