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RAIN WATER HARVESTING AT THE PLANTATION

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Abstract

This study aims to analyze the rainwater harvesting system and calculate the volume of rainwater that can be accommodated for water needs at the plantation site. The research method used is the Rational method. The data used are rainfall data and catchment area which are then calculated using hydrological analysis and hydraulics analysis. The calculation of the average daily rainfall uses the Gumbel method, while the calculation of rainfall intensity uses the Vanbreen method with the Talbot formula, and to find the channel discharge using the Rational method. From the results of the calculations and analysis above, it can be concluded that 1) Rainwater harvesting can be used as an alternative for managing water resources on plantations. 2) The intensity of rainfall for the 5-year return period is 30,644 mm/hour. 3) the catchment area of the garden house 2 x 13.5 m2 can produce a rainwater discharge of = 0.0000828050 m3/second. 4) The volume of 2 sewer tanks can accommodate 1570 liters of water. 5) Farmers can take advantage of stored rainwater for up to 20 days.

Keywords: Rain water harvesting, Rational method, plantation, Bili-bili

Introduction

Water is the source of life in the world (Palacio et al., 2014; Zhongming & Wei, 2020), water is also an indispensable element for life (Salman & McInerney-Lankford, 2004). Water sources come from rain, rivers, lakes, seas, or from the ground. On the other hand, extreme events such as droughts and floods have increased in almost all parts of the world (Z. X. Xu et al., 2004).

Improving the efficiency of water use and building a society characterized by water conservation and low pollution has become the focus of the global community (Ma et al., 2016). Suboptimal use of water can be disastrous (Florince et al., 2016). Excess water will result in flooding, and lack of water will have an impact on drought disasters, especially during the dry season (Farooq et al., 2009). Rainwater comes from the process of evaporation of water into the air which then gathers into clouds and when it falls it will dissolve objects in the air that can contaminate and pollute rainwater such as gas (O2, CO2, N2), dust, and others (Hasnawir, 2012). Rainwater is a relatively clean water source and with the necessary care it can even be used for portable consumption (Rahman et al., 2019). Rainwater is one of the water sources that can be accessed directly and used for various purposes, including adding water reserves in urban areas (Asrib & Arfandi, 2018).

In urban communities, the need for clean water is generally supplied by a government agency such as a regional drinking water company (PDAM) (Kusumastuti & Chandra, 2021). For people who do not have PDAM water supply, they will use ground water for their daily needs (Hadipuro, 2010). Groundwater is a source of water for household needs because ground water will be refilled during the rainy season (Murdiana et al., 2019). In plantation areas, people rely on groundwater by pumping groundwater into reservoirs or directly irrigating plantation areas (Maryono, 2020).

Population growth and economic growth will encourage the growing need for clean water (Falkenmark & Widstrand, 1992), (Suheri et al., 2019). Excessive exploitation of groundwater will have a negative impact on the environment (Aigbedion & Iyayi, 2007). Groundwater exploitation can cause land subsidence (Pacheco-Martínez et al., 2013). When this happens, it will also have an impact on the difficulty of clean water until there is a water crisis (Panagos et al., 2016; Shiva & Opel, 2013). However, not all land can produce clean water (Al-Salaymeh et al., 2011). To avoid a clean water crisis, one of the efforts that can be done is to save water, make water absorption holes or biopori (Andreas et al., 2021). As well as developing technology to convert seawater into fresh water, developing wastewater technology, and making rain harvests (Muliawati, 2015; Sudarmanto, 2010).

Rainwater harvesting is a series of activities to collect, use and/or absorb rainwater into the soil (Lee et al., 2016). Rainwater harvesting has been widely applied (Auliyani & Wahyuningrum, 2020). This is due to the relatively low cost of implementation and maintenance and does not require expert skills (Ndiritu et al., 2014).

Rainwater harvesting is an effort to conserve water resources (Şahin & Manioğlu, 2019). It is also expected to reduce the rate of groundwater exploitation (Almazroui et al., 2017). In addition, rainwater harvesting can also increase the availability of groundwater through re-absorption into the soil (J. Xu et al., 2021). This is stated in the Regulation of the State Minister of the Environment Number 12 of 2009 concerning the Utilization of Rainwater and the Regulation of the Minister of Public Works Number 11 of 2014 concerning the Management of Rainwater in Buildings and Lands. These two regulations are a reference for government administrators in Indonesia in the context of conserving water resources and controlling environmental damage (Umum, 2014).

Gowa Regency is an area that produces horticultural commodities such as rice, vegetables, and fruits in the province of South Sulawesi (Hasanuddin et al., 2020). Farmers in Gowa district often bring supplies to their farms and plantations because the distance between their homes and their place of cultivation is quite far. The main supplies they brought were mainly drinking water and food needs. This can be seen in the farming community in Romang Loe Village, Bonto Marannu District.

Heavy burdens are often an obstacle for them to bring supplies, especially if their location is far enough away that they build a garden house as a place to rest from the hot sun and rain. When it rains, they often collect the water to be used as raw material for drinking water. It's just that, because the container is small and often dirty, it can only be used a little to be used as drinking water.

Some of these problems should make us pay attention to the availability of clean water sources (Aladenola & Adeboye, 2010). Collecting rainwater that falls is considered one of the most effective ways of dealing with water problems (Tian et al., 2003; Yuan et al., 2003). However, to be able to accommodate rainwater optimally and also meet good water quality so that later it can be reused, it is necessary to have a good rainwater harvesting system (De Kwaadsteniet et al., 2013)

Based on various research results and the condition of the farming community in Romang Loe Village, the application of rainwater harvesting methods at farmers' plantation locations can be carried out to meet the community's drinking water needs on plantation lands communally so that it can be utilized by the community. Based on the background of the problem above, the formulation of the problem that will be studied in this study is rainwater harvesting carried out at the plantation site in order to utilize rainwater as a source of clean water.

The limitations of the problem in this study are: 1) The method used to calculate the rainwater discharge is the rational method (Mahmoud et al., 2014); 2) Calculation of rainfall intensity using a period of 5 years (Ali et al., 2017); 3) The test is carried out by theoretical and experimental methods at the location of the farmer's garden house; 4) Calculation of average daily rainfall and rainfall intensity using Microsoft Excel application.

Research Methods

The research location is in Romang Loe Village, Kec. Bonto Marannu, Gowa Regency. Data collection using Primary Data and Secondary Data. Primary data is data obtained by observations and measurements in the field. In general, the definition of primary data is data obtained from the first source / data source or data collected by researchers directly through the object of research. The data obtained is the size of the catchment area, which is the size of the roof area of the garden house. A culvert model reservoir with a diameter of 1 m, a height of 1 meter. Measurement aims to determine the volume of rainwater that can be accommodated.

Secondary data comes from rainfall data obtained from the Jeneberang-Pompengan River Area Center at the Kampili Dam Rainfall Station. Collecting data using observation and documentation. Field survey observations were carried out in order to evaluate the rainwater harvesting system in the plantation and calculate the water requirement that can be accommodated by rainwater. While the documentation obtained from the relevant agencies that process rainfall data.

Hydrological data analysis using the Gumbel (Sarbidi, 2015) method by applying several equations, including:

$$X_{Tr} = \bar{X} \frac{Y_{Tr} - Y_n}{S_n} . S \qquad (1)$$

where:

X_{Tr} = large variable with a birthday period of T years
= mean value
S = standard deviation
K = frequency factor of gumbel
Y_n = *reduced mean* which depends on the number of samples/data n
S_n = *reduced standard deviation* which also depends on the number of samples n
Y_{Tr} = *reduced variate*

Results and Discussion

Daily Rainfall

Data Hydrological Analysis Hydrological analysis is a process of calculating raw data obtained from the Central Jeneberang-Pompengan River Basin. Monthly maximum rainfall data from rainfall recording stations in the Kampili Weir which is near the study area. The maximum daily rainfall data is described in Table 1.

Table 1. Maximum Daily Rainfall Data for Kampili Weir Station

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Agst	Sep	Okt	Nov	Des	**Biggest**
2010	117	115	75	75	58	45	50	30	50	70	70	85	117
2011	80	70	65	66	30	25	-	-	-	91	50	60	91
2012	150	100	109	65	38	74	-	-	-	19	120	70	150
2013	142	100	75	57	100	84	80	80	-	16	100	100	142
2014	75	90	100	100	90	70	-	-	-	-	-	93	100
2015	133	110	55	82	60	31	-	-	-	-	25	140	140
2016	125	132	71	155	42	60	32	-	155	120	93	57	155
2017	160	120	120	60	60	60	30	8	18	16	77	108	160
2018	122,0	159,0	122,0	30,0	13,0	24,0	0,0	0,0	0,0	0,0	48,0	93,0	159
2019	163,0	66,0	48,0	24,0	8,0	30,0	-	-	-	-	-	-	163

Source: Jeneberang-Pompengan River Basin Center (BBWS), 2021

From Table 1, it can be seen that the largest maximum daily rainfall occurred in 2019 at 163 mm/hour, and the smallest in 2011 at 91 mm/hour.

Calculation of Maximum Average Rainfall Plan for the Gumbel method

Table 2. Calculation of maximum rainfall using the Gumbel method.

No.	**Year**	**x (mm)**	**x^2 (mm)**
1	2010	117	13689
2	2011	91	8281
3	2012	150	22500
4	2013	142	20164
5	2014	100	10000
6	2015	140	19600
7	2016	155	24025
8	2017	160	25600
9	2018	159	25281
10	2019	163	26569
	Total	**1377**	**195709**
	Average	**137,7000**	**19570,900**

ased on Table 2, the standard deviation value of the rainfall data (Sx) is 26,026.

Next, look for the Yn value by looking at the Reduce Mean (Yn) table for the Gumbel method, which is 0.4952. Then look for the Sn value by looking at the Reduce Standard deviation table using the Gumbel method, and the number is 0.9496. Furthermore, the value of Yt is obtained at 1.49994. Based on all these values, the maximum daily rainfall using the Gumbel method is 165.237 mm/day.

Calculation of Maximum Rainfall Intensity

Table 3. Rainfall Intensity for 4 hours

t (minute)	I (mm/hour)
5	158,726
10	145,763
20	125,298
40	97,827
60	80,236
80	68,007
120	52,120
240	30,644

In SNI 03-3424-1994, Van Breen conducted an investigation that the rain was concentrated for 4 hours with the amount of rain being 90% of the total rain for 24 hours (Khaerina et al., 2020). Based on Table 3, it can be seen that if it rains for 4 hours continuously, then the intensity of rain is 30.644 mm/hour.

Rainwater Discharge

The method used to calculate the rainwater discharge is the USSCS (1973) rational method (Sari et al., 2021). The general form of this equation is as follows:

Qah = 0.00278 CIA m3/s. …… (1)

Where:

Q = design flood discharge (m3/s),
C = run off coefficient,
I = rain intensity for constant time (mm/hour)
A = roof catchment area (m2).

Figure 1. Rainwater catchment through roof

Example calculation on channel 1 obtained the following results:

Run off coefficient (C) = 0.75 - 0.95
Rain intensity (I) = 30,644 mm/hour
(*Catchment Area* A) = 3 mx 4.5 m
= 13.5 m^2
= 0.00135 ha Slope
Coefficient (Cs) = 0.9
(Syarifudin, 2017)

Then the rainwater discharge generated from the roof of the garden house is:

Qah = 0.00278 . C . Cs. I . A m^3/sec.
Qah = 0.00278 x 0.8 x 0.90 x 30,644 x 0.001389
= 0.0000828050 m^3/second

Figure 2. Water storage tank

The reservoir used is a concrete culvert model which is arranged into 2 parts, with a culvert diameter of 1 m and a height of 0.5 m. There are 2 culverts that are made to collect rainwater in the garden house. Thus, the volume of the water reservoir is V = p . r^2 = 0.785 m^3. So that for one reservoir it can accommodate 785 liters of water, and for two reservoirs, it can accommodate 1,570 liters of water or 1.57 m^3.

The average rain in the Bonto Marannu sub-district lasts at least 20 minutes or 1200 seconds a day. The rainwater runoff that can be accommodated for the two roof areas is 2 x 0.000082805 m3/second x 1200 seconds = 0.1987 m3 = 198.7 liters. Thus, both reservoirs can be fully filled when it rains for 3 hours and 20 minutes. If it rains for 4 days then the rainwater discharge that can be accommodated is 198.7 liters x 4 days = 794.8 liters.

The need for water in a garden house is actually not much. From the standard, the need for clean water is 60 liters/person/day, so the need for clean water in garden houses is only one third. Therefore, the water needs of the garden owner can be calculated if the activities in the garden house consist of 4 people, namely father, mother and 2 children). The water needs of the four people are 4 people/house x 20 liters/day/person = 80 liters/day. Thus, if it rains for 4 days, the water reservoir will be full of 785 liters and can be used by garden farmers for 20 days by utilizing 2 reservoirs.

From the above calculation and analysis, it can be concluded that:

1. Rainwater harvesting can be used as an alternative for managing water resources on plantations.
2. The intensity of rainfall for the 5-year return period is 30,644 mm/hour
3. The catchment area of the garden house 2 x 13.5 m2 can produce a rainwater discharge of = 0.0000828050 m3/second
4. Volume of 2 culvert reservoirs - the culvert can hold 1570 liters of water
5. Farmers can take advantage of the rainwater stored for up to 20 days

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