International Journal of Eco-Innovation in Science and Engineering (IJEISE) Vol. 4 (1), 2023 (1-5)
https://ijeise.upnjatim.ac.id/ E-ISSN: 2721-8775

Article

Sustainability Assessment of Rural Water Supply System in Lamongan, Indonesia

Syadzadhiya Qothrunada Zakiyayasin Nisa'[1a]*, Rizka Novembrianto[1b], Restu Hikmah Ayu Murti[1c], Muhammad Abdus Salam Jawwad[1d]

1 Department of Environmental Engineering, Faculty of Engineering, UPN Veteran Jawa Timur, Indonesia
E-mail: [a]syadzadhiya.tl@upnjatim.ac.id, [b]rizka.tl@upnjatim.ac.id, [c]restu.hikmah.tl@upnjatim.ac.id, [d]muhammad.abdus.tl@upnjatim.ac.id
*Corresponding author: syadzadhiya.tl@upnjatim.ac.id

Received: 8th January 2023; Revised: 2th April 2023; Accepted: 4th May 2023;
Available online: 15th May 2023; Published regularly: May and November

Abstract

The commitment to provide clean water and proper sanitation is one of the goals of the Sustainable Development Programs (SDGs). The government of each region needs to strive for clean water for the community. Efforts to provide clean water can be realized with the Water Supply System. Water Supply System sustainability indicators need to fulfill three aspects of quality, quantity, and continuity. The aim of this research was to assess the sustainability of the 'Sugio' Water Supply System in Lamongan Regency, which served three villages, namely Sugio, Lebakadi, and Sekarbagus. The aspect of water quality, seen from the results of the analysis of the quality of production water, met the quality standards for drinking water. The aspect of water quantity was calculated to meet water needs for the next 20 years. The calculation showed that the daily average debit requirement was 17 L/s and the daily maximum debit was 19 L/s, while the existing debit was 15 L/s. The aspect of water continuity was calculated by the ability to distribute water during an emergency. The calculation showed that the distribution of clean water when there was no source of electrical energy could only be carried out in a maximum of 1 hour, 13 minutes, and 48 seconds. The conclusion obtained was that the sustainability of the 'Sugio' Water Supply System from the perspective of water quantity and continuity needed to be improved.

Keywords: water supply system, water quality, water quantity, water continuity

1. Introduction

Water is a vital need and plays a very important role in human life on this earth. It is important to always maintain the preservation and sustainability of water resources. Efforts to protect water resources by implementing good water management, such as saving and not throwing rubbish and waste into water bodies, which can pollute the water and thus disrupt the existing ecosystem [1].

Commitment to managing water for sanitation purposes continues to be improved. This commitment is supported through the Sustainable Development Programs (SDGs). SDGs are a new development framework replacing the Millennium Development Goals (MDGs) program, which ended in 2015. SDGs are a global program agreed upon by many countries for the 2015–2030 period [2]. The SDGs program has 17 goals, one of which is goal number 6, which is clean water and sanitation. The goal number 6 indicator ensures that water and sanitation resources can be accessed easily in all regions and that water is safe in quality and continuous for use [3].

The availability of clean water is the responsibility of the government to support the welfare of society. The unavailability of clean water can have a negative impact on health and the environment. Clean water that is good in quality and continuous in quantity can improve proper sanitation. Sanitation is an indicator of community welfare. In Indonesia, there are still 37.86% of

households that do not have access to proper sanitation [4].

The government of each region needs to strive for clean water for the community. Clean water can be obtained from surface water, such as rivers, lakes, reservoirs, and swamps, and also from ground water [5]. Efforts to provide clean water can be realized with the Water Supply System. The sustainability indicators of the water supply system need to fulfill three aspects of quality, quantity, and continuity [6].

Water supply system sustainability is the achievement of aspects of quality, quantity, and continuity in the supply of water as a clean water service to the community and provides environmental sanitation and health benefits. The water supply system is determined to be sustainable when it is running and can be used [7]. The water supply system runs for a long time without having a negative impact on the environment; all operational and maintenance financing is met; there is an institution that manages it; and it gets proper support from outsiders [8].

The Regional Drinking Water Company of Lamongan Regency has the 'Sugio' Water Supply System, which is located in Sugio District, Lamongan Regency. The 'Sugio' Water Supply System has been operating since 1997. The 'Sugio' Water Supply System's water source comes from the Gondang Reservoir. The main objective of developing and operating the 'Sugio' Water Supply System is to provide clean water services to the community and also build, maintain, and operate clean water facilities, which include Sugio Village, Lebak Adi Village, and Sekar Bagus Village. The 'Sugio' Water Supply System provides clean water for the majority of communities that have not yet been reached by the Regional Drinking Water Company of Lamongan Regency. The 'Sugio' Water Supply System's sustainability needs to be analyzed based on aspects of water quality, water quantity, and water continuity so that it can become the basis for operational evaluation.

2. Material and Method

The analytical method applied to this research is quantitative analysis. The data obtained through primary and secondary data collection.

Water quality

Water quality data collection was carried out by sampling the water produced by the 'Sugio' Water Supply System. Several water quality parameters were tested in this study. Water temperature and pH were tested directly using a water thermometer and pH meter. Other parameters, such as TDS, turbidity, color, sulfate, chloride, fluoride, cyanide, hardness, iron, cadmium, zinc, lead, hexavalent chromium, and detergent, were tested in the laboratory. Water quality was compared with the quality standards in the regulations that apply to drinking water.

Water Quantity

The quantity calculated in this study was water debit. The water debit of the 'Sugio' Water Supply System was currently obtained through secondary data collection owned by the Regional Drinking Water Company of Lamongan Regency. In this study, the calculation of the water debit needs for the 'Sugio' Water Supply System services for the next 20 years was carried out. The number of populations and their growth rate influenced the need for water debit [9]. Population projections were calculated using three methods, namely Arithmetic, Geometric, and Least Square. The results of the population projection chosen were those of the method that gave a correlation value close to 1 [10]. The calculation of the water debit used the following equation [11]:

$$Q = P \times q \quad (1)$$

$$Q_{md} = Q \times f_{md} \quad (2)$$

Information:
Q = daily average debit
P = number of people served (person)
q = water requirement per person per day (liters/person.day)
Q_{md} = daily maximum debit
f_{md} = daily maximum factor

Water Continuity

The 'Sugio' Water Supply System's continuity is analyzed based on its ability to distribute drinking water when there is no source of electrical energy. The calculation used the following equation:

$$t = \frac{V}{Q} \quad (3)$$

Information:
t = duration of water supply time
V = reservoir volume
Q = daily average debit

3. Results and Discussion

The 'Sugio' Water Supply System is one of the Water Supply System units owned by the Regional Drinking Water Company of Lamongan Regency. The 'Sugio' Water Supply System serves as much as 4.58% of the total services of all Water Supply System units in Lamongan Regency. The scope of the 'Sugio' Water Supply System services covers three villages, namely Sugio, Lebakadi, and Sekarbagus.

3.1. Water Quality

The raw water source for the 'Sugio' Water Supply System comes from the Gondang Reservoir. Raw water is taken through the intake building and treated in water treatment units, including coagulation, flocculation, sedimentation, filtration, and disinfection units. These units' function is to reduce water pollutant parameters so that water quality can meet sanitation hygiene water quality standards. The water treatment units in the 'Sugio' Water Supply System can be seen in Figure 1.

(a)

(b)

Fig. 1. (a) coagulation-flocculation-sedimentation unit; (b) filtration unit

Based on data for each water parameter, the quality of water produced by the 'Sugio' Water Supply System meets the quality standards of hygienic-sanitary water. This standard is equal to class 1 water quality. Water quality in class number 1 is water that is used as raw water for drinking water.

Table 1. Water Quality of the 'Sugio' Water Supply System

Parameter	Analysis	Standard	Unit
Temperature	25	Dev 3	°C
TDS	248	1,000	mg/L
Turbidity	1.34	25	NTU
Color	15	15	Pt-Co
pH	7.9	6 – 9	-
Sulfate	76.12	300	mg/L
Chloride	24	300	mg/L
Fluoride	0.28	1	mg/L
Cyanide	0.00	0.02	mg/L
Hardness	171.43	500	mg/L
Iron	0.12	0.3	mg/L
Cadmium	0.000	0.01	mg/L
Zinc	0.01	0.05	mg/L
Lead	0.00	0.03	mg/L
Hexavalent chromium	0.00	0.05	mg/L
Detergent	0.00	0.2	mg/L

3.2. Water Quantity

The maximum volume of the Gondang Reservoir, based on official records, is 23,500,000 m^3 during the rainy season, while the minimum volume is 2,000,000 m^3 during the dry season. The current debit for taking raw water from the Gondang Reservoir is 15 L/s. In this study, a comparison of the existing debit to the debit

requirement for the projection of the next 20 years was carried out.

Population projections were calculated for the coverage of the 'Sugio' Water Supply System services, namely the villages of Sugio, Lebakadi, and Sekarbagus. The chosen projection method was the Least Squares method. The results of the population projection for the next 20 years were 6,664 people in the Sugio Village, 3,813 people in the Lebakadi Village, and 5,988 people in the Sekarbagus Village. The projected population was used to calculate debit requirements.

The 'Sugio' Water Supply System service level was assumed to be 60% of the total population. This assumption was made because some households still use well water as a source of clean water. The assumed value was determined with the consideration that the water supply system has a higher sustainability value than taking groundwater from wells, so that in the future it is expected that groundwater withdrawal from wells will decrease [12]. The clean water consumption per person is 110 L/day [13]. The water loss factor in the clean water distribution channel was considered in the calculation of the daily average debit; the value determined was 20% [14]. The calculation result for the daily average debit needed by the 'Sugio' Water Supply System was 17 L/s. The maximum daily discharge needed to be calculated to find out the water demand during peak hours of activity. The daily maximum factor value ranges from 1.15 to 1.7 [10], and this study used a value of 1.2. The calculation result for the daily maximum debit was 19 L/s.

3.3. Water Continuity

The 'Sugio' Water Supply System has one reservoir unit as a production water reservoir. The volume of the reservoir is 75,000 L. The 'Sugio' Water Supply System does not provide any generators, so if the source of electrical energy goes out, the processing unit stops, and the distribution of clean water only relies on water that has been stored in the reservoir. The period of water distribution in the reservoir based on the calculation was 1 hour, 13 minutes, and 48 seconds. Based on this period, it could be seen that the 'Sugio' Water Supply System can still distribute water supply during a power outage, up to a maximum of 1 hour, 13 minutes, and 48 seconds. Water continuity shows that water distribution to customers must run continuously for 24 hours without any water jams [15]. If there is a power outage at the 'Sugio' Water Supply System, it is necessary to have another source of electricity to support the operation of the water treatment and distribution unit.

4. Conclusions

The 'Sugio' Water Supply System's sustainability can be assessed based on aspects of quality, quantity, and continuity. The 'Sugio' Water Supply System can meet quality standards through processing in water treatment units. The water debit requirement for the 'Sugio' Water Supply System services is analyzed for the next 20 years, and it is found that the water production capacity needs to be increased to meet the needs for an average daily debit of 17 L/s and a daily maximum debit of 19 L/s. The continuity aspect of the 'Sugio' Water Supply System needs to be improved for emergency conditions, such as when the power outage is only able to distribute water for a maximum of 1 hour, 13 minutes, and 48 seconds, so a replacement energy source is needed to continue to run the 'Sugio' Water Supply System unit operations.

References

[1] M. A. Pereira and R. C. Marques, "Sustainable water and sanitation for all: Are we there yet?," *Water Res.*, vol. 207, p. 117765, 2021.

[2] W. Wahyuningsih, "Millenium Develompent Goals (MDGs) and Sustainable Development Goals (SDGs) in Social Welfare," *Bisma*, vol. 11, no. 3, p. 390, 2018.

[3] R. K. Pratama and E. Hendrakusumah, "Ensuring the Availability and Management of Clean Water and Sustainable Sanitation in Cipaganti," *Perenc. Wil. dan Kota*, pp. 578–585, 2019.

[4] S. Purwoko, "Adequate Drinking Water and Sanitation Indicators in Supporting Environmental Health Efforts in Residential Homes," *Univ. Nahdalatul Ulama Surabaya J.*, vol. 1, no. 1, pp. 62–67, 2018.

[5] S. Q. Z. Nisa, P. S. A. Sitogasa, K. Fadila, and S. Munir, "Interpretative Structural Modeling in Institutional Analysis of Sutami Reservoir Water Quality Control,"

J. EnviScience, vol. 6, no. 1, pp. 45–54, 2022.

[6] M. Reza and H. Burhanudin, "Study On The Development Of A Regional Drinking Water Supply System To Support The Cirebon Metropolitan Area," *Pros. Perenc. Wil. dan Kota*, vol. 5, no. 2, pp. 421–428, 2019.

[7] K. Rathnayaka, H. Malano, and M. Arora, "Assessment of sustainability of urban water supply and demand management options: A comprehensive approach," *Water (Switzerland)*, vol. 8, no. 12, 2016.

[8] A. S. Swastomo and D. A. Iskandar, "Sustainability of Community-Based Rural Drinking Water Supply Systems," *J. Litbang Sukowati Media Penelit. dan Pengemb.*, vol. 4, no. 2, p. 14, 2020.

[9] I. Domínguez, E. R. Oviedo-Ocaña, K. Hurtado, A. Barón, and R. P. Hall, "Assessing sustainability in rural water supply systems in developing countries using a novel tool based on multi-criteria analysis," *Sustain.*, vol. 11, no. 19, pp. 6–9, 2019.

[10] A. Cristiyan and A. Rosytha, "Planning for Clean Water Distribution System at Kecamatan Maduran Kabupaten Lamongan," *Publ. Ris. Orientasi Tek. Sipil*, vol. 4, no. 1, pp. 48–58, 2022.

[11] I. W. Diasa, P. Doddy, H. Ardana, I. K. Widarmawa, and T. H. Pamungkas, "Feasibility Analysis of Drinking Water Supply System Investment in Wanagiri Village, Sukasada District, Buleleng Regency," vol. 11, no. 2, pp. 1–9, 2022.

[12] S. Maryati, T. Firman, and A. N. S. Humaira, "A sustainability assessment of decentralized water supply systems in Bandung City, Indonesia," *Util. Policy*, vol. 76, p. 101373, 2022.

[13] W. W. Gunawan, S. Welerubun, C. Kusumastuti, and P. Sudjarwo, "Analysis of Makassar Clean Water Needs in 2030," *J. Dimens. Pratama Tek. Sipil*, vol. 8, no. 2, pp. 324–330, 2019.

[14] E. Ociepa, M. Mrowiec, and I. Deska, "Analysis of Water Losses and Assessment of Initiatives Aimed at Their Reduction in Selected Water Supply Systems," *Water*, vol. 11, no. 5, p. 1037, 2019.

[15] N. Astuti, "Provision of Clean Water by the Regional Drinking Water Company in Sangatta City, East Kutai Regency," *eJournal Adm. Negara*, vol. 3, no. 2, pp. 678–689, 2014.