Rainwater Harvesting: Embracing Sustainable Solutions for Water Supply in Small Island Communities

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Abstract. Community adaptation due to climate and environmental change is a necessity in the water management sector in Indonesia, particularly among community in small island across Indonesia. Both Pasaran Island and Siantan Island are small island located on Lampung and Anambas archipelago, Indonesia respectively. Pasaran Island has an area of 12 ha with 1,233 inhabitants compare to Siantan Island that has an area of 10,598 ha with population of 14,461. The both islands have been faced problem of clean water availability. The annual availability of clean water on the Pasaran was less than 7% while most of Siantan Island area is categorized as very low on water's carrying capacity. The main objective of this paper is to identify the most suitable rainwater harvesting (RWH) technology, as well as the water balance on the both islands.

Keywords: Rainwater Harvesting, Sustainability, Water Supply.

1 Introduction

Pasaran Island is located in Lampung province on the area of Lampung Bay. The island is part of the administrative region of Kota Karang Village, Teluk Betung Timur District, City of Bandar Lampung. Pasaran Island consists of RT 09 and RT 010 LK II. The Island is typically a fishery area (KPU-BD-BL-57, KPU-BD-BL-58), minapolitan area is a marine and fisheries development approach based on local economic empowerment. Main driving force of the program basically is marine and fisheries sector in the context of increasing people's income. According to data from the sub-district of Kota Karang, the Pasaran Island area was used to be 3.5 hectares wide, as due to natural changes and population increases, the people expand their territory by making foundations using rocks as footholds for residential land. Since the year of 2021 the area of the Pasaran Island becomes two hectares (1)

The Pasaran Island, like most other small island, faces its problems related to the potential and availability of clean and fresh water. Based on research conducted, the availability of groundwater with a debit of 179,359.74 liters/year or less than the total requirement of clean water which is 2,709,864 liters/year (74,040 liters/day) in 2020. Therefore, this condition implies that the potential availability of clean water on the

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island is classified as low, since the clean water availability is not sufficient compared to daily water requirement of the whole island (2).

The lack of groundwater availability on the island has resulted in the availability of clean water sources being a serious concern of the community; they must buy water from outside the island. Rainwater Harvesting (RWH) is a rainwater harvesting system that can be part of an alternative solution in providing water sources. The research aims to propose alternative solutions for the community in providing a source of clean water using rainwater harvesting system. The main purpose of this study is to analyze the clean water balance within the Pasaran Island, analyze the potential for rainwater during dry, normal and wet years as an alternative source of clean water.

2 Method

This research was conducted from July 2022 to September 2022 located on Pasaran Island in the Karang City subdistrict, Teluk Betung Timur District, Bandar Lampung City, Lampung Province. Rainfall data available in the research area consist of 2 (two) rainfall station (1).

Table 1. Related Rainfall station.

No	Name Post Rain	Data Year	
1	PH-001 – North Betung Bay	2010	2020
2	PH-004 – Princess Well	2010	2020

Source : BBWSMS

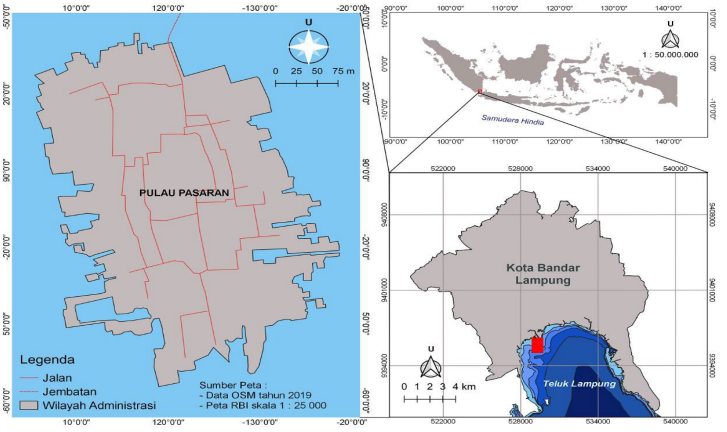

Fig. 1. Map of the Pasaran island (Source:(3)).

This research is quantitative research, by using questionnaire and interview method as

well as relevance secondaries data. The need for clean water per capita, the area of the rainwater catchment area and the state preference for RWHs were obtained from interviews with primary data. Secondary data were obtained from literature studies, previous research, and data from related agencies.

Table 2. Data Source Matrix.

No	**Data**	**Source**
1	Area Map	BPS 2021
2	Total Population of Pasaran Island	BPS 2021
3	Rain Station Location Map	BBWS MS 2020
4	Rainfall (PH-01, PH-04)	BBWS MS 2020
5	Availability of groundwater	Previous Research
6	Clean water needs	Interview
7	Area of Rainwater Catchment Area	Interview
8	RWH state preference	Interview

This study used a simple random sampling approach and it is assumed that the distribution of the population is homogeneous. The determination of the number of samples in this thesis uses the Slovin method (4)(5).

$$n = \frac{N}{1 + Ne^2} \quad (1)$$

in which:
n = Number of Samples (KK)
N = Number of population (KK)
e = Margin error (10%).

In general, water needs are categorized into two aspects, namely water needs for domestic and non-domestic purposes. This domestic need is intended for the use of various household needs which include water for drinking, cooking, bathing, washing and other uses. While non-domestic needs, namely the need for water intended for urban support activities. This water requirement is influenced by physical activity and the habits of each person are different.

Pasaran Island is categorized as a densely populated area; therefore, geometry method was chosen to forecast population in 2026, this method is widely used based on its reasonable accuracy(6–8).

The calculation formula: $Pn = Po (1 + r) n$
Where :

Pn	= total population in the projected year (people)
Po	= total population at the beginning of the base year (people)
A	= average population growth (%)
N	= difference between the projection year and the base year (year).

Projected demand of clean water is assumed to be based on projected population growth from 2022-2026. The projected demand of clean water was calculated by multiplying the population, at a certain time, by the per capita water demand. Meanwhile the water balance provided by ratio between availability and demand of clean water (1).

2.1 Rainwater harvesting potential analysis.

Rainwater harvesting is an effort to conserve water resources because it can reduce the rate of exploitation of groundwater. Besides that, rainwater harvesting can also be an alternative solution for island areas/regions that have difficulty getting clean water.

Supply and Demand of drinking water which takes into account available monthly rainfall and runoff coefficient. According to (9,10) the equation to determine the potential amount of water as follows:

Supply= Rainfall x area x Runoff Cofficient
In which :

Supply	= Average water to be received in a year (m^3/year)
Rainfall	= Average annual rainfall (m)
areas	= Rainwater catchment area (m^2)
Runoff Coefficient	= Runoff coefficient.

This research was also conducting interviews with the people of the Pasaran Island regarding the selection of related technology that is in accordance with the wishes of the community, with three kinds of choices.

a. RWH installations use cement/concrete pools

Fig. 2. Concrete Pond Storage.

b. RWH installation using a plastic tube.

Fig. 3. RWHs using a plastic tube.

3 Result and Discussion

With a population growth rate in the City of Bandar Lampung of 3.3%, the projection of the population can be calculated using the geometric method.

Table 3. Projected population and family members on the island.

Year	population	Family member
2021	1262	316
2022	1304	326
2023	1347	337
2024	1391	348
2025	1437	360
2026	1484	372

Source: Calculations 2023

Table 4. Results of projected calculations of clean water demand on Pasaran Island.

Year	Total population	Water Needs (l/day/person)	Total Water Requirement (l/day)	Total Water Requirement (m^3/day)
2021	1262	133	167846	167,846
2022	1304	133	173432	173,432
2023	1347	133	179151	179,151
2024	1391	133	185003	185,003
2025	1437	133	191121	191,121
2026	1484	133	197372	197,372

Source: Calculation Results (2023)

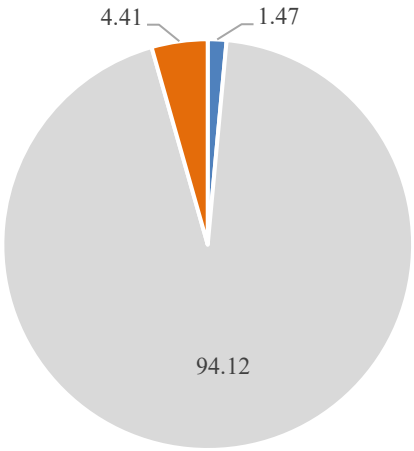

Fig. 4. Graph of RWH based on state preference.

Identification of PAH technology on Pasaran Island showed that 64 respondents (94.12%) chose to use a torn, three respondents (4.41%) chose to use plastic and one respondent (1.47%) chose to use concrete as a tool. rainwater tamping.

Rainfall intensity is defined as the ratio of the total amount of rain (rain depth) and is expressed in mm/hour. In determining the intensity of rain at a certain duration, the Mononobe method is used.

Table 5. IDF calculation results using the Mononobe method.

Duration (Hours)	2 yrs	5th	10 yrs	25 yrs	50 yrs	100 th
	92,110	**175,693**	**231,033**	**300,954**	**352,826**	**404,314**
0.083	167,375	319,256	419,814	546,870	641,127	734,688
0.167	105,440	201,119	264,466	344,506	403,885	462,824
0.333	66,423	126,697	166,603	217,025	254,431	291,561
0.500	50,690	96,688	127,142	165,621	194,167	222,503
1	31,933	60,909	80,095	104,335	122,318	140,168
2	20,116	38,371	50,456	65,727	77,055	88,300
4	12,673	24,172	31,786	41.405	48,542	55,626
5	10,921	20,831	27,392	35,682	41,832	47,937

Source: Calculation Results (2023)

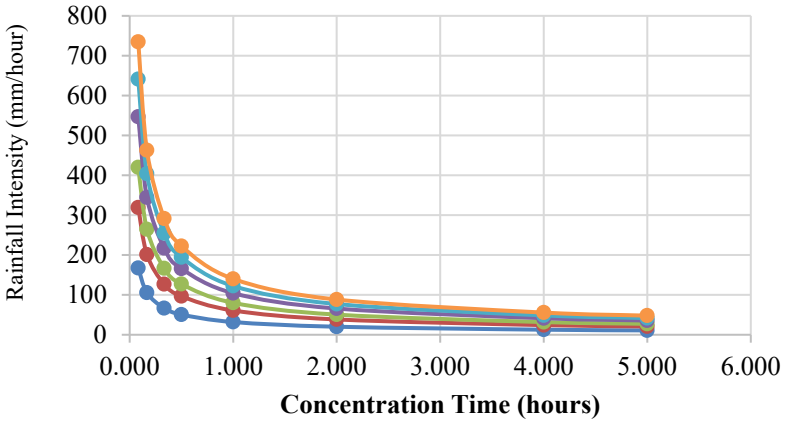

Fig. 5. Graph of IDF Mononobe method (Calculation Results (2023)).

Assuming a return period of two years and a duration of rain for two hours, a rain intensity of 20.16 mm/hour is obtained.

The amount of rainwater that can be utilized on Pasaran Island with the condition of the catchment area (roof area) is 23,700 m^2 with an average flow rate coefficient of 0.186 and a rain duration of two hours, the discharge value is obtained as follows.

Table 6. Results of calculating the flood discharge with the Rational method.

Period T (year)	R(mm)	I (mm/h)	C	A (km^2)	Q (m^3/sec)	l/sec	l/day
2	92.1101	20,116	0.186	0.0237	0.0200	20	144,000
5	175.6933	38,371	0.186	0.0237	0.0500	50	360,000
10	231.0326	50,456	0.186	0.0237	0.0600	60	432,000
25	300.9540	65,727	0.186	0.0237	0.0800	80	576,000
50	352.8257	77,055	0.186	0.0237	0.0900	90	648,000
100	404.3143	88,300	0.186	0.0237	0.1100	110	792,000

Source: Calculation Results (2023)

The potential of rainwater that can be utilized on Pasaran Island at a two-year return period with a rain duration of two hours is 144,000 liters/day. The results of this study indicate that the potential for rainwater is very large and can meet the needs of clean water on Pasaran Island by 80.4% in 2023 (5,11).

Compare to daily water requirement in Anambas Island, Pasaran Island has a higher water requirement particularly for non-domestic use (12,13). However, the amount of total water requirement in Anambas Island much higher.

Conclusion

The availability of clean water at the island is recorded of less than 7% compared to the total annual requirement for clean water of the entire island in year 2020. It is clearly necessary to identify not only the most effective technology of RWH (Rainwater Harvesting) but also its public preference. Preference is claimed to be an important aspect to maintain sustainability of clean water sources management for the community. The most suitable RWH's technology is communal RWH with capacity of service for three houses. The co-creation and community development approach are essential to maintain sustainability of RWH across the island.

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