Evaluation and development planning for clean water supply system of Sanih Fountain in Buleleng regency

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Abstract. The rising population and economic activity have induced an increase in the demand for clean water in Buleleng Regency, especially in Sawan, Kubutambahan, and Tejakula District, respectively. The distribution of clean water supply is carried out through house connections and public hydrant by the Water Supply Company of Buleleng Regency with service coverage only reaching 40.09% in 2018. So it is necessary to evaluate and develop plans for the existing clean water supply system to increase service coverage. The evaluation of the water supply system includes an analysis of the availability and demand of clean water based on the population, with a projection for the next 25 years. Analysis of the clean water supply system development plan considers the availability of water resources potential. The evaluation results show that the existing system has not met the water demands in the service area. The development plan carried out to fulfill the demand for clean water is by optimizing the discharge of the Sanih Fountain by 125 liters/second and the construction of the Bungkulan 2 well.

Keywords: clean water, water distribution, water supply

1. Introduction

Water is a natural resource essential in human life [1, 2, 3]. The increase in population and the growth of economic activity have led to a significant increase in water consumption. However, at the same time, water availability has also decreased due to climate change [4]. The decrease in the availability of water resources is also caused by the narrowing of water catchment areas, decreased water absorption in the soil, unprotected water sources, and non-optimal use of water. As a result, several countries worldwide are experiencing an issue of the disparity of water demand and water availability [5, 6]. Ensuring water availability for the entire population and sustainable water management is one of the Sustainable Development Goals (SDGs) targets until 2030 as a form of the United Nation's commitment to dealing with water supply problems [7, 8].

To address this issue, the Indonesian Government is committed to implementing the SDGs program with a target of 90% of Indonesians having access to clean water, as stated in the National Development Plan of 2020-2024 [9]. Therefore, the Indonesian Government continues to develop clean water infrastructures that involve developing potential water sources, water sources management, and existing infrastructure assets management. The development of this infrastructure is expected to be able to provide equitable benefits to the community. The clear water supply system is one of the infrastructures built to complete the community's clean water demands.
The development of water distribution infrastructure certainly requires a huge investment. So it is necessary to maintain the assets that have been built, which will inevitably experience a decline in function and performance due to the age of the infrastructure, environmental conditions, and damage to components in the system [10]. Therefore, evaluation of the existing system is one part of infrastructure management [11, 12]. The evaluation results will be useful for making decisions in system development or other potential water source development.

As one of the provinces in Indonesia, Bali has a water access rate in 2018 of still 90.90% [13]. While Buleleng Regency, the largest region in Bali Province, has service coverage in 2018, which is still 48.09% of the entire population in Buleleng Regency (administrative coverage) and 90.23% of the population in the service area of Water Supply Company Buleleng Regency (technical coverage) [14]. Based on the technical report of Water Supply Company Buleleng Regency, one of the systems that have not been optimal to fulfill water needs is the Sanih Springs system, which is managed by the Water Supply Company branch of Kubutambahan. The percentage of service coverage at the Kubutambahan branch is still around 37.33%. In order to increase service coverage, it is necessary to evaluate the existing system, where the results of this evaluation will later be used as a basis for determining the plan to develop a clean water distribution system. This study aims to evaluate and develop the plan for the availability and demand of the Sanih water supply system over the Local Water Supply Company Kubutambahan branch from 2019 to 2044.

2. **Study area**
The study region was located in Buleleng Regency, Bali Province, Indonesia (Figure 1). The water supply system of Water Supply Company Buleleng Regency branch of Kubutambahan covers three districts, namely Sawan District (Giri Mas Village and Bungkulan Village), Kubutambahan District (Kubutambahan Village and Bukti Village), and Tejakula District (Bondalem Village, Julah Village and Pacung Village).

![Figure 1. Map of Buleleng Regency including the study area (blue highlights).](image)

The production capacity of the existing water supply system is 83 liters/second (lt/s) which consists of several water sources, namely Sanih Springs at 35 lt/s, Ponjok Batu Wells at 10 lt/s, Gang Salak Wells at 10 lt/s, Bungkulan Wells at 12 lt/s, Giri Mas Wells at 8 lt/s, and Bali Ervina Wells at 8 lt/s (Figure 2).
3. Data and methods

3.1. Data
Various datasets were used to evaluate the clean water supply system of Sanih fountain are population data, spring discharge, and existing water supply system. The basic population data were used to analyze the water demands is data in 2019. This data was obtained from the village head office, namely Bukti Village, Kubutambahan Village, Bungkulan Village, Giri Mas Village, Bondalem Village, Pacung Village, and Julah Village, respectively. Data on the condition of the existing water source, the condition of the existing network, the condition of the existing service, and the condition of the potential water source were obtained from the technical report of the Water Supply Company Buleleng Regency.

3.2. Methods
The evaluation stage of the existing clean water distribution system in Sanih Springs consists of an analysis of population projections, an analysis of water demands and availability in the initial year, and projections. The population projection analysis is very important in determining the number of samples to estimate the service area's projected water demand. Arithmetic, geometric, and exponential techniques were used to determine the number of population from the initial year (2019) to 25 years ahead (2044) [16, 17]. The population growth rate is obtained based on Buleleng Regency in Figure from the Central Bureau of Statistics of Buleleng Regency in 2018, which is 0.55%.

Analysis of water demand is the next stage after obtaining the projected population. An accurate analysis of water demand estimation is an essential thing in planning a clean water supply system [18]. Water demands for the community are generally separated into two components, namely domestic water demands and non-domestic water demands [19]. Domestic water demands are determined based on Water Supply Company Buleleng Regency consumer water usage data in 2018 in each service area, while non-domestic water demands are determined using the reference of the Directorate General of Human Settlements within the Ministry of Public Works Indonesia. The total water demand is calculated based on the initial year (2019) population and projections for the next 25 years (2044). The evaluation of the clean water supply system is carried out by comparing the production capacity and water demand.
The evaluation result was used to determine the development planning of the water supply system to complete the water demands in the service area. The water supply system development is based on the potential of water resources. The information about the potential of water resources was obtained from the technical report of the Water Supply Company Buleleng Regency.

4. Results and discussion

The existing water distribution system is evaluated by calculating the water availability and demand based on the population in the initial year (2019) and projected year (2044). Meanwhile, the system development plan is analyzed based on the potential of available water sources around the study area.

4.1. Population projection

The total future water demand is calculated based on the projected population. The population projection analysis is calculated for the next 25 years. The population of the initial year and the results of the projections in each service area calculated using the arithmetic, geometric, and exponential methods can be seen in Figure 3. The results of the population projection analysis show that the exponential method provides the largest projection value compared to the arithmetic and geometric methods so that the results of the exponential projection are used in the analysis of water demand.

![Figure 3. Population projection in the service area of Sanih Springs water supply system.](image)

4.2. Water demands and production capacity

Domestic water demands are determined based on water consumption recorded at Water Supply Company Buleleng Regency branch of Kubutambahan in 2018. Then the average daily demand is determined. The amount of water demand in the service area of the Sanih Springs distribution system is obtained by rounding up from actual daily consumption (Table 1). The daily water demand in the service area is between 60 to 150 liter/person/day. The daily water demand is consistent with the previous study results in Busungiu District, Buleleng Regency, which is 60-120 liters/person/day [14]. The determination of the water demand was used in this study is more than the minimum daily water consumption standard based on the World Health Organization (WHO), which is 50 liters/person/day.
It also met the domestic water demand standard—based from Directorate General of Human Settlements within the Ministry of Public Works Indonesia in 2003 and Indonesian National Standard in 2002 (SNI 19-6728.1-2002), which is a minimum of 60 liters/person/day for rural areas and 120 liters/person/day for urban areas.

| Service Area | Water consumption (lit/person/day) | Determination of daily water demands (lit/person/day) |
|--------------|----------------------------------|-----------------------------------------------------|
| Kubutambahan | 144.75                           | 150                                                 |
| Bondalem     | 57.21                            | 60                                                  |
| Julah        | 93.80                            | 95                                                  |
| Bukti        | 109.32                           | 110                                                 |
| Pacung       | 93.71                            | 95                                                  |
| Bungkulan    | 81.23                            | 85                                                  |
| Giri Mas     | 77.68                            | 80                                                  |

Total water needs are calculated based on the number of water users (domestic water needs), non-domestic water needs, water loss factors, and peak hour needs in the base year (2019) and projections for the next 25 years (2044). Non-domestic demand is assumed to be 15% of domestic water demand [2]. In comparison, the water loss factor and peak hour demand are assumed to be 20% [2, 3] and 165%, respectively. The results of the analysis of total water demand for each service area in the Sanih Springs water distribution system for 2019 and 2044 can be seen in Table 2. The total water demand for all service areas for 2019 and 2044 is 156.58 lt/s and 179.67 lt/s, and respectively, there is an increase in water demand due to the projected population for 25 years 14.74%. Another study also showed an increase in water demand by 10%-50% due to the projected population for 20 years in Klungkung Regency [21].

| Service Area | Water Demands (lt/s) | Water Sources | Production Capacity (lt/s) | Balance (lt/s) |
|--------------|----------------------|---------------|----------------------------|---------------|
|              | 2019                 | 2044          |                            | 2019          | 2044          |
| Kubutambahan | 57.92                | 66.45         | Sanih Springs              | 35            |               |
| Bondalem     | 23.96                | 27.49         | Gang Salak Wells           | 10            |               |
| Julah        | 11.38                | 13.06         | Ponjok Batu Wells          | 10            |               |
| Bukti        | 11.69                | 13.41         | Bungkulan Wells            | 12            |               |
| Pacung       | 10.67                | 12.24         | Giri Mas Wells             | 8             |               |
| Bungkulan    | 35.00                | 40.16         | Bali Ervina Wells          | 8             |               |
| Giri Mas     | 5.97                 | 6.85          |                            |               |               |
| Total        | 156.58               | 179.67        | 83.00                      | -73.58        | -96.67        |

Table 2 also describes the production capacity of each water resource in the service area of the Water Supply Company Buleleng Regency branch of Kubutambahan. The current total available water discharge for the service area is 83 lt/s. Based on the water demand analysis results in Table 2, a discharge of 156.58 lt/s is required to meet water demands in 2019 and 179.67 lt/s to meet water demands in 2044 in the service area of the Kubutambahan branch. There was a deficit of water availability of 73.58 lt/s in 2019 and 96.67 lt/s in 2044, which means that this system cannot fulfill the service demands of clean water for all service areas in 2019 and 2044. The results of the evaluation of the availability and demand for water in this service area will be used as the basis for determining plans for developing existing systems based on the availability of potential water sources to meet water needs for the entire community.
4.3. Development planning

The development of a clean water supply system is a basic thing that must be done to increase the coverage area of services. The development of the distribution system is planned by considering the potential of available water resources. The availability of raw water sources is potential for developing a water supply system at the Water Supply Company Buleleng Regency branch of Kubutambahan. The potentially available water resources are Sanih Springs at 125 lt/s and groundwater potential in Bungkulan Village at 10 lt/s. The plan for service capability of the development Sanih Springs water supply system for each service area can be seen in Table 3 and Figure 4. System development by optimizing the production capacity of springs was also carried out in a previous study in Klungkung Regency, namely optimizing the discharge of Guyangan Springs to increase service coverage in the Nusa Penida District [21]. The Sulangai II Spring discharge optimization was also carried out to fulfill the drinking water demands in the Petang District, Badung Regency [22]. Groundwater potential in Bali Province is also quite large at 3035 lt/s based on the JICA (Japan International Cooperation Agency) study [23].

Table 3. Service capability of the development plan Sanih Springs water supply system in 2019 and 2044.

| Service Area System | Name of Village | Water Demands (lt/s) | Water Sources | Production Capacities (lt/s) | Balance (lt/s) |
|---------------------|-----------------|---------------------|---------------|-----------------------------|---------------|
|                     |                 | 2019 | 2044 |                  | 2019 | 2044 |                |
| Western Area Service System | Kubutambahan | 57.92 | 66.45 | Sanih Springs | 58.00 | | 10.08 | 1.55 |
| Western Area Service System | | | | | | | | |
| Total | | 57.92 | 66.45 | | 68.00 | 10.08 | 1.55 |
| Western Area Service System | Bungkulan | 35.00 | 40.16 | Sanih Springs | 10.00 | | | |
| Western Area Service System | Giri Mas | 5.97 | 6.85 | Bungkulan Wells | 12.00 | | | |
| Western Area Service System | | | | | | | | |
| Total | | 40.97 | 47.01 | | 48.00 | 7.03 | 0.99 |
| Eastern Area Service System | Bukti | 11.69 | 13.41 | Sanih Springs | 57.00 | | | |
| Eastern Area Service System | Pacung | 10.67 | 12.24 | Ponjok Batu Wells | 10.00 | | | |
| Eastern Area Service System | Julah | 11.38 | 13.06 | | | | | |
| Eastern Area Service System | Bondaalem | 23.96 | 27.49 | | | | | |
| Total | | 57.70 | 66.21 | | 67.00 | 9.30 | 0.79 |

Table 3 and Figure 4 show that the supply of water from Sanih Springs is divided into two systems: western area service and eastern area service. The distribution to the western region includes the villages of Kubutambahan, Bungkulan, and Giri Mas, while the distribution to the east region includes the villages of Bukti, Pacung, Julah, and Bondalem. The development of the Sanih Spring is planned to have a production capacity of 125 lt/s. This production capacity will be distributed to the western region of 68 lt/s and the eastern region of 57 lt/s. The distribution in the western region will be divided for the western region 1 (Kubuaddan Village) and the western region 2 (Bungkulan Village and Giri Mas Village) at 58 lt/s and 10 lt/s, respectively. The construction of the Bungkulan II Wells with a discharge of 10 lt/s is planned to fulfill the service area in Bungkulan Village, which is not covered by the Sanih Spring distribution system due to elevation problems. The results of the analysis between total water demand and production capacity in each system show that the system can provide services for all residents in the service area for the next 25 years. The surplus water in the system for the western region 1, the western region 2, and the eastern region is 1.55 lt/s, 0.99 lt/s, and 0.79 lt/s, respectively in 2044.
Figure 4. The development plan scheme of Sanih Springs water supply system.

Conclusion
The production capacity of the existing clean water supply system at the Water Supply Company Buleleng Regency branch of Kubutambahan, which includes the use of the Sanih Springs and five wells, can still not meet the total water needs of the service areas in 2019 and 2044. Water deficiency still occurs in 2019 and 2044 by 73.58 lt/s and 96.67 lt/s, respectively. The system development plan is implemented by optimizing the flow of the Sanih Springs to 125 lt/s and constructing the Bungkulan 2 wells with a capacity of 10 lt/s. Details design of the addition of the broncaptering, reservoir, and distribution pipeline network are a requirement as the next step. Continuous evaluation and improvement of asset management strategies is an essential factor after the system construction is complete.

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