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Fulfillment of Clean Water Needs in Tamangil Nuhuten Village with Addition of New Spring

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A B S T R A C T

Seventy-two million Indonesians have difficulty accessing clean water, especially in rural communities. This causes various diseases and has an impact on people's welfare. Currently, the community's need for clean water in Tamangil Nuhuten Village depends on the Wiak spring and often experiences shortages. This research aims to analyze the need and availability of clean water in Tamangil Nuhuten Village. The need for clean water is calculated using water consumption data and the projected population. As for water availability, the water source discharge data is collected from the government and measures the water discharge directly to validate the data. It is necessary to analyze the water balance to determine the ability to meet the demand for clean water. The results showed that the need for clean water for the next 10 years is 2.0 liters/second, while the water supply is 1.06 liters/second, so it is still insufficient. Fulfillment can be done by adding the Baluruk spring 1.8 km away. Baluruk Spring can discharge of 83.3 liters/second with constant conditions throughout the year and meets clean water quality. Intake of clean water can be done by building two reservoirs to reduce the sediment content with dimensions of 4m x 6m x 3m, which are placed 500m from the village. As well as used two 6-inch pipes for transmission pipes and one 4-inch pipe for distribution. Thus the water needs of the Tamangil Nuhuten Village community can be fulfilled until 2031.

1. Introduction

Indonesia is one of Southeast Asia's largest archipelagic countries with up to 17,500 islands [1]. Supplying clean water in archipelagic areas needs special attention because people on small islands have difficulty accessing clean water due to limited supply [2]. According to the 2018 report by the National Development Planning Agency (BAPPENAS) of the Republic of Indonesia, around 72 million Indonesians have difficulty accessing clean water, especially in rural communities. [3]. The seventh target of the Millennium Development Goals (MDGs)

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is to ensure environmental sustainability, including household access to proper sanitation facilities [4].

Tamangil Nuhuten is one of the villages in the south of Kei Besar District, Southeast Maluku, which has not yet received clean water services and only depends on the Wiak spring. Tamangil Nuhuten Village has an area of ± 4.99 km2, with a population of 883 people. Currently, the Tamangil Nuhuten Village community is facing difficulty obtaining clean water, especially during the dry season. This is caused by a very small water debit in the existing springs during the dry season. Groundwater sources are very difficult to obtain because they are located very deep, and the condition of the soil layer is in the form of coral rocks. In addition, drought will likely hit Tamangil Nuhuten Village in the future. The low availability of clean water can be a risk factor for several diseases, such as common stomach aches, diarrhea, typhus, intestinal worms, dysentery, and urinary tract infections. [5].

The provision of clean water is considered capable of reducing 25-27% of disease. Water quality can also reduce disease by 17% to 42%, while sanitation can achieve a risk reduction of 22-37%.[2]. Available clean water in adequate amounts will be able to support the level of productivity. Thus, it can improve public welfare [6][7]. Efforts to meet the need for clean water can be made in various ways, such as purification equipment [8], rainwater harvesting [9][10], and utilizing springs such as groundwater, rivers, lakes, and reservoirs [11]. In addition, coastal communities can desalinate seawater using a reverse osmosis system [12] and evaporation [13]. Each topography of an area has its way of meeting its clean water needs. As in Bogori Village, West Kalimantan, meeting the need for clean water is done by constructing a piping system [14]. In addition, in Oenoni 1 Village, Kupang Regency, the need for clean water cannot be fulfilled because the discharge of the water source is very small compared to the need. [15]. Many studies have been conducted, but most are limited to studying the need for and availability of clean water. Therefore it is necessary to have research that reveals the efforts made to increase the availability of clean water so that the need is fulfilled.

This research aims to analyze the need and availability of clean water in Tamangil Nuhuten Village. From this, it can be seen whether the village can meet the need for clean water in the future. If not, efforts will be made to meet water needs. So that with these efforts, it is hoped that the village community will be able to fulfill their clean water needs in the future.

2. Research Method

The research was conducted in Tamangil Nuhuten Village, Kei Besar Selatan, Southeast Maluku, with coordinates5°49'37.49" " S132°54'13.04" " E. The research was

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conducted by taking primary data in water discharge at water sources, while secondary data was in the form of water consumption, population numbers, and water discharge. The research begins with projecting the number of residents. Then do the calculation of domestic and non-domestic clean water needs. After that, a water balance analysis was carried out.

2.1 Projection on the Number of Population

Projection number of population in the future could be used other methods like Arithmetic Method [16], Geometric method [17], Least Square Method [18], and Exponential Method [19].

Method selection is determined based on the method that has the highest correlation value. To determine the selection of projection method on the growth of the population, it is used the correlation method uses the following equation [20] (1):

$$r = \frac{n\,(\Sigma xy) - (\Sigma x)(\Sigma y)}{\sqrt{[n(\Sigma x^2) - (\Sigma x)^2].\,[n(\Sigma y^2) - (\Sigma y)^2]}} \quad (1)$$

Where r is the correlation value (0 – 1), n is the amount of data, and x y is the variable. The number on the correlation value (r) shows the closeness of the relationship between the two variables tested, namely population and time (year) [21]. If the correlation number gets closer to 1, then there is a stronger correlation between both variables, which means that the population changes as the year increases.

2.2 Calculation Water Needs

The calculation of water needs is based on population growth [18]. Meanwhile, water consumption for household needs (domestic) is 120 l/person/day, and for public facilities (non-domestic) is 30 l/person/day. The service coverage is assumed to increase by 5% every year, with a baseline in 2022 of 25%. The amount of water demand is obtained from the number of users served multiplied by the consumption of water needs.

2.3 Calculation Water Supply

To find out water availability, namely by measuring the discharge available in the spring. The amount of discharge is obtained from the flow rate formula Q = V x A (m3/second) [22], where V is the flow velocity (m/second) and A is the cross-sectional area (m2). The experiment was carried out 5 times at 3 different heights, namely 1/3h, 1/2h, and 3/4h from the water level. This measurement is used to validate whether the spring water discharge at RISPAM.

2.4 Water Balance Analysis

Water balance analysis is carried out by comparing water needs and water availability for the next 10 years so that it can be known in which year is experiencing a shortage or excess.

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years of water shortage, it can be determined when to fulfill the deficiencies [23]. It is hoped that by looking at the results of the water balance all raw water needs can be provided.

3. Results and Discussions

3.1 Projection on Number of Population

Projection on the number of population until the next 10 years, namely 2022 to 2031, uses data on the number of population taken from the Tamangil village for the last 4 (four) years, as seen in **Table 1.**

Table 1. Data on the Number of Population in Tamangil Nuhuten Village.

Years	Population
2018	594
2019	574
2020	574
2021	883

Source: BPS Southeast Maluku Regency [24]

Correlation calculation results using the following arithmetic Method is 0.001; the geometric method is 0.730; Least Square Method is 0.739; and Exponential Method is 0.730. Among these methods, the one with the highest correlation value is the Least Square method., the least square method is used to estimate the population of Tamangil Nuhuten Village for the next 10 years. The calculation for the Least square method of the constant values and coefficient Furthermore, the equation model is as follows Y = 656,25 + 43,35 X

By using the Last Square equation, the results of the projection of the population in Tamangil Nuhuten village for the next 10 years are presented in **Table 2.**

Table 2. Projection on the Number of Population in Tamangil Nuhuten Village.

Projection years	Number of population
2022	873
2023	960
2024	1046
2025	1133
2026	1220
2027	1307
2028	1393
2029	1480
2030	1567
2031	1653

Source: Author Analysis.

Based on the table above, the population will increase over time. The total population of the village of Tamangil Nuhuten in 2031 is 1653.

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3.2 Clean Water Needs

Calculation of the need for clean water is based on domestic and non-domestic.

a. Domestic Clean Water Needs

The calculation of domestic clean water needs in the next ten years is presented in **Table 3.**

Table 3. Water Needs for Household (Domestic).

Years	Number of population	Service coverage (%)	Number of served ones	Water consumption (L/people/day)	Total Water Needs (L/day)	Total Water Needs (L/second)
2022	873	25	218	120	26190	0.3031
2023	960	30	288	120	34549	0.3999
2024	1046	35	366	120	43949	0.5087
2025	1133	40	453	120	54389	0.6295
2026	1220	45	549	120	65869	0.7624
2027	1307	50	653	120	78390	0.9073
2028	1393	55	766	120	91951	1.0643
2029	1480	60	888	120	106553	1.2333
2030	1567	65	1018	120	122195	1.4143
2031	1653	70	1157	120	138877	1.6074

Source: Analysis (2022).

From **Table 3**, it can be seen that for 10 years, water needs for household connections have increased 5 times, from 0.3 liters / second to 1.6 liters /second.

b. Non-Domestic Clean Water Needs

The results of the calculation of water needs for public facilities can be seen in **Table 4.**

Table 4. of Water for Public Facility (Non-Domestic)

Years	Number of population	Service coverage (%)	Number of served ones	Water consumption (L/people/day)	Total Water Needs (L/day)	Total Water Needs (L/second)
2022	873	25%	218	30	6548	0.0758
2023	960	30%	288	30	8637	0.1000
2024	1046	35%	366	30	10987	0.1272
2025	1133	40%	453	30	13597	0.1574
2026	1220	45%	549	30	16467	0.1906
2027	1307	50%	653	30	19598	0.2268
2028	1393	55%	766	30	22988	0.2661
2029	1480	60%	888	30	26638	0.3083
2030	1567	65%	1018	30	30549	0.3536
2031	1653	70%	1157	30	34719	0.4018

Source: Analysis (2022).

From **Table 4**. it can be seen that for ten years, water needs for public facilities have increased 4 times, from 0.7 liters / second to 0.4 liters per seconds. Based on household

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(Domestic) and public facilities (Non-Domestic) water needs, the total water needs in Tamangil Nuhuten Village can be calculated for each year as follows:

Table 5. Needs of Water in Tamangil Nuhuten Village.

Years	Domestic Water Needs (L/second)	Non Domestic Water Needs (L/ second)	Total of Water Needs (L/ second)
2022	0.3031	0.0758	0.3789
2023	0.3999	0.1000	0.4998
2024	0.5087	0.1272	0.6358
2025	0.6295	0.1574	0.7869
2026	0.7624	0.1906	0.9530
2027	0.9073	0.2268	1.1341
2028	1.0643	0.2661	1.3303
2029	1.2333	0.3083	1.5416
2030	1.4143	0.3536	1.7679
2031	1.6074	0.4018	2.0092

Source:Author's Analysis (2022).

From **Table 5.** it can be seen that the amount of water demand until 2031 is total water requirement is 2 liters/second.

3.3 Clean Water Supply

To determine the water supply, it is by making measurements on the available debit in the Wiak Springs. A discharge of 1.2 l/sec was obtained based on the manual measurements results. However, this measurement is only done at one time, while to determine the debit of the Wiak spring in one year, data from RISPAM is used as follows.

Table 6. The Debit of Wiak Spring Throughout the Year.

Months	Debit (L/Sec)
January	1.48
February	1.48
March	1.53
April	1.39
Mei	1.29
June	1.26
July	0.27
Augustus	0.53
September	0.48
October	0.36
November	1.19
December	1.39
Average	**1.06**

Source: Rispam [25].

Based on the measurement of the water debit in Wiak Spring by 1,33 liter /second, meanwhile based on the information stating that the average water debit in Wiak Spring is 1,06 liter/second. The difference is caused by the different times of the measurement, namely the measurement was in location during the rainy season, so it was greater than during the time of

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the dry season. Discharge measurement is intended to control that the existing discharge information is under conditions in the field Thus, it is used water balance calculation of average debit.

3.4 Evaluation of Clean Water

Water balance analysis is used to evaluate whether the existing clean water supply will be able to meet future needs.

Table 7. Evaluation of Needs and Supply of Wiak Spring.

Years	Supply (L/sec)	Needs (L/sec)	Remaining (L/sec)
2022	1.06	0.379	0.681
2023	1.06	0.499	0.561
2024	1.06	0.636	0.424
2025	1.06	0.787	0.273
2026	1.06	0.953	0.107
2027	1.06	1.134	-0.074
2028	1.06	1.330	-0.270
2029	1.06	1.541	-0.481
2030	1.06	1.768	-0.708
2031	1.06	2.009	-0.949

Source: Analysis (2022).

The calculation results show that the water supply is 1.06 liters/second, and the total water requirement is 2.01 liters/second, so there is still a shortage of 0,949 liters/second. So, it can be concluded that the current clean water supply cannot meet the needs of clean water until 2031.

3.5 Addition Water Source

Seeing that Tamangil Nuhuten village cannot meet its water needs, what can be done is to add a water source near the village, namely the Baluruk spring, even though it is located farther from the Wiak spring. Therefore, it is necessary to study the Baluruk Spring before it is utilized as an additional source of raw water.

3.5.1 Water Debit

Measurement of the discharge of the Baluruk spring is presented in the table below.

Table 8. Supply of Baluruk Spring Debit.

Measurement		Calculation	
1	V =	0.167	m/sec
	A =	0.5	m2
	Q =	83.33	L/ sec
2	V =	0.20	m/ sec
	A =	0.5	L/ sec
	Q =	100	L/ sec
3	V =	0.164	m/ sec
	A =	0.5	m
	Q =	82.12	L/ sec

Source: Analysis (2022).

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Based on the results of measuring the water debit at the Baluruk spring, the average debit is 83.33 - 100 liters/sec. To calculate the water balance, the lowest discharge is taken. The calculation of the water balance is presented in the table below.

Table 9. Evaluation of Needs and Supply of Baluruk Spring.

Years	Supply (L/sec)	Needs (L/sec)	Remaining (L/sec)
2022	83.3333	0.379	82.9543
2023	83.3333	0.499	82.8343
2024	83.3333	0.636	82.6973
2025	83.3333	0.787	82.5463
2026	83.3333	0.953	82.3803
2027	83.3333	1.134	82.1993
2028	83.3333	1.330	82.0033
2029	83.3333	1.541	81.7923
2030	83.3333	1.768	81.5653
2031	83.3333	2.009	81.3243

Source: Analysis (2022).

Based on the water balance, the total water supply is 83.33 liters/second, while the total water needs in Tamangil Nuhuten Village is 2.01 liters/second. It can be concluded that the existence of the Baluruk Spring can properly meet the need for clean water in Tamangil Nuhuten Village until 2031.

3.5.2 Quality of Baluruk Spring

Based on RISPAM data by Maluku province in 2021, it was described that the quality of Baluruk spring met the class-1 Quality standards (standard spring for drinking water). For the quality of the Baluruk spring, it can be seen in **Table 10.**

Table 10. Laboratory Results of Baluruk Spring Quality.

No	Parameter	Units	Test results K 0314	Testing method	Limit of detection	Maximum level	Information
	A. Physics						
1	Turbidity	NTU	0,29	SNI 06-6989.25-2005	0.24	25	Safe
2	Flavor	-	No flavor	Organoleptic	-	No flavor	Safe
3	Smell	-	No smell	Organoleptic	-	No smell	Safe
4	Temperature	°C	25,2	SNI 06-6989.23-2005	27	-	Safe
5	TDS	mg/l	142,2	Photometry	500	1000	Safe
	B. Chemistry						
1	Iron (Fe)	mg/l	<0,0310	SNI 06-6989.4-2009	0,0313	1	Safe
2	Detergent	mg/l	0,025	Spectrophotometry	0,001	0,05	Safe
3	hardness as.$CaCO_3$	mg/l	110	SNI 06-6989.12-2004	72,71	500	Safe
4	Nitrite (No_2)	mg/l	0,0028	SNI 06-6989.9_2004	0,0017	1	Safe
5	pH*	mg/l	6,49	SNI 06-6989.11-2019	-	-	Safe
6	Zinc (Zn)	mg/l	<0,0330	SNI 06-6989.7-2009	0,0330	15	Safe
7	KmnO4	mg/l	1,842	Titrimetric	0,003	10	Safe
8	Manganese (Mn)	mg/l	<0,0350	SNI 06-6989.5-2009	0,0350	0,5	Safe
9	Sulfate (SO'_4)	mg/l	3,649	SNI 06-6989.20-2019	0,1651	400	Safe

Source: RISPAM of Maluku Province (2021)[25].

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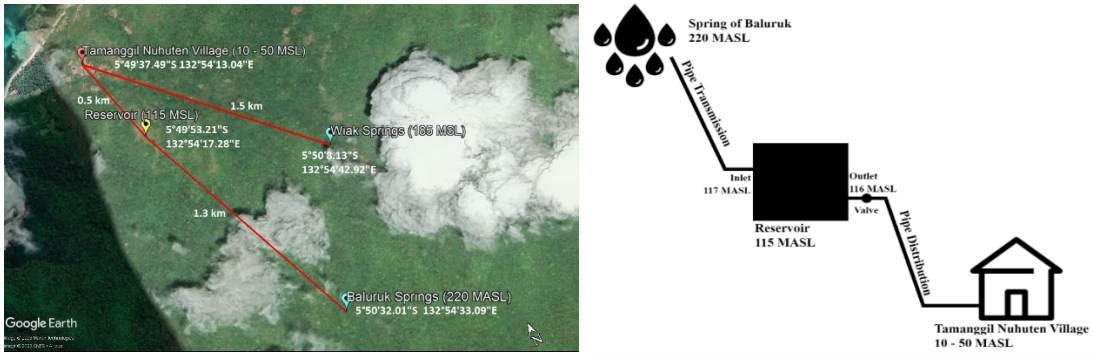
Based on **Table 10.** in the laboratory results, The value of all parameters is below the maximum limit, so the water is in a safe condition for use.

3.6 Location and Planning of Clean Water Distribution System

The position of the Village and Springs, along with the Planning for the primary water network system, can be seen in **Figure 1.**



(a) (b)

Source: Author Analysis.

Figure 1. (a) Position Plan of Village, Reservoir, and Spring; (b) Scheme of Baluruk Spring Clean Water Distribution.

Water from the Baluruk Spring (220 MASL) is first collected in a water reservoir to reduce sediment content. For the transmission pipe from the source to the reservoir, two pieces of 6-inch PVC pipes are estimated to be capable of flowing a discharge of 83 liters per second. The water reservoir is located near the village with an elevation (115 MASL) and is 1.3 km from the spring, so there is a slope of 0.0766. Two water reservoirs are used to maintain the continuity of the water supply if a problem occurs so that the water can continue to flow. Each water reservoir is 4m x 6m x 3m with a total volume capacity of 144 m3 equipped with a control valve. The distance from the water reservoir to Tamangil Nuhuten Village is 500 meters, and one 4-inch distribution pipe is used. The village elevation ranges from 10 - 50 MASL, so there is a difference of 65m from the water reservoir. This height difference is sufficient to provide energy to distribute water to the village without a pump graphically.

4. Conclusion

The total water demand in Tamangil Nuhuten Village in 2031 is 2.01 liters/second. The village's clean water supply from the Wiak spring has a debit of 1.06 liters/second, so it is insufficient to meet water needs. The Baluruk spring can provide a discharge of 83,3 liters/second with relatively stable conditions throughout the year and meets the quality of clean water. Tamangil Nuhuten Village can take clean water from the Baluruk spring by building two

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water reservoirs to reduce the sediment content with dimensions of 4m x 6m x 3m placed 500m from the village. As well as used two 6-inch pipes for transmission pipes and one 4-inch pipe for distribution. With this, the water needs of the Tamangil Nuhuten Village community can be met until 2031.

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