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ANALYSIS OF RAINWATER MANAGEMENT ON THE BUILDING SITE AND CONSTRUCTION IN THE CITY OF SAMARINDA

By

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ABSTRACT

Rain is water vapor that is condensed and falls from the atmosphere to the earth in all its forms in the hydrological cycle. Rainwater must be managed properly, if it is not managed it will cause various problems, such as flooding, soil erosion, and water pollution as well as negative impacts on people's health and welfare. Along with the influx of development investors into the city of Samarinda, the city's development continues to increase and makes this city continue to grow. However, during this growth and development, Samarinda City cannot be separated from the problem of flooding. Floods not only submerge housing and settlements, they can also damage community socio-economic service facilities and public infrastructure and can even claim lives, losses will be greater if economic and government activities are disrupted or even stopped. This research aims to analyze the management of rainwater in buildings and plots to reduce flooding in the city of Samarinda using the 95th percentile method by the mandate of Government Regulation Number 16 of 2021 Article 38 which states that every building, by its function and classification, must be equipped with a management system. Rainwater. The research was conducted in Samarinda using analysis and calculation methods. The research stages are divided into 3 stages, namely literature study, data collection, and data processing stage. The research results show that (1) by managing rainwater in buildings and plots through rainwater utilization and soil infiltration, rainwater runoff will be reduced; and (2)from the rainwater management calculation process using the 95th percentile method, the City of Samarinda is required to manage 21,185,343.9 m³ of rainwater. Rainwater management carried out by the Samarinda City Government can take the form of creating retention ponds (folders) in several areas, especially those where inundation or flooding frequently occurs, and in each building or area according to its function and classification, a retention or ground pond is provided.

Keywords:

Rainwater management, retention ponds.

I. INTRODUCTION

Samarinda is a city and the provincial capital of East Kalimantan Province, Indonesia. Samarinda City is also one of the cities with the largest population on Kalimantan Island, with a population of 861,878 people (Central Bureau of Statistics Samarinda City, 2023). Samarinda has an area of 783 km² with hilly geographical conditions with heights varying from 10 to 200 meters above sea level and is approximately 113 km from the Capital City of the Archipelago (IKN) which is located in the North Penajam Paser Regency area. The city of Samarinda is bisected by the Mahakam River and is the gateway to the interior of East Kalimantan via river, land, and air. And the largest population in East Kalimantan. With an area of only 0.56 percent of the area of East Kalimantan Province, Samarinda City is the third smallest area after Bontang City and Balikpapan City.

Along with the influx of development investors into the city of Samarinda, the city's development continues to increase and makes this city continue to grow. However, during this growth and development, Samarinda City cannot be separated from the problem of flooding. Floods not only submerge housing and settlements, they can also damage community socio-economic service facilities and public infrastructure and can even claim lives, the losses will be greater if economic and government activities are disrupted or even stopped.

The rapid development in the city of Samarinda has had a lot of influence on land use. Currently, land has been converted into buildings, concrete and asphalt roads, and residential areas, which has a major impact on the reduction of water catchment areas.

The hydrological conditions of Samarinda City are influenced by around 20 river basins. One of these tributaries is the Karang Mumus River with a watershed area of around 218.80 km, where until now the Karang Mumus River has been used by the people of Samarinda City as a place to live, bathe, wash, and dispose of rubbish, this condition worsens. The city of Samarinda is prone to flooding. Thus, to support sustainable development, the management of rainwater runoff is an urgent concern.

The research aims to analyze rainwater management in buildings and plots to reduce flooding in the city of Samarinda using the 95th percentile method by the mandate of Government Regulation Number 16 of 2021 Article 38.

2. Research Methods

2.1. Location

The research was conducted in Samarinda using analysis and calculation methods.

2.2. Research Stages

The research stages are divided into 3 stages, namely literature study, data collection, and data processing stage.

2.3. Data Collection

The data collected consists of secondary data in the form of rainfall data.

2.4. Data Processing

2.4.1. Planning for Rainwater Management Facilities (95th Percentile Rainwater Management Mandatory Status)

As stated in the Regulation of the Minister of Public Works of the Republic of Indonesia number 11/PRT/M/2014, the mandatory volume of rainwater management is the total volume of rainwater per day that must be managed on an area of land by utilizing natural elements and utilizing artificial elements. The stages carried out are as follows:

a. Rainfall data

The local Meteorology, Climatology, and Geophysics Agency (BMKG) provides daily rainfall information for 95th percentile rainfall analysis. Rainfall information can also be obtained at local airports, universities, water treatment plants, or other facilities that have the competence to record long-term rainfall. In general, each record should have the following information:

1) Location (monitoring station)
2) Recording time (usually in the form of starting time from the stage time);
3) Total depth of rainfall during the stage time.

b. 95th percentile rainfall calculation

Steps to process data to determine the 95th percentile of rainfall using a worksheet. These steps are as follows:

1) Obtain daily rainfall data that can represent rainfall events on the building plot in question over at least 10 years.
2) Enter the rainfall data into the worksheet.
3) Arrange all daily rainfall records according to the order of occurrence (Table 1)

Table. 1. Daily Rainfall Data (Minimum 10 Years)

01/01/1999	0,5
02/01/1999	6
03/01/1999	6
04/01/1999	9
05/01/1999	19
06/01/1999	0
07/01/1999	0
08/01/1999	0
09/01/1999	19
11/01/1999	21
12/01/1999	29
.....	.....
...etc	...etc

Source: Samarinda City Meteorology and Geophysics Agency

4) Remove all bad data (eg incorrect data) from the data set.
5) Remove all minor rainfall data less than 2.5 mm per day (Table 2)

Table. 2. Daily rainfall data above 2.5 mm per day

02/01/1999	6
03/01/1999	6
04/01/1999	9
05/01/1999	19
09/01/1999	19
10/01/1999	16
11/01/1999	21
12/01/1999	29
13/01/1999	36
....	....
...etc	...etc

Source: Samarinda City Meteorology and Geophysics Agency

6) Sort the rainfall data from smallest to largest and add column I as data numbering (Table 3).

Table 3. Daily Rainfall Data Above 2.5 mm per Day Has Been Sorted

i	Date	Daily Rainfall (mm)
1	01/02/2004	2,5
2	23/02/2004	2,5
3	22/03/2005	2,5
4	22/03/2006	2,5
5	31/03/2007	2,5
6	24/11/2008	2,5
7	07/12/2008	2,5
8	03/06/2012	2,5
9	18/02/2003	2,6
10	05/12/1999	2,7
....	....	....
...etc	...etc	...etc

Source: Samarinda City Meteorology and Geophysics Agency

7) Calculate the ordinal ranking for the 95th percentile as follows:

$$n = \frac{95}{100} \times N + \frac{1}{2}$$

Information :
n: ordinal ranking for the 95th percentile
N: Number of rainfall data in the dataset

8) Round off n, then look for the suitability of the results in column I and determine the rainfall height n 95th percentile as the rainfall value in the same row.

9) The 95th percentile has been calculated in the previous stage. However, if the user wishes to see this information represented in a graph and obtain relative considerations, the following methodology can be used. Create a table showing percentiles compared to rainfall depth. Next, draw the curve of the relationship between percentiles and rainfall in (Table 4).

Table. 4. Daily Rainfall Percentile 0% - 100%

Percentile	Rainfall (mm)
0%	2.54
10%	2.79
20%	3.56
30%	4.32
40%	5.33
50%	6.60
60%	8.13
70%	10.16
80%	12.19
90%	18.03
93%	20.80
94%	22.35
95%	23.88
96%	26.92
97%	29.24
98%	31.45
99%	43.33
100%	69.34

Source: Samarinda City Meteorology and Geophysics Agency

2.4.2. The volume of rainwater that must be managed within the building plot

Calculation of the mandatory volume of rainwater management using the formula:

$$Vwk = th \times A$$

Information :

Vwk = required volume to manage (m^3)

th = height of rainfall (mm). th is obtained from the 95th percentile rainfall map or 95th percentile rainfall calculation.

A = plot area (m^2)

Mandatory volume management (Vwk) does not all have to be managed in the form of rainwater management facilities. Rainwater that falls on yards that are not covered by pavement is planned as rainwater that experiences direct infiltration from the ground surface. The volume of rainwater that must be managed using rainwater management facilities is rainwater that has the potential to run off due to the ground being covered by buildings and pavement. According to Maryono (2016), good rainwater management in an area can help overcome flooding problems in the rainy season and drought problems in the dry season.

2.4.3. Flood contribution volume

The volume of flood contribution is the volume of rainwater that falls into the cistern field, which will be released into rainwater absorption wells (Rachman, et.al 2014; Ropiqoh et al, 2019). The volume of flood contribution is part of the volume required to manage rainwater which has the potential to overflow from the building plot.

If the entire building plot is covered by buildings and pavement, the volume of flood contribution is the same as the volume required to manage rainwater. To calculate the volume of flood contribution, use the formula, namely:

$$Vab = Vwk$$

Information :

Vab = Volume of flood contribution (m^3)

Vwk = Volume required to manage (m^3)

However, if the building plot has a yard/green space that is capable of absorbing soil, the volume of flood contribution is only calculated from the area covered by the building and pavement using the formula,namely :

$$Vab = 0.855 \times Ctadah \times Atadah \times th$$

Information:
Atadah = KDB x A; KDB = Basic Building Coefficient (assuming the building will be built with the maximum KDB); A = plot area (m²); Ctadah = runoff coefficient of the cross-section of the building where rainwater will be channeled inside infiltration well (set Ctadah = 0.85); and Atadah = the projected cross-sectional area of the building on the horizontal plane where the rainwater will flow channeled into absorption wells (m²)

3. RESULTS AND DISCUSSION

3.1. Results

The city of Samarinda is the capital of East Kalimantan Province, one of the regions in Indonesia that has relatively high humidity and rainfall. Rainfall data in the city of Samarinda from 2010 to 2019 shows quite varied variations each year. In recent years, seasonal conditions have been uncertain and tend to be difficult to predict.

In the months that are supposed to be the rainy season but in reality, there is no rain or vice versa, when the months that are supposed to be the dry season it turns out that rain still occurs frequently. Differences in rainfall trends from year to year can be influenced by various factors, including global climate change, air circulation patterns, La Nina or El Nino, as well as local geographic and environmental factors. Samarinda city rainfall data for 2010-2019 can be seen based on Table 5 below:

Table 5. Rainfall data above 2.5 mm

Date	Daily Rainfall (mm)	Date	Daily Rainfall (mm)	Date	Daily Rainfall (mm)	Date	Daily Rainfall (mm)	Date	Daily Rainfall (mm)
1		2		3		4		5	
1/1/2010	15.5	2/1/2011	6	3/1/2012	65.5	4/8/2013	4	1/1/2014	16.8
2/1/2010	2.9	3/1/2011	32	4/1/2012	44.9	7/8/2013	17.5	3/1/2014	7.3
4/1/2010	27.8	5/1/2011	93	5/1/2012	29.1	8/8/2013	2.7	5/1/2014	43
8/1/2010	2.5	7/1/2011	11.3	6/1/2012	2.8	15/8/2013	19.5	7/1/2014	12
10/1/2010	4.5	8/1/2011	6.1	8/1/2012	32	17/8/2013	26.3	8/1/2014	18.5
12/1/2010	32	9/1/2011	24.9	9/1/2012	14.9	30/8/2013	3.3	9/1/2014	19.8
13/1/2010	28.5	10/1/2011	6	12/1/2012	24	1/9/2013	2.5	10/1/2014	56.5
18/1/2010	16	11/1/2011	11.7	14/1/2012	8.5	2/9/2013	4.4	15/1/2014	7.4
19/1/2010	3.8	17/1/2011	4.5	18/1/2012	23.5	3/9/2013	84.3	16/1/2014	55
20/1/2010	12	18/1/2011	3.5	19/1/2012	12.8	4/9/2013	14	19/1/2014	2.6
23/1/2010	3.5	19/1/2011	13.5	24/1/2012	35.9	5/9/2013	3.5	30/1/2014	16.8
24/1/2010	9	22/1/2011	15.5	30/1/2012	26.4	6/9/2013	33	10/2/2014	30.5
25/1/2010	4.5	27/1/2011	23.3	1/2/2012	5	7/9/2013	8	11/2/2014	75.5
29/1/2010	5.5	30/1/2011	6.5	6/2/2012	60.5	8/9/2013	26	13/2/2014	15.6
30/1/2010	5.5	2/2/2011	6	7/2/2012	4.5	14/9/2013	14.5	14/2/2014	4.6
2/2/2010	4	4/2/2011	31.9	10/2/2012	6.3	17/9/2013	27.6	15/2/2014	6.5
19/2/2010	39.4	5/2/2011	16.5	15/2/2012	65.5	18/9/2013	5	16/2/2014	27.5
20/2/2010	86.5	6/2/2011	15	16/2/2012	8.5	29/9/2013	28.5	21/2/2014	28
21/2/2010	2.7	7/2/2011	31.7	17/2/2012	3.6	5/10/2013	18	25/2/2014	6.4
22/2/2010	19.3	8/2/2011	9.9	18/2/2012	7.5	6/10/2013	10.5	3/3/2014	13.8
27/2/2010	4.9	11/2/2011	4	20/2/2012	16.4	7/10/2013	3.5	6/3/2014	46.6
4/3/2010	5.2	12/2/2011	5	26/2/2012	13	8/10/2013	10.3	7/3/2014	26.5
11/3/2010	7.7	13/2/2011	11	28/2/2012	13.2	10/10/2013	27.2	14/3/2014	6.5
12/3/2010	8.6	16/2/2011	3.7	2/3/2012	4.5	11/10/2013	11.5	21/3/2014	33.5

Date	Daily Rainfall (mm)	Date	Daily Rainfall (mm)	Date	Daily Rainfall (mm)	Date	Daily Rainfall (mm)	Date	Daily Rainfall (mm)
1		2		3		4		5	
13/3/2010	17.4	20/2/2011	3	5/3/2012	14.1	12/10/2013	10.8	22/3/2014	3.5
23/3/2010	10.6	22/2/2011	17.5	7/3/2012	23.3	20/10/2013	18	26/3/2014	16
27/3/2010	9.2	23/2/2011	2.6	8/3/2012	61	24/10/2013	20.5	27/3/2014	4.8
29/3/2010	15.9	25/2/2011	9	10/3/2012	6.5	26/10/2013	14	28/3/2014	28
31/3/2010	72	1/3/2011	9.3	24/3/2012	26	27/10/2013	11	29/3/2014	86
1/4/2010	5.6	5/3/2011	3.9	25/3/2012	21.3	29/10/2013	10.5	30/3/2014	47
3/4/2010	4.6	11/3/2011	13.8	27/3/2012	65.9	30/10/2013	23.5	2/4/2014	5
5/4/2010	15.2	13/3/2011	25.7	30/3/2012	27	31/10/2013	16	5/4/2014	14
7/4/2010	6	14/3/2011	4	1/4/2012	27.9	1/11/2013	7.8	6/4/2014	12.5
8/4/2010	29	15/3/2011	4.6	4/4/2012	31.2	2/11/2013	5	7/4/2014	9.3
14/4/2010	12.6	18/3/2011	28.5	5/4/2012	33.5	5/11/2013	34.5	8/4/2014	3
17/4/2010	15.9	19/3/2011	7.5	8/4/2012	4.3	6/11/2013	83.5	9/4/2014	23
18/4/2010	3	21/3/2011	29.1	9/4/2012	11	12/11/2013	13.8	11/4/2014	2.7
19/4/2010	6.8	23/3/2011	28	10/4/2012	22.8	15/11/2013	13.5	15/4/2014	4
23/4/2010	33.4	24/3/2011	6.9	11/4/2012	7	17/11/2013	5	16/4/2014	3.6
28/4/2010	13.2	25/3/2011	32.3	15/4/2012	4.4	19/11/2013	3.2	22/4/2014	7
29/4/2010	45	30/3/2011	7.1	16/4/2012	12.5	8/12/2013	6.5	29/4/2014	33.8
30/4/2010	22.5	31/3/2011	27.5	18/4/2012	4.1	13/12/2013	26	1/5/2014	21.5
4/5/2010	11.1	6/4/2011	22.5	22/4/2012	45.5	15/12/2013	33	3/5/2014	6.6
5/5/2010	10.6	9/4/2011	85.9	25/4/2012	44.8	19/12/2013	8.8	8/5/2014	34
6/5/2010	5.5	10/4/2011	9.3	26/4/2012	79.6	20/12/2013	7	11/5/2014	11
8/5/2010	68.4	12/4/2011	28	28/4/2012	3.5	23/12/2013	5.5	12/5/2014	24.8
9/5/2010	3.5	15/4/2011	9	30/4/2012	30.8	25/12/2013	6.3	13/5/2014	5.3
12/5/2010	16.5	17/4/2011	7.8	1/5/2012	30.8	26/12/2013	2.5	16/5/2014	4.8
13/5/2010	19.5	23/4/2011	5	3/5/2012	36.5	27/12/2013	6.5	18/5/2014	5
15/5/2010	7.5	24/4/2011	105.5	8/5/2012	18.3	29/12/2013	11.5	20/5/2014	15.5
19/5/2010	5.5	27/4/2011	47.5	12/5/2012	7.5	31/12/2013	6.3	23/5/2014	28.5
21/5/2010	20.8	30/4/2011	2.5	14/5/2012	5			24/5/2014	7.5
26/5/2010	30.6	1/5/2011	29.5	15/5/2012	22			28/5/2014	66
1/6/2010	2.5	2/5/2011	7.5	22/5/2012	6.8			29/5/2014	27
4/6/2010	30.3	4/5/2011	3.5	23/5/2012	3.5			31/5/2014	15
7/6/2010	7.3	5/5/2011	7.1	25/5/2012	8.5			2/6/2014	21.7
9/6/2010	20.5	6/5/2011	20	29/5/2012	6.3			5/6/2014	14.5
10/6/2010	52.5	7/5/2011	15.5	2/6/2012	57.8			7/6/2014	6
12/6/2010	14	8/5/2011	48	3/6/2012	4			8/6/2014	4.7
13/6/2010	25	9/5/2011	7.8	5/6/2012	10.4			11/6/2014	32
14/6/2010	14	12/5/2011	7.5	9/6/2012	4			16/6/2014	10
15/6/2010	9.8	15/5/2011	10.6	10/6/2012	39.6			18/6/2014	8.5
17/6/2010	66.5	22/5/2011	11.5	11/6/2012	4.3			20/6/2014	44.5
19/6/2010	9.5	25/5/2011	57.1	17/6/2012	7.7			23/6/2014	12.5
20/6/2010	9.7	27/5/2011	23.2	20/6/2012	10.6			25/6/2014	6.8
23/6/2010	17	29/5/2011	4.2	22/6/2012	8			27/6/2014	5.8
24/6/2010	12.3	31/5/2011	27.5	26/6/2012	12.5			1/7/2014	34
25/6/2010	7	5/6/2011	10.8	29/6/2012	8			4/7/2014	7.8
29/6/2010	2.5	8/6/2011	9.5	5/7/2012	32.1			7/7/2014	7.6
30/6/2010	31.1	15/6/2011	7	6/7/2012	25.9			8/7/2014	5.5
2/7/2010	11	16/6/2011	53.4	7/7/2012	20.5			11/7/2014	12.6
3/7/2010	84	28/6/2011	5.5	10/7/2012	3.3			12/7/2014	7.8
4/7/2010	38	3/7/2011	7.5	11/7/2012	13.3			14/7/2014	5
15/7/2010	5.5	8/7/2011	24	14/7/2012	12			2/8/2014	14.8
16/7/2010	21.7	10/7/2011	51.6	15/7/2012	19.4			3/8/2014	3
17/7/2010	3.5	11/7/2011	59.7	18/7/2012	3.4			4/8/2014	16
18/7/2010	8.9	14/7/2011	3.5	20/7/2012	2.5			5/8/2014	4.3
19/7/2010	15.8	15/7/2011	24.9	24/8/2012	4.4			6/8/2014	2.6
21/7/2010	5.4	18/7/2011	10.5	27/8/2012	2.8			9/8/2014	7.7
23/7/2010	42	19/7/2011	20.2	28/8/2012	98.9			10/8/2014	11.8
28/7/2010	9	20/7/2011	27.5	30/8/2012	22.1			12/8/2014	6.8
1/8/2010	3.5	22/7/2011	6.4	31/8/2012	7.8			20/8/2014	6.7
2/8/2010	3	15/8/2011	4.5	12/9/2012	8.1			4/9/2014	4.2
4/8/2010	12.8	17/8/2011	8.7	17/9/2012	58			6/9/2014	6.3
8/8/2010	5.6	27/8/2011	27.5	18/9/2012	10.2			7/9/2014	6.5
10/8/2010	22.5	28/8/2011	7.2	21/9/2012	7.2			15/9/2014	5
13/8/2010	4	30/8/2011	46.7	30/9/2012	26.4			23/9/2014	30
15/8/2010	30	31/8/2011	27.5	1/10/2012	6			22/10/2014	5.4
19/8/2010	7.5	4/9/2011	22.5	8/10/2012	4.7			23/10/2014	21.5
21/8/2010	7	7/9/2011	45.6	11/10/2012	7.5			24/10/2014	35.6

Date	Daily Rainfall (mm)	Date	Daily Rainfall (mm)	Date	Daily Rainfall (mm)	Date	Daily Rainfall (mm)	Date	Daily Rainfall (mm)
1		2		3		4		5	
22/8/2010	3	12/9/2011	6.1	14/10/2012	6.5			29/10/2014	32.5
23/8/2010	8	13/9/2011	21.6	15/10/2012	2.5			1/11/2014	14.3
24/8/2010	44	14/9/2011	17.5	18/10/2012	3.3			8/11/2014	2.8
30/8/2010	9.5	16/9/2011	6.1	19/10/2012	3.5			12/11/2014	43.8
2/9/2010	14	17/9/2011	7.5	21/10/2012	10.8			18/11/2014	2.7
4/9/2010	11.5	22/9/2011	3.4	23/10/2012	21.6			19/11/2014	102.5
5/9/2010	11.5	1/10/2011	39.4	25/10/2012	18.5			21/11/2014	2.5
6/9/2010	9.3	2/10/2011	7.1	26/10/2012	6.8			23/11/2014	16
8/9/2010	14	4/10/2011	7.9	29/10/2012	16.2			24/11/2014	9.5
10/9/2010	14.5	5/10/2011	10	3/11/2012	3.9			25/11/2014	7
12/9/2010	9.1	8/10/2011	4.8	6/11/2012	13			26/11/2014	18
16/9/2010	14.1	11/10/2011	38.4	10/11/2012	10.2			27/11/2014	23
18/9/2010	12.4	17/10/2011	3	15/11/2012	4.5			28/11/2014	58
19/9/2010	4.5	23/10/2011	36	17/11/2012	65.7			1/12/2014	7.2
20/9/2010	7	25/10/2011	7	20/11/2012	28.4			2/12/2014	38.8
22/9/2010	38.3	26/10/2011	18.1	22/11/2012	29.7			3/12/2014	63.6
27/9/2010	14	27/10/2011	14.5	23/11/2012	7.2			5/12/2014	12.5
28/9/2010	30	30/10/2011	27.5	24/11/2012	35			6/12/2014	15
29/9/2010	17	5/11/2011	14	28/11/2012	16.2			7/12/2014	17.1
30/9/2010	4	6/11/2011	50.5	30/11/2012	73.8			9/12/2014	19.3
3/10/2010	10.3	13/11/2011	24.4	3/12/2012	15.2			10/12/2014	16.7
4/10/2010	37.2	15/11/2011	8.6	8/12/2012	52.5			14/12/2014	2.8
5/10/2010	17	17/11/2011	16.5	9/12/2012	5.4			16/12/2014	38.5
6/10/2010	3.9	21/11/2011	10.8	10/12/2012	5.3			17/12/2014	3.6
8/10/2010	6	22/11/2011	27	13/12/2012	2.6			20/12/2014	21.5
11/10/2010	6	25/11/2011	3.6	14/12/2012	2.5			21/12/2014	8
15/10/2010	11	28/11/2011	28	25/12/2012	50			22/12/2014	76.4
18/10/2010	23.8	30/11/2011	11.8	28/12/2012	9.5			24/12/2014	54
19/10/2010	4.4	3/12/2011	10.5	30/12/2012	7.3			28/12/2014	62
21/10/2010	17.4	5/12/2011	41.5	31/12/2012	64.5			31/12/2014	4.5
22/10/2010	3.6	9/12/2011	5.2						
25/10/2010	17.5	12/12/2011	43.9						
26/10/2010	14	13/12/2011	11.8						
27/10/2010	5.3	16/12/2011	4.5						
28/10/2010	20.9	20/12/2011	5						
29/10/2010	3.2	21/12/2011	3.4						
31/10/2010	27.5	22/12/2011	53.7						
2/11/2010	41	25/12/2011	7.7						
4/11/2010	5.5	26/12/2011	10.8						
6/11/2010	44.1	27/12/2011	11						
9/11/2010	6	28/12/2011	27.6						
10/11/2010	4.8								
12/11/2010	8								
14/11/2010	6.8								
16/11/2010	27								
18/11/2010	18								
21/11/2010	5.3								
22/11/2010	7								
24/11/2010	28.8								
1/12/2010	5.3								
2/12/2010	57.5								
3/12/2010	3.2								
7/12/2010	2.8								
8/12/2010	5.1								
9/12/2010	3.5								
17/12/2010	44.5								
18/12/2010	4.8								
19/12/2010	48.9								
20/12/2010	3.9								
27/12/2010	19								
29/12/2010	12								

Table. 5. Rainfall data above 2.5 mm (Continued)

Date	Daily Rainfall (mm)	Date	Daily Rainfall (mm)	Date	Daily Rainfall (mm)	Date	Daily Rainfall (mm)	Date	Daily Rainfall (mm)
6		7		8		9		10	
5/1/2015	29.3	4/1/2016	19.8	5/1/2017	9.5	6/1/2018	10	2/1/2019	27.4
6/1/2015	6.6	13/1/2016	4.3	6/1/2017	5	7/1/2018	12	3/1/2019	18.5
7/1/2015	11.8	21/1/2016	37	7/1/2017	14	13/1/2018	2.6	10/1/2019	4.8
8/1/2015	28.8	22/1/2016	86.3	9/1/2017	18	14/1/2018	60.6	22/1/2019	6.3
9/1/2015	11.9	23/1/2016	6.7	12/1/2017	4.3	15/1/2018	18	23/1/2019	20
10/1/2015	31.3	12/2/2016	44.3	14/1/2017	8.5	21/1/2018	10.8	26/1/2019	4
12/1/2015	11.5	17/2/2016	16.5	15/1/2017	5.5	23/1/2018	15	27/1/2019	19.4
14/1/2015	27.2	23/2/2016	8	16/1/2017	3	24/1/2018	21.5	30/1/2019	2.5
18/1/2015	23	28/2/2016	7.8	19/1/2017	2.5	26/1/2018	58.6	1/2/2019	3.8
19/1/2015	8.6	29/2/2016	25	20/1/2017	2.5	31/1/2018	3.8	3/2/2019	2.9
20/1/2015	44.3	1/3/2016	22	21/1/2017	4.7	2/2/2018	36	8/2/2019	3
23/1/2015	14	2/3/2016	4.5	23/1/2017	62.5	6/2/2018	4.7	9/2/2019	6.2
28/1/2015	76	16/3/2016	2.6	24/1/2017	17.5	7/2/2018	8	9/3/2019	10.5
29/1/2015	10.3	18/3/2016	53.3	2/2/2017	31.3	8/2/2018	18.4	10/3/2019	13.5
2/2/2015	3.3	21/3/2016	22.1	3/2/2017	10	10/2/2018	3.5	11/3/2019	2.5
6/2/2015	37.2	23/3/2016	9	5/2/2017	5.7	11/2/2018	10.2	15/3/2019	5.4
9/2/2015	27.8	26/3/2016	3.7	6/2/2017	2.5	12/2/2018	2.5	16/3/2019	48.6
11/2/2015	8.5	1/4/2016	2.6	13/2/2017	7.3	15/2/2018	3.5	17/3/2019	2.5
12/2/2015	21	10/4/2016	28.7	17/2/2017	17.8	18/2/2018	2.8	22/3/2019	14.6
13/2/2015	18.4	11/4/2016	47.9	19/2/2017	4.2	3/3/2018	4.8	25/3/2019	16.5
14/2/2015	3.5	13/4/2016	3.5	21/2/2017	7.6	16/3/2018	8	27/3/2019	21.1
21/2/2015	20.2	14/4/2016	120.1	22/2/2017	3.5	18/3/2018	3	29/3/2019	6.7
2/3/2015	2.5	15/4/2016	11	23/2/2017	10	20/3/2018	12.4	31/3/2019	52.6
3/3/2015	37.3	16/4/2016	22.7	24/2/2017	2.7	22/3/2018	88.5	3/4/2019	11.9
4/3/2015	23.5	17/4/2016	31.3	25/2/2017	13.7	25/3/2018	7.6	8/4/2019	3
5/3/2015	28.2	24/4/2016	3.9	26/2/2017	18.4	30/3/2018	11.5	9/4/2019	29.6
6/3/2015	12.8	28/4/2016	28.8	1/3/2017	5.4	31/3/2018	11.4	11/4/2019	18.1
7/3/2015	3.8	30/4/2016	78.8	4/3/2017	3.5	2/4/2018	5.7	12/4/2019	17.1
14/3/2015	12.5	8/5/2016	6.3	5/3/2017	7.4	3/4/2018	5.4	13/4/2019	3.9
16/3/2015	5	17/5/2016	37.3	8/3/2017	3.8	4/4/2018	3.1	14/4/2019	5.5
18/3/2015	25.4	18/5/2016	2.5	13/3/2017	3	5/4/2018	6.6	25/4/2019	33
19/3/2015	4.2	19/5/2016	44.1	16/3/2017	9.5	6/4/2018	7	26/4/2019	8.6
21/3/2015	26.5	21/5/2016	12.8	21/3/2017	16.3	10/4/2018	3.5	29/4/2019	5.5
22/3/2015	6.4	22/5/2016	6.5	25/3/2017	18	12/4/2018	9.5	2/5/2019	10.5
23/3/2015	9.7	24/5/2016	18.6	27/3/2017	5	17/4/2018	13	5/5/2019	6
3/4/2015	57.5	27/5/2016	37.2	31/3/2017	3.5	18/4/2018	11.7	8/5/2019	6
4/4/2015	17.7	28/5/2016	33.6	1/4/2017	8	24/4/2018	73.7	10/5/2019	13.9
5/4/2015	8.4	29/5/2016	4.6	2/4/2017	15.4	26/4/2018	23.8	11/5/2019	6.1
12/4/2015	24.7	30/5/2016	16.1	3/4/2017	47	27/4/2018	5.2	14/5/2019	2.5
20/4/2015	4	31/5/2016	9.8	4/4/2017	34.4	30/4/2018	5.3	15/5/2019	3.5
21/4/2015	50.8	4/6/2016	11.4	5/4/2017	54	1/5/2018	3	16/5/2019	6
22/4/2015	67.1	5/6/2016	4.6	6/4/2017	17	2/5/2018	5.4	17/5/2019	99.7
23/4/2015	59.8	10/6/2016	27.8	11/4/2017	22.5	8/5/2018	51.1	18/5/2019	2.5
24/4/2015	26.8	14/6/2016	6.3	12/4/2017	11.4	9/5/2018	34	20/5/2019	2.7
26/4/2015	56.5	15/6/2016	36.5	13/4/2017	24.7	13/5/2018	25.5	23/5/2019	17.5
5/5/2015	13.5	16/6/2016	38.5	16/4/2017	29.8	16/5/2018	2.8	25/5/2019	2.8
6/5/2015	18.4	18/6/2016	6.5	19/4/2017	2.5	18/5/2018	6	31/5/2019	9.2
8/5/2015	15.3	22/6/2016	3.2	20/4/2017	27.5	19/5/2018	133	1/6/2019	32
11/5/2015	3.2	27/6/2016	6.4	28/4/2017	35.5	20/5/2018	9.5	3/6/2019	14.9
12/5/2015	29	28/6/2016	12.1	29/4/2017	6.5	22/5/2018	101.5	4/6/2019	49
13/5/2015	16.6	2/7/2016	5.9	2/5/2017	17	24/5/2018	3	7/6/2019	9.2
15/5/2015	3	4/7/2016	5.8	4/5/2017	3.2	27/5/2018	11.1	8/6/2019	3.5
16/5/2015	8	18/7/2016	4.7	6/5/2017	26.5	28/5/2018	3.1	9/6/2019	60.7
17/5/2015	34.2	19/7/2016	14.2	7/5/2017	23	29/5/2018	13.9	15/6/2019	19
18/5/2015	22.2	20/7/2016	16.5	10/5/2017	5.3	1/6/2018	25.3	16/6/2019	11.6
24/5/2015	7.5	21/7/2016	20.5	11/5/2017	21	5/6/2018	22	17/6/2019	9.4
25/5/2015	23.5	22/7/2016	11.5	12/5/2017	16.6	8/6/2018	24	20/6/2019	23
29/5/2015	18.5	26/7/2016	5.4	13/5/2017	7	13/6/2018	20.5	26/6/2019	27.4
31/5/2015	12	27/7/2016	18.7	15/5/2017	18.7	17/6/2018	30.7	4/7/2019	33.8
1/6/2015	30	28/7/2016	24.9	18/5/2017	9.3	21/6/2018	10.7	7/7/2019	6.2
2/6/2015	46.5	30/7/2016	14.5	20/5/2017	14.1	23/6/2018	3.4	15/7/2019	2.5
6/6/2015	4.3	31/7/2016	23.5	21/5/2017	5.5	24/6/2018	46.4	14/8/2019	23
7/6/2015	28.6	3/8/2016	13.2	22/5/2017	40.3	25/6/2018	4	19/8/2019	12.7
8/6/2015	14	4/8/2016	25.7	29/5/2017	55.7	26/6/2018	3.4	21/8/2019	15.7
9/6/2015	3.8	7/8/2016	7	30/5/2017	40.7	28/6/2018	4.6	23/8/2019	5.4

Date	Daily Rainfall (mm)	Date	Daily Rainfall (mm)	Date	Daily Rainfall (mm)	Date	Daily Rainfall (mm)	Date	Daily Rainfall (mm)
6		7		8		9		10	
13/6/2015	29.1	8/8/2016	3.6	1/6/2017	46.3	1/7/2018	5.5	25/8/2019	3.7
14/6/2015	5.1	15/8/2016	2.8	2/6/2017	43.5	2/7/2018	16.9	29/9/2019	8.5
19/6/2015	11.6	28/8/2016	4.3	3/6/2017	5.3	6/7/2018	40.8	30/9/2019	37.5
20/6/2015	21.3	31/8/2016	32.8	4/6/2017	13.4	22/7/2018	33.5	3/10/2019	22
24/6/2015	4	2/9/2016	9.2	6/6/2017	6.8	30/7/2018	2.5	4/10/2019	4
25/6/2015	28.5	7/9/2016	31.7	8/6/2017	30.3	31/7/2018	23	5/10/2019	3
28/6/2015	24.6	9/9/2016	5.7	10/6/2017	4	2/8/2018	28.6	7/10/2019	27.4
18/7/2015	13.3	10/9/2016	7.4	11/6/2017	19.3	11/8/2018	6	12/10/2019	23.5
19/7/2015	14.7	13/9/2016	42.4	13/6/2017	12.4	18/8/2018	4.7	13/10/2019	5
21/7/2015	15.5	14/9/2016	22.2	14/6/2017	2.5	29/8/2018	5.5	16/10/2019	6.3
22/7/2015	78.8	15/9/2016	16	16/6/2017	20.5	30/8/2018	3.5	18/10/2019	4.3
27/7/2015	4.8	18/9/2016	34.9	19/6/2017	68.7	2/9/2018	12.5	19/10/2019	21.5
28/7/2015	19.8	19/9/2016	42.5	22/6/2017	34	6/9/2018	4	20/10/2019	6.5
29/7/2015	3.1	21/9/2016	4	23/6/2017	3.8	17/9/2018	2.5	21/10/2019	20.8
31/7/2015	2.5	22/9/2016	13.8	24/6/2017	4	18/9/2018	17.2	24/10/2019	2.6
28/8/2015	2.9	23/9/2016	2.8	7/7/2017	18.3	19/9/2018	12.5	25/10/2019	8.3
29/8/2015	54.2	24/9/2016	14.4	10/7/2017	5.8	25/9/2018	74.5	26/10/2019	31.4
6/10/2015	7	25/9/2016	10.4	13/7/2017	5.1	3/10/2018	22	27/10/2019	2.9
26/10/2015	13.3	30/9/2016	3	14/7/2017	7.9	6/10/2018	28	1/11/2019	12.3
28/10/2015	36.5	2/10/2016	6.2	15/7/2017	2.9	8/10/2018	7	6/11/2019	12
29/10/2015	2.6	5/10/2016	5.8	16/7/2017	7	11/10/2018	16.8	7/11/2019	6.5
31/10/2015	14.8	7/10/2016	25.4	17/7/2017	46.7	12/10/2018	7.3	10/11/2019	48
1/11/2015	7.3	8/10/2016	6.7	28/7/2017	13.8	13/10/2018	24.4	12/11/2019	8
8/11/2015	8.5	10/10/2016	8.8	29/7/2017	51.5	14/10/2018	3	13/11/2019	17
10/11/2015	6	12/10/2016	48.8	3/8/2017	3.8	15/10/2018	3	20/11/2019	10.4
19/11/2015	16	13/10/2016	9.5	4/8/2017	15.3	19/10/2018	5	22/11/2019	3.6
22/11/2015	6.3	16/10/2016	2.5	10/8/2017	3.3	22/10/2018	29.1	23/11/2019	4.2
24/11/2015	6	17/10/2016	7.4	12/8/2017	18.8	23/10/2018	4.8	29/11/2019	5
25/11/2015	3.5	21/10/2016	6	13/8/2017	24.4	3/11/2018	3.5	4/12/2019	3.5
26/11/2015	8	23/10/2016	2.5	15/8/2017	4.8	8/11/2018	3.5	5/12/2019	2.7
28/11/2015	2.7	27/10/2016	3	17/8/2017	102.3	9/11/2018	2.9	9/12/2019	15.4
3/12/2015	18.2	28/10/2016	25.8	24/8/2017	42	12/11/2018	20.6	11/12/2019	69.5
12/12/2015	58.3	29/10/2016	18.5	26/8/2017	10	13/11/2018	2.8	12/12/2019	40
15/12/2015	59.5	6/11/2016	11.6	28/8/2017	3.8	14/11/2018	37.7	13/12/2019	27.7
17/12/2015	29	7/11/2016	5.8	29/8/2017	3.8	15/11/2018	8.5	20/12/2019	6.6
21/12/2015	8.7	8/11/2016	12	5/9/2017	31.2	18/11/2018	3.7	21/12/2019	92.7
26/12/2015	18.2	9/11/2016	12.6	9/9/2017	12.1	20/11/2018	5.7	22/12/2019	25.1
		11/11/2016	16.5	12/9/2017	6.7	24/11/2018	6.5	27/12/2019	27.8
		14/11/2016	32.5	14/9/2017	5.9	26/11/2018	25.3	28/12/2019	79.8
		16/11/2016	22.2	16/9/2017	13	18/12/2018	12.7	29/12/2019	5.8
		19/11/2016	24	17/9/2017	5.9	21/12/2018	19.8		
		28/11/2016	73.7	18/9/2017	15.1	22/12/2018	10.1		
		29/11/2016	72.7	24/9/2017	7.5	23/12/2018	12.5		
		3/12/2016	37.6	26/9/2017	3.4				
		4/12/2016	22	2/10/2017	16.3				
		5/12/2016	5	4/10/2017	53.1				
		7/12/2016	29.2	6/10/2017	9.7				
		9/12/2016	8.7	9/10/2017	15				
		10/12/2016	6	12/10/2017	12.8				
		11/12/2016	28	13/10/2017	3				
		12/12/2016	8.5	17/10/2017	19.8				
		17/12/2016	19	18/10/2017	12.2				
		20/12/2016	5.7	29/10/2017	4.1				
		21/12/2016	9.9	1/11/2017	16.9				
		22/12/2016	9.9	5/11/2017	7				
		23/12/2016	27.5	12/11/2017	25				
		25/12/2016	4.2	14/11/2017	40.8				
		26/12/2016	33	16/11/2017	34.5				
		27/12/2016	4	17/11/2017	3.7				
		28/12/2016	8.9	20/11/2017	6.2				
		29/12/2016	7	21/11/2017	3				
		30/12/2016	5.5	24/11/2017	6				
		31/12/2016	72	25/11/2017	3.4				
				26/11/2017	9.7				
				28/11/2017	29.2				
				29/11/2017	24				
				3/12/2017	5				

Date	Daily Rainfall (mm)	Date	Daily Rainfall (mm)	Date	Daily Rainfall (mm)	Date	Daily Rainfall (mm)	Date	Daily Rainfall (mm)
6		7		8		9		10	
				6/12/2017	63				
				10/12/2017	18				
				11/12/2017	5.8				
				14/12/2017	4				
				15/12/2017	12.2				
				17/12/2017	8				
				20/12/2017	8.8				
				24/12/2017	16.2				
				25/12/2017	24.9				
				27/12/2017	17.2				
				28/12/2017	5				
				31/12/2017	31				

Source: Samarinda City Meteorology and Geophysics Agency

Based on the data in Table 5 above, shows that the daily rainfall range between 2.5 – 102.3 mm is classified as very low to high. High-intensity rainfall in Samarinda City not only causes flooding but also has the potential to cause landslides, health problems such as dengue hemorrhagic fever and diarrhea as well as several negative impacts of high rainfall which will also of course cause economic losses.

Of course, high rainfall cannot be controlled by humans, but humans can minimize the negative impacts that occur as a result of high rainfall, such as carrying out reforestation, building flood control embankments, changing flood-prone areas into areas with lots of water absorption and creating and managing drainage well. So that it can function optimally.

3.2. Discussion

3.2.1. Rainwater catchment system

With a rainwater catchment system, rainwater that falls on the roof of the building will flow through the gutter and into a pipe connected to the first water reservoir. The dust and rubbish that pollutes the water are then filtered into an intermediate tank containing sand and gravel.

3.2.2. Rainwater distribution system, including standpipes and drainage within the plot

The clean rainwater then flows into the main reservoir. If the main tank is no longer able to hold water because it rains continuously, the water will flow through the outlet pipe into a rainwater reservoir approximately 3 meters deep. Rainwater in the storage tank will seep into the soil and increase the water content of the soil. The walls of this infiltration well can be made of concrete up to 10 cm thick.

Rainfall value (I) = 58 mm/hour

Rainwater catchment area (A) = 4,892 m^2

Runoff coefficient (C) = 0.70

Drainage channel length = 292.78 meters

Q = C I A

= 0.70 x 58 mm/hour x 4,892 m^2

= 198.62 m^3/hour

= 0.055 m^3/sec

Drainage is a construction that becomes a medium for flowing water from one point to another which is considered very important to help the process of flowing water such as rainfall, so that puddles or flooding do not occur.The scheme of the drainage network system in buildings is presented in Figure 1.

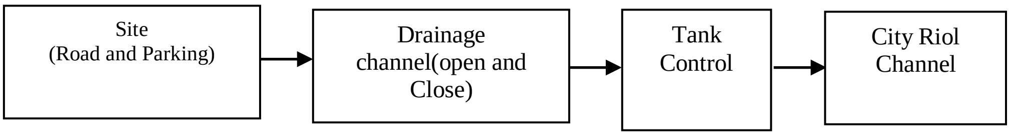

Figure 1. The scheme of the drainage network system in buildings
(Source: Analysis Results and Planning Concept for 2023)

3.2.3. Rainwater collection, processing, infiltration, and disposal system

The Rainwater Management System (PAH) is a groundwater conservation system through collects and utilizes rainwater to meet water needs for sanitation. This system has many benefits, including reducing groundwater use and reducing emissions, thereby reducing the impact of climate change and global warming. This PAH system can provide an additional source of water for daily life and purification (worship) purposes. This system has several basic components with a closed system to channel water from the gutter to the ground tank. It was stated by Abdulla and Al Shareef, (2009) that the rainwater management system generally consists of several systems, namely:place to catch rain (collection area), rainwater channels that channel rainwater from the place to catch rain to storage tanks (conveyance), filters, reservoirs (storage tanks), drains, and pumps.

3.2.4. Rainwater utilization system

The Rainwater utilization system was a groundwater conservation system through collecting and utilizing rainwater to meet water needs for sanitation. This system has many benefits, including reducing groundwater use and reducing emissions, thereby reducing the impact of climate change and global warming. This rainwater utilization system can provide an additional source of water for daily life and purification (worship) purposes. This system has several basic components with a closed system to channel water from gutters to tanks or absorption wells (Kulonprogo District Environmental Service, 2021).

The basic principle of rainwater utilization is to channel rainwater that falls on the roof surface through gutters to be collected into a storage tank. Then the water runoff that comes out of the full storage tank is channeled into the absorption well or reused for daily needs.

The results of the calculation of the mandatory volume of rainwater management are as follows:

a) The calculation of ordinal ranking for the 95th percentile is as follows:

$$n = \frac{95}{100} \text{ X } N + \frac{1}{2}$$

Information :
n = ordinal ranking for the 95th percentile
N = Number of rainfall data in the dataset
Samarinda City Land Area = 718 Km²
Building Area = 70%

n = (95/100) x 1160 x (1/2) = 58

b) Calculation of the mandatory volume of rainwater management

The mandatory volume for managing rainwater was:

$$Vwk = th \times A$$

Plot condition: A = 718 Km²
th = 58 mm/day = 58 L/m²/day

Information:
Vwk = required volume to manage (m^3)
th = height of rain (mm)
A = plot area (m^2)

Calculation: Vwk = 58 x 502.6 Km^2= 29,150,800 m^3
In one day the volume required to manage building plots is 29,150,800 m^3

c) Calculation of the volume of flood contribution

If the plot is completely covered by pavement and buildings, then:

$$Vab = Vwk$$

Vab = 29,150,800 m^3
Vab = Volume of flood contribution (m^3)
Vwk = Volume required to manage (m^3)

If the plot is not completely covered by pavement and buildings, then:

$$Vab = 0.855.\ Ctadah.\ Atadah.th$$

Information :
Atada = KDB x A
KDB = Basic Building Coefficient (assuming the building will be built with the maximum KDB)
A = plot area (m^2)
Ctadah = runoff coefficient of the cross-section of the building whose rainwater will be channeled into the absorption well (set Ctadah = 0.85)
The projected cross-sectional area of the building on the horizontal plane where rainwater will be channeled into the infiltration well (m^2)

Assumption: KDB = 70%
Atadah = KDB x A
= 70 % x 718 Km^2 = 502.6 Km^2
Vab = 0.855. Ctadah. Atadah. th
= 0.855 x 0.85 x 502.6 x 58
= 21,185,343.9 m^3
The volume of flood contribution was 21,185,343.9 m^3

Based on the results of the analysis, it was found that the volume required to manage building plots not covered by pavement and buildings was 29,150,800 m^3, whereas if they were covered by pavement and buildings it was only 21,185,343.9 m^3.

4. CONCLUSIONS AND SUGGESTIONS

4.1. Conclusion

Based on the results of the analysis and discussion, it can be concluded, namely:

1. By managing rainwater in buildings and plots through rainwater utilization and soil infiltration, rainwater runoff will be reduced.
2. From the rainwater management calculation process using the 95th percentile method, the City of Samarinda is required to manage 21,185,343.9 m^3 of rainwater. Rainwater management carried out by the Samarinda City Government can take the form of creating retention ponds (folders) in several areas, especially those where inundation or flooding frequently occurs, and in each building or area according to its function and classification, a retention or ground pond is provided.

4.2 . Suggestion

To make the city of Samarinda flood-free, the author provides suggestions as input for interested parties as follows.

1. Increase outreach to the general public about the Samarinda City flood control program.
2. Require the community to build ground tanks/rainwater storage on each land or building according to its intended purpose.
3. Prepare a Mayor's Regulation which regulates the Main Duties and Functions of the Public Works Department in the field of Human Settlements and Spatial Planning in flood control to then be made into a Mayor's Regulation which regulates flood control in the City of Samarinda.

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