Multi Effect of Rain Harvesting in the Floating Village of Malahing on the Coast Bontang Developed by the CSR of PKT

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Abstract. The residents of the floating village of Malahing, Bontang, East Kalimantan, earn their living as fish catching fishermen and seaweed farming. Residents even experience a clean water crisis, every month they require a budget IDR 300,000 until IDR 400,000 to buy clean water at Tanjung Laut by ketinting. The PKT programmed rain harvesting for Malahing residents to supply clean water. The method used was field observations and surveys as well as simple calculations using the program of Office Excel. The PKT carried out gutter procurement for every resident's house, provided three plastic drums of 200 litres to collect rainwater, provided filters to filter rainwater, train the residents to care for and repair the filters. As a result, the residents get clean water to meet their daily base, grow vegetables for family needs and do greening in their yard and water them. They can also water communal latrines so that defecation is not carried out at sea. Malahing residents can save IDR. 356,000 until IDR 456,000 per month, help save fossil fuels and reduce carbon dioxide emissions so they become healthier, prosperous and environmentally friendly.

1. Introduction

As a follow-up to the previous global agreement namely the MDGs or the Millennium Development Goals, the United Nations (UN) in September 2015 launched the SDGs or Sustainable Development Goals which is a global agenda that continues the efforts and achievements of the previous agenda. The global MDGs have 8 noble goals that have changed the face of the world 15 years for the better, while the SDGs have 17 noble goals; one of them is to get access to adequate drinking water. Indonesia as a member of the United Nations then participates in implementing 17 agreed sustainable development goals and also implementing them through Presidential Regulation no. 59 of 2017. In accordance with the body of the 1945 Constitution article 27 paragraphs 2, it states that every citizen has the right to work and a decent living for humanity [1].

Bontang City has land area of 29.70% and the sea of 70.30%. The population of Bontang City is mostly migrants from various islands and tribes in Indonesia. Most of the residents of Bontang city live on
the coast, such as Tihi-Tihi, Gusung, Selangan and Malahing. The clean water service in Bontang city is managed by PDAM Taman Tirta using pipeline, but the coastal areas are not covered by the distribution line. For coastal residents, the PDAM provides a large water reservoir with a capacity of 10 cubic meters on land in Tanjung Laut village after the water in the reservoir is filled up by the PDAM using a water truck. The residents in the four villages often complain of experiencing a water crisis because the reach to take water is very far, limited quantity, and quite expensive price for fishermen.

In 1999, some Mamuju residents from Sulawesi to Bontang lived in Malahing, a floating village in the middle of the sea with no land at all. Malahing residents earn a living as fishing net fishermen and seaweed farmers. From the results of the social mapping conducted by Pupuk Kaltim, they need clean water which is their basic daily needs. The source of clean water is even inexistent because the water resource in the surrounding sea is salt water which cannot be used to support daily life. Malahing village atmosphere is arid and hot because there is no greenery planted by the residents.

To get clean water, Malahing villagers must buy it in the land area of Tanjung Laut using a traditional small boat transportation called Ketinting which requires 2 liters of gasoline to and fro Malahing and Tanjung Laut. The price of water from the PDAM is only IDR 5,000 per cubic in the land area of Tanjung Laut, but when sold to communities on the island it can be IDR 50,000 or sold IDR 1,000 per 20 liters (per jerry can). The fact occurs because the intermediaries or managers earn very high profit. The residents must spend around IDR 250,000 - up to IDR 300,000 per month per Head of Family, and for fishermen residents it is very burdensome. The average need for clean water per household per day is 200 liters or requires IDR 20,000 per day [2].

From this background and based on the social mapping, one of the PKT’s CSR programs for Malahing was the provision of clean water. From the results of the observations and surveys conducted by the PKT’s clean water project team for Malahing consisting of process engineer, construction engineer, and CSR team, the supply of clean water with the raw material of sea water processed using thermal desalination and Reverse Osmosis (RO) is not possible because it is classified as high technology. To operate a thermal desalination unit requires a large supply of steam and electricity, specific maintenance, and educated and skilled personnel so it is not suitable for the Malahing community. Furthermore a literature review on the weather in Bontang city shows that the rainfall in the city is quite high with an average rainy day of 14-23 days per month, so it was decided to provide clean water in Malahing by harvesting rainwater which is then filtered. Thus, abundant clean water is available in Malahing village to meet daily needs and greening and watering vegetables for consumption by residents [3].

2. Method

2.1 Weather study of Bontang city

From the results of the BPPS literature review relating to weather, there is potential to provide clean water by harvesting rainwater because the climate in Bontang is quite humid and often rainy. By climatology, Bontang city is located on the Equator and influenced by a wet tropical climate with typical characteristics of rain occurring throughout the year so that it has almost no difference in the change of rainy season and dry season. Based on the data from the Department of Food Security, Fisheries and Agriculture (DKP3) of Bontang, the temperatures range from 21 – 33 °C with relative humidity around 61 - 97%. Rainfall ranges from 67.90 mm - 346.80 mm and the average number of rainy days is 14 - 19 days per month. Even in certain areas (Telihan), it reaches 23 rainy days per month, so rainwater is quite abundant as shown in the following table in Past 5 years.

2.2 Survey on the gutters of resident houses

From the results of the survey of residents' houses in Malahing, almost all of them did not have gutters so
that rainwater that almost every day comes is allowed to fall into the sea in vain. Therefore, the CSR program launched by Pupuk Kaltim was to meet the basic needs of the residents for clean water by harvesting rainwater so that rainwater that falls on the roof of the houses can be accommodated requiring a driving gutters so that the PKT conducted a gutter procurement program. Gutter procurement program was carried out by installing the gutters on one side of the roof of the resident houses with gutters made of PVC material carried out in mutual cooperation with the residents, Indonesian Armed Forces, and Pupuk Kaltim.

2.3 Survey on rainwater reservoirs

The results of the survey of rainwater reservoirs found 13 large blue water reservoirs. Ten of them were in good conditions and three others leaked so that they could not be used. They have the volume of 3000 liters each from Bontang City Government scattered throughout Malahing village. In certain places and Malahing residents’ houses, they almost did not have a special shelter. In average, they only had water jerry can with a size of 20-30 liters. From the calculation of water needs per person in Indonesia, their water needs per day is around 125 liters. When each household consists of 4 people, the water needs are around 500 liters per household. The PKT provided a 200 liter blue plastic drum to collect/harvest rainwater. The number of households in Malahing was 43, and each family gets three drums. About 129 drums were needed. The public facilities such as mosques, communal toilets, meeting halls, schools and some residential houses were provided with 40 pieces of PVC water reservoir @ 1200 liters.

2.4 Addressing the quality of rainwater to be clean water

The quality of rainwater in Malahing has normal average PH around 7, rather yellowish and dirty because it is exposed to house roofs, so a dirt filtering device is needed. Then, Pupuk Kaltim made a simple rainwater filter called a penjaring (crawler). Penjaring (Crawler) is a small sand filter made of former container as auxiliary material in the PKT’s factory that had been cleaned or plastic bucket of 50 liters. The filter was equipped with an arrangement of water filter material consisting of aquarium filters, silica sand and activated carbon arranged in layers in a plastic bucket or plastic drum used for factory supporting material container of 50 liters designed by the Pupuk Kaltim's process engineering team with a volume of about 26 liters with the dimensions of 30 cm in diameter and 37 cm high so that they can filter rainwater into clean and clear water that is suitable for daily needs [4].
Figure 1. Scheme of rainwater filtration in Malahing

![Flow Inlet]

5 cm mechanical filter (3.53 L)
2 cm silica sand (1.413 L)
13 cm activated carbon (9.19 L)
5 cm mechanical filter (3.53 L)

Flow Outlet

Figure 2. Material composition of filter

![Three-dimensional filter]

Figure 3. Three-dimensional filter

3. Budget of clean water supply cost in Malahing

The cost required for the water harvesting program in Malahing can be seen in Table 1.

| No | Item description                        | unit      | price per unit, IDR | Total requirements | Total price, IDR  |
|----|------------------------------------------|-----------|---------------------|--------------------|-------------------|
| 1  | Gutters & accessories and crawler filters| Set       | 1,200,000           | 43                 | 51.6 million      |
| 2  | Holding drum, 200 lt                     | Ea        | 250,000             | 129                | 32.25 million     |
| 3  | Reservoir, 1200 lt                       | Ea        | 1,300,000           | 40                 | 52,000,000        |
| 4  | Man Power                                | people    | 1,000,000           | 5                  | 5,000,000         |
The amount of rainwater that can be utilized with rainy day of 19 days, 129 holding drums with the volume of 200 liters from 43 families, 40 water reservoir with the volume of 1200 liters, 13 large water reservoirs with the volume of 3000 liters. They can be seen in table 2.

### Table 2. The amount of rainwater harvested in Malahing

| No. | Description Item                              | Number | @ Volume Liter | Total Vol Liter | Total 1 month, 19 days, liter | Price per 20 liters, IDR 1000, (savings) |
|-----|----------------------------------------------|--------|---------------|----------------|-------------------------------|--------------------------------------------|
| 1   | Drum container                               | 129    | 200           | 25800          | 490200                        | 24,510,000                                 |
| 2   | Additional water reservoir                    | 40     | 1200          | 48000          | 912000                        | 45,600,000                                 |
| 3   | Reservoir from the municipal government       | 10     | 3000          | 30000          | 570000                        | 28.5 million                               |

| Total | 19,722 million | 98.61 million |

From table 2 above, the rainwater that could be harvested in Malahing for 1 month with 19 days of rain days was 19,722 million liters (1972.2 m³), when filtered with a filter quality meeting the standard of the Ministry of Health, equal to PDAM water. The amount of cost that could be saved was a minimum of IDR 98,610,000.

### 3.1 Calculation of the water needs of Malahing residents according to the average Indonesian as follows:

Indonesian needs water of 125 liters per day per person.
The total was 43 households with 4 people (father, mother and 2 children) per household.
Total water needs = 43 households x 4 people/households x 125 liters/person/day x 30 days/month = 645,000 liters/month.
The water harvesting result per month was 1,972,200 liters.
The percentage of needs = (645,000/1,972,200) x 100% = 32.7% of the total rain harvesting.
The conclusion is that the water harvesting > the water needs of the Malahing residents meaning that the water harvesting is abundant, so it can be used for other purposes.

### 3.2 The validation of the calculation of water harvesting in Malahingin reality:

The rainwater obtained per house/family = 300 liters/day/family x 19 days of rain per month = 5,700 liters/month/family.
Quantity of rain harvesting for the whole Malahing = 5,700 liters/month/family x 43 households = 245,100 liters.
Average clean water needs per household in Malahing = 200 liters/day. Real demand for clean water of 43 households per month = 200 liters/day/households x 30 days/month x 43 households = 258,000 liters/month
40 water reservoirs sized 1,200 liters = (300 liters of rain per 19 days of rain per month x 40 drums) = 228,000 liters/month
10 reservoirs from the city government = 10x300 liters x 19 =57,00 liters/month
Total water in Malahing = 245,100 + 57,000 + 228,000 = 530,100 liters/month
Percentage of water use = 258,000/530,100x100% = 48.67% (excess water)
The actual percentage of rainwater harvesting to the potential of rainwater that can be harvested = (530,100/1,972,200) x 100% = 26.9%
When some residents still lacked of water because the number of family members, was more than 4 people, they can take water from a large blue reservoir of 3000 liters provided by the City Government, ask the other residents who have excess water, or install additional gutters on one side of their house roofs.

4. Results

4.1 Water availability for basic daily activities of the residents

The residents of Malahing can carry out daily basic activities well, such as bathing, washing clothes, cooking, watering plants and flushing the toilet when defecating in a communal toilet equipped with bio filter as a waste processing tool, so its output as pollutant free water flows directly into the sea.

4.2 Savings of the Residents

Malahing residents have additional income from saving water purchases every month of IDR. 300,000, and purchasing fuel of 2 liters/week x 4 weeks/month x IDR 7,000 per liter = IDR. 56,000/month. Minimum monthly savings is IDR 356,000.

4.3 Saving fossil fuels and reducing CO2 gas emission.

Every household in Malahing after getting clean water from rainwater harvesting filtered with a filter does not buy water anymore in Tanjung Laut so that it does not need gasoline to operate ketinting for transportation to buy clean water in Tanjung Laut. Then, it reduces the emissions in the air. The amount of emissions can be reduced in the simple calculation below.

Every household buy water once a week, and each time requires 2 liters of gasoline for transportation using ketinting. Then, a household requires 8 liters per month. The number of households in Malahing was 43 people, so the need for gasoline per month was 43 households x 8 liters of gasoline/households = 344 liters. Each liter of gasoline according to the IPCC calculation contributes a number of emissions = 2.34 kg equivalent to CO2. The total emission reduction was 804.96 kg equivalent to CO2 (IPCC, 2017).

4.4 Greening in Malahing

Malahing Village before arid almost had no greening in Malahing because there is no fresh water to water the plant. After rain harvesting was filtered into clean water and the results were abundant, the people were assisted by the PKT to go green by planting vines on the urea road in Malahing village, right in front of the arrival gate and on the ammonia road to the meeting hall. The plants were shade plants in 100-liter plastic drums, growing vegetables in the home yards in used and hydroponic container pots such as kale, spinach, eggplant, tomatoes, chillies and others fertilized using compost made by the residents of Malahing as a result of replication from the Mekarsari Compost group in Guntung so that the residents could pick vegetables planted in their yards to supplement family nutrition.

4.5 Clean water quality meeting Ministry of Health standards.

The clean water available in Malahing is from harvested rainwater filtered through a quality filter meeting the Ministry of Health standard no: 416/Menkes/Per/IX/1990 on September 3, 1990 so that the residents can use it.
4.6 **Household harmony**

Small quarrels between husband and wife due to the unavailability of water at home are reduced. Previously it was a trigger when the head of family came home to catch fish in a tired condition and his wife asked to buy water in Tanjung Limau. There was usually a little frustration and a small fight to buy clean water.

5. **Conclusion**

From the description above, the presence of rainwater harvesting in fact brings many positive effects to the residents of Malahing compared to before the rainwater harvesting. Conditions of Malahing residents after rain water harvesting are clean water is available from filtered rainwater so that the quality meets health standards, saving IDR 356,000 per month, Bathing and washing clothes every day, Defecating in the communal toilets provided by PKT and flushing using rainwater, the presence of greening and vegetable plants in the courtyard houses so that the atmosphere of Malahing is beautiful and the people can eat vegetable plants themselves Reduced dispute between husband and wife associated with fresh water supply.

References

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