SUPPLY AND DEMAND ANALYSIS IN DRINKING WATER AND SANITATION PROVISION PROGRAMS

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Abstract

Water is a vital resource for human life, both for domestic and non-domestic needs. However, the availability of clean water often faces challenges, especially in rural areas during the dry season. This study aims to analyze the balance of water supply and demand in the PAMSIMAS program in Kampung Gobang, which involves four neighborhood units (RT) with a total of 80 households. The research used a descriptive quantitative method with a storage measurement approach to calculate water demand and supply during rainy and dry seasons. The results showed that during the rainy season, the water supply of 150,334 liters/day exceeded the community's demand of 106,143.5 liters/day, while in the dry season the supply decreased to 95,040 liters/day, lower than the required demand. To address this shortage, water distribution was managed alternately among the RTs according to the proportion of households and daily water needs, resulting in RT 09 receiving 39,600 liters, RT 06 receiving 19,800 liters, RT 05 receiving 11,880 liters, and RT 04 receiving 23,760 liters within 24 hours. The findings suggest that although the supply is sufficient in the rainy season, demand cannot be fully met in the dry season, requiring a fair distribution strategy to minimize conflict and ensure equitable access to clean water.

Keywords: Water Supply, Water Demand, PAMSIMAS, Rural Community, Distribution Strategy

INTRODUCTION

Water is the source of life for living creatures, especially humans, who have developed various basic human needs. Water is a primary necessity for daily activities such as drinking, cooking, bathing, and industrial processing, so that its function is not limited to economic purposes, but also has a social function (Beker & Kansal, 2023). This social function is closely related to the condition of water, which must be healthy, clear, and clean, making it very important for all parties to understand in order to maintain and improve public health. The social and economic functions of water in meeting daily needs are important to note. The Pamsimas program in Gobang Village began in 2019 and will continue until 2023. However, in 2023, there were many reports of complaints from the community regarding water shortages and unmet needs during the dry season. A questionnaire was then conducted among the Gobang village community regarding complaints about water shortages, and 36 family cards reported complaints about water shortages. Therefore, the availability of water in adequate quantity and quality is non-negotiable because it can lead to conflicts over the control and ownership of water resources.

The drinking water and sanitation sector is a public service that is closely linked to poverty alleviation (Nengsi, 2019). Inadequate drinking water and sanitation infrastructure and facilities, especially in rural and peri-urban areas, have a negative impact on health and environmental conditions, which in turn have a knock-on effect on family economic levels (Dini & Firdaus, 2024). The provision of adequate water supply and sanitation infrastructure and facilities will have an impact on improving environmental quality and health. The following is data on water shortages from year to year:

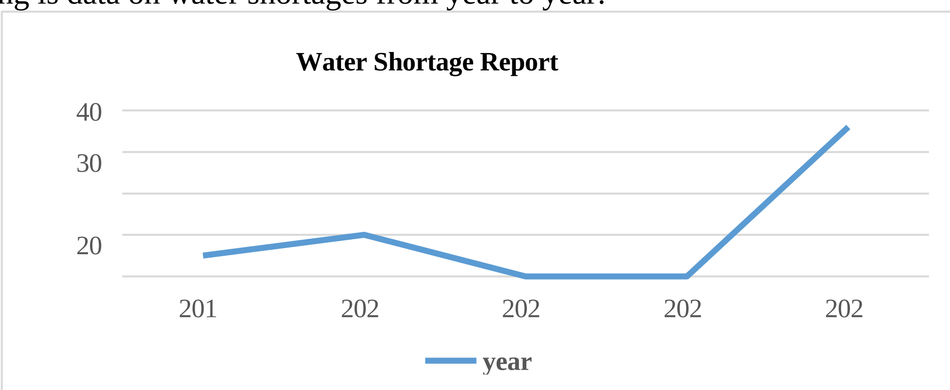

Figure 1. Water Shortage Report Data for 2023

The graph shows the number of water reports from the community from year to year. In 2019, there were 5 reports, and in 2020, there were 10 reports of complaints from the community regarding water shortages and unmet needs. After that, from 2021 to 2022, there were no complaints from the community, but in the following year, 2023, there was a sharp increase in complaints from the community, with 36 complaints regarding water shortages and unmet needs. -maintaining the sustainability of the clean water facilities that have been built and have a usage fee, which is a fee paid by each member who uses/benefits from drinking water and sanitation facilities for the use of water and sanitation facilities.

REVIEW OF LITERATURE

Clean Water and Clean Water Infrastructure Management

Water is a chemical compound that is very important for the life of living things on earth. The function of water for life cannot be replaced by other compounds (Pamungkas et al., 2023). The primary and most vital use of water for life is as drinking water. The concept of clean water management and clean water sources basically includes efforts to develop the utilization and conservation of water resources by distributing available water in terms of space, time, quantity, and quality in a region to meet the basic needs of the community. According to Minister of Public Works Regulation No. 18/PRT/M/2007 concerning the Implementation of Drinking Water Supply System (SPAM) Development, the management of the Drinking Water Supply System includes planning, implementation, supervision, operation, utilization, administration, and institutionalization of SPAM. SPAM management aims to produce drinking water that meets applicable standards and to maintain drinking water infrastructure and facilities so that they can serve the community's drinking water needs on an ongoing basis. Minimum drinking water service standards must meet the provisions of applicable regulations (Taufiq et al., 2022).

Sanitation

Sanitation is a health effort to maintain and preserve the environment so that it remains clean from contaminants, for example by providing clean water for hand washing and providing trash bins so that trash is not thrown away indiscriminately (Mitra et al., 2022). Based on its type, sanitation is divided into physical sanitation and toilets. Physical sanitation is a sanitation and drinking water sector program focused on low-income communities in rural and suburban areas and is carried out by empowering the community. Sanitation and water are aspects that are identified with individual lifestyles and subsequently determine health levels. An individual's health level will affect their personal quality and performance efficiency, which in turn also affects their well-being. The high incidence of diarrheal diseases is caused by difficult access to sanitation and drinking water, as well as low public awareness of healthy and cleanliving patterns (Werkneh & Gebru, 2023). Toilets are protected and comfortable places to defecate. Various types of toilets are used in families, schools, places of worship, and other institutions. Proper toilets are effective in breaking the cycle of disease transmission (Dickin et al., 2021; Schrecongost et al., 2020).

Supply and Demand for Clean Water

Clean water supply is the most important and vital component of urban infrastructure. In the past, internal water supply networks were very small (Huang & Yin, 2017). Untreated industrial waste flowed directly into lakes and rivers, many of which were sources of drinking water. Efforts to purify water continued to decline, and only a few cities were found to treat wastewater (Chapagain et al., 2022). Today, due to urban population growth, industrial development, water shortages, rural-to-urban migration, modern lifestyles, and public health concerns, many problems with water supply have arisen. Therefore, access to safe drinking water is one of the most important human needs. For this reason, the proper design and standards of urban water supply networks are one of the top priorities for the development and expansion of residential, industrial, and agricultural areas. Meanwhile, daily water needs refer to the water used for daily activities, in this case, the need for clean drinking water. Water demand/needs refer to the water required to support all human activities, including domestic and non-domestic clean water (Alemu & Dioha, 2020).

RESEARCH METHOD

This research method uses descriptive research with a quantitative approach. The flow of analysis in this study is as follows:

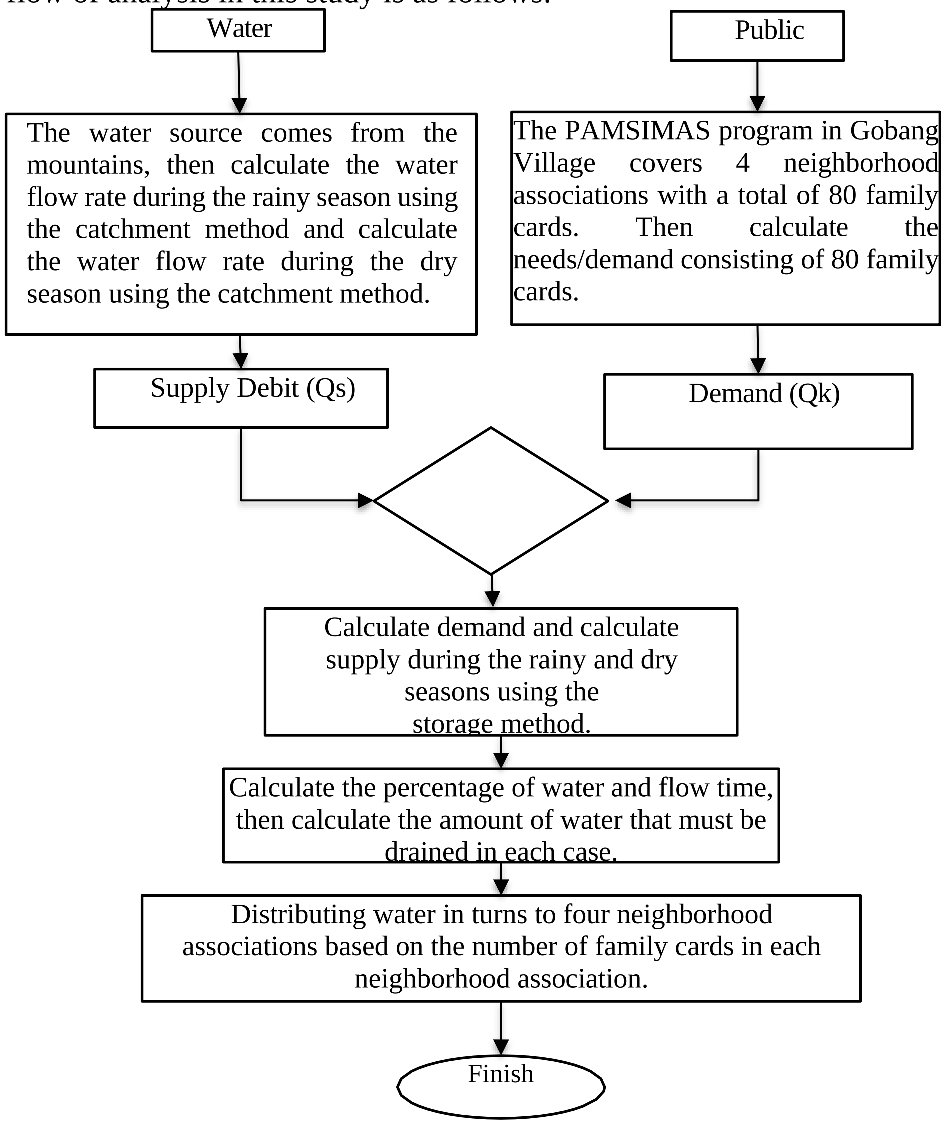

Figure 2. Research Flow Chart

Water Source Measurement Method

This method is required for measuring water sources that are not dispersed and can be formed into a cascade (shower). The tools required for measuring water discharge using this method are:

a. The container can be a 1.5-liter mineral water bottle or another container with a known volume, such as a bucket or basin.
b. A stopwatch or other time-measuring device (watch). Smartphones have a clock application.
c. Writing instruments for recording measurement results.

The steps for conducting measurements using this method are:

a. Prepare a container with a known volume.

b. Form the flow as a shower or waterfall (to facilitate measurement, the water source can be dammed and then the water flow can be channeled using bamboo, pipe pieces, etc.).
c. Three (3) people are needed to take the measurements. One person holds the container, one person operates the stopwatch, and the third person takes notes.
d. The process begins with a signal from the person holding the stopwatch when the water collection begins, and ends when the container is full. The time required from the start of water collection until the container is full is recorded (T) in the measurement form. Measurements are taken five times (to correct the measurement results), and
e. The measurement results are averaged to obtain the average T value. The average time is the result of dividing the total measurement time by the number of measurement repetitions.

$$T\ average = \frac{\Sigma time}{n}$$

Where:

T average : average time (seconds)
∑time : total measurement time
N : number of measurement repetitions

Water Flow Supply Measurement Method

Water flow supply is the amount of water flowing at a given time in a specific place, generally measured in liters per second (L/sec) or cubic meters per second (m^3/sec). Rainy season water flow supply is the amount of water flowing in rivers or waterways during the rainy season. It usually increases during the rainy season due to higher rainfall, which causes an increase in water supply to the river or waterway system. It is important to monitor the rainy season water flow supply rate to manage flooding and maintain the balance of the water ecosystem. The dry season water flow supply rate is the amount of water that flows through a river or waterway during the dry season when rainfall is low (Rossi et al., 2021). This water discharge is influenced by the volume of water available at the water source, such as rivers or lakes, as well as high levels of evaporation during the dry season. These factors can have an impact on the availability of water for use in daily activities, agriculture, industry, and the environment in the region. In accordance with the definition of water discharge, the formula for water discharge is as follows (Rahman N & Khaidir, 2021):

$$Water\ flow\ rate = \frac{Volume\ of\ flowing\ water\ (liters)}{Time\ (seconds)}$$

RESULTS AND DISCUSSION

This research was conducted in Kampung Gobang as a research area that carried out the task of supervising the implementation of the Community-Based Drinking Water and Sanitation Program (PAMSIMAS) due to the many problems that were found. The following is a map of the research location:

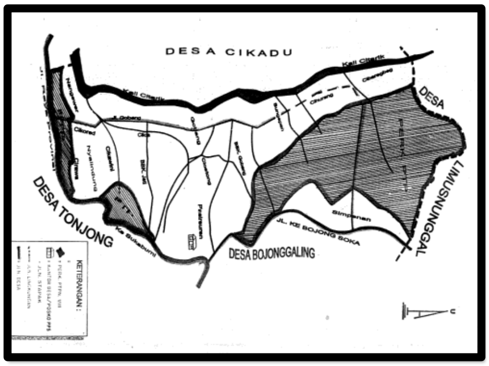

Figure 3. Research Location Map

Recording Water Discharge Measurement Results Using the Storage Method (Rainy Season)

Measurement Date : March 4, 2024
Water Source Name : PAMSIMAS Kp. Gobang
Water Source Location (Coordinates/Block/Zone) : Kp. Gobang

The following is the measurement time calculation:

Table 1.
Measurement Time Calculation

Measurement	Time (T) (seconds)	Container Volume (V) Liters (*)
P1	12,22	20
P2	11,58	20
P3	10,48	20
P4	12,13	20
P5	11,39	20
Total	**57,8**	**100**
Average	**11,56**	**20**

The average time is the result of dividing the total measurement time by the number of measurement repetitions.

$$t = \frac{\Sigma time}{n}$$

$$t = \frac{12{,}22 + 11{,}58 + 10{,}48 + 12{,}13 + 11{,}39}{5}$$

$$t = \frac{57.8}{5}$$

$$t = 11.56$$

Flow rate formula

$$Q = \frac{v}{t}$$

Where:

Q = Flow rate (liters/second)
V = Volume (liters)
t = Time (seconds)

Therefore:

$$Q = \frac{v}{t}$$

$$Q = \frac{20}{11.56}$$

Q = 1,74 liters/second x 60
Q = 104,4 liters/minute x 60,
Q = 6264 liters/hour x 24,
Q = 150334 liters/day

Recording of Water Discharge Measurement Results Using the Storage Method (Dry Season)

Measurement Date : March 4, 2024
Water Source Name : PAMSIMAS Kp.
Gobang Location (Coordinates/Block/Zone) : Kp. Gobang

Table 2. Measurement Time Calculation

Measurement	Time (T) (seconds)	Reservoir Volume (V) Liters (*)
P1	18,23	20
P2	17,42	20
P3	18,26	20
P4	18,52	20
P5	18,39	20
Total	**90,82**	**100**
Average	**18,16**	**20**

The average time is the result of dividing the total measurement time by the number of measurement repetitions.

$$t = \frac{\Sigma time}{n}$$

$$t = \frac{18{,}23 + 17{,}42 + 18{,}26 + 18{,}52 + 18{,}39}{5}$$

$$t = \frac{90.82}{5}$$

$$t = 18.16$$

Flow rate formula

$$Q = \frac{v}{t}$$

Where:
Q = Flow rate (liters/second)
V = Volume (liters)
t = Time (seconds)
Therefore:

$$Q = \frac{v}{t}$$

$$Q = \frac{20}{18.16}$$

Q = 1.10 liters/second x 60
Q = 66 liters/minute x 60 ,
Q = 3960 liters/hour x 24,
Q = 95040 liters/day.

Calculation Results for Q Debit and Q Debit Supply

From these calculations, the following data was obtained:

Table 3. Results of Q Discharge and Q Supply

Q Rainfall	Q Dry Season	Q Demand
150334 liters/day	95040 liters/day	106143,5 liters/day

From the data in the table above, Q demand during the rainy season is met, because Q demand is 106,143.5 liters/day and Q discharge during the rainy season is 150,334 liters/day. However, during the dry season, Q demand is not met because Q discharge during the dry season is 95,040 liters/day, while Q demand is 106,143.5 liters/day. After recording and calculating the data, an analysis can be conducted. The analysis steps that can be made are as follows:

1. Percentage of water in the PAMSIMAS Program in Gobang Village

Table 4. Percentage of Water

RT	**Water demand (liters/day)**	**Q Demand (liters/day)**	**Q Percentage (%)**	**Percentage (%)**
RT 09	44,544.50	106,143.50	100%	42%
RT 06	23,053.50	106,143.50	100%	22%
RT 05	12,655.50	106,143.50	100%	12%
RT 04	25,890.00	106,143.50	100%	24%
Total				100%

2. Calculation of water flow time in the PAMSIMAS Program in Gobang Village

Table 5. Calculation of Water Flow Time

RT	**Percentage (%)**	**Time/Day (Hours)**	**Water Flow Time Results (Hours)**
RT 09	42%	24	10
RT 06	22%	24	5
RT 05	12%	24	3
RT 04	24%	24	6
Total			**24 haurs**

3. Water demand

The demand in the PAMSIMAS program in Kampung Gobang is 106,143.5 liters/day, while the supply during the dry season is 95,040 liters/day. To overcome this water shortage, the water supply flow rate during the dry season is distributed as follows:

Q = 1.10 liters/second x 60 seconds
Q = 66 liters/minute x 60 minutes
Q = 3,960 liters/hour
The water flow is 3,960 liters/hour

Table 6. Water Flow Results

RT	Water flow during the dry season (liters/hour)	Water flow time (hours)	Total water flow (liters)
RT 09	3,960	10	39,600
RT 06	3,960	5	19,800
RT 05	3,960	3	11,880
RT 04	3,960	6	23,760
Total			**95.040 liters**

So, the way to overcome water shortages during the dry season is as follows:

Table 7. Water Requirements per Region

RT	Total Households	Total Water Demand (liters)	Persentase	% time	Water Demand % Time (liters)
RT 09	36 KK	44,544.5	42%	10 haurs	39,600
RT 06	13 KK	23,053.5	21%	5 haurs	19,800
RT 05	15 KK	12,655.5	11%	3 haurs	11,880
RT 04	16 KK	25,890.0	24%	6 haurs	23,760
Total	80 KK	106,143.5	100%	24 haurs	95,040

To overcome water shortages during the dry season, water is distributed or rotated alternately so that RT 09 receives 39,600 liters in 10 hours, RT 06 receives 19,800 liters in 5 hours, RT 05 receives 11,880 liters in 3 hours, and RT 04 receives 2,376 liters in 6 hours, as shown in the following table:

Table 8. Water Solution

Time	Water usage			
	RT 09	**RT 06**	**RT 05**	**RT 04**
00.00 – 01.00	-	-	-	7000 L
01.00 – 02.00	2000 L	-	-	-
02.00 – 03.00	-	8000 L	-	-
03.00 – 04.00	-	-	-	4760 L
04.00 – 05.00	3000 L	-	-	-
05.00 – 06.00	-	-	3960 L	-
06.00 – 07.00	4600 L	-	-	-
07.00 – 08.00	-	-	-	2000 L

Time	Water usage			
	RT 09	RT 06	RT 05	RT 04
08.00 – 09.00	-	2800L	-	-
09.00 – 10.00	5000 L	-	-	-
10.00 – 11.00	-	-	3960 L	-
11.00 – 12.00	-	3000 L	-	-
12.00 – 13.00	3000 L	-	-	-
13.00 – 14.00	2000 L	-	-	-
14.00 – 15.00	-	-	-	4000 L
15.00 – 16.00	6000 L	-	-	-
16.00 – 17.00	-	-	3960 L	-
17.00 – 18.00	-	3500 L	-	-
18.00 – 19.00	7000 L	-	-	-
19.00 – 20.00	-	-	-	3000 L
20.00 – 21.00	-	2500 L	-	-
21.00 – 22.00	5000 L	-	-	-
22.00 – 23.00	-	-	-	3000 L
23.00 – 24.00	2000 L	-	-	-
Total	**39600 L**	**19800 L**	**11880 L**	**23760 L**

In this regard, the dry season supply debit in the PAMSIMAS Program in Kampung Gobang consists of 4 neighborhood associations (RT) and is supplied with water in turns within 24 hours.

CONCLUSION

Based on the results of the research and discussion presented, the supply flow during the rainy season meets the demand flow. while during the dry season, the demand is not met in each neighborhood unit (RT), so calculations are made of the percentage of water, the time the water must be distributed, and the amount of water needed in each RT per day according to the number of households in each RT. After these calculations are completed, the water is distributed according to the time and amount of water that must be distributed alternately for 24 hours.

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