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Rainwater Harvesting for Drought Disaster Prevention in Seraya Village, Karangasem Regency, Bali Province, Indonesia

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ABSTRACT Drought is a recurring disaster in several regions of Indonesia, often happening from April to September annually. During the dry season, a substantial reduction in rainfall leads to inadequate water supplies and drought. Drought significantly affects food crop output, water scarcity, and reduced water availability for daily necessities, disrupting everyday activities like bathing, washing, and cooking. Seraya Village, situated in Karangasem Regency, Bali Province, frequently faces drought conditions. Seraya, a settlement prone to drought, was officially designated as such by the Karangsem Regent by Regulation Number 36 of 2008, specifying the location of drought natural disasters in Seraya settlement, East Seraya, and West Seraya in the Karangasem District. This study aimed to compare the capacity of rainwater harvesting with the current home water demand in Seraya-Karangasem Village to determine the feasibility of using rainwater to address water shortages and avert drought. This study employs quantitative descriptive methods by analyzing primary data on the regional conditions and limits of the study area, along with secondary data on demographic (population), geographical, and rainfall data spanning a decade. The study revealed that the rainwater harvesting potential in Seraya Village, Karangasem District, was 254,342,191.15 liters per year, while the total water demand was 227,660,565 liters yearly. This resulted in excess harvested water amounting to 26,681,626.15 liters per year, 12% more than the total water needs. The excess amount of rainwater that may be harvested compared to the entire domestic water demand demonstrates the effective utilization of rainwater harvesting systems in preventing water shortages and droughts in Seraya, Karangasem Village.

KEYWORDS Disaster, Drought, Dry Season, Rainfall, Rainwater Harvesting

1 INTRODUCTION

Water is essential for all living beings and serves as the basis of life. Nevertheless, this resource is becoming more limited and of lower quality for millions of people worldwide. Ensuring sufficient water supply for a rapidly expanding population in the face of global climate change is a significant concern in recent times. The growth in water-related disasters has become a significant issue in the context of global change (Masago et al., 2019). The number of casualties and economic damage caused by water-related calamities such as floods, droughts, landslides, and land subsidence is increasing rapidly. Climate change and variability, land use changes, urbanization, migration patterns, energy challenges, and food production driven by demographic shifts and economic development may increase unpredictable threats. Drought catastrophes have diverse physical and social dimensions. Lack of rainfall impacts water supplies and agricultural systems, and the impact can be severe, depending on conditions and the resilience of local communities and populations (Grafton et al., 2011). Drought can impede numerous societal water uses, including energy production, at local and regional levels (Jimenez-Cisneros, 2015).

Drought is a frequent catastrophe in several regions of Indonesia. In Indonesia, droughts typically happen during the dry season, from April to September. During the dry season, a substantial reduction in rainfall leads to inadequate water supplies and drought. The effects of drought in Indonesia include crop failure, scarcity of drinking water, and insufficient water supply for daily requirements (Khairullah et al., 2023; Rahmawati et al., 2023). Inadequate resources for necessities will significantly affect daily tasks, including bathing, cleaning, and cooking. This issue can lead to the formation of slums, interrupted sanitation, and an uninhabitable environment (Suryani, 2020). Seraya Village is in the Karangasem District of Karangasem Regency, Bali Province. It covers an area of 13.98 km^2 and is less than 500 m above sea level. The community is divided into 13 banjars. Seraya Village experiences arid environmental conditions throughout the dry season, with an average annual rainfall of 1796.84 mm over the past decade. Seraya Village in Karangasem frequently faces drought disasters throughout the dry season, as reported in many forms of the media. Seraya Village in Karangasem has been identified as prone to drought disasters, as stated in the Karangasem Regent Regulation Number 36 of 2008 concerning the Determination of the Location of Drought Natural Disasters in Seraya Village, East Seraya and West Seraya Karangasem District in 2008.

Reducing or preventing drought is generally possible by increasing the usage of existing water supplies. Rainwater harvesting is one way that efforts can be made. Rainwater, surface water, and groundwater are the three water sources that are most commonly used (Judeh et al., 2022; Ertop et al., 2023; Sakati et al., 2023). Rainwater can be obtained by building rainwater harvesting systems; surface water can be obtained by making reservoirs, weirs, dams, and similar buildings, while groundwater can be obtained by building wells. According to Rahaman et al. (2019); Mansouri et al. (2021); Habibi et al. (2022); Agha et al. (2023), rainwater harvesting is one way that may be utilized to gather water during the wet season and then use it during the dry season. There has been a significant amount of research conducted in Indonesia about the collection of rainwater. In one of the investigations that Yushananta (2021) carried out, it was discovered that rainwater collection is a simple and highly inexpensive water treatment method. The only further treatment necessary is general treatment, which includes sedimentation, filtration, and disinfection. Previous study by Marwoto et al. (2021) provided evidence that the rainwater harvesting system has the potential to conserve water by 214 cubic meters per year, which is equivalent to four percent of the total domestic water consumption in residential areas located in Durensari Village, Bagelen District, Purworejo Regency. According to previous research, in Antalya, which has about half of the greenhouses in Turkey, the amount of water in the rain harvest that can be obtained in greenhouses is 224,992,795.8 m^3 per year (Ertop et al., 2023). Based on these findings, rainwater harvesting can be an effective strategy for overcoming water scarcity problems, especially for water-stressed areas or water scarcity due to drought.

This study will compare the annual rainwater harvesting capacity with the yearly water requirements. The rainwater harvest volume is determined by analyzing the rainfall levels throughout wet and dry months to understand the variations in the volume of rainwater collected throughout the year. The water requirements are determined by multiplying the number of persons in Seraya Village by the amount of water used per person. The findings from the study can serve as a foundation for stakeholders to develop preventive and mitigation plans for drought catastrophes in Seraya Village and other places worldwide. The rainwater harvesting system proposed in this research is expected to be a successful strategy for addressing drought.

2 METHODOLOGY

This study employed quantitative descriptive methodologies and utilized primary and secondary data as supporting evidence. The main data in this study consists of information regarding the status and borders of the study area gathered through interviews with Seraya Village Office employees and on-site observations. Secondary data include demographic and geographic data from the Central Bureau of Statistics of Karangasem Regency (BPS Karangasem Regency) and rainfall data spanning a decade from the Region III Meteorology, Climatology, and Geophysics Agency (BMKG Area III).

2.1 Research Location

The study was conducted at Seraya Village, in Karangasem District, Karangasem Regency, Bali. Seraya Village covers an area of 13.98 square kilometers, with specific land use breakdowns as follows: dry field (*tegalan*) area of 282.35 hectares, yard area of 43.15 hectares, plantation area of 714 hectares, cemetery area of 10 hectares, and other uses area of 348.5 hectares. Seraya Village in Karangasem has arid soil for purposes other than rice cultivation. The soil is conducive for cultivating coffee, cloves, coconut, cashew, and guava trees (Central Bureau of Statistics of Karangasem Regency, 2021). Seraya Village in Karangasem is situated on a hill with arid, rocky soil, resulting in hot and dry weather, particularly during the dry season. In Seraya Village, the settlement design is characterized by dwellings being spread out with a more than 100 meters distance between each house.

Seraya Village relies on Local Water Supply Utility (PDAM) water as its primary water source. In some Banjar Dinas, water is distributed twice weekly, requiring residents to store water for multiple days until the subsequent distribution. A weir in Seraya Village regulates the river water flow during the rainy season and for irrigation purposes in the dry season. The weir in the Seraya Village area needs to be fixed due to technical limitations and topography. The village is situated at a higher elevation than the weir, making distributing water to residents' homes challenging. Multiple water well locations in the coastal region are intended to serve as a water source for the local population. The well in Seraya Village - Karangasem needs to be more effective in providing sufficient water due to its susceptibility to tides, resulting in salty water during high tide. Distributing water from wells to residents' homes incurs significant expenses, mainly due to the challenges of pipeline installation and water distribution are caused by the varying conditions of residents' homes and the hilly geographical terrain.

Based on the map of the Karangasem District area obtained from Karangasem Statistics (Central Bureau of Statistics of Karangasem Regency, 2021), it can be seen that Seraya Village is geographically located in Karangasem District, Karangasem Regency, Bali, with the following boundaries: the regional boundary in the west is directly adjacent to Seraya Barat Village and Bukit Village, in the north is directly adjacent to Abang District, Karangasem Regency, in the east is directly adjacent to Seraya Timur Village, and in the south is directly adjacent to the South Bali Sea. More clearly and in detail related to the location where this research was carried out can be seen in Figure 1.

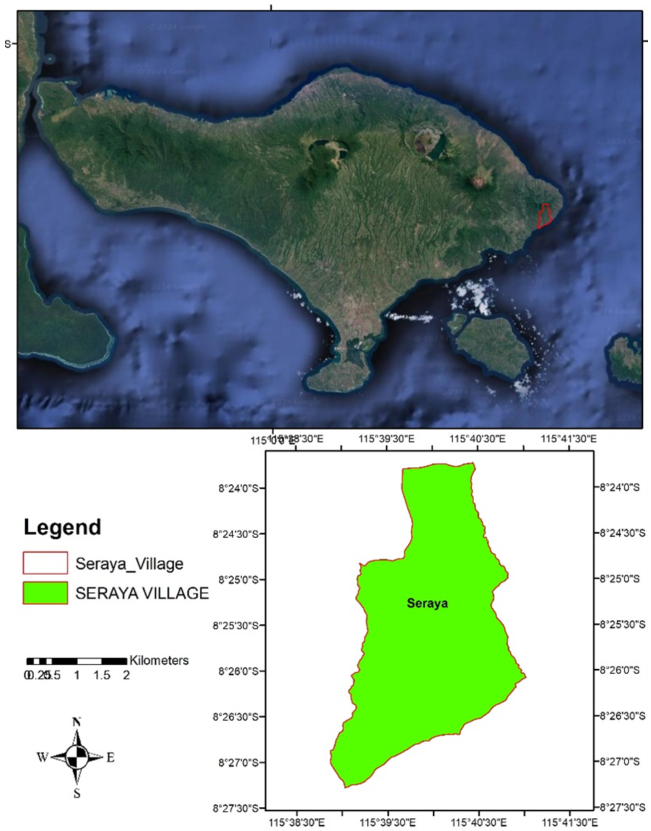

Figure 1 Map of Seraya Village

2.2 Population and Research Sample

According to Mundir (2012), conclusions can be made about a studied variable by employing inferential statistics to generalize data from test samples to the population. The population refers to the individuals, areas, and objects to whom study findings are generalized. A sample can be representative of the population itself, as reported by Roflin et al. (2021). A representative sample closely mirrors the population's characteristics (Alamsyah and Hartono, 2022). Simple random sampling is suitable for selecting samples from homogeneous populations, as all individuals have an equal opportunity to be chosen (Arieska and Herdiani, 2018).

In calculating the number of samples needed, if the total population number (N) and the level of accuracy or significance are known, the Slovin formula can be used (Hanafiah et al., 2020). The solving formula can be seen in Equation (1) below:

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

where n is the number of samples, N is the number of populations, and α is the level of significance.

According to Sugiyono (2011), the significant or error rate that can be used in Equation (1) is 10% for large populations and 20% for small populations.

2.3 Weather and Climate

Weather is a series of changes occurring in the atmosphere in the short term at a particular place and time (Anasi, 2022). If this weather condition is collected and calculated in a specific time, it will be the average weather conditions called climate (Ufi et al., 2021). One classification system often used in Indonesia to determine the type of climate in an area based on rainfall is the Schmidth-Ferguson classification system (Anwar et al., 2019). To use this classification, it is necessary to calculate the average dry month period with Equation (2) and the average wet month period with Equation (3). The group of wet and dry months can be seen from the amount of rainfall where the wet month is a month that has more than 100 mm (>100 mm) of rainfall, and the dry month is a month that has less than 60 mm (<60 mm) of rainfall (Laimeheriwa et al., 2019).

$$\frac{\sum fd}{T} = Md \quad (2)$$

Where $\sum fd$ is the frequency of dry months, T is the number of years of research, and Md is the average dry month period.

$$\frac{\sum fw}{T} = Mw \quad (3)$$

Where $\sum fw$ is the frequency of wet months, T is the number of years of research, and Mw is the average dry month period.

After knowing the average wet and dry months, the climate type (Q) can be calculated using Equation (4).

$$\frac{Md}{Mw} \times 100\% = Q \quad (4)$$

Table 1. Climate type classification Schmidth-Ferguson

Climate type	Criterion (%)	Information
A	0 <Q <14.3	Very wet
B	14.3 <Q <33.3	Wet
C	33.3 <Q <60	Slightly wet
D	60 <Q <100	Moderate
E	100 <Q <167	A bit dry
F	167 <Q <300	Dry
G	300 <Q <700	Very dry
H	700 ⩾ Q	Extreme dry

The Q value obtained in the calculation in Equation (4) above can be used in determining the climate type of an area based on Table 1 (Lakitan, 2002).

2.4 Rainwater Harvesting

Rainwater harvesting is a technique used to collect rainwater that flows on the surface and is then channeled into a reservoir. Generally, rainwater harvesting is carried out in high rainfall conditions and is used for low rainfall conditions (Silvia, 2018). This technique, in its application, does not require a complicated distribution system and requires low costs so that it can be used as an alternative water source (Kurnia, 2017). In addition to being used as an alternative water source, rainwater harvesting can also be used to improve the quantity and quality of groundwater through infiltration wells and can be used to reduce the volume of surface water runoff (Ardana and Pamungkas, 2016; Pamungkas, 2022). According to Silvia (2018), rainwater harvesting techniques based on the scope of their implementation can be classified into 2 (two) categories, namely: rooftop rainwater harvesting (rainwater harvesting techniques by utilizing the roof of buildings) and rainwater harvesting techniques by utilizing reservoir buildings, such as reservoirs, trench dams, reservoirs, and so on. The components of the rainwater harvesting technique, which uses the roof of the building, can be seen in Figure 2, and the description of each element is as follows:

a) The catching area utilizes the building's roof to absorb rainwater, with the amount collected dependent on the roof's area and material (Arifin and Ramadhan, 2021).
b) The rainwater drainage system is designed to transport collected water from the catchment region to the reservoir using pipe materials (Pamungkas, 2022).
c) Dirt filters are used to remove dirt, bacteria, and dangerous compounds from gathered water to maintain its quality (Arifin and Ramadhan, 2021).
d) The storage unit is designed to store gathered water based on factors such as the anticipated rainfall, length of the dry season, and water requirements (Elgara et al., 2016).
e) A sewer is designed to quickly remove rainwater because it is believed to carry contaminants still (Herlambang et al., 2021).

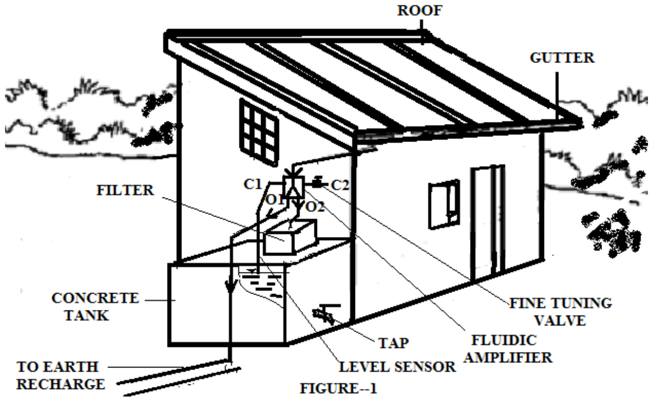

Figure 2 Element of rooftop rainwater harvesting (Silvia, 2018).

The calculation of potential rainwater that can be harvested by rainwater harvesting techniques with building roofs using Equation (5) as below (Safriani, 2021):

$$A \times R \times C = S \tag{5}$$

where A is the area of rainwater catchment area (m^2), R is precipitation (mm), C is run off coefficient (0.8), and S is the amount of potential rainwater that can be harvested (liter).

2.5 Water Requirement Calculation

Water is a vital natural resource essential for the survival of organisms. Water is frequently misused and mishandled, requiring efforts to maintain a balance between water supply and demand through enhancing water quality, conservation, resource development, and protection (Langoy, 2016). Water requirements can be categorized into five primary groups: irrigation, animal husbandry, fisheries, river management, and residential, urban, and industrial uses (The National Standardization Agency of Indonesia, 2015). Household water demands, also known as domestic water needs, relate to the water required for daily activities, including washing, drinking, cooking, and bathing. Domestic water requirements differ for each individual due to many external and internal factors (Noviana et al., 2018; Wijaya, 2020). Table 2 displays the standards of domestic water demand for various criteria, whereas Table 3 shows the percentage of home water usage for daily activities.

The calculation of domestic water demand at certain intervals can be calculated using Equation (6).

Table 2. Standard criteria for domestic water demand (Wijaya, 2020)

No	Sources	Criterion	Necessity
1	The National Standardization Agency of Indonesia (2002)	Urban Rural	120 lt/person/day 60 lt/person/day
2	Linsley et al. (1991)	Major cities Rural	150-250 lt/person/day 40 lt/person/day
3	WHO Standard	General	1000 - 2000 m^3/year
4	Minister of State for the Environment (2009) KLH Standard	General	1600 m^3/person/year
5	The National Standardization Agency of Indonesia (2015)	Urban Rural	120 lt/person/day 60 lt/person/day

Table 3. Percentage of domestic water use for daily activities (Fair et al., 1971)

No	Types of activities	Percentage of water usage (%)
1	Toilet flush	41
2	Bathing and washing	37
3	Activities in the kitchen	6
4	Drinking water	5
5	Wash clothes	4
6	Home Hygiene	3
7	Watering plants	3
8	Washing family furniture	1

$$t \times \{q(u) \times P(u) + q(r) \times P(r)\} = Q \quad (6)$$

where t is the calculation time (day), $q(u)$ is the consumption of water in urban areas (lt/person/day), $P(u)$ is the number of inhabitants of the city (person), $q(r)$ is water consumption in rural areas (lt/person/day), $P(r)$ is the number of villagers (person), and Q is domestic water needs (liter).

3 RESULTS AND DISSCUSSION

3.1 Sample Data Analysis

This study focuses on the aggregate number of residences in Seraya Village as of 2022. The Perbekel of Seraya Village stated that the number of dwellings in the village is equal to the number of heads of households. In Seraya Village, it is a tradition for newly married couples to live separately from their parents and construct their own house, with the exception of the youngest child, who stays with their parents. The data from the population registration register at the Seraya Village Office shows that in 2022, there were 3,370 households with an average monthly population of 10,943 individuals, resulting in an average of 4 people per household. Refer to Table 4 for comprehensive information on the population and number of households in Seraya Village in 2022.

Table 4. Number of residents in Seraya Village in 2022

Month	Population (thousand)	Number of Heads of Families	Number of people in the family
January	10,958	3,365	4
February	10,958	3,365	4
March	10,956	3,365	4
April	10,957	3,371	4
May	10,946	3,371	4
June	10,933	3,371	4
July	10,933	3,371	4
Agustus	10,936	3,371	4
September	10,934	3,371	4
October	10,934	3,372	4
November	10,929	3.372	4
December	10,938	3,372	4
Average	10,943	3,370	4

The study investigated a sample of housing data due to the vast size of the housing population in Seraya Village. The samples found in the field are homogeneous in terms of probability and features, making them suitable to represent the total population. The characteristics and attributes of the sample are similar. Hence, a basic random sampling approach is used in this study with a specific number of samples as follows:

$n = \frac{3370}{1+(3370\times0.2^2)} = 24.82$ samples, rounded up to 25 samples.

3.2 Rainfall

The rainfall data for Seraya Village is collected daily from the Seraya Tengah station with rain post number 051, built by BMKG-Staklim Jembrana in 2007. The rain gauge is situated in Banjar Dinas Yeh Kali, Seraya Village, Karangasem District, Karangasem-Bali Regency. Its precise location is at 8.452640° S latitude and 115.652260° E longitude, with an elevation of 44.9 meters above sea level. This station uses an observatory rain gauge, often known as an ombrometer. The study utilized daily rainfall data spanning 11 years, specifically from 2012 to 2022. Each year, the daily rainfall data is summarized. The table in Table 5 from the 2012-2022 rainfall summary shows that the highest annual rainfall was recorded in 2013 at 2032.00 mm, while the lowest annual rainfall was in 2015 at 858.10 mm. The mean annual precipitation from 2012 to 2022 was 1410.59 mm.

Table 5. 2012-2022 Rainfall Recapitulation

Month	Rainfall (mm)											Average
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	
January	221.00	516.00	403.6	241.0	62.00	250.00	404.00	302.20	326.20	298.80	291.50	301.48
February	228.00	117.00	187.8	85.80	286.90	332.20	283.40	312.00	145.20	429.00	295.60	245.72
March	194.00	397.00	35.00	93.40	40.00	163.00	43.00	220.00	268.80	182.20	146.40	162.07
April	108.00	151.00	17.60	169.2	114.80	127.40	32.40	141.80	36.80	97.60	94.00	99.15
May	104.00	166.00	37.60	50.90	180.40	138.40	39.00	11.00	155.00	19.40	72.40	88.55
June	15.00	189.30	27.60	11.00	152.40	77.00	22.00	9.00	12.60	45.20	77.80	58.08
July	26.00	79.10	80.00	1.00	126.60	26.80	0.00	0.00	33.80	2.60	42.40	38.03
August	1.00	0.00	14.40	0.00	25.40	6.00	104.00	0.00	0.00	4.80	62.00	19.78
September	23.00	1.80	0.00	10.00	32.00	5.00	10.20	7.00	26.00	58.40	21.60	17.73
October	44.00	7.00	0.00	0.00	20.60	194.80	8.40	9.00	123.60	92.20	206.60	64.20
November	226.00	122.40	67.00	8.00	113.00	122.40	139.20	6.00	57.80	279.60	120.40	114.71
December	133.00	285.40	111.2	187.80	328.60	240.20	153.00	96.80	179.80	242.60	253.60	201.09
Total	1323.00	2032.00	981.80	858.10	1482.70	1683.20	1238.60	1114.80	1365.60	1752.40	1684.30	1410.59
Average	110.25	169.33	81.82	71.51	123.56	140.27	103.22	92.90	113.80	146.03	140.36	117.55

3.3 Determination of Climate Classification and Season Periods

To identify the climate type and seasonal patterns in the Seraya – Karangasem Village area, one must initially assess the climate classification based on Schmidt Ferguson's method, which involves evaluating the frequency of dry, humid, and wet months.

Table 6 shows the distribution of dry, humid, and wet months in Seraya Village from 2012 to 2022. Out of 132 total observations, 56 months had rainfall below 60 mm (dry months), 14 months had rainfall between 60-100 mm (humid months), and 62 months had rainfall above 100 mm (wet months).

The climate classification calculation in Equation (4) begins with calculating the average dry month period in Equation (2) and the average wet month period in Equation (3).

$\sum fd = \frac{56}{11} = 5.09$ months, rounded up to 5 months.

$\sum fw = \frac{62}{11} = 5.64$ months, rounded up to 6 months.

$\frac{Md}{Mw} \times 100\% = \frac{5}{6} \times 100\% = 83.33\%$, based on the climate classification in Table 1, it is included in the type D (moderate) climate category.

Based on the previous hydrological analysis, the conclusion is that Seraya Village has a temperate, tropical climate with a 6-month dry season (including humid months for 1 month) and a 6-month rainy season, receiving an annual rainfall of 1,410.59 mm.

3.4 Calculation of Rainwater Harvesting Potential

Rainfall harvesting potential can be determined by applying Equation (5) to compute the volume of rainfall that can be collected from the roofs of buildings in Seraya Village. When determining the feasibility of rainwater collection, two crucial pieces of information are required: roof area data and rainfall data. The roof area of the house was calculated using 25 sample houses based on earlier measurements. The housing sample's average roof area was estimated using a geographic information system (GIS) tool. The calculated roof area for the sample building is displayed in Table 7.

After obtaining the average roof area in Seraya Village of 66.91 m^2, annual rainfall of 1410.59 mm, and run-off coefficient of 0.8, then the volume of potential rainwater harvesting for one housing unit can be calculated using Equation (5).

$A \times R \times C = 66.91 \times 1410.59 \times 0.8 = 75,511.62$ liter/year

The potential volume of harvested water in one housing unit is 75,511.62 liter/year and the total potential volume of harvested water in all houses in Seraya Village is 254,342,191.15 liter/year. More details can be seen in Table 8.

According to Lutfiana (2022), the dry season in Indonesia occurs from April to September and the rainy season occurs from October to March. The dry season in several regions of Indonesia is experiencing drought including Seraya Village, Karangasem District.

Based on the diagram in Figure 3, 77% of rainwater potential can be harvested in the rainy season, and only 23% of rainwater potential can be harvested in the dry

Table 6. Period of dry months, humid months, and wet months year 2012-2022

Month classification	Year											Total
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	
BK (<60 mm)	5	3	7	7	4	3	7	7	6	5	2	56
BL (60-100 mm)	0	1	2	2	1	1	0	1	0	2	4	14
BB (>100 mm)	7	8	3	3	7	8	5	4	6	5	6	62
Average												132

*BK is dry month, BL is humid month, and BB is wet month

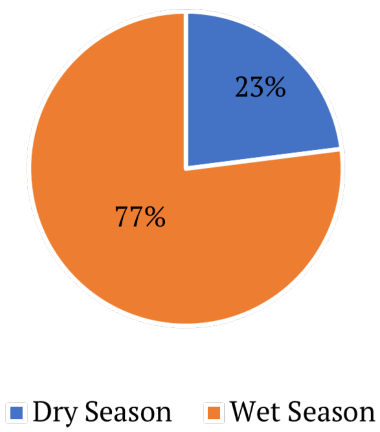

Figure 3 Comparative diagram of rainwater harvest in the dry season and rainy season.

Table 7. The roof area of houses in Seraya Village

No. sample	Roof area (m^2)	No. sample	Roof area (m^2)
1	60.68	15	92.46
2	64.83	16	92.40
3	85.77	17	57.31
4	60.79	18	71.96
5	61.42	19	39.46
6	70.86	20	50.70
7	61.35	21	28.09
8	93.01	22	55.17
9	79.92	23	96.87
10	46.05	24	64.24
11	65.42	25	56.84
12	43.11	Total	1672.87
13	93.58	Average	66.91
14	80.58		

season. The existence of this gap has the potential to create drought disasters if, in the rainy season, rainwater is left to be wasted. There is a need for rainwater storage in the rainy season to increase water supply in the dry season. This statement is in line with the results of Ertop et al. (2023) research, which shows that 87% of rainwater can be harvested in the rainy season and 13% in the dry season.

3.5 Water Requirement Calculation

The water needs calculated in this study are domestic water demand in rural areas with a significant need of 60 liters/person/day. Based on the results of the recapitulation of the number of residents per month, the length of days per month, and the number of heads of families per month, the calculation of domestic water needs for the entire population within 1 year or in monthly can be calculated using Equation (6) with the results can be seen in Table 9. Table 9 shows that the overall domestic water demand for all residents in Seraya Village is 239,642,700 liters or 71,115.49 liters per year per family in 1 housing unit.

3.6 Comparison of Rainwater Harvesting Results and Water Requirements

The comparative value between the potential amount of rainwater that can be harvested and the required domestic water demand can explain, in general, the likely success of rainwater harvesting in meeting existing water needs. This makes it possible to see when to carry out rainwater harvesting and when stored water is needed. More details regarding the comparison of domestic water needs with the potential of rainwater that can be harvested can be seen in Table 10.

According to Table 10, it can be explained that the potential rainwater that can be harvested for one year can meet the total domestic water demand with an excess of 12% of the total demand or has an excess of 26,681,626.15 liters per year. In Figure 4, it can be seen that from April to October, the potential rainwater harvest is lower than the water demand in that month, so it is necessary to collect rainwater in months where the value of rainwater harvest is greater than the water demand in that month such as November to March. The excess water in the rainy season can be accommodated

Table 8. Potential rainwater harvest volume

Month	Rainfall average (mm)	Average of roof area m^2	Runoff coefficient	Potential PAHs per house (liter)	Total of houses	Total potential of PAHs (liter)
January	301.48	66.91	0.8	16,138.90	3,365	54,307,384.19
February	245.72	66.91	0.8	13,153.76	3,365	44,262,409.53
March	162.07	66.91	0.8	8,676.06	3,365	29,194,947.54
April	99.15	66.91	0.8	5,307.44	3,371	17,891,396.94
May	88.55	66.91	0.8	4,740.49	3,371	15,980,203.34
June	58.08	66.91	0.8	3,109.23	3,371	10,481,215.39
July	38.03	66.91	0.8	2,035.67	3371	6,862,251.37
August	19.78	66.91	0.8	1,058.96	3371	3,569,748.74
September	17.73	66.91	0.8	948.97	3371	3,198,993.58
October	64.20	66.91	0.8	3,436.75	3372	11,588,715.05
November	114.71	66.91	0.8	6,140.60	3372	20,706,089.86
December	201.09	66.91	0.8	10,764.78	3372	36,298,835.60
Total				75,511.62		254,342,191.15

Table 9. The amount of domestic water demand

Month	Population (person)	Number of family	Rural domestic water needs (Lt/person/d)	Total water requirement liter)	Water requirement per family (liter)
January	10,958	3,365	60	20,381,880	6,057.02
February	10,958	3,365	60	18,409,440	5,470.86
March	10,956	3,365	60	20,378,160	6,055.92
April	10,957	3,371	60	19,722,600	5,850.67
May	10,946	3,371	60	20,359,560	6,039.62
June	10,933	3,371	60	19,679,400	5,837.85
July	10,933	3,371	60	20,335,380	6,032.45
August	10,936	3,371	60	20,340,960	6,034.10
September	10,934	3,371	60	19,681,200	5,838.39
October	10,934	3,372	60	20,337,240	6,031.21
November	10,929	3,372	60	19,672,200	5,833.99
December	10,938	3,372	60	20,344,680	6,033.42
Total				239,642,700	71,115.49

Table 10. Comparison of water demand and rainwater availability

Month	Water demand (liter)	Rainwater availability (liter)	Water surplus/deficit (liter)	Percentage of water surplus/deficit	Information
January	19,362,786.00	54,307,384.19	34,944,598.19	180%	Rainwater surplus
February	17,488,968.00	44,262,409.53	26,773,441.53	153%	Rainwater surplus
March	19,359,252.00	29,194,947.54	9,835,695.54	51%	Rainwater surplus
April	18,736,470.00	17,891,396.94	-845,073.06	-5%	Rainwater deficit
May	19,341,582.00	15,980,203.34	-3,361,378.66	-17%	Rainwater deficit
June	18,695,430.00	10,481,215.39	-8,214,214.61	-44%	Rainwater deficit
July	19,318,611.00	6,862,251.37	-12,456,359.63	-64%	Rainwater deficit
August	19,323,912.00	3,569,748.74	-15,754,163.26	-82%	Rainwater deficit
September	18,697,140.00	3,198,993.58	-15,498,146.42	-83%	Rainwater deficit
October	19,320,378.00	11,588,715.05	-7,731,662.95	-40%	Rainwater deficit
November	18,688,590.00	20,706,089.86	2,017,499.86	11%	Rainwater surplus
December	19,327,446.00	36,298,835.60	16,971,389.60	88%	Rainwater surplus
Total	227,660,565.00	254,342,191.15	26,681,626.15	12%	Rainwater surplus

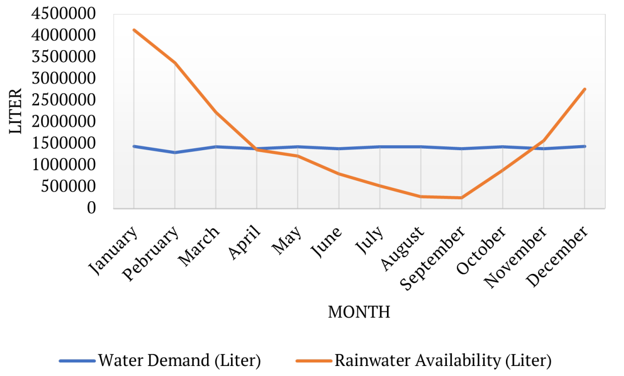

Figure 4 Comparison diagram of rainwater harvesting results with domestic water needs per month.

with a reservoir to meet water needs in the dry season so that the drought problem that often occurs in Seraya Village, Karangasem District, can be resolved. The results of this study are in line with the research of Hammes et al. (2020); Al-Khafaji et al. (2022); Judeh et al. (2022); Ertop et al. (2023) reporting that there is a potential surplus between water demand and rainwater availability.

The investigation revealed that the possible rainwater harvesting volume is 254,342,191.15 m^3 annually. The rainwater harvesting system in Seraya Village includes a roof as a catchment area, horizontal gutters and vertical pipes for distribution connected to a reservoir, and an above-ground tank or tank building for storage. The size of the storage tank volume needed for each dwelling is determined using the demand-side approach method. This method is the most straightforward way to calculate the volume of a storage tank using data on the annual water use per household and the duration of the dry season. The reference data for this computation is the water needed per family, specifically 71,115.49 liters per year. A storage tank is necessary in Seraya Village to meet water demands throughout the 6-month dry season. The storage tank needed to fulfill home water requirements in the dry season is 35.558 m^3, with dimensions of 6 meters in length, 3.95 meters in width, and 1.5 meters in height (6m x 3.95m x 1.5m).

4 CONCLUSION

The research on rainwater harvesting in Seraya Village, Karangasem District, indicates a potential volume of 254,342.19 m^3 per year. The total water demand is 227,660.56 m^3 per year, resulting in an excess of harvested water of 12% of the total demand, equivalent to 26,681.63 m^3 per year. The surplus in rainwater harvesting capacity compared to the overall domestic water requirement indicates that this approach could help avert water scarcity and droughts in Seraya Village, Karangasem District. According to the calculations and tests, rainwater harvesting is a financially beneficial technology. Widespread rain harvesting can help preserve water continuity, develop sustainability, and use water resources more efficiently.

DISCLAIMER

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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