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Analysis of Clean Water Supply Needs In Mengkendek District, Tana Toraja Regency

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Abstract

The coverage of clean water services from PDAM in Mengkendek District, Tana Toraja Regency in 2022 is 6.07%, so there are still 93.93% of the population who cannot be served. This condition will worsen as water demand increases every year. This study aims to determine the scope of services, maximum water needs, water balance and clean water potential, so that it is expected to answer the problems to be discussed. The study began by calculating population growth over the next 20 years. The mathematical model used is the Exponential Model. This model is selected taking into account the resulting Standard Deviation and Correlation Coefficient. The calculation of water needs is obtained from the needs of the number of customers. Furthermore, water needs will be linked to the production capacity plan so as to produce a water balance. Water demand in 2023 is 85 liters/s and will increase in the following year until in 2042 water demand reaches 148 liters/s. The water balance is in deficit at the moment. Answering this, researchers made observations to determine the potential of clean water sources that can be used for the development of clean water supply systems in Mengkendek District, Tana Toraja Regency. The observation results show that there is a potential river water discharge of 23.21 m3 / s or 23,214 lps that can be utilized. By utilizing this potential, 90% service coverage until 2042 can be achieved.

Keywords
water balance; max water requirement; service coverage

I. Introduction

The coverage of clean water services from PDAM of Tana Toraja Regency in Mengkendek District in 2022 is 6.07%, so that there are still 93.93% of the population that cannot be served. Clean water services in an area that have not been able to meet the entire population can be caused by several factors, including the provision of the number of customers as the population grows so rapidly, and also the availability of clean water that is not properly planned for the fulfillment of clean water in the future. . Tana Toraja Regency as a tourist destination, is directly required to develop water infrastructure. To obtain population growth projections, scientific analysis is needed as a measuring tool to find out the approach to population numbers in the future.

The results of the researchers' observations show that the Mengkendek District has very adequate resources for the development of clean water needs. Sources of clean water from surface water such as watersheds have the potential to be developed in meeting the demand for clean water in this region. Currently, one of the rivers, namely the Malillin River, has been utilized by the PDAM of Tana Toraja Regency, but has not been able to reach all corners of the Mengkendek District. This is due to the geographical condition of this region which is quite large and consists of mountains so that it is necessary to develop clean water from other potential water sources.

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The scope of this research is limited to the analysis of population growth for the next 20 years, analysis of clean water needs, and observation of river water discharge. The results of this study are expected to be used by future researchers for the development of a clean water supply system in Mengkendek District, Tana Toraja Regency.

Many previous studies have discussed the analysis of clean water needs in a region. For example, Analysis of Needs for Clean Water Supply in Palembang City [1], Analysis of Water Supply and Demand in the Sampean Watershed [2]. Based on this literature, an analysis of the need for clean water is calculated according to domestic and non-domestic needs using standard regulations from the Ministry of Public Works, where water consumption is calculated based on the number of residents and existing public infrastructure.

It is hoped that this analysis can provide input and guidance for PDAM Tana Toraja Regency in dealing with clean water management in the Mengkendek District area in the next 20 years.

II. Review of Literature

The availability of water on the earth's land will continue to be maintained because of rain. Rain can occur due to natural mechanisms that take place cyclically and continuously [3]. The availability of water due to the hydrological cycle needs to be used optimally to meet the demand for clean water. Water demand is the amount of water that is reasonably needed for basic human needs and other activities that require water. Based on the provisions of the Ministry of Public Works and Public Housing, there are 2 (two) standards for the need for clean water, namely the Standard for Supply of Domestic and Non-Domestic Water. The standard for domestic water supply is calculated based on the number of inhabitants (people), while non-domestic water is calculated based on the availability of public infrastructure in an area. Statistical methods are used to calculate population projections including Simple Linear Regression, Arithmetic Methods, Geometry Methods, Exponential Models [4] and Logistic Growth Models [5]. The selection of statistical methods will be used, selected by calculating the correlation coefficient and standard deviation [6]. The results of the needs analysis and calculation of the population in the future will be used as a guideline for the development of a clean water supply system.

2.1 Clean Water Needs

The need for clean water is the volume of water needed for household, industrial, city office and other needs. Water demand is the amount of water that is reasonably needed for basic human needs and other activities that require water. The higher the demand for water which is not matched by an increase in water sources, people often complain about water with a small discharge or even not flowing at all [7]. The water requirement determines the size of the system and is determined based on water usage. There are 2 (two) types of standards for clean water requirements, namely (Ministry of Public Works and Public Housing of the Republic of Indonesia, 1996):

a. Domestic Water Supply Standards

Domestic Water Supply Standards are determined by the number of domestic consumers which can be known from existing population data. Standards for supplying domestic needs include drinking, bathing, cooking, and so on.

Domestic water needs for cities are divided into several categories, namely:

- City category I (Metropolitan)
- Cities category II (Big Cities)
- City category III (Medium City)
- City category IV (Small Town)
- City category V (Village)

b. Non-Domestic Water Supply Standards

Non-domestic water supply standards are determined by the number of non-domestic consumers which include facilities such as offices, health, industry, commercial, public, and others. Non-domestic consumption is divided into several categories, namely:

- Public, including: places of worship, hospitals, schools, terminals, offices and so on,
- Commercial, including: hotels, markets, shops, restaurants and so on,
- Industry, including: animal husbandry, industry and so on

2.2 Water Balance

Water balance or water balance is a balance of input or output of water in a place or region for a certain period, so that the amount of water can be known as excess (surplus) or deficiency (deficit). The water balance can be calculated using the formula [7].

$$\text{Water balance} = \text{Water Availability Debit} - \text{Water Demand Debit}$$

2.3. Clean Water Source

Water sources are one of the main components in a clean water supply system, because without a water source a clean water supply system will not function. In choosing a raw water source for clean water, the main requirements must be considered which include quality, quantity, continuity and low cost from the extraction process to the processing process. Water sources that are maintained and in good condition, of course, will produce clean water in good condition. According to Sutrisno in (Astuti, 2014) [8] water sources include seawater, atmospheric water or meteriological water, surface water (river water, swamp water or lakes) and groundwater (shallow groundwater, deep groundwater, and springs water).

III. Research Method

The method used in this research is field observation/survey and collection of related data from government agencies. The data obtained are in the form of:

- Geographical map of the region,
- Public facility data,
- Population statistics of Mengkendek District from 2013 to 2013 s.d. 2022,
- Field survey, in the form of measurement results of river water discharge.

IV. Result and Discussion

4.1 Research Location Characteristics

This research was conducted in the Mengkendek District area with an administrative area of 196.74 km² divided into 13 lembang (Buntu Datu, Buntu Tangti, Gasing, Ke'pe Tinoring, Marinding, Pakala, Palipu, Patengko, Randanan, Rante Dada, Sim throw, Uluway , Uluway Barat) and 4 sub-districts (Lemo, Rante Kalua', Tengan, Tampo). The total population is 37,092 people [9] . The city category based on the criteria of the Ministry of Public Works is the Small City category (20,000 to 100,000).

4.2 Population Growth Analysis

Calculation of population growth is the basis of the analysis of clean water needs [6]. Population growth calculations use BPS data for the last 10 years, from 2013 to 2013. 2022.

Table 1. Total population of the Mengkendek District in 2013 s.d. 2022

No	YEAR	Number of Population (Person)
1	2013	27.670
2	2014	27.756
3	2015	27.769
4	2016	27.842
5	2017	27.898
6	2018	27.963
7	2019	28.028
8	2020	28.073
9	2021	36.390
10	2022	37.092

Population projections are calculated using Arithmetic, Geometry and Exponential methods.

a. Arithmetic Method

The mathematical equation of the Arithmetic method is as follows [4]:

$$P_n = P_0(1 + r.t) \quad (1)$$

Where :
Pn = Population of n years in the future.
P0 = Total population in the initial year.
r = Population growth rate.
t = Time period in years.
The results of calculations using the Arithmetic method are as follows:

Table 2. Results of calculating population growth using the Arithmetic method

No	YEAR	Number of Population (Person)
1	2013	27.670
2	2014	28.717
3	2015	29.764

4	2016	30.811
5	2017	31.858
6	2018	32.904
7	2019	33.951
8	2020	34.998
9	2021	36.045
10	2022	37.092

b. Geometry Method

The mathematical equation of the Geometry method is as follows:

$$P_n = P_0 (1 + r)^n, \quad \text{....................................... (2)}$$

Where :
Pn = Population of n years in the future.
P0 = Total population in the initial year.
r = Population growth rate.
t = Time period in years.

The results of calculations using the Arithmetic method are as follows:

Table 3. Results of population growth calculations using the Geometry method

No	YEAR	Number of Population (Person)
1	2013	27.670
2	2014	28.586
3	2015	29.532
4	2016	30.509
5	2017	31.519
6	2018	32.562
7	2019	33.640
8	2020	34.753
9	2021	35.904
10	2022	37.092

c. Exponential Method

The mathematical equation of the Exponential method is as follows [10]:

$$P_n = P_0 e^{rt}, \quad \text{.. (3)}$$

Where :
Pn = Population of n years in the future.
P0 = Total population in the initial year.
r = Population growth rate.
t = Time period in years.

Table 4. Exponential population growth calculation results

No	YEAR	Number of Population (Person)
1	2013	27.670
2	2014	28.493
3	2015	29.340
4	2016	30.213

5	2017	31.111
6	2018	32.036
7	2019	32.989
8	2020	33.970
9	2021	34.981
10	2022	36.021

Of the 3 (three) methods, the standard deviation and correlation coefficient are calculated using the following equation:

$$S^2 = \frac{n\sum y^2 - (\sum y)^2}{n(n-1)} \quad \text{.. (4)}$$

Where :
S : Standard Deviation
n : Amount of Data
x : Year n
y : Number of Population in year n

$$r = \frac{n\sum xy - \sum y \sum x}{\sqrt{\{n\sum y^2 - (\sum y)^2\}\{n\sum x^2 - (\sum x)^2\}}} \quad \text{..................... (5)}$$

Where :
r : correlation coefficient
n : Amount of Data
x : Year n
y : Number of Population in year n.
The calculation results are presented in the following table:

Table 5. Result of calculation of standard deviation and correlation coefficient

Metode	S	r
Geometri	3.169,17	0,74
Aritmatika	3.169,61	0,72
Eksponensial	2.808,93	0,74

By taking into account the smallest standard deviation and the correlation coefficient that is close to 1 (one), the method chosen to calculate population growth is the exponential method. By using the Exponential method, population growth over the next 20 years can be calculated. The calculation results are as in table 6 below.

Table 6. The results of calculating population growth using the exponential method for the next 20 years.

No	YEAR	Number of Population (Person)
1	2023	38.195
2	2024	39.331
3	2025	40.501
4	2026	41.705
5	2027	42.945
6	2028	44.222

7	2029	45.538
8	2030	46.892
9	2031	48.286
10	2032	49.722
11	2033	51.201
12	2034	52.724
13	2035	54.292
14	2036	55.906
15	2037	57.569
16	2038	59.281
17	2039	61.044
18	2040	62.859
19	2041	64.728
20	2042	66.653

4.3 Clean Water Needs

Water demand is the large amount of clean water needed for household, industrial, office, and other needs [7]. Water demand analysis is calculated using the results of population growth analysis calculations in table 6 above, taking into account several parameters based on regulatory provisions of the Ministry of Public Works and Public Housing of the Republic of Indonesia, as in table 7.

By considering some of these parameters, the need for clean water in the Mengkendek sub-district for the next 20 years can be projected. The projection results can be presented in table 8.

Table 7. Small Town Water Requirement Standards

Description	Need	Ket
Service Scopes (%)	90	CL
Consumption of House Connection Units (SR) (liters/person/day)	10-120	SR
Consumption of Non-Domestic Units (%)	30	ND
Water Loss (%)	20-30	HA
Maximum Day Factor	1,15-1,25	HM
Peak Hour Factor	1,75	JP
Hydrant Unit Consumption (liters/person/day)	30	HU
SR : HU	70 : 30	SH

Table 8. Clean Water Needs for the Next 20 Years

No	Year	Population	CL	Clean Water Needs (Liters/second)							
				SR	ND	HA	JML	HU	HM	JP	Total
1	2023	38.195	34.376	26	8	8	42	11	50	74	85
2	2024	39.331	35.398	27	8	9	43	11	52	76	87
3	2025	40.501	36.451	27	8	9	45	12	53	78	90
4	2026	41.705	37.535	28	8	9	46	12	55	80	92
5	2027	42.945	38.651	29	9	9	47	12	57	83	95
6	2028	44.222	39.800	30	9	10	49	13	58	85	98

7	2029	45.538	40.984	31	9	10	50	13	60	88	101
8	2030	46.892	42.203	32	10	10	52	14	62	90	104
9	2031	48.286	43.457	33	10	11	53	14	64	93	107
10	2032	49.722	44.750	34	10	11	55	14	66	96	110
11	2033	51.201	46.081	35	10	11	56	15	68	99	113
12	2034	52.724	47.452	36	11	12	58	15	70	102	117
13	2035	54.292	48.863	37	11	12	60	16	72	105	120
14	2036	55.906	50.315	38	11	12	62	16	74	108	124
15	2037	57.569	51.812	39	12	13	63	17	76	111	128
16	2038	59.281	53.353	40	12	13	65	17	78	114	131
17	2039	61.044	54.940	41	12	13	67	18	81	118	135
18	2040	62.859	56.573	43	13	14	69	18	83	121	139
19	2041	64.728	58.255	44	13	14	71	19	85	125	143
20	2042	66.653	59.988	45	14	15	73	19	88	128	148

Based on table 8 above, the maximum water demand in 2042 is 148 liters/second.

4.4. Water Balance

Statistical data presented by the Central Statistics Agency for 2022 stated that the amount of water channeled was 1,231,506 m3 or with an average water discharge of 39.05 liters/second. At the beginning of 2023, this figure is still relatively the same because there has been no capacity addition to the PDAM intake. If the water debit is used by the population in 2023, it will experience a deficit of 45.5 liters/second (39.05 – 85). The water deficit will continue to increase continuously until 2042 if there is no development of the clean water supply system, in which in 2042 there will be a clean water deficit of 108.95 liters/second (148-39.05). By utilizing a potential source of clean water, it is hoped that there will be a surplus of clean water in the Mengkendek District in the coming year.

4.5. Observation of Availability of Water Sources

Observation of water availability was carried out to find out the potential sources of clean water in the Mengkendek District. This stage begins with conducting short interviews with Lembang officials. The interview sheet was carried out using the Googleform application. The observation results show that there are 4 (four) rivers that have the potential to be developed for the supply of clean water to the community. After the location coordinates were obtained, the next researcher conducted a field survey to measure the existing river water discharge. The tools used are a length measuring instrument to measure the length of the sample as well as the width and depth of the river, as well as a stopwatch and ping pong ball to calculate the speed of the river current. The researchers observed that the results of the following calculations may change with changes in rainfall, land conditions and changes that occur in the river channel. The measurement results obtained river water discharge as follows:

Table 9. Results of water discharge measurements

No	River Address	Coordinate Location	Elevasi (mdpl)	Debit (liter/s)
1	Lembang Simbuang	-3.181129°, 119.957327°	1013	4.874,61

2	Lembang Patengko	-3.215547°, 119.899134°	862	8.988,11
3	Lembang Buntu Datu	-3,243093°, 119.891407°	837	8.711,03
4	Lembang Uluwai	-3,282034°, 119.985816°	1096	640,25
	Jumlah			23.214,01

Assuming that 10% of the water debit is used to build the PDAM intake, 2321.4 liters/s is obtained. By utilizing this potential, when compared with the results of the calculation of the need for clean water as shown in table 8, it can be concluded that the need for clean water in the Mengkendek sub-district for the next 20 years can be met.

V. Conclusion

Based on the discussion above, it can be concluded several things as follows:

1. The results of the analysis of the correlation coefficient and standard deviation of the statistical method for calculating population growth in the Mengkendek District, it is known that the exponential method is the most effective method. With a population growth rate of 2.93%, the initial population P0 = 37,092 people in 2022, and for 20 years, the total population in 2042 is 66,653 people.
2. The maximum amount of water needed to meet the clean water needs of the population is 59,988 people in 2042, with a clean water debit requirement of 148 liters/second.
3. The current water deficit is 45.5 liters/second, and will continue to increase in line with population growth. Until 2042 there will be a clean water deficit of 108.95 liters/second. However, this can be overcome by utilizing water sources from available river basins.
4. There is potential for watersheds that can be used to fulfill clean water in the Mengkendek District, namely in Simbuang Lembang, Patengko Lembang, Buntu Datu Lembang, and Uluwai Lembang. The total water debit is 23,214.01.

Based on the above conclusions, it is suggested to the reader to carry out further research for the development of a clean water supply system in the Mengkendek District by utilizing the potential of existing clean water sources. Due to the geographical condition of the area which is quite wide, the development of a clean water supply system can be carried out by dividing the area into zones of service areas.

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