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Analysis of fulfillment of domestic clean water needs of *Muara Baru* village, Air *Kumbang* subdistrict, *Banyuasin* regency using the rainwater harvesting (RWH) method

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Abstract: Rainwater Harvesting (RWH) is a method of collecting rainwater for alternative sources of clean water. The purpose of this study is to carry out RWH planning, including determining strategies and conducting feasibility analysis based on the quality and quantity of rainwater in Muara Baru Village, which is an area with critical water catchment conditions and is not yet served by a clean water pipeline network. The primary data collected included three types of houses, the number of different residents, and sampling the quality of rainwater and groundwater at the site. The selected water catchment area is the roof surface of the house. In terms of quantity, the potential supply of rainwater meets the needs for non-drinking water use. In terms of quality, rainwater samples have not met the quality standards for clean water based on Permenkes 32/2017. The rainwater collected will go through a disinfection and filtration process so that it meets the quality standards of clean water, and then it will be stored in the ground tank and roof tank to be distributed to each house. Thus, the planned RWH is able to provide an alternative source of clean water for the community in the Muara Baru Village area.

Keywords: *Clean water feasibility analysis, Clean water, Rainwater harvesting.*

1. Introduction

Air Kumbang District often experiences a clean water crisis every year. This is due to the inadequate availability of water. The water that is often used by the community only comes from excavations sourced from the soil. However, the excavation certainly cannot survive if the dry season arrives. Slowly the water discharge is small until it dries up, depending on how long the dry season lasts. When the rainy season arrives, the water source is brown because it mixes with the soil. PDAM services in Air Kumbang District already exist but access to use is still limited and has not reached all villages, especially Muara Baru Village.

Muara Baru Village is one of the villages located in Air Kumbang District, with an area of 2,062 hectares, and with a population of 2,085 residents [1]. The need for clean water for the residents of Muara Baru Village in carrying out daily activities such as toilets and consumption, in general, only relies on water from simple wells made by a few residents, PDAM services have touched Muara Baru Village, it's just that the surrounding residents are unable to pay the water price set by the PDAM. The quality of the water accessed also does not meet the standards suitable for consumption, the water remains in a colored and flavorful condition.

Conditions like this certainly cannot be allowed to continue, water management is needed in order to create a balance of water resources. One of the solutions offered through this study is to apply the rainwater harvesting method (*rainwater harvesting*) in Muara Baru Village, Air Kumbang District, Banyuasin Regency. Apart from being one of the water conservations measures, the application of this method has great potential to be applied in Banyuasin Regency which has a fairly high rainfall, which is

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an average of 2,197mm/year [1]. This method is also an activity to collect rainwater that is stored in one storage tank so that the collected water can be reused as an alternative source of clean water as well as an effort to maintain the availability of groundwater and the balance of the hydrological cycle.

Rainwater Harvesting (RWH) can be done by utilizing the roof of the building in obtaining a source of clean water that requires a little treatment before being used or consumed. The use of rainwater as an alternative water source has great potential to be applied in Indonesia considering that Indonesia is a tropical country with high rainfall [2]. The use of rainwater as an alternative to clean water will provide economic benefits. The burden of household expenses to buy water or pay for PDAM water will certainly be reduced [3].

Rainwater harvesting can be used as an efficient solution in water use as well as saving water costs that will be spent, this is evidenced by research on Rainwater Harvesting as an alternative to meeting clean water needs by Littaqwa, et al. [4] the results of the study show that rainwater catches more than the amount of water used based on interviews, with the rainwater harvesting system located below the surface of the building [4].

The same conclusion is evidenced by a study in 2022 which stated the conclusion of the results of simulations and analyses carried out that the Rainwater Harvesting (PAH) system is highly recommended as an alternative to domestic water sourced from groundwater. In addition to having a very small or no negative impact, rainwater harvesting is also very minimal in its installation [5].

Therefore, one of the best steps to develop village areas to propose is to pay attention and find the best solution to meet the water needs of villagers, and it is very appropriate if the application of the *rainwater harvesting* began to be realized sustainably for the future as an alternative to replace the provision of clean water.

2. Literature Review

2.1. Previous Research

The following is a study related to the Analysis of Fulfilling Domestic Clean Water Needs Using the RWH Method.

1) Research by Littaqwa, et al. [4] with the title Rainwater Harvesting as an Alternative to Fulfilling Clean Water Needs, with the conclusion that the number of rainwater catches is 6,265.41 m3, and the amount of water used as a result of the interview is 4,051.55 m3, which means that rainwater harvesting is a solution in water use efficiency and saving water costs incurred.
2) Research by Sedo [5] with the title Potential of Rainwater Harvesting in Meeting Domestic Water Needs at SD N 02 Gunung Terang Bandar Lampung, with the conclusion of the results of simulations and analyses carried out that the Rainwater Harvesting (PAH) system is highly recommended as an alternative to domestic water sourced from groundwater. In addition to having a very small or even no negative impact, this rainwater harvesting is also very minimal in its installation.

2.2. Rainwater Harvesting

It is a rainwater collection and collection system so that it can be used for multiple purposes such as washing, bathing, and can even be used for cooking if the quality of the water meets health standards. [6, 7]. There are three basic components that must be present in the rainwater harvesting system, namely: 1) *catchment*, which is a rainwater catcher in the form of a roof surface; 2) *delivery system*, which is a system for distributing rainwater from the roof to the shelter through gutters; and 3) *storage reservoir*, which is a place to store rainwater in the form of barrels, tubs or ponds. Shelters in most cases are the roofs of houses or buildings. The effective area of the roof and the materials used in building the roof affect the efficiency of water collection and quality. A conveying system usually consists of gutters or pipes that can drain rainwater that falls on the roof towards a water tank.

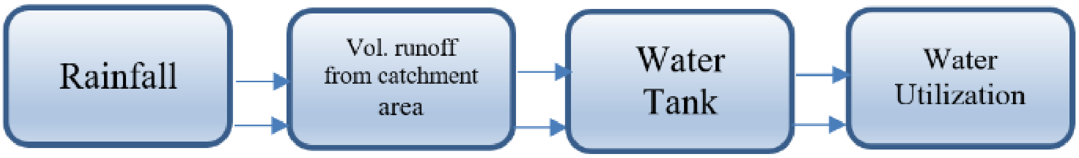


Figure 1.
Rainwater Utilization Process.

2.3. The Advantages of Rainwater Harvesting (RWH)

Here are some of the benefits of implementing the Rainwater Harvesting (RWH) Method:

1) As a source of clean water;
2) As one of the steps to conserve water;
3) as a source of water for domestic purposes (domestic water);
4) Minimizing environmental impacts;
5) The application can use existing instruments (rooftops, parking lots, parks, yards, etc.) so that it can save the procurement of new instruments;
6) Infiltrating excess rainwater into the ground can reduce the volume of flooding on the road;
7) The rainwater collected is relatively cleaner and the quality meets the requirements as clean water raw water with or without treatment;
8) Rainwater harvesting can reduce dependence on supply systems;
9) Rainwater harvesting is an easy and flexible technology and can be built as needed.

2.4. Rainwater Harvesting (RWH) System Components

1) Catchment *Area*, in its application, the Rainwater Harvesting system, applies a stipulation where the size of the Catchment Area will determine the amount of rainfall that can be harvested.
2) Catchment Area Material, the total potential rainfall that can be captured is defined as the area of the roof multiplied by Coefficient C. Coefficient C = 0 means that no runoff can be caught and stored in the storage tank.
3) The slope of the roof will certainly affect the speed of rainwater runoff. Roofs with steeper surfaces will collect rainwater faster than flatter roofs. Roofs with flatter surfaces will cause water to move more slowly, causing the possibility of water to be contaminated.
4) The area of the roof, the size of the roof will affect the amount of rainwater that can be harvested. The catchment area is calculated based on the footprint (foot print) of the roof (Figure 3). The amount of rainwater that can be captured and stored depends on the size of the catchment area.
5) Storage Tanks are one of the factors that most affect the design of the Rainwater Harvesting (RWH) system. This is because storage tank components require the most cost compared to other components. Therefore, it is very important to plan the appropriate storage tank capacity in order to save costs and make it more efficient. Table 3 is the following. clean water needs according to the type of building according to the Directorate General of Cipta Karya of the Public Works Office:

Table 1.
Clean water needs after building type.

Building Allocation	Clean Water Usage
Luxury Homes	250 liters/occupants/day
Ordinary House	150 liters/occupants/day
Apartment	250 liters/occupants/day
Flats	100 liters/occupants/day
Boarding house	120 liters/occupants/day
Clinics/Health Centers	3 liters/visitor/day
Luxury Hospital	1,000 liters/patient bed/day
Intermediate Hospital	750 liters/patient bed/day
General Hospital	425 liters/patient bed/day
Primary school	40 liters/student/day
Junior High School	50 liters/student/day
High School	80 liters/student/day
College	80 liters/student/day
Shophouses/Offices	100 liters/occupant and employee/day
Office Building	50 liters/employee/day
Convenience Stores	5 liters/m2 floor area/day
Factory	50 liters/employee/day
Station	3 liters/passenger arriving & departing/day
Airport	3 liters/passenger arriving & departing/day
Restaurant	15 liters/seat/day
Performance Hall	10 liters/seat/day
Cinema	10 liters/seat/day
2-star hotels	150 liters/bed/day
3 Star Hotels and Above	250 liters/bed/day
Houses of Worship	5 liters/person/day

As a simulation, if the water tank size is needed for an ordinary house with 4 residents, then:

Capacity = 150 liters/person/day x 4 residents = 600 liters
So, the size of the water tank for an ordinary house inhabited by 4 residents per day is 600 liters.

6) Storage Tank Material, can be composed of various materials. Each ingredient certainly has its own disadvantages and advantages. Materials that are often used as storage tanks are made of Metal, Betn, Fiber Glass and Plastic.
7) Filters / Filters, Filters are used to filter pollutants that are carried in rainwater. Filters can be in the form of media such as fibers, sand, gravel that function to remove impurities from water before entering the next system or storage area.
8) Distribution Pipeline System, required to drain storage water to the outlet point. In a house, the simplest example of a water delivery system is a u/PVC pipe or it can also be a gutter.
9) Pump, used to drain water from the storage bin to the water fixture. The size of the pump used is adjusted to the capacity and discharge flowing.

2.5. Algorithm Yield Before Spillage dan Yield After Spillage

The basic parameters used to identify the performance of the RWH system are *inflow, overflow and yield*. In simple terms, the YBS algorithm is that when it rains, harvesting or using rainwater is carried out first before the water fills the tank and then spills. While the YAS algorithm is the opposite of YBS. Rainwater is allowed to fill the tank and spill first and then then used.

a) *Yield After Spillage* (YAS), in the YBS algorithm the operations that occur in the system can be described as *inflow*, determine *the yield*, issue *the yield* and then overflow occurs. The formula used in this algorithm is as follows:

$$Yield = min\begin{cases} Dt \\ V_{t-1} + Q_t \end{cases} (1)$$

$$Vt = min\begin{cases} V_{t-1} + Q_t - y_t \\ S \end{cases} (2)$$

Information:
Dt = Demand at time interval t (m3)
Vt-1 = Volume of water in the tank at t-1 (m^3)
Qt = Inflow entering the tank at t (m^3)
S = storage tank capacity (m^3)

b) *Yield Before Spillage* (YBS), in the YAS algorithm the operations that occur in the system within t time intervals are defined as: *runoff* goes into the storage tank, *overflows*, and then *the yield* is ejected by the system. The rules that apply in the YAS algorithm are as follows:

$$Yield = min\begin{cases} Dt \\ V_{t-1} \end{cases} (3)$$

$$Vt = min\begin{cases} V_{t-1} + Q_t - y_t \\ S - y_t \end{cases} (4)$$

Information:
Dt = Demand at time interval t (m3)
Vt-1 = Volume of water in the tank at t-1 (m^3)
Qt = Inflow entering the tank at t (m^3)
S = storage tank capacity (m^3)

3. Research Method

This research aims to provide solutions *alternative* which is the most efficient and effective both from planning to application to meet water needs in Banyuasin Regency, especially in Muara Baru Village, Air Kumbang District. The sources and types of data used are primary data obtained through field observation at the study site in the field such as house type data, house map, type and area of the roof of the house and secondary data in the form of statistical data to find out the number of residents at the research location, and also rain data from BMKG stations. The steps of the study stages of this study include:

1) Rain data analysis with 4 rain frequency analysis methods to obtain the maximum average daily rainfall (mm/day);
2) Calculate the amount of rainwater that can be harvested;
3) Calculate the average water use for the household needs of Muara Baru Village residents;
4) Analysis of the potential of rainwater harvesting with the use of water for the household needs of Muara Baru Village residents.

3.1. Data Processing

The initial stage of this research involves collecting secondary data, including domestic water demand and rainfall data. The rainfall data used for calculations is obtained from Earthdata NASA and consists of rainfall records from the past 10 years. Once the secondary data is collected, data processing is carried out, followed by an analysis of water demand and rainfall data. Daily rainfall data is used to calculate rainfall potential, which is determined using Equation 5.

$$Rainfall\ Potensial\ (R_{eff}) = \frac{\mathrm{R\ x\ A\ x\ C}}{1000} \qquad (5)$$

Information:
R = Daily rainfall (mm)
A = Roof surface area used for rainwater collection (m^2)
C = Rainwater catchment coefficient (0,9 is used for ceramic roofs)

Next, the inflow (V inflow) from the rainwater harvesting system enters the tank through gutters. On the first day of analysis, the inflow is assumed to be equal to the daily rainfall (Reff t) on that day. For the following days, in the RWH system implementation, the storage tank is typically placed underground [8]. As a result, the effects of evaporation and system leakage can be neglected [9] and the storage tank volume capacity (Volume Storage) is calculated using Equation 6.

$$V\ storage_{(t)} = V_{tangki\ t-1} + R_{eff_t} - (Jumlah\ penghuni\ x\ kebutuhan\ demand) \quad (6)$$

Information:

Vt = Storage volume at t (m^3)
V_{t-1} = Previous day's tank storage volume (m^3)
R_{eff_t} = Rainfall potential on that day (m^3)

At the end of the simulation time interval t, there are two possible conditions for the amount of water in the tank (Vt):

1) Full Tank ($Vt = V$), This occurs when the water volume in the tank at the end of the previous time interval (Vt-1) plus the inflow (Qt) minus the water usage volume is greater than or equal to the tank capacity (V).
2) Not Full ($Vt < V$), This happens when the water volume in the tank at the end of the previous time interval (Vt-1) plus the inflow (Qt) minus the water usage volume is less than the tank capacity (V). If the water volume in the tank at the end of the previous time interval (Vt-1) plus the inflow (Qt) minus the water usage volume exceeds the tank capacity (V), an overflow will occur (see Equation 7).

$$Overflow = \max\left\{\begin{matrix} 0 \\ V_{t-1} + R_{eff_t} - Ct - V \end{matrix}\right. \quad (8)$$

Information

Ct = Water usage Volume

This study applies a behavioral modeling method, which consists of two types of approaches:

Yield Before Spillage (YBS) In this approach, the tank releases water for usage before any overflow occurs, following Equation 2 and Equation 3. Yield After Spillage (YAS) In this approach, the tank releases water for usage only after overflow has occurred, following Equation 3 and Equation 4.

4. Results and Discussion

4.1. Rainfall Data

The rainfall data used for the calculation is data from Nasa's Earthdata. The Rainfall data used is rainfall data for the past 10 years and is summarized in Table 2. as follows:

Table 2.
Annual Max Daily Rainfall (2014-2023).

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
CH Max (mm/hari)	52.0107	96.1076	54.4044	51.4973	73.3425	67.8877	71.7647	67.5122	67.4888	67.2827

4.2. Water Requirements

In the analysis, water storage containers with a capacity of 0.5 m^3, 1 m^3 and 2 m^3 were used. The water needs per person are taken from Table 3. The standard for clean water needs is 60 l/person/day.

Table 3.
Water needs for each number of residents in one house.

Number of Residents (Residents)	Water Requirements
3	0.18
5	0.3
7	0.42

4.3. Fulfillment of Water Needs for a 2 m³ Tank

The fulfillment of water needs by rainwater is analyzed with several scenarios. This subsection discusses the fulfillment of water needs using a 2 m^3 tank with variations in roof catchment areas of 45 m^2, 70 m^2, and 90 m^2 to meet the water requirements for households with 3, 5, and 7 residents. Tables 4 to 6 show the number of days the water needs are met for each roof area as a rainwater catchment.

Table 4.
Fulfilment of water needs for 3 residents with a 2 m^3 tank volume.

A 2 m^3 tank for 3 Residents		
Roof catchment area (m^2)	**WSE**	**Time Reliability**
45	87%	84%
70	90%	89%
90	92%	91%

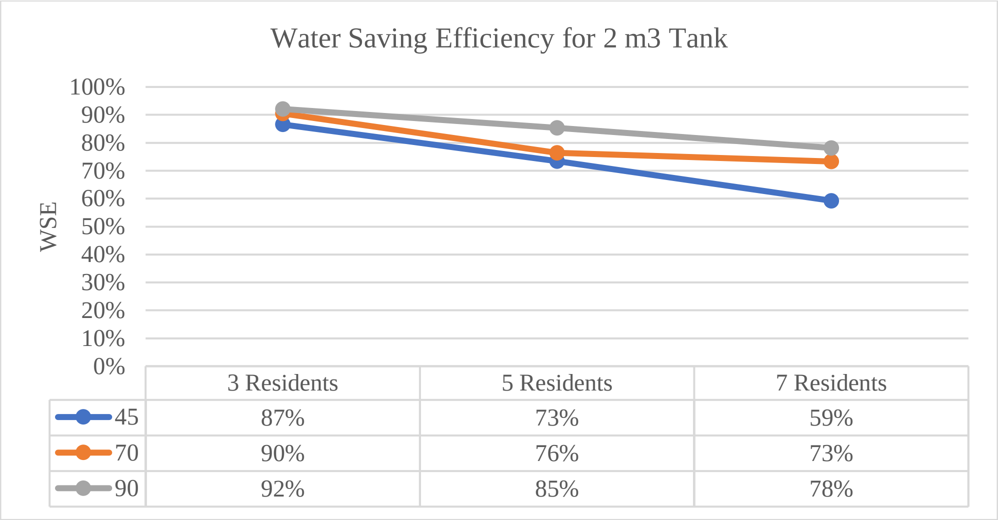
Table 5.
Fulfilment of water needs for 5 residents with a 2 m^3 tank volume.

A 2 m^3 tank for 5 Residents		
Roof catchment area (m^2)	**WSE**	**Time Reliability**
45	73%	67%
70	76%	79%
90	85%	83%

Table 6.
Fulfilment of water needs for 7 residents with a 2 m^3 tank volume.

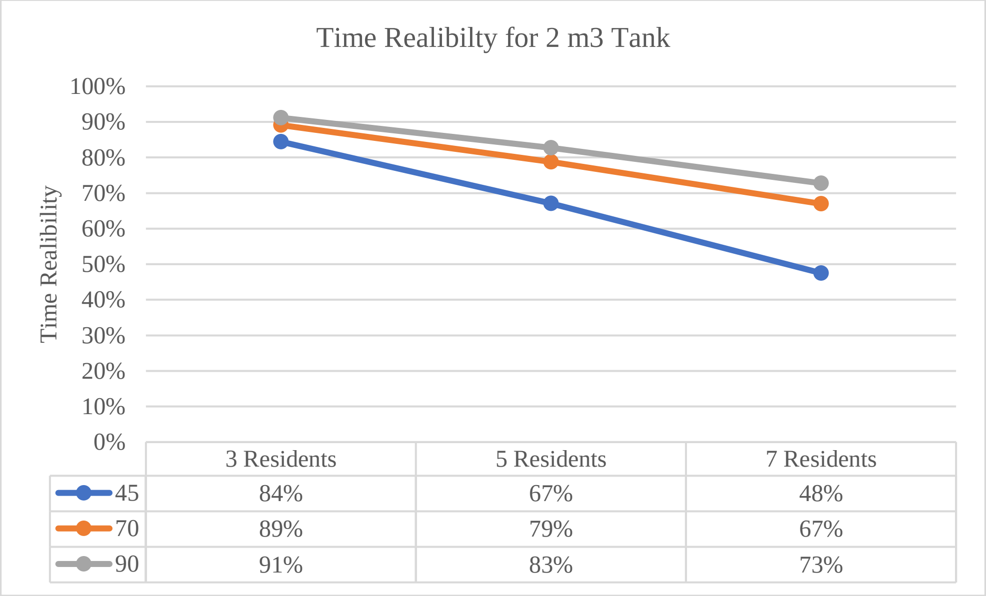
A 2 m^3 tank for 7 Residents		
Roof catchment area (m^2)	**WSE**	**Time Reliability**
45	59%	48%
70	73%	67%
90	78%	73%

The comparison of water demand for each number of residents can be seen in Figures 2 – 4 below. Figure 2 shows that a roof area of 90 m^2 with 3 residents can meet 91% of the water demand, and the lowest is for 7 residents, which is 73%. Figure 2 also shows that the highest water-saving efficiency is achieved with a roof area of 90 m^2, with a water-saving efficiency of 78% for 7 residents. Meanwhile, a roof area of 70 m^2 for 7 residents can save up to 72%. Both figures indicate that the larger the roof area used and the lower the water demand, the better the system's performance.



	3 Residents	5 Residents	7 Residents
45	87%	73%	59%
70	90%	76%	73%
90	92%	85%	78%

Figure 2.
Graph of water saving efficiency comparison for a 2 m^3 tank volume.



	3 Residents	5 Residents	7 Residents
45	84%	67%	48%
70	89%	79%	67%
90	91%	83%	73%

Figure 3.
Graph of time reliability comparison for a 2 m^3 tank volume.

4.4. Fulfillment of Water Needs for a 1 m^3 Tank

The fulfillment of water needs by rainwater is analyzed with several scenarios. This subsection discusses the fulfillment of water needs using a 1 m^3 tank with variations in roof catchment areas of 45 m^2, 70 m^2, and 90 m^2 to meet the water requirements for households with 3, 5, and 7 residents. Tables 7 to 9 show the number of days the water needs are met for each roof area as a rainwater catchment.

Table 7.
Fulfilment of water needs for 3 residents with a 1 m^3 tank volume.

A 1 m^3 Tank for 3 Residents		
Roof catchment area **(m^2)**	**WSE**	**Time Reliability**
45	82%	78%
70	86%	84%
90	88%	86%

Table 8.
Fulfilment of water needs for 5 residents with a 1 m^3 tank volume.

A 1 m^3 Tank for 5 Residents		
Roof catchment area **(m^2)**	**WSE**	**Time Reliability**
45	68%	59%
70	76%	71%
90	80%	75%

Table 9.
Fulfilment of water needs for 7 residents with a 1 m^3 tank volume.

A 1 m^3 Tank for 7 Residents		
Roof catchment area (m^2)	**WSE**	**Time Reliability**
45	55%	41%
70	60%	57%
90	72%	64%

The comparison of water needs for each number of residents can be seen in Figures 4 – 5 below. Figure 5 shows that a roof area of 45 m^2 with 7 residents can meet the lowest water demand at 41% and the highest for 3 residents at 78%. Meanwhile, for catchment areas of 70 m^2 and 90 m^2, the difference in water fulfillment for 3 residents is only 2%. Figure 4 indicates that the highest water saving efficiency is achieved with a roof area of 90 m^2, with water savings of 72% for 7 residents. Meanwhile, the catchment area of 70 m^2 for 7 residents can save 60% of water. The larger the catchment area and the smaller the volume of water used, the greater the water saving efficiency and time reliability, thus improving the system's overall performance.

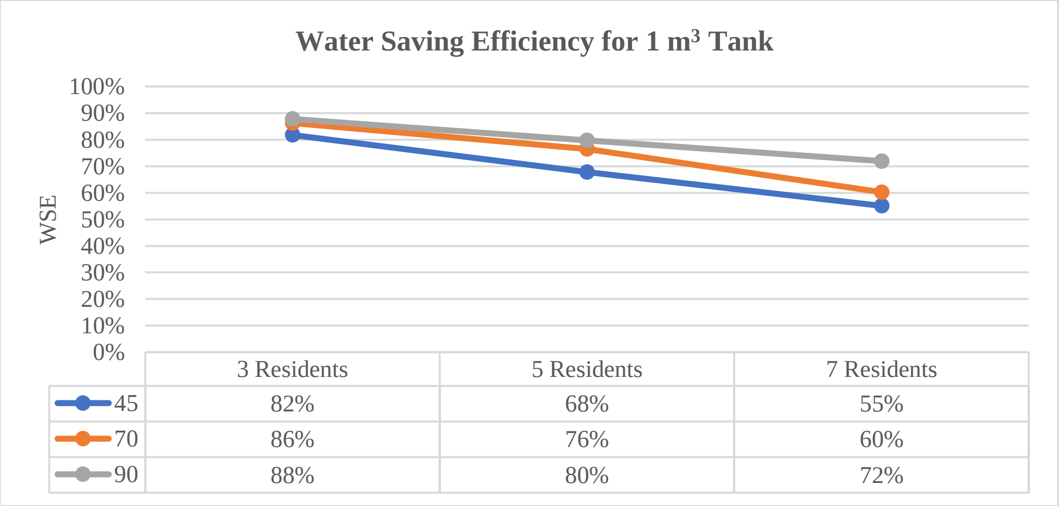


Figure 4.
Graph of water saving efficiency comparison for a 1 m^3 tank volume.

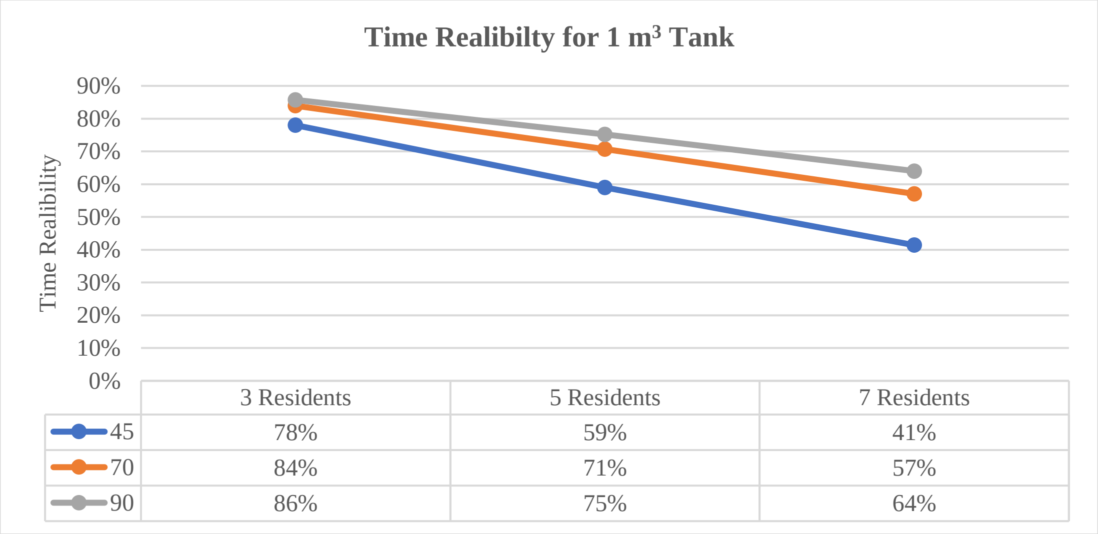


Figure 5.
Graph of time reliability comparison for a 1 m^3 tank volume.

4.5. Fulfillment of Water Needs for a 0,5 m^3 Tank

The fulfillment of water needs by rainwater is analyzed with several scenarios. This subsection discusses the fulfillment of water needs using a 1 m^3 tank with variations in roof catchment areas of 45 m^2, 70 m^2, and 90 m^2 to meet the water requirements for households with 3, 5, and 7 residents. Tables 10 to 12 show the number of days the water needs are met for each roof area as a rainwater catchment

Table 10.
Fulfilment of water needs for 3 residents with a 0,5 m^3 tank volume.

A 0.5 m^3 Tank for 3 Residents		
Roof catchment area (m^2)	**WSE**	**Time Reliability**
45	76%	69%
70	81%	76%
90	82%	79%

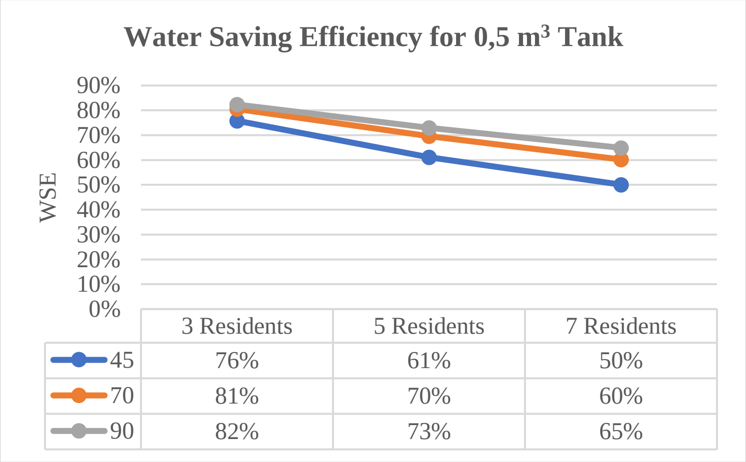
Table 11.
Fulfilment of water needs for 5 residents with a 0,5 m^3 tank volume.

A 0.5 m^3 Tank for 5 Residents		
Roof catchment area (m^2)	**WSE**	**Time Reliability**
45	61%	48%
70	70%	60%
90	73%	64%

Table 12.
Fulfilment of water needs for 7 residents with a 0,5 m^3 tank volume.

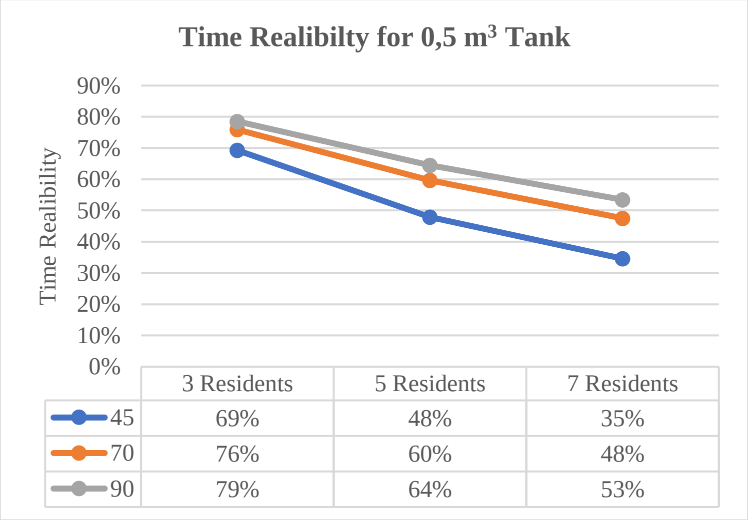
A 0.5 m^3 Tank for 7 Residents		
Roof attachment area (m^2)	**WSE**	**Time Reliability**
45	50%	35%
70	60%	48%
90	65%	53%

The comparison of water demand for each number of residents can be seen in Figures 6 – 7 below. Figure 6 shows that a roof area of 70 m^2 with 5 residents can meet 60% of the water demand, and the highest is for 3 residents, reaching 76%. Meanwhile, for roof areas of 45 m^2 and 90 m^2, the difference in water fulfillment for 3 residents is 10%. Figure 7 indicates that the highest water-saving efficiency is achieved with a roof area of 90 m², with water savings of 82% for 3 residents. Meanwhile, a roof area of 70 m² for 7 residents can save 48% of water. Both figures show that the larger the area used and the smaller the amount of water consumed, the greater the water-saving efficiency and time reliability, thereby improving the system's performance for 2,868 days (7 years, 10 months, and 13 days).



	3 Residents	5 Residents	7 Residents
45	76%	61%	50%
70	81%	70%	60%
90	82%	73%	65%

Figure 6.
4.6. Graph of water saving efficiency comparison for a 1 m³ tank volume.

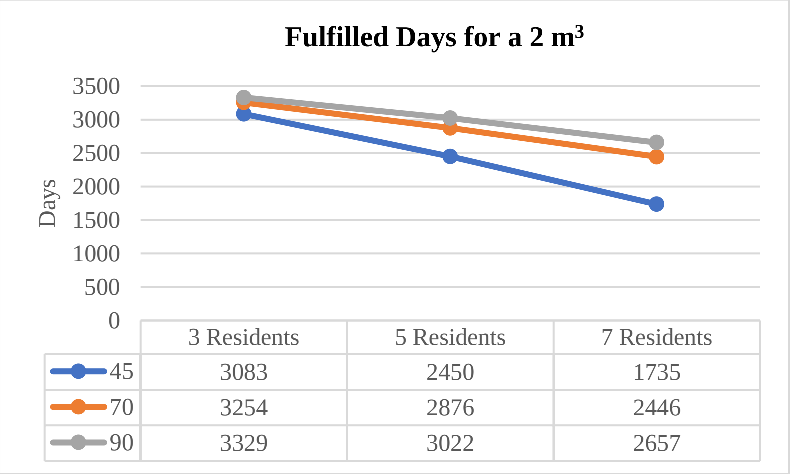


	3 Residents	5 Residents	7 Residents
45	69%	48%	35%
70	76%	60%	48%
90	79%	64%	53%

Figure 7.
Graph of time reliability comparison for a 1 m³ tank volume.

4.6. Comparison of Water Supply Fulfillment Based on Tank Volume

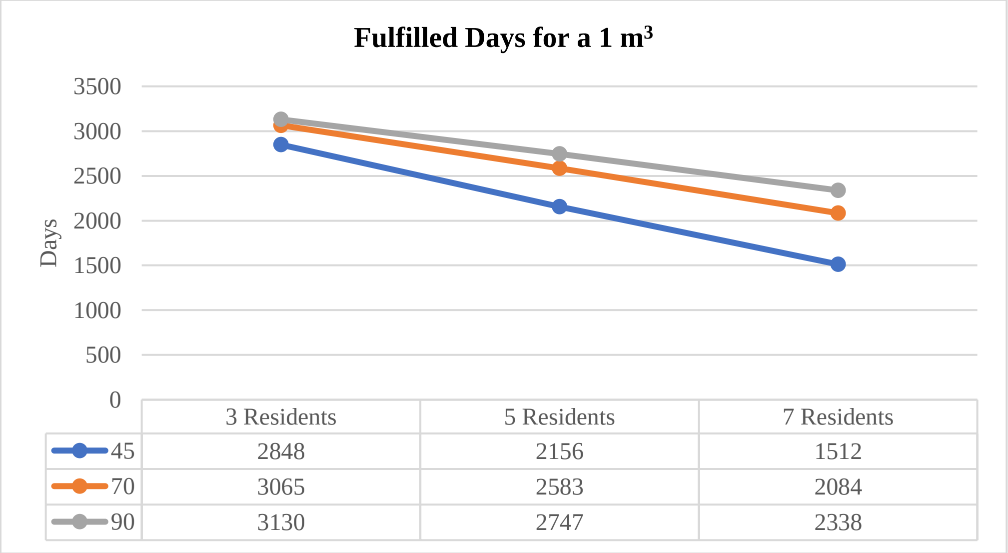
Water supply fulfillment from each tank volume is influenced by the roof area and the number of residents. Figure 8. illustrates the relationship between the number of residents and the duration of water sufficiency for a 2 m³ water tank, based on variations in roof area of 45 m², 70 m², and 90 m². The results show that the larger the roof area, the longer the duration of water fulfillment, as a greater volume of water is collected. For example, for 3 residents with a roof area of 45 m², the tank can supply water for 3,083 days, whereas with a roof area of 90 m², the duration increases to 3,329 days. The same trend is observed for 5 and 7 residents, indicating that a larger roof area extends the duration of water supply fulfillment.


Fulfilled Days for a 2 m^3

	3 Residents	5 Residents	7 Residents
45	3083	2450	1735
70	3254	2876	2446
90	3329	3022	2657

Figure 8.
Graph of fulfilled days for a 2 m3.

The comparison of water supply fulfillment for a 1 m^3 tank volume, based on Figure 9, shows that water availability is significantly influenced by roof area and the number of residents. With a roof area of 45 m^2, water needs can be met for 2,848 days for 3 residents, but the duration decreases to 2,156 days for 5 residents and only 1,512 days for 7 residents. A larger roof area, such as 70 m^2, allows the tank to collect water more efficiently, fulfilling needs for 3,065 days for 3 residents, 2,583 days for 5 residents, and 2,084 days for 7 residents. A 90 m^2 roof area provides the best results, ensuring water supply for 3,130 days for 3 residents, 2,747 days for 5 residents, and 2,338 days for 7 residents.


Fulfilled Days for a 1 m^3

	3 Residents	5 Residents	7 Residents
45	2848	2156	1512
70	3065	2583	2084
90	3130	2747	2338

Figure 9.
Graph of fulfilled days for a 1m^3.

Based on Figure 10, it can be seen that roof area and the number of residents have a significant relationship with the duration of water supply fulfillment. With a roof area of 45 m^2, the tank can meet water needs for 2,530 days for 3 residents, but the duration drops significantly to 1,751 days for 5 residents and only 1,263 days for 7 residents. A larger roof area, such as 70 m^2, provides more optimal results, fulfilling water needs for 2,772 days for 3 residents, 2,181 days for 5 residents, and 1,736 days for 7 residents. Under the best conditions, with a roof area of 90 m^2, water supply fulfillment increases to 2,868 days for 3 residents, 2,355 days for 5 residents, and remains sufficient for 1,952 days for 7 residents.

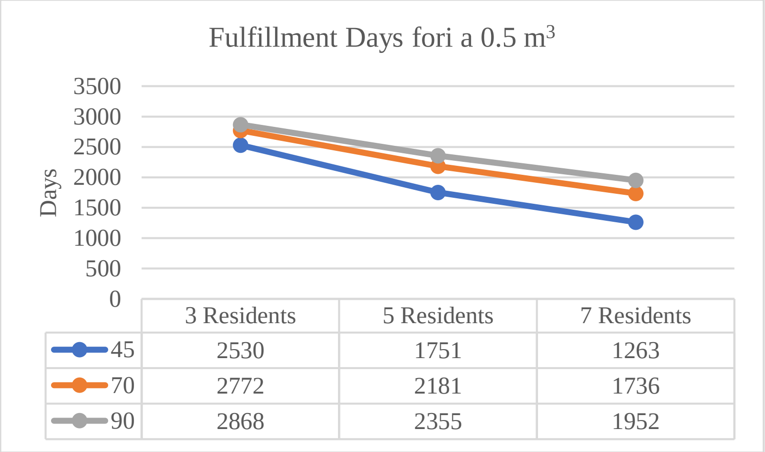


Figure 10.
Graph of fulfilled days for a 0,5 m^3.

These three comparisons show that the larger the roof area used for rainwater harvesting, the higher the potential for water supply fulfillment, even with a limited tank capacity such as 0.5 m^3. Additionally, an increase in the number of residents significantly shortens the duration of water availability, emphasizing the importance of adequate tank capacity planning to ensure sufficient water supply based on the number of occupants and an optimized rainwater harvesting system design.

4.7. Performance of the RWH System

The calculation is divided into several scenarios based on tank capacity, the number of household occupants, and domestic water usage. The total water demand is 60 liters per person per day. The catchment area sizes are 45 m^2, 70 m^2, and 90 m^2, while the number of occupants is categorized into 3, 5, and 7 residents.

1) For a catchment area of 45 m^2, the lowest Water Supply Efficiency (WSE) value is 50%, which occurs with a 0.5 m^3 tank capacity and a water demand for 7 occupants. The highest WSE value is 87%, achieved with a 2 m^3 tank capacity and water demand for 3 occupants.
2) For a catchment area of 70 m^2, the lowest WSE value is 60%, occurring with a 0.5 m^3 tank capacity and water demand for 7 occupants. The highest WSE value is 90%, achieved with a 2 m^3 tank capacity and water demand for 3 occupants.
3) For a catchment area of 90 m^2, the lowest WSE value is 65%, occurring with a 0.5 m^3 tank capacity and water demand for 7 occupants. The highest WSE value is 92%, achieved with a 2 m^3 tank capacity and water demand for 3 occupants.
4) These findings indicate that larger roof areas, fewer occupants, and larger tank volumes result in higher WSE values and longer fulfillment durations (TR). As a result, the RWH system can effectively meet the occupants' water needs, and its performance improves accordingly.

4.8. Water Feasibility Test

The water quality standards used in the testing are Regulation of the Minister of Health of the Republic of Indonesia Number 32 of 2017 concerning environmental health quality standards and water health requirements for sanitary hygiene purposes, swimming pools, solus per aqua, and public baths. This test uses a Potentiometric test carried out at the Chemical Engineering Laboratory of Sriwijaya State Polytechnic. The sample used rainwater samples on September 12, 2024 and was immediately handed over to the laboratory. The results of testing on Rainwater and Well Water samples in Muara Baru Village are presented in Table 13. below.

Table 13.
Table of water feasibility test results.

Sample name	Test Parameters	Results of Analysis	Meet/ Not Compliant
Rainwater	TDS	30.1 ppm	Meet
	Salinity	44.0 ppm	Meet
	Resistivity	12.35	Meet
	OF	4.18 mg/l	Meet
	ORP	205.3 mV	Meet
	Ph	4.08	Not Compliant
	Turbidity	1.59 NTU	Meet
	Conductivity	53.26 mS	Meet
Well Water	TDS	199.0 ppm	Meet
	Salinity	195.5 ppm	Meet
	Resistivity	2.515	Meet
	OF	4.72 mg/l	Meet
	ORP	283.2 mV	Meet
	Ph	3.28	Not Compliant
	Turbidity	22.0 NTU	Meet
	Conductivity	220.2 mS	Meet

The results of rainwater and well water quality tests in Muara Baru Village show that almost all hygienic water quality standard requirements are met. However, in Chemical Parameters, pH (Hydrogen Potential) is a scale of measure used to measure the activity of hydrogen ions (acid formers). Rainwater is usually acidic, this is because rainwater dissolves gases in the atmosphere, such as carbon dioxide (CO2), sulfur (S), and nitrogen oxide (NO2) gases that can form weak acids. Based on BMKG, the Normal Rainwater pH Threshold Value (NAV) is 5.6. Meanwhile, based on the Indonesian Minister of Health Regulation No. 32 of 2017, the standard for environmental health quality and water health requirements for sanitary hygiene purposes for water pH is 6.5 – 8.5. Rainwater is said to be acidic rain if the $pH < 5$ [10]. The pH of rainwater in Muara Baru Village showed a figure of 4.08 and well water of 3.28, this figure is still below the range of sanitary hygienic water (6.5-8.5). Thus, the pH of this rainwater needs to be increased so that rainwater can be used for clean water or hygienic water, by filtering rainwater using a water filter.

4.9. YBS and YAS Analysis

In simple terms, the YBS algorithm is that when it rains, harvesting or using rainwater is carried out first before the water fills the tank and then spills. While the YAS algorithm is the opposite of YBS. Rainwater is allowed to fill the tank and spill first and then then used. The inflow of water from the rainwater harvesting system enters the tank through gutters. A comparison is then made based on the tank volume used. If the inflow volume exceeds the tank capacity, only the maximum tank volume, 0.248 m^3, is considered. For the YBS approach, simulations are conducted using Equations 2 and 3, followed by the overflow calculation using Equation 7. In contrast, for the YAS algorithm approach, the overflow is calculated first, followed by the YAS computation. The comparison graph between YBS and YAS can be seen in Figures 11 and 12.

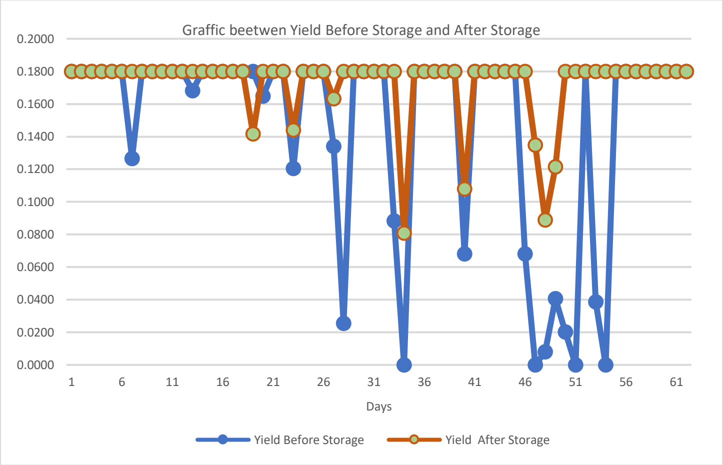


Figure 11.
Graph between YBS and YAS.

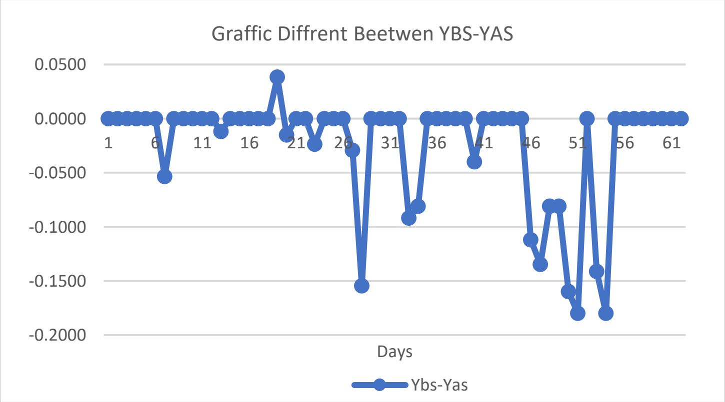


Figure 12.
Difference between YBS and YAS.

Based on Figure 11, it can be seen that Yield After Spillage (YAS) performs better than Yield Before Spillage (YBS). This is evident in the YAS algorithm, where the tank fails to meet the occupants' water demand of 0.18 m³/day for only 8 days out of 61 days. In contrast, the YBS algorithm results in 17 days where the tank's water volume is insufficient to meet the occupants' needs.

The difference between the YBS and YAS algorithms lies in the method of utilizing rainwater stored in the tank. In YBS, the incoming water is immediately used to meet demand before considering the tank's maximum capacity, causing excess water to be lost as spillage more quickly. Meanwhile, in YAS, the stored water is maximized up to full capacity before spillage occurs, making water usage more efficient.

This difference leads to varying outcomes, where YAS fails to meet demand for only 8 days out of 61 days, while YBS fails for 17 days due to faster spillage without tank capacity optimization. Figure 12 shows that the difference between YBS and YAS is not very significant. Based on the analysis, for 44 days, a 1 m³ tank successfully meets the occupants' water demand of 0.18 m³/day.

5. Conclusion

1) The pH of rainwater in Muara Baru Village showed a figure of 4.08 and well water of 3.28, this figure is still below the range of sanitary hygienic water (6.5-8.5). So the pH of this rainwater needs

to be increased so that rainwater can be used for clean water or hygienic water, by filtering rainwater using a water filter.

2) The larger the roof area used as a rainwater catchment and the greater the tank capacity, the better the performance of the RWH system. This can be proven by observing the WSE and TR percentages in each scenario.
3) Based on the analysis results, it can be concluded that the RWH system performance in Muara Baru Village achieved values ranging from 50% to 92%, with tank sizes ranging from 0.5 m^3 for 3 occupants to 2 m^3 for 7 occupants, indicating a high potential for meeting clean water needs.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

Copyright:

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