Jurnal Darma Agung
Volume: 31, Nomor: 3, (2023), Juni : 434 - 447
https://dx.doi.org.10.46930/ojsuda.v31i3.xxxx

P-ISSN:0852-7296
E-ISSN:2654-3915

ANALYSIS OF THE NEED FOR CLEAN WATER SUPPLY IN THE MENGKENDEK DISTRICT TANA TORAJA REGENCY

Hardianto Pabilang [1], Baharuddin Hamzah [2], Samsuddin [3]
[1]Program Studi Teknik Perancanaan Prasarana Universitas Hasanuddin, Makassar, Indonesia
[2] Fakultas Teknik Universitas Hasanuddin, Makassar, Indonesia
Corresponding Author: hp230886@gmail.com [1], baharsyah@yahoo.com [2]

Abstrak

Pada tahun 2022, hanya 6,07% dari penduduk di Kecamatan Mengkendek, Kabupaten Tana Toraja memiliki akses layanan air bersih yang disediakan oleh PDAM, sehingga 93,93% penduduk tidak mendapatkan layanan tersebut. Situasi ini diperkirakan akan semakin memburuk karena peningkatan permintaan air setiap tahunnya. Penelitian ini bertujuan untuk mengatasi masalah ini dengan menentukan cakupan layanan, permintaan air maksimum, keseimbangan air, dan sumber potensial air bersih. Penelitian ini dimulai dengan memproyeksikan pertumbuhan penduduk selama 20 tahun ke depan, menggunakan Model Eksponensial sebagai kerangka matematis, dengan mempertimbangkan Standar Deviasi dan Koefisien Korelasi. Kebutuhan air dihitung berdasarkan jumlah pelanggan, dan permintaan air kemudian dikaitkan dengan rencana kapasitas produksi untuk menetapkan keseimbangan air. Saat ini, terdapat defisit air. Untuk mengatasi hal ini, para peneliti melakukan pengamatan untuk mengidentifikasi sumber potensial air bersih yang dapat dimanfaatkan untuk pengembangan sistem pasokan air di Kecamatan Mengkendek, Kabupaten Tana Toraja. Temuan tersebut mengungkapkan adanya debit air sungai potensial sebesar 23,21 m3/ detik atau 23.214 liter/ detik, yang dapat dimanfaatkan. Dengan memanfaatkan potensi ini, cakupan layanan sebesar 90% dapat tercapai hingga tahun 2042.

Kata kunci: Neraca Air, Kebutuhan Air Maksumum, Cakupan Layanan

Abstract

In 2022, only 6.07% of the population in Mengkendek District, Tana Toraja Regency has access to clean water services provided by PDAM, leaving 93.93% of the population without service. This situation is expected to worsen due to increasing water demand each year. This research aims to address these issues by determining the extent of services, maximum water demand, water balance, and potential sources of clean water. The study begins by projecting population growth for the next 20 years, using the Exponential Model as the mathematical framework, considering Standard Deviation and Correlation Coefficient. Water needs are calculated based on the number of customers, and the water demand is then linked to production capacity plans to establish a water balance. As of now, there is a water deficit. To tackle this, the researchers conducted observations to identify potential sources of clean water that can be utilized for developing a water supply system in Mengkendek District, Tana Toraja Regency. The findings reveal a potential river water discharge of 23.21 m3/s or 23,214 liters/s, which can be harnessed. By tapping into this potential, a service coverage of 90% can be achieved until 2042.

Keywords: *Water Balance, Maximum Water Demand, Service Coverage*

INTRODUCTION

History:
Received : 12 Juni 2023
Revised : 15 Juni 2023
Accepted : 23 Juni 2023
Published: 25 Juni 2023

Publisher: LPPM Universitas Darma Agung

In 2022, only 6.07% of the population in Mengkendek District, Tana Toraja Regency, has access to clean water services provided by the local water utility (PDAM), leaving a significant 93.93% of the population unserved. The lack of comprehensive clean water services in certain areas can be attributed to various factors, such as the rapid population growth leading to an overwhelming increase in customers and inadequate planning for future clean water availability. Considering Tana Toraja Regency's status as a popular tourism object, there is a pressing need to build infrastructure for water. To determine forecasts of population growth and formulate appropriate strategies, a scientific analysis is essential in order to accurately gauge future population trends.

Based on the researchers' observations, it has been determined that the Mengkendek District possesses abundant resources suitable for addressing the clean water requirements of the area. The district has access to surface water sources, such as watersheds, which hold potential in order to provide a clean water supply in the region. Currently, the local water utility, PDAM of Tana Toraja Regency, utilizes the Malillin River as a water source. However, due to the large size and mountainous terrain of the Mengkendek District, the current water supply does not reach all parts of the district. Therefore, it becomes necessary to explore and develop alternative water sources to cater to the clean water needs of the entire region.

This research study focuses on analyzing the population growth, evaluating clean water requirements, and observing river water discharge within the specified timeframe of the next 20 years. The objective of this study is to generate valuable insights that can be utilized by future researchers and stakeholders involved in the creation of a reliable infrastructure for providing clean water in the Mengkendek District of the Tana Toraja Regency. The findings and outcomes of this research are intended to serve as a foundation for further investigations and initiatives aimed at enhancing the availability and accessibility of clean water in the district.

The evaluation of a region's demands for clean water has been covered in many earlier studies. For example, Analysis of Needs for Clean Water Supply in Palembang City (Kurniawan et al., 2021) , Analysis of Water Supply and Demand in the Sampean Watershed (Sari et al., 2011) . According to this research, the Ministry of Public Works' usual regulations—which stipulate that water consumption is governed by the population and the condition of the general infrastructure—are used to calculate the demand for pure water in line with residential and non-domestic demands.

It can be expected that this research will help PDAM Tana Toraja Regency in the coming 20 years when it comes to managing clean water in the Mengkendek District region.

Rain will ensure that there is always water available on Earth's surface. There are cyclical and continual natural processes that might cause rain (Bryan et al., 1996) . To fulfill water purification needs, it is essentials to make the best use of the water that is made available by the hydrological cycle. The needs for water is the quantity of water that would realistically be for the fulfillment of fundamental human requirements and other water-dependent functions. There are 2 (two) criteria for the need for safe water, as determined by the policies of the Ministry of Public Works and Housing, namely the Standard for Supply of Domestic and Non-Domestic Water. The prerequisite for household water availability is determined by the population, but the benchmark for foreign water is determined by the presence of general infrastructure in a certain region. To calculate population projections, statistical methods are used consisting of Simple Linear Regression, Arithmetic Methods, Geometric Methods, and Exponential Models (Hartati et al., 2019) and Logistic Growth Models (Febdian & ., 2013) . By determining the correlation coefficient and standard deviation, a variety of statistical techniques will be applied (Maskur, 2021) . The outcomes of the needs study and future population predictions will be utilized as a framework for developing mechanism for supplying clean water.

a. Needs For Clean Water

The requirement for pure water refers to the quantity of water necessary for domestic, manufacturing, municipal, and another purposes. Water consumption is the number of water that is ostensibly necessary to fulfill fundamental human needs and for various water-dependent functions. When the demand for water surpasses the available water sources, individuals frequently express dissatisfaction with low water flow or even complete absence of water (Primandani et al., 2022) . Based on water consumption, needs for water are determined, which determines the system's size. According to the Ministry of Public Works and Housing of the Republic of Indonesia in 1996, there are two categories of clean water standards

1) Standards for Domestic Water Supply

   The Domestic Water Supply Standards are established based on how many domestic consumers there are, which is attainable from available population information. These criteria encompass various aspects of fulfilling domestic needs, such as drinking, bathing, cooking, and more. For cities, Household water requirements are divided into a number of categories, including:

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

2) Standards for Non-Domestic Water Supplies

   The amount of non-domestic customers, which include a variety of services including offices, healthcare institutions, industries, commercial enterprises, general structures, and others, determines the non-domestic water supply requirements. The types of non-domestic water usage are further broken down, which include:

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

- Industry, including: livestock, industry and so on

b. Water Balance

Water balance or hydrological balance refers to the equilibrium between water input and output within a specific area or region over a given period. It allows us to determine whether there is a surplus or deficit of water in that particular location. The following formula may be used to determine the water balance (Primandani et al., 2022) .

Water balance = Available Water Charge - Water Demand Charge

c. Source of Clean Water

A clean water supply system relies heavily on water sources as its primary elements, as the absence of a water source renders the system ineffective. When selecting a raw water source for clean water production, several crucial factors need to be taken into account, such as quality, quantity, continuity, and cost-effectiveness throughout the extraction and processing stages. By ensuring the preservation and optimal state of water sources, clean water of high quality can be obtained. According to Sutrisno in (Astuti, 2014) there are various types of water sources, such as seawater, atmospheric water (or water in the atmosphere), surface water (which includes river water, swamp water, and lake water), and groundwater (which comprises shallow groundwater, deep groundwater, and springs).

RESEARCH METHODS

The study employed field observation/survey as well as data collection from government agencies as its methodology. The acquired data took the following forms:

- Map of the area's geography,
- data on public facilities,
- Mengkendek District population figures from 2013 to 2022,
- Field research that takes the form of river water discharge measurements.

RESULTS AND DISCUSSION

Specifications of the Research Location

The study took place in the Mengkendek District, which has an administrative area spanning 196.74 km². The district is divided into 13 lembang areas, namely Buntu Datu, Buntu Tangti, Gasing, Ke'pe Tinoring, Marinding, Pakala, Palipu, Patengko, Randanan, Rante Dada, Sim throw, Uluway, and Uluway Barat. Additionally, there are 4 sub-districts, namely Lemo, Rante Kalua', Tengan, and Tampo. The total population in this area is 37,092 individuals (Figures, 2022) . According to the criteria set by the Ministry of Public Works, the city falls under the Small City category, which is defined as having a population ranging from 20,000 to 100,000 residents.

Analysis of Population Growth

Analyzing the demand for clean water relies on the calculation of population growth. (Maskur, 2021) . The calculation of population growth utilizes data from the Central Statistics Agency (BPS) spanning the past 10 years, specifically from 2013 to 2022.

Table 1. Total population of the Mengkendek District from 2013 to 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	28028
8	2020	28,073
9	2021	36,390
10	2022	37,092

Population projections are derived through the application of three methods: Arithmetic, Geometric, and Exponential.

Arithmetic Approach

The mathematical equation for the Arithmetic approach is as follows (Hartati et al., 2019) :

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

Where :

P_n = Population n years from now.

P_0 = total population in the first year.

r = rate of population increase.

t = the length of time in years.

The following are the outcomes of equations made using the arithmetic approach:

Table 2. Results of using the arithmetic technique to population growth

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

Geometric Approach

The mathematical equation for the Geometry method is as follows:

$P_n = P_0 (1 + r)^n$, ... (2)

Where :

P_n = Population n years from now.

P_0 = total population in the first year.

r = rate of population increase.

t = the length of time in years.

The following are the outcomes of equations made using the geometric approach:

Table 3. Calculations of population increase using the geometry approach

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

Exponential Approach

The mathematical equation for the Exponential method is as follows (Excellent, 2020) :

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

Where :

P_n = Population n years from now.

P_0 = total population in the first year.

r = rate of population increase.

t = the length of time in years

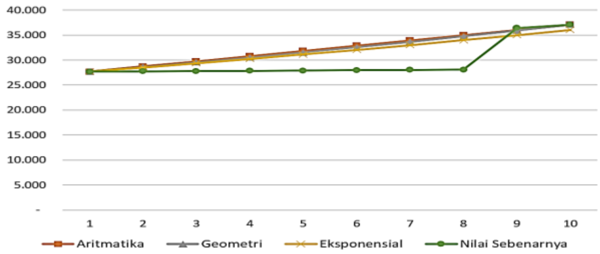
Table 4. Results of an exponential population growth calculation

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	36021

The comparison graph of population growth from the three methods is as follows:

Graph 1: Comparison of population growth



For the three methods, the standard deviation and correlation coefficient are calculated using the following equation:

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

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

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

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

Table 5. Results of calculating the correlation coefficient and standard deviation

Method	S	r
Geometry	3,169.17	0.74
Arithmetic	3,169.61	0.72
Exponential	2,808.93	0.74

The exponential technique is the method of choice to compute population increase after taking into account the minimum standard deviation and a correlation value near to 1. The exponential approach may be used to estimate population increase over the following 20 years. The computations' outcomes are shown in Table 6 below.

Table 6. The population growth for the next 20 years was determined by employing the exponential method

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

Clean Water Needs

Water demand refers to the substantial quantity of pure water required to meet various purposes such as domestic, industrial, commercial, and other requirements (Primandani et al., 2022) . The determination of water demand involves utilizing the outcomes of numbers for growing population presented in the aforementioned table 6. This process considers several parameters in accordance with the regulatory guidelines specified by the Ministry of Public Works and Housing of the Republic of Indonesia, as outlined in table 7.

By taking into account various parameters, it becomes possible to project the demand for clean water in the Mengkendek sub-district over the next two decades. The projected results can be conveniently displayed in table 8.

Table 7. Small Town Water Requirement Standards

Description	Need	Ket
Service Coverage (%)	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
SRs: HU	70 : 30	sh

Table 8. Needs for Clean Water Over the Next 20 Years

No	Year	Total population	CL	Clean Water Needs (Liters/second)							
				SR	nd	HA	QMS	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

According to the data presented in table 8, the estimated peak water demand in the year 2042 reaches 148 liters per second.

Water Balance

The Central Statistics Agency's statistics figures for the year 2022 show that the volume of water supplied amounted to 1,231,506 m3, equivalent to a typical discharge rate of 39.05 liters per second. Commencing in the year 2023, This number essentially doesn't change as no additional capacity has been added to the water utility's intake system. If the population relies on this water discharge in 2023, there will be a shortage of 45.5 liters per second (39.05 - 85). In the absence of changes to the clean water supply system, this water shortage will continuously expand until 2042. By that time, the projected clean water shortage will reach 108.95 liters per second (148 - 39.05). However, by harnessing the possibility of alternative clean water sources, it is anticipated there is a plenty of pure water can be achieved in the Mengkendek District in the upcoming years.

Observation of Availability of Water Sources

The water accessibility assessment in the Mengkendek District involved conducting observations to identify potential sources of clean water. This process began with short interviews conducted with officials from Lembang. The interview data was collected using the Google Form application. The observations revealed the presence of four rivers that hold potential for development to meet the community's clean water supply needs. After getting the coordinates for the site, the researchers went ahead and conducted a field investigation to gauge the rivers' water output. For this purpose, they measured the length, width, and depth of the river, in addition to the sample length, using a length measuring device. Additionally, a stopwatch and ping pong ball were used to determine the velocity of the river. It is important to note that the calculated results may vary due to adjustments to the river channel, changes to the terrain, and variations in rainfall. The measurements yielded the following river water discharges:

Table 9. Results of water discharge measurements

No	River Address	Location Coordinate	Elevation (masl)	debit (liters/s)
1	Lembang Simburan	-3.181129 ° , 119.957327 or	1013	4,874.61
2	Patengko	-3.215547 °	862	8988,11

	Valley	, 119.899134 o.k		
3	Lembang Buntu Datu	-3.243093 o , 119.891407 o.k	837	8711.03
4	Uluwai Valley	-3.282034 o , 119.985816 o.o	1096	640.25
		Amount		23214.01

Providing that 10% of the water discharge is allocated for building the PDAM intakes, a value of 2,321.4 liters per second is obtained. By harnessing this potential, and comparing it with the calculated pure water demand as presented in table 8, it may be said that the clean water requirements for the Mengkendek sub-district over the next 20 years can be adequately fulfilled.

CONCLUSION

Several important implications may be taken from the debate just stated:

1. By analyzing the correlation coefficient and standard deviation using statistical methods to calculate population expansion in the Mengkendek District, it has been determined indicates the most efficient strategy is the exponential one. With a rate of population increase of 2.93% and a starting population of 37,092 in 2022 (P_0), it is predicted that 66,653 people would be living in the country as a whole in 2042.
2. In 2042, considering a population of 59,988 people, the most pure water necessary to suit their demands is estimated to be 148 liters per second.
3. At present, there is a water deficit of 45.5 liters per second, and this deficit is expected to grow as the population increases. By 2042, the projected clean water shortage will reach 108.95 liters per second. Utilizing water supplies from the accessible river basins, nevertheless, will help to solve this problem.
4. In the Mengkendek District, there are several potential watersheds that can be utilized to fulfill the clean water needs. These watersheds include Simbuang Lembang, Patengko Lembang, Buntu Datu Lembang, and Uluwai Lembang. Collectively, these watersheds have a total water debit of 23,214.01 liters per second.

Considering the aforementioned findings, it is recommended that further research be conducted to facilitate the creation of a system for providing clean water in the Mengkendek District by exploiting the possible sources of clean water that are already available. Considering the region's vast geographic scope, it is advisable to consider dividing it into distinct zones of service areas for the implementation of the clean water supply system. This approach will help ensure efficient and targeted distribution of clean water to meet the specific needs of different zones within the district.

REFERENCES

Angka, K. M. dalam. (2022). Dalam Angka Dalam Angka. In *Kecamatan Mengkendek Dalam Angka*. BPS Kabupaten Tana Toraja.

Astuti, N. (2014). Penyediaan Air Bersih Oleh Perusahaan Daerah Air Minum (PDAM) Kota Sangatta Kabupaten Kutai Timur. *EJournal Administrasi Negara*, *3*(2), 678–689.

Bryan, K., Wuisan, C., Wuisan, E. M., & Binilang, A. (1996). Kriteria Perencanaan Ditjen Cipta Karya Dinas PU. *Kriteria Perencanaan Ditjen Cipta Karya Dinas PU*, *5*(4), 195–204.

Febdian, L., & . E. (2013). Menentukan Model Pertumbuhan Penduduk Provinsi Sumatera Barat. *Jurnal Matematika UNAND*, *2*(4), 54. https://doi.org/10.25077/jmu.2.4.54-58.2013

Hartati, Indrawati, Sitepu, R., & Tamba, N. (2019). Metode geometri, metode aritmatika, dan metode eksponensial untuk memproyeksikan penduduk Provinsi Sumatera Selatan. *Prosiding Seminar Nasional Sains Matematika Informatika Dan Aplikasinya IV*, *4*(4), 7–18.

Kurniawan, M. A., Fitriani, H., & Hadinata, F. (2021). Analisis Kebutuhan Penyediaan Air Bersih di Kota Palembang City. *Jurnal Saintis*, *21*(02), 105–112. https://doi.org/10.25299/saintis.2021.vol21(02).7611

Maskur, A. (2021). Volume 05 No. 01 - APRIL, 2021. *JALUSI Jurnal Ilmu Sipil*, *05*(01).

Primandani, V. C., Purwono, N. A. S., & Barkah, A. (2022). Analisis Kebutuhan Dan Ketersediaan Air Bersih Di Wilayah Pelayanan Instalasi Pengolahan Air. *Teknik Sipil Universitas Warmadewa*, *11*, 112–121. https://doi.org/10.22225/pd.11.1.4469.112-121

Sari, I. K., Limantara, L. M., & Priyantoro, D. (2011). Analisa Ketersediaan dan Kebutuhan Air pada DAS Sampean. *Jurnal Teknik Pengairan: Journal of Water Resources Engineering*, *2*(1), 29–41.

Unggul, U. E. (2020). *MODUL DASAR-DASAR KEPENDUDUKAN*. *Ksm 123*, 0–14.