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RAINWATER HARVESTING FOR FISH FARMING WATER fielS IN BOYOLALI REGENCY, INDONESIA

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ABSTRACT

Climate change causes dry and rainy seasons to shift. Hydrology also shows that the number of rainwater changes with the uncertainty of its potential occurrence. In catfish farming and hydroponic farming, ensuring water availability is important for the sustainability of the project. Existing research is about managing rainwater, which can help partially supply water for both projects' benefit. The research location is in Jeron Village, Nogosari District, Boyolali Regency. Boyolali Regency is a 22 % residential area of the total area. It means 570 m3 potential storage. However, the result shows that only 17% of the roof area can collect rainfall for residential houses. In this study's residential case example, 17% of the roof area gives 97.8 m3 / year. The problem is that currently, there is no Rain Water Harvesting (RWH). A system capable of supporting the water supply. Using RWH provides a benefit based on the potential supply. This study highlights the potential benefits of using RWH. This pool yields a profit of up to (Indonesian Rupiah) IDR. 36,643,718 / month or IDR. 439,724.61 / year, with a probability of 80%. It means that in 5 years, it failed once. Moreover, water needs can supply from RWH.

Keywords: Rainwater harvestin, water supply for fish farming, dependable volume, houseroof area

1. INTRODUCTION

Indonesia is a tropical climate country with two seasons, the rainy season and the dry season. Climate change has an impact on the retreating of the rainy season and dry season. It also has an impact on the volume of water excess that becomes discharged or runoff.

In recent years, environmental changes and an increase in global population have led to an increased threat of water scarcity. Therefore, it is necessary to develop a sustainable and resilient water supply system. The rainwater harvesting system (RWH) is a decentralized sustainable water supply system with the potential to be implemented. Rainwater harvesting system is a system that functions to store rainwater that is captured from the catchment area, flowed through a pipe, and stored in a storage tank. Rain Water Harvesting (RWH) is a effective technology to increase drought resistance. This keeps rainfall closer to where it falls and storing it for any use after that reduces runoff and the risk of flooding. The RWH's main advantages are that the technology is simple and small-scale. A farmer can use the water in the pond whenever it is needed and for any crop.

Rainwater is clean water, which frees to obtain. In urban areas, collected rainwater could replace purchased water (Justice Wicaksana et al., 2018). Rainwater can help fulfill partially or completely daily water requirements in several districts (Indriatmoko and Rahardjo, 2018). In addition, to meet the needs of fish farming for maintenance and for ponds. This research focuses on the use of rainwater for fish farming ponds. The problem is that it could not measure the financial feasibility and the potential amount of water stored. The method developed uses a tank with dimensions determined according to actual conditions (Campisano et al., 2013). A rainwater harvesting system (RWH) is a method to store the Potential water (Semaan et al., 2020) (Kementerian PUPR, 2014). In Urban areas, it depends on the rainwater storage site's location and the house's roof. The research method calculates the potential for rain to fall on the roof of the house and enter the storage tank is the volume potential with an 80% reliability, meaning that the 5-year planning can fail a year. The purpose of this research is to design rain water harvesting and apply it directly to catfish farms. In this study, it will be found how much potential the rain catchment area in Boyolali Regency is. In addition, the benefits obtained because they have utilized rainwater with rainwater storage from the roof.

2. MATERIALS AND METHOD

First is data collection, including rainfall data from Pabelan rainfall station 1996-2019, land use map of Boyolali Regency, and survey data for case study locations. Based on the land use map, it is possible to calculate the the resedential area percentage in the Boyolali Regencyf. It becomes a rainwater catchment area.

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The dependable rainfall calculates based on the data on the Pabelan rainfall station by the basic year method. The calculation of the dependable volume of Boyolali Regency is obtained based on the calculation of dependable rainfall with an 80% probability (Kementerian PUPR, 2013). The entire residential area of Boyolali Regency potentially to accommodate the rainfall. In residential areas, rainwater can be collected in a tank through the house's roof as an RWH System. The area of the roof shows the ability to accommodate the volume of rainwater.

This analysis is how a house accommodated the potential of water. As a sample case, is a resident residents' houses in Jeron Village. The storage obtained calculate based on the roof area. The maintenance of fish farming ponds uses the collected water. Maintenance water requirements for each pool range are from 10 to 20 liters per pond (as the survey). Simulations were done based on a 15 daily rainfall analysis.

The simulation shows that it could use the water potential to maintain the fish farming pond during the rainy season. This free water user replaces the paid water, thereby saving water purchases during the rainy season.

The method used is the calculation of rainfall to calculate the capacity of rain water harvesting to be installed. Furthermore, it is calculated how much potential profit obtained by catfish farmers. Previously, catfish farmers used water from PDAM (local water company) which paid for it so that during the dry season they experienced drought. By utilizing this rainwater, the benefits will be more.

3. THEORY/CALCULATION

Based on the topographic map, residential land use in Boyolali Regency is 22.42% of the total area, as shown in Figure 1. The purple color is the residential area. Meanwhile, the gray color is land use other than settlement.

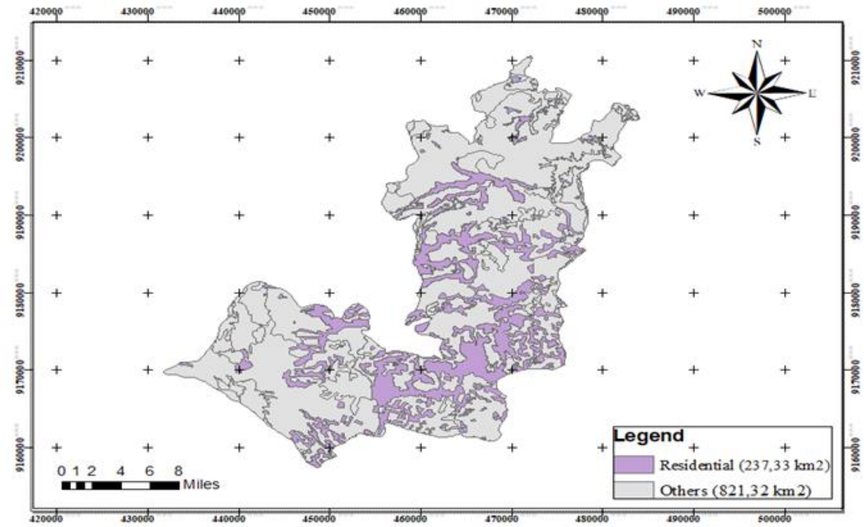

Fig. 1. Land use of residents in Boyolali District, Indonesia

The dependable rainfall calculation uses the Weibull Probability theory with the Basic Year method to determine the 80% dependable rainfall, called P80 (Kementerian PUPR, 2013). P80 use as an input to calculate the volume with a reliability of 80%, called Vol_80.

Based on the Basic year method, the rainfall patterns with a probability of 80% use 2013 as a rainfall pattern for analysis of dependable rainfall graph. See Figure 2.

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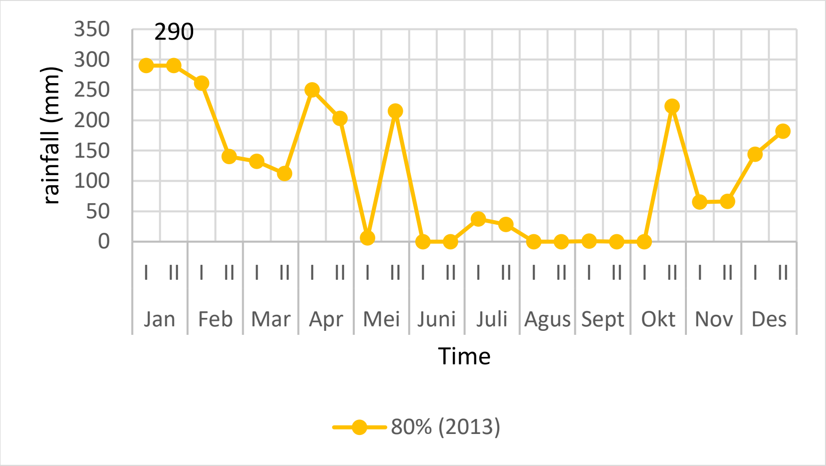

Fig. 1. Dependable Volume, Vol_80, in Boyolali District, Indonesia

The rainy season's potential storage is predicted based on the rainfall from January to April and November to December. The storage volume is predicted based on the 2013 rainfall pattern with a probability of 80%. Volume calculations using a rational method (Kementerian PUPR, 2013).

$$Vol\_80 = C.I.A \quad (1)$$

Where, Vol_80 = dependable volume at 80% (m3/period); C = coeficient; I = rainfall intensity (mm/period); A = catchment area (km2).

Based on the rational method, dependable volume (Vol_80) in Boyolali Regency is 282,478,781.8 m3/year ~ 282 million m3/year. In the case of housing, the analysis results show that the roof area with the potential to collect rainwater is less than 50%. Based on Figure 3, the rainwater catchment area's sketch of the house roof is only at sites where the collection pipe is possible.

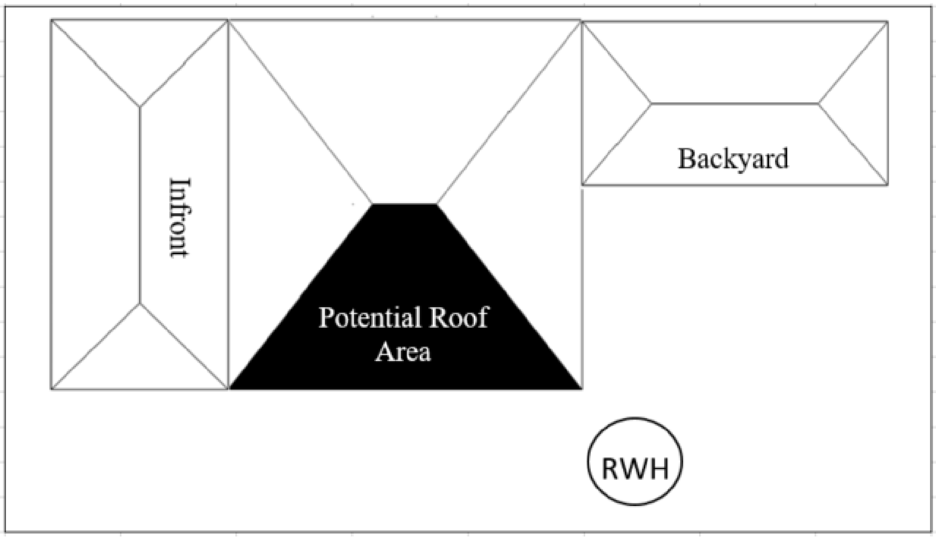

Fig. 2. Dependable Volume, Vol_80, in Boyolali District, Indonesia

Figure 3 shows the black block area on the roof function as the case study's rainwater catchment area. The usable roof area is 40.91 m2 from 239.59 m2. It means only 17.07% has the potential to collect water.

With an area of about 17%, the volume of water collected is 97.38 m3 / year. If this volume is obtained from paid water, IDR 5,750 / m3 will save up to IDR 559,940.00 / year. However, not all water can be stored in a relatively small site, and relatively limited in reality.

There are three types of the pond of different sizes that need a water supply. Analysis of water supply uses the simulation method. It is according to Table 1. If each pond requires 10 to 20 liters/pond/day, Table 2 shows the simulation.

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The calculations in Table 2 show, if the pool maintenance water requirement is 20 l/pond/day, it equals 6900 l / period. If it needs 15 l/pool/day, it equal to 5175 l/period. Then if it needs 10 l/pool/day, it equals 3450 l / period. Table 2 shows the optimum calculation of water requirement, and Figure 4 presents cost savings.

Table 2 shows the water requirements and saving value if it uses the entire of the roof areas. However, in reality, only 17.07% of the roof area is used for water storage areas. The dependable volume and costs can be saved based on the roof area, as in Figure 4.

Table 1. The size of the fishpond type

Pond type	Sizes (m^3)	Total of pond	The volume of the pond (liters)
Type A	3x3x1.2	8	10800
Type B	2x2x1.2	12	4800
Type C	2.5x4x1.2	3	12000
Total		23	27600

Table 1.Water requirement of ponds

Type of pond	WR (l/pond/ day)	Total of WR (l/type)	Total of WR. (l/period)	WR (l/pond/d ay)	Total OF WR (l/ type)	Total WR. (l/period)	WR. (l/pond/d ay)	Total WR(l/ type)	Total WR. (l/period)
Type A (8 ponds)	20	160	2400	15	120	1800	10	80	1200
Type B (12 ponds)	20	240	3600	15	180	2700	10	120	1800
Type C (3 ponds)	20	60	900	15	45	675	10	30	450
Jumlah		460	6900		345	5175		230	3450

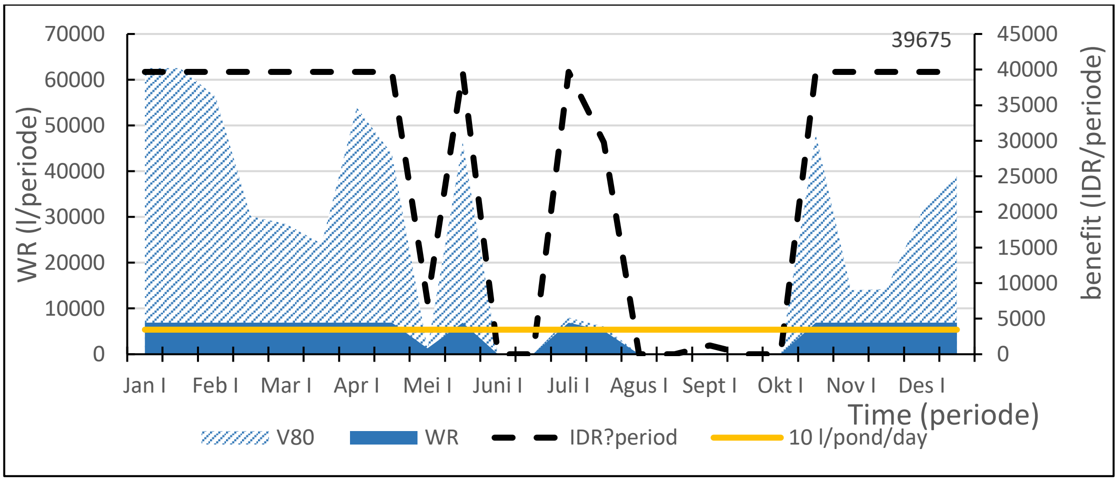

Fig. 3. Vol_80 and saving cost based on the entire roof area

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4. RESULTS AND DISCUSSION

The calculations show that Boyolali Regency has considerable potential rainwater saving if all its residential areas apply a rainwater storage system (rainwater harvesting system). If using the entire house roof to collect the water will supply all of the water requirements. It saves up to IDR 52,796,715/month or IDR 633,560.58/year.

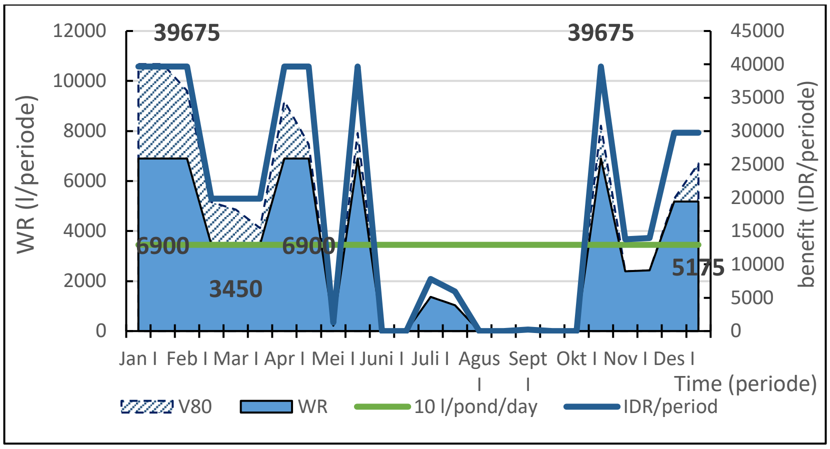

Fig. 4. Vol_80 and benefit based on the roof area used

However, only 17.07% of the house roof area can collect the water. The pattern of water requirement supply is in January, February first period, April, May second period, and Oktober second period is 20 l/pond/day, in December it is15 l/pond/day, while in the February second period, and March is 10 l/pond/day. For the first period of May, July, the first period of September, and November, the dependable volume can fill the pond but fill not all ponds, and in June, August, September second period and the first period of October, there is no rain, so there is filling no pond. In that period, use the remaining water in the previous period. The cost saving by installing PAH at the site are up to IDR 36,643.718/month or IDR 439,724.61/year. It means all of the water requirement can supply RWH with supply 10-20 l/pond/day.

Based on Fig 4, it also shows that there was a shift in the rainy season. The rainy season generally occurs between October - April, and the dry season occurs from April to October. However, based on the calculation, the rainy season occurs from the second period of October to May, but it occasionally rains in November. The dry season occurs from June to early October. Meanwhile, it occasionally rains during the first period of July and September. This seasonal shift occurs as a result of climate change.

In this study, the volume of collected rainwater fills the pond and saves water supply costs up to IDR 36,643,718 / month or IDR 439,724.61 / year, and excess water can flow into absorption wells (Harsoyo, 2010). The excess water that enters the infiltration well becomes a groundwater recharge.

The performance of rainwater harvesting will be more affected by the dry season. The existing tank sizes were unable to fill. The potential for water supply is reduced due to the reduced number of rainy days so that the possibility of the tank is empty will increase due to the long dry season than the rainy season (Abadi et al., 2018).

Table 4 shows a shift in the rainy season, so there is still rain in a few months in the dry season. This shift makes the onset of the season and the number of rainy days challenging to predict. Climate change will impact the rainwater harvesting system, but not all dry season years are dominant. There are years where the rainy season is dominant.

The research site was in Jeron Village, Boyolali. This area is in the category of the district with low density. The spatial pattern of high potential rainwater catchment values is located in urban areas with low densities, where the rainwater catchment system is expected to have better performance (Santos and de Farias, 2017).

5. CONCLUSION

Based on the analysis and discussion, it concluded that:

1. Potential catchment area for Rainwater Harvesting (PAH) in the Boyolali Regency of 237,327 km2 or 22% of the total area of the Boyolali Regency with 80% dependable volume in Boyolali Regency of 282478781.8 m3 / year.
2. In an urban area, around 17% roof area that can collect the water. It can save costs up to IDR. 36,643,718/month or IDR. 439,724.61/year.
3. There is a shift in the season according to the 2013 rainfall pattern on probability 80%. The rainy season occurs from the October second period to May, but it occasionally rains in November. The dry season occurs from June to October

of the first period. It occasionally rains during the first July and September. Seasonal shifts will impact the reservoir's prediction during the rainy season on the Rainwater Harvesting (RWH) system's performance.

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