

Estimation and Forecasting on Clean Water Demand in Palopo City South Sulawesi Province, Indonesia

ABSTRACT

Life is not possible without water, so we need a sufficient supply of water to sustain life. Lack of clean water is a major problem faced by urban communities today. For this reason, it is necessary to estimate the demand for water. This is very useful when planning clean water supply in cities. The research is conducted as a case study site in Palopo City, South Sulawesi. Population data is used as a reference when calculating domestic water requirements. The purpose of this study is to calculate the clean water needs of the people of Palopo City over the forecast period of up to 20 years. As a result of this survey, the water demand in Palopo City community in 2027 is 29,510.37 m³/person/day for domestic use, and 10,773.95 m³ for non-domestic use, including water loss from fire hydrants and leakage. It is shown that there is 31,685.72 m³/person/day for households in 2032, 13,493.76 m³/person/day for non-households, 33,744.08 m³/person/day for households in 2037, 13,884.27 m³/person for non-households /day, 35,741.65 m³/person/day for households and 14,183.00 m³/person/day for non-households in 2042. The city of Palopo's water production from multiple sources is 65,664.00 m³/day. Therefore, it can be concluded that Palopo's clean water demand will be quantitatively covered until 2042.

Keywords: *Clean Water, Population, Domestic Water Needs, Non-Domestic Water Needs*

1. INTRODUCTION

Water is a very important substance or material or element for all life forms known so far, and water covers almost 80% of the earth's surface. The properties of water cannot be replaced by mixtures or other compounds, and almost all human activities use water. resources [1, 2].

Water can exist in solid, liquid, and gaseous forms. Water is the main regular substance in the outer layers of the Earth that can exist in the form of these three structures. Water is a synthetic substance with the chemical formula H₂O, where a water particle consists of two hydrogen molecules covalently bonded to an oxygen particle. The properties of water are colorless, tasteless and odorless under normal conditions [3]. However, clean water remains the biggest obstacle to improving overall health quality. Currently, only 25% of the state's population and 40% of the metropolitan population have access to water that fully meets their needs. I am benefiting. Several variables affect water accessibility and quality. We are seeing a change in land use, especially in developing countries. For example, agricultural land is being transformed into residential and industrial areas. In principle, land use change should also meet human needs for housing and various other needs [4, 5].

Water is a community right that should be realized by both local and central governments. The availability of drinking water is one of the determinants of improving human welfare, increasing productivity and driving economic growth in communities. Urban communities commonly use PDAM services to meet their clean water needs. In addition, we use clean water sources from rivers, lakes, rainwater and springs. In addition to the limited potential for water treatment, accessibility and suitability for drinking water supplies are of great importance [6, 7].

Water availability is strongly influenced by population (demand) and the availability of water sources (supply). Population growth is an important factor to consider when calculating water demand over the next few years. In Canada, future water demand was estimated by developing various estimation models, as was done by calculating projected water demand using the ELM modeling method used to simulate UWD in the City of Calgary. Several studies have been conducted to predict of the water demand using linear regression analysis or time series analysis or techniques based on soft computing have also been used to forecast daily, monthly and yearly water demand [8,9,10]. Other studies report using artificial intelligence to predict water demand [11, 12, 13].

The survey was conducted to determine the water needs for his 20-year forecast for Palopo City, South Sulawesi, based on population data that is estimated to continue to grow each year. Long-term (annual) forecasts are very important in the planning stage of water networks, calculation of capacity and production capacity. The study is intended to be a data source for stakeholders, especially governments as policy makers, communities and social organizations to plan for future clean water needs.

2. LOCATION OF STUDY AREAS AND METHODOLOGY

2.1. Study areas

Palopo City is one of the administrative cities within the administrative district of South Sulawesi. In general, the landscape features of the city of Palopo consist of three variations: coastal lowlands, central hills and flat hills, and some hills and mountains in the north directly adjacent to the west, south, and east. I'm here. to the coastal waters. Bone. The city of Palopo is located at the coordinates of 2°53'15" - 3°04'08" S, 120°03'10" - 120°14'34" E, the reference position of South Sulawesi Province. Location of the city is located in the northern part of South Sulawesi Province, about 375 km away from Makassar City (**Figure. 1**). The city of Palopo covers an area of 247.5 km² and consists of nine districts: South Wala,

Sendana, Wala, East Wala, Mungkajang, North Wala, Bara, Terwanua and West Wala. Population Based on Palopo City BPS data, Palopo City will have a population of 187,331 by the end of 2021, with an annual population growth rate of 1.92%.

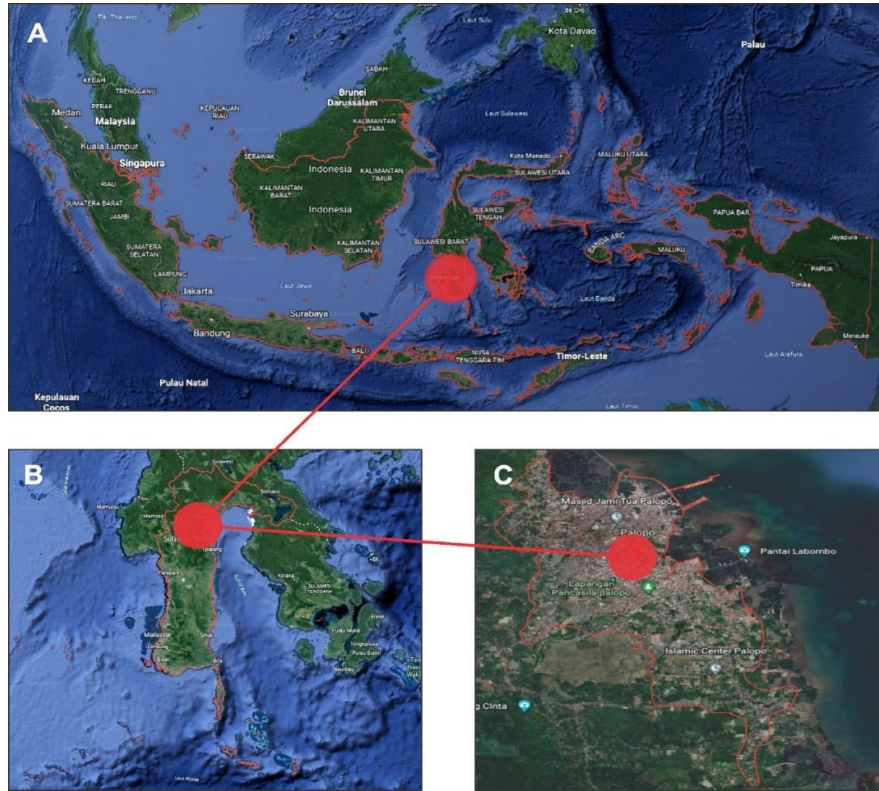


Figure 1. Research Location : Indonesian Map (A), South Sulawesi Province (B), Palopo City (C).

2.2. Methodology

2.2.1. Data Collection

Data collection was carried out using a survey method namely field observations conducted by observing the physical conditions of the research location and documentation. In addition, secondary data was collected from various related sources, such as the Office of the Municipal Water Supply Company (PDAM) of Palopo City and the Office of the Central Bureau of Statistics for the City of Palopo, besides, that data was also obtained online from the websites of related institutions.

2.2.2. Data Analysis

Calculation of Water Needs

Calculation of the need for clean water based on the amount to be served and the average need for clean water for each person. For this reason, population projections are first carried out and then the calculation of clean water needs is carried out as follows:

Projected population in 2025 (with geometric method):

$$P_t = P_o (1+r)^n \quad (1)$$

Where :

P_o = Number of Population in Initial Year

P_t = Number of Population in Final Year

r = Average Population Growth Rate

n = Year Projection

Calculation of water discharge

The water discharge (Q) is the product of the multiplication of the cross-sectional area (A) of the channel/stream and the speed (v) of the water flow.

$$Q = A \times V \quad (2)$$

where:

Q = Flow rate (m³/second)

A = Channel cross-sectional area (m²)

V = Velocity of water flow (m/sec)

3. RESULTS AND DISCUSSION

Population Analysis

Analysis is performed to identify and obtain projections of demographic changes such as population growth and composition, identify and obtain the social condition of the population, and provide an overview of the structure and characteristics of the population bottom.

A forecasting method is an estimate of the dynamics of a particular variable in the future. Future projections of many changes in spatial planning variables must take into account changes in internal factors (population and economic growth) and changes in external factors, especially development policy patterns and market demand factors.

The analysis begins with population growth using the logarithmic or logarithmic forecasting calculus forecasting methods, as the population of the city of Palopo is on the rise. Formulas for predicting population over the next 20 years can be found in the formulas, charts, and tables below.

Table 1. Population growth trend of Palopo City in 2017 – 2021

SUBDISTRICT	TOTAL POPULATION				
	2017	2018	2019	2020	2021
Wara Selatan	11.598	11.846	12.106	18.679	19.163
Sendana	6.546	6.685	6.829	7.381	7.490
Wara	38.286	39.101	39.955	31.539	31.910
Wara Timur	38.042	38.853	39.701	38.344	38.762
Mungkajang	7.933	8.102	8.279	10.062	10.323
Wara Utara	22.637	23.119	23.621	20.645	20.888
Bara	27.580	28.169	28.781	30.660	31.021
Telluwana	13.328	13.614	13.911	15.887	16.179
Wara Barat	10.957	11.189	11.431	11.484	11.595
Palopo	176.907	180.678	184.614	184.681	187.331

Source : Statistics of Palopo Municipality [14]

Forecasting population growth for the next 20 years is calculated using the Logarithmic Method with the following formula:

$$y=17762 \times L(x)+140541 \quad (3)$$

Table 2. Population projection of Palopo City in 20 years

Year	Population	Year	Population
2021	187.331	2032	226.895
2022	190.928	2033	230.492
2023	194.525	2034	234.089
2024	198.121	2035	237.686
2025	201.718	2036	241.282
2026	205.315	2037	244.879
2027	208.912	2038	248.476
2028	212.508	2039	252.073
2029	216.105	2040	255.669
2030	219.702	2041	259.266
2031	223.299	2042	262.863

Source : Researcher Team analysis

Based on the calculation of the population forecast for the next 20 years, the population in 2042 is 262,863 people. Forecasting calculations are carried out by taking into account the growth and development cycle of the City every 5 years so it is important to know how the dynamics of regional development, especially for the need for clean water that needs to be served.

Water Demand Analysis

Existing Water Needs

To find out the existing water needs in Palopo City, a calculation of the amount of water needs is carried out based on the population in the last year or 2021 as the population whose clean water needs will be served.

Based on the estimated results of calculating the need for clean water in Palopo City, in the existing year or the latest population data for 2021, the maximum water demand per day is 36,973.65 m³/person/day.

Future Water Needs

Clean water demand analysis based on the 2000 Minimum Service Standards for quality clean water services, determined according to city size levels, namely:

- a. Metropolitan Municipality (> 1 million population), has a service coverage of 65-75% with a consumption rate of 190-220 liters/person/day.
- b. Big cities (500 thousand – 1 million population), have service coverage of 60-70% with a consumption rate of 150-170 liters/person/day.
- c. Medium/small city (<500 thousand population), has a service coverage of 55-65% with a consumption level of 110-130 liters/person/day.
- d. District/Regional scale with a population not exceeding 50,000 people, has a service coverage of 50-55% with a consumption rate of 60-75 liters/person/day.

Estimated drinking water needs for Palopo City are based on standards that refer to standards issued from Kimpraswil (Decree of the Minister of Settlement and Infrastructure No. 534/KPTS/M/2001, applicable water needs, namely as follows:

Domestic Needs = Population X Average household needs (100 ltr/sec and 60 ltr/day).

Non-Domestic Needs

- a. Public facilities = 15% x domestic needs
- b. Office = 15% x domestic needs
- c. Commercial = 20% x domestic needs
- d. Industry = 10% x domestic needs
- e. Hydrant = 10% X (Domestic + Non-Domestic Port)
- f. Water loss = 10% X (Domestic Needs + Non-Domestic Needs)

Based on these calculations, the total demand for clean water will be reviewed at 5-year time intervals, namely 2027, 2032, 2037 and 2042 (20 year projection), this is done to anticipate the dynamics of population growth which tends to increase each period of time. . Water

production in Palopo City for 2022 can be seen in table 3 and the existing domestic and non-domestic clean water needs in Palopo City can be seen in **table 4**.

Table 3. Water production in Palopo City, 2022

IKK	L/sec	L/day	M ³ /day	Demands in 2022 (m ³ /day)	Family (m ³ /day)
WTP 1	40	40	3.456.000		Exceed the needs of Palopo City
WTP 2	100	100	8.640.000		
WTP 3	70	70	6.048.000		
WTP 4	50	50	4.320.000		
IPAM II WTP	90	90	7.776.000		
IPAM III WTP	20	20	1.728.000		
IPA Latupa	390	390	33.696.000		
Total Production	760	60	65.664,00	36.973,65	28.690,35

Source: Regional Water Beaurau of Palopo City [15] and Researcher Team analysis 2022

Table 4. Domestic Water Needs and Non-Domestic Existing in Palopo City

Subdistrict	Domestik Water Demand (2022)			Non-Domestik Water Demand (2022)					Hydraa	Water Losses	Qr (mean of water demand)	Max. Day (maks)	Max. Hour (Peak)
	Population 2021 (person)	Qp (1/person/day)	Qd (m ³ /day)	Public Facilities	Office	Commercial	Industrial	Amount					
Wara Selatan	19.163	100	1.916,3	166,05	166,05	221,40	110,70	664,70	177,12	354,24	2.125,44	2.444,26	3.188,16
Sendana	7.490	100	749,90	93,74	93,74	124,98	62,49	374,94	99,98	199,97	1.199,81	1.379,78	1.799,71
Wara	31.910	100	3.191,0	548,24	548,24	730,98	365,49	2.192,94	584,78	1.169,57	7.017,41	8.070,02	10.526,11
Wara Timur	38.762	100	3.876,2	544,79	544,79	726,38	363,19	2.179,14	581,10	1.162,21	6.973,25	8.019,24	10.459,87
Mungkajang	10.323	100	1.042,3	113,63	113,63	151,50	75,75	454,50	121,20	242,40	1.454,40	1.672,56	2.181,60
Wara Utara	20.888	100	2.088,8	324,14	324,14	432,18	216,09	1.296,54	345,74	691,49	4.148,93	4.771,27	6.223,39
Bara	31.021	100	3.102,1	395,00	395,00	526,66	263,33	1.579,98	421,33	842,66	5.055,94	5.814,33	7.583,90
Telluwana	16.179	100	1.617,9	190,91	190,91	254,54	127,27	763,62	203,63	407,26	2.443,58	2.810,12	3.665,38
Wara Barat	11.595	100	1.159,5	156,95	156,95	209,26	104,63	627,78	167,41	334,82	2.008,90	2.310,23	3.013,34
Palopo	187.331	100	18.744,0	2.533,41	2.533,41	3.377,88	1.688,94	10.133,64	2.702,30	5.404,61	36.973,65	37.291,80	48.641,47

Based on table 3 and table 4, it shows that the population of the city of Palopo for 2021 is 187,331 people as the basis for calculating the need for clean water for 2022, from the calculation results it is obtained that for 2022 clean water production from 7 Water Treatment Installations in Palopo City, in total produces 65,664.00 m³/day, while the need for 2022 is 36,973.65 m³/day including hydrants and water loss, so there is an overproduction of 28,690.35 m³/day. Projections of clean water demand in Palopo City, both domestic and non-domestic for the next 20 years with an interval of 5 years, are presented in **table 5** and **table 6**.

Table 5. Domestic Clean Water needs in Palopo City

Year	Water needs in 2027			Hydrant	Water loss	Qr (water needs average)	Maks. Daily (qmaks)	Maks. Hour
	Pd (person)	Qp (l/person/day)	Qd (m ³ /day)					
2027	208.912	100	20.891,20	2.873,06	5.746,11	29.510,37	39.648,15	51.714,98
2032	226.895	100	22.689,50	2.998,61	5.997,61	31.685,72	41.380,86	53.975,03
2037	244.879	100	24.487,90	3.085,39	6.170,79	33.744,08	42.578,45	55.537,11
2042	262.863	100	26.286,30	3.151,78	6.303,57	35.741,65	43.494,60	56.732,09

Table 6. Projection on Non-domestic clean water needs in Palopo City

Year	Non-Domestic water needs				Hidrant	Water loss	Total
	Public facilities	Office	Commerce	Industry			
2027	1.795,60	2.693,49	1.795,59	1.795,66	1.346,80	1.346,80	10.773,95
2032	2.811,20	2.811,20	3.748,27	1.874,13	1.124,48	1.124,48	13.493,76
2037	2.892,56	2.892,56	3.856,74	1.928,373	1.157,02	1.157,02	13.884,27
2042	2.954,80	2.954,80	3.393,73	1.969,86	1.181,91	1.181,91	14.183,00

Based on Table 5 and Table 6, the community's need for clean water in Palopo City in 2027 for domestic is 29,510.37 m³/person/day, non-domestic including water that stays in pipes and water loss due to leaks and others is 10,773.95 m³/person/day, in 2032 for domestic is 31,685,72 m³/person/day and non-domestic is 13,493.76 m³/person/day, in 2037 for domestic is 33,744.08 m³/person/day and non-domestic 13,884.27 m³/person/day, and in 2042 for domestic as much as 35,741.65 m³/person/day and for non-domestic as much as 14,183.00 m³/person/day.

4. CONCLUSION

This research identifies the need for water in Palopo City, South Sulawesi Province for up to 20 years of projections to come, which is based on data on the number of residents who are expected to continue to increase every year, where in 2022 there will be 190,928 people, in 2027 there will be 208,912 people, in 2032 there will be 226,895 inhabitants, in 2037 as many as 244,879 people and in 2042 as many as 262,863 people, with a population increase of around 1.92% each year. The results show that the need for clean water for the community in Palopo City in 2027 for domestic is 29,510.37 m³/person/day, non-domestic including water that stays in pipes and water loss due to leaks and others is 10,773.95 m³/person/day, in 2032 for domestic as much as 31,685.72 m³/person/day and non-domestic as much as 13,493.76 m³/person/day, in 2037 for domestic as much as 33,744.08 m³/person/day and non-domestic 13,884.27 m³/person/day, and in 2042 for domestic as much as 35,741.65 m³/person/day and for non-domestic as much as 14,183.00 m³/person/day, so it can be

concluded that in terms of quantity, the need for clean water in Palopo City is still fulfilled until 2042.

REFERENCES

1. Nnorom, I.C.; Ewuzie, U.; Eze, S.O. Multivariate statistical approach and water quality assessment of natural springs and other drinking water sources in Southeastern Nigeria. *Heliyon*, 5, e01123.2019
2. Mishra, A.P.; Khali, H.; Singh, S.; Pande, C.B.; Singh, R.; Chaurasia, S.K. An assessment of in-situ water quality parameters and its variation with Landsat 8 level 1 surface reflectance datasets. *Int. J. Environ. Anal. Chem.* 1–23. 2021.
3. Tyagi, S.; Sharma, B.; Singh, P.; Dobhal, R. 2013. Water quality assessment in terms of Water Quality Index. *Am. J. Water Resour.* 1, 34–38.
4. World Health Organization. *Guidelines for Drinking-Water Quality: Second Addendum*; World Health Organization: Geneva, Switzerland; Volume 1, Recommendations. 2008.
5. Putu, N., Artini, R., Putu, D., Va, R., Kadek, N., & Fujiastuti, M. Penelitian Kualitas Air Sungai Balian, Tabanan, Bali Tahun 2018. *Jurnal Kesehatan Terpadu*, 2(1), 25–30. 2018.
6. Tokatli, C. 2019. Drinking water quality assessment of Ergene River basin (Turkey) by Water Quality Index: Essential and toxic elements. *Sains Malays.* 48, 2071–2081. 2019.
7. Panneerselvam, B.; Muniraj, K.; Duraisamy, K.; Pande, C.; Karuppannan, S.; Thomas, M. An integrated approach to explore the suitability of nitrate-contaminated groundwater for drinking purposes in a semiarid region of India. *Environ. Geochem. Health*, 1–17. 2022.
8. Tiwari, M.; Adamowski, J.; Adamowski, K. 2016. Water demand forecasting using extreme learning machines. *J. Water Land Dev.* 28, 37–52.
9. Brentan, B.M.; Luvizotto, E., Jr.; Herrera, M.; Izquierdo, J.; Pérez-García, R. Hybrid regression model for near real-time urban water demand forecasting. *J. Comput. Appl. Math.* 2017, 309, 532–541
10. Vonk, E.; Cirkel, D.G.; Blokker, M. Estimating peak daily water demand under different climate change and vacation scenarios. *Water* 2019, 11, 1874.
11. De Souza Groppo, G.; Costa, M.A.; Libânio, M. 2019. Predicting water demand: A review of the methods employed and future possibilities. *Water Supply*, 19, 2179–2198.
12. Mala-Jetmarova, H., Sultanova, N. & Savic, D. 2017. Lost in optimisation of water distribution systems? A literature review of system operation. *Environ. Model. Softw.* 93, 209–254
13. Antunes, A.; Andrade-Campos, A.; Sardinha-Lourenço, A.; Oliveira, M. 2018. Short-term water demand forecasting using machine learning techniques. *J. Hydroinform.* 20, 1343–1366.
14. BPS-Statistics of Palopo Municipality. 2022. Palopo Municipality in Figures 2022.
15. PDAM Kota Palopo. 2022. Annual Report 2022.