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The Future Challenge: Water Demand Forecasting

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Abstract

Palembang has abundant water sources; the city of Palembang is traversed by one of the longest rivers in Indonesia, the Musi River. However, population growth is increasing over time, as is the need for clean water. Projections of the amount of clean water demand in the future are needed; apart from anticipating water shortages, water demand projections are required to construct clean water facilities and infrastructure. This research was conducted using statistical calculations to calculate the population in the next ten years. The population of Palembang in 2030 is projected to increase to1,898,221 inhabitants. The results of this population projection are used in calculating the total water demand in 2030. The total water demand is obtained from the calculation of domestic, non-domestic, fire hydrant, and water loss needs. In 2030, the total amount of water needed is 6,816 L / second.

Keywords: Forecasting, Water Demand, Water Need, Population.

INTRODUCTION

Water is one of the important components in life. All living things on this earth need water to survive. Plants, animals, and humans need water in their daily life. In particular, they need water for drinking, washing, cooking, transportation, etc. (Langi & Mangangka, 2015). Earth contains a lot of water, which consists of rivers, seas, lakes, etc. However, only 3% of freshwater that can be used comes from rivers, lakes, and groundwater(June & Goals, 2018).

The life of urban communities is very dynamic, resulting in the need for water to be essential (Nugraha Sadeli Utama, 2019). In general, the need for clean water increases every year, while water availability is increasingly limited(Afrianto, 2015). the catchment area is getting narrower over time, displaced by the development and exploitation of natural water sources that do not pay attention to the environment around the water source (Suheri et al., 2019).

Palembang City is one of the most densely populated Metropolitan cities in Indonesia. The area of the city of Palembang is 400.61 km2, with a population of 1.6 million people by 2020 (Central Statistics Agency of South Sumatra). The population growth continues to increase every year the amount of water needed. Palembang City is one of the cities that has abundant water resources because this city is traversed by one of the longest rivers in Indonesia, namely the Musi River. But, this great water is not followed by good water quality(Suryani, 2016). Industrial activities such as mining, plantation, agriculture, and household activities in this river have resulted in a decrease in water quality, which is exposure to heavy metals such as mercury (Heru Setiawan, 2014). Household, industrial and agricultural activities result in waste that cannot be

appropriately treated to impact environmental quality degradation(Suriawiria, 1996). Water degradation is the impact of untreated waste. The waste is disposed of directly into the river body uncontrollably. Many developments along the river have also resulted in a reduced carrying capacity of the river against pollutants(Kospa & Rahmadi, 2019). This has resulted in a reduced amount of water in Palembang City that can be utilized.

Based on the existing problems, projections of the amount of water demand in the future are needed. The prediction of the amount of water demand in the future is also needed for the construction of better clean water facilities and infrastructure capable of serving the community equally.

METHODS

Water is one of the important components in the life of living things, especially humans. Water needs are unlimited and sustainable needs. The increase in population automatically increases water demand. However, rising in demand was not matched by an enlarge in service capabilities (Langi & Mangangka, 2015). For an increase in the amount of water needed to be balanced within servants and projection data. Hence, the facilities and infrastructure for water needs can be immediately built to improve services.

The amount of water demand is the total amount of water needed for domestic and non-domestic needs (household, educational facilities, industrial facilities, religious facilities, and others). Domestic and non-domestic water needs are a priority (Deny, 2010).

Prediction of Population Number

The increase of the population also escalation the amount of water needed.

There are three methods commonly used to calculate population predictions:

a. Arithmetic Method

This method uses the assumption that the population growth rate is constant each year. The equation is as follows:

$$P_n = P_o + (K_a.X)$$

$$K_a = \frac{P_o - P_t}{t}$$

Where :
Pn = total population n in the coming year
Po = Total population at the beginning of the data year
Pt = total population at the end of the data year
X = Time interval (year from year n - last year)
t = Data year time interval (n-1)

b. Geometry Methods

This method assumes that population development automatically doubles with population increase. In this method, the possibility of downward development is not considered. The equation is as follows:

$$Yn = P_t(1+r)^n$$

$$r = \left(\frac{P_t}{P_o}\right)^{\left(\frac{1}{t}\right)} - 1$$

Where :
Pn = total population in the next n years
Po = Total population at the beginning of the data year
Pt = total population at the end of the data year
n = number of projection years
r = The ratio of average population increase per year
t = Data year time interval (n - 1)

c. Least Square Method

This method is used for areas with a linear trend in population growth, although population growth does not always increase. The equation is as follows:

$$Yn = a + b.X$$

$$a = \frac{(\sum Y.\sum X^2) - (\sum X.\sum XY)}{(n.\sum X^2) - (\sum X)^2}$$

$$b = \frac{(n.\sum XY) - (\sum X.\sum Y)}{(n.\sum X^2) - (\sum X)^2}$$

Where :
Yn = Total population in the next n years
a, b = Constants
X = Year increment
n = amount of data

Water Supply Standards

There are two types of standards for clean water needs, namely (DPU, Dirjen Cipta Karya):

a. Domestic Water Supply Standards

Domestic water supply standards are obtained from the number of domestic users, which can be seen from population data. Standard domestic needs include drinking, bathing, cooking, etc.

Domestic water demand based on city size can be seen in the table below:

Table 1. Water Needs Base on City Size

Category	City Size	Needs Water / Lt / person / day
I	Metropolitan	190
II	Big city	130
III	Medium City	120
IV	Small town	90
V	District City	75
VI	Rural	60

b. Non-Domestic Water Supply Standards

Domestic water supply standards are obtained through non-domestic consumers, consisting of offices, health, industrial, commercial, public, etc.

Non-domestic water needs based on planning criteria at the Public Works Office can be seen in the table below:

Table 2. Non-Domestic Water Needs for Cities Category I, II, III, IV

SECTOR	SCORE	UNIT
School	10	lt / student / day
Hospital	200	lt / bed / day
Public health center	2000	lt / unit / day
Mosque	3000	lt / unit / day
Office	10	lt / employee / day
Market	12000	lt / hectare / day
Hotel	150	lt / bed / day
Restaurant	100	lt / seat / day
Military Complex	60	lt / person / day
Industrial area	0.2-0.8	lt/second/day
Tourism Area	0.1-0.3	lt/second/day

Table 3. Non-Domestic Water Needs for Category V (Village)

SECTOR	SCORE	UNIT
School	5	lt / student / day
Hospital	200	lt / bed / day
Public health center	1200	lt / unit / day
Mosque	3000	lt / unit / day
Prayer room	2000	lt / unit / day
Market	12000	lt / hectare / day
Commercial / Industrial	10	lt / day

Table 4. Non-Domestic Water Needs for Other Categories

SECTOR	SCORE	UNIT
Airfield	10	lt / person / sec
Port	50	lt / person / sec
Train Station and Bus Terminal	10	lt / person / sec
Industrial area	0.75	lt / sec / hectare

RESULTS AND DISCUSSION

Data On The Number Of Populations Of Palembang City 2011-2020

Data on Palembang's population was obtained from the BPS (Central Statistics Agency) of Palembang City in 2020. This data is used to estimate population growth and the number of clean water needs of Palembang City in 2021-2030. Population data for 2011-2020 is presented in the table below.

Table 5. Total Population of Palembang City, 2011-2020

YEAR	TOTAL POPULATION
2011	1490576
2012	1513424
2013	1535936
2014	1558494
2015	1580517
2016	1602071
2017	1623099
2018	1643488
2019	1662893
2020	1681374

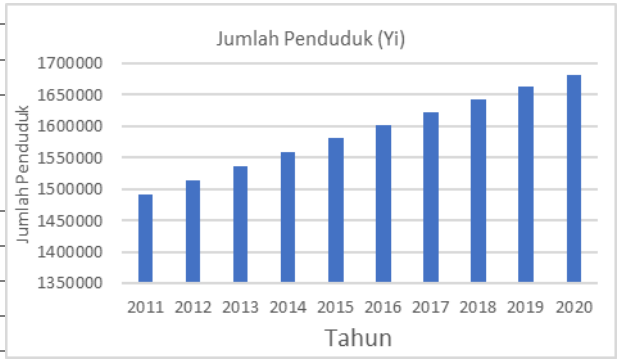

Figure 1. Total Population of Palembang City, 2011-2020

From the data above, it can be seen that there is an increase in the population of Palembang City every year. So that the amount of water needs every year also increases.

Prediction of the amount of water demand in the future is necessary to know the ratio between the availability of clean water and the need for clean water.

Forecasting the Number of Population

There are three population projection methods: Arithmetic Method, Geometry Method, and Method *Least Square*. The projection calculation method selected will be based on the results of the value of Standard Deviation (SD) and the correlation coefficient (r). The correlation coefficient value must be close to 1, and the value of Standard Deviation (SD) is the smallest value chosen.

a. Arithmetic Method

The results of calculating the population projection of Palembang City using the Arithmetic Method are presented in the table below:

Table 6. Population Projection of Palembang City with Arithmetic Method

YEAR	Xi	Pn
2021	1	1702574
2022	2	1723774
2023	3	1744973
2024	4	1766173
2025	5	1787373
2026	6	1808573
2027	7	1829772
2028	8	1850972
2029	9	1872172
2030	10	1893372

With the Arithmetic method, the Standard Deviation (SD) value is obtained of 4226.26 and a correlation coefficient (r) of 0.99.

b. Geometry Methods

The results of calculating the population projection of Palembang City using the Geometry Method are presented in the table below:

Table 7. Population Projection of Palembang City with Geometry Method

YEAR	Xi	Pn
2021	1	1704027
2022	2	1726986
2023	3	1750254
2024	4	1773835
2025	5	1797734
2026	6	1821956
2027	7	1846503
2028	8	1871381
2029	9	1896595
2030	10	1922148

With the Geometry Method, the Standard Deviation (SD) value is 6440.05 and a correlation coefficient (r) of 0.99.

c. Least Square Method

The results of calculating the population projection of Palembang City using the Least Square Method are presented in the table below:

Table 8. Projection of Population in Palembang City with Least Square Method

YEAR	Xi	Pn
2021	11	1706407
2022	13	1727720
2023	15	1749032
2024	17	1770345
2025	19	1791658
2026	21	1812970
2027	23	1834283
2028	25	1855596
2029	27	1876909
2030	29	1898221

With the Least Square method, the standard deviation (SD) value is 2198.19, and the correlation coefficient (r) is 0.99.

Projection Method

The choice of population growth projection method is based on the value of Standard Deviation (SD) and the correlation coefficient (r). Considerations in choosing a strategy include:

1. Standard Deviation (SD) must be the smallest. The slight Standard Deviation (SD) value indicates that the data obtained from the projection is not much different from the original data.
2. The correlation coefficient (r) must be 1 or -1 or close to both.

The recapitulation of the calculation results of the Standard Deviation value and the correlation coefficient (r) of the three methods above are presented in the table below:

Table 9. Comparison of Standard Deviation Value (SD) and Correlation Coefficient (r).

METHOD	CORRELATION COEFFICIENT	DEVIATION STANDARD
Arithmetic	0.999	4226.26
Geometry	0.998	6440.05
Least Square	0.999	2198.19

From the comparison data of the Standard Deviation (SD) and Correlation Coefficient (r) values, the smallest SD value is obtained, namely the Method *Least Square* with a value of 2198.19 and an r-value of 0.999 (close to 1).

From the calculation of the population projection using the method, *Least Square*It is found that the estimated population of Palembang City in 2030 will reach 1,898,221 people. This population growth is quite significant compared to the data from observations in 2020, which was 1,681,374 people.

Area Facilities Projection

The types of area facilities to be projected are:

a. Educational Facilities

The educational facilities that will be projected are based on the number of students in the educational facilities. The projected types of facilities are Kindergarten, SD / MI, SMP, SMA, and University.

b. Worship Facilities

The projected types of worship facilities are mosques, prayer rooms, churches, monasteries, and temples.

c. Medical facility

The projected types of health facilities are: hospital/polyclinic (number of beds), health center, pharmacy.

d. Industrial Facilities

The industrial facilities projected are based on the number of employees working in the industrial sector in Palembang City.

e. Public facilities

The projected types of public facilities are: offices and a sports building.

f. Trade and Service Facilities

The projected types of trade and service facilities are terminals, shops, markets (wide), restaurants (seats), hotels (beds), cinemas.

Determination Of Domestic Water Needs

a. Determination of Domestic Water Needs

The calculation of domestic water demand is calculated using standards from the Ministry of Public Works (PU), namely the Technical Guidelines for Planning the Technical Design of the Drinking Water Supply System (1998). Domestic water demand can be seen in the table below.

Table 10. Service Coverage for Domestic Needs 2021-2030

Year	amount Population	Scope Service	
		%	Soul
2021	1,706,407	60	1,023,844
2023	1,749,032	65	1,136,871
2025	1,791,658	70	1,254,160
2028	1,855,596	75	1,391,697
2030	1,898,221	80	1,518,577

Table 11. Number of House Connections (SR) and Public Hydrant (HU) for Domestic Needs 2021-2030

Year	amount Population	SR		HU	
		%	Soul	%	Soul
2021	1,706,407	70	1,194,485	30	511,922
2023	1,749,032	70	1,224,323	30	524,710
2025	1,791,658	70	1,254,160	30	537,497
2028	1,855,596	80	1,484,477	20	371,119
2030	1,898,221	80	1,518,577	20	379,644

Table 12. Water Requirement for House Connections 2021-2030

Year	amount Population Served (Soul)	Std Water Consumption (L / o / day)	Needs Water (L / sec)

2021	1,706,407	190	3,753
2023	1,749,032	190	3,846
2025	1,791,658	190	3,940
2028	1,855,596	190	4,081
2030	1,898,221	190	4,174

Table 13. Water Requirement for General Hydrant 2021-2030

Year	amount Population Served (Soul)	Std Water Consumption (L / o / day)	Needs Water (L / sec)
2021	1,706,407	30	593
2023	1,749,032	30	607
2025	1,791,658	30	622
2028	1,855,596	30	644
2030	1,898,221	30	659

b. Determination of Non-Domestic Water Needs

The calculation of non-domestic water needs is calculated based on the Ministry of Public Works standard, namely the standard of water needs for urban facilities.

1) Educational Facilities

The need for drinking water for education facilities is calculated based on the standards of the Directorate General of Human Settlements, Public Works, 1998. With the standard requirement of 10 L / Student/day. The need for drinking water for educational facilities shows in the table below:

Table 14. Total Need for Drinking Water for Educational Facilities

No.	Year	Standard Needs (L / student / day)	Total Water Needs (L / sec)
1	2023	10	59.5
2	2028	10	63.1
3	2030	10	64.6

2) Worship Facilities

The need for drinking water for worship facilities is calculated based on the standards of the Ministry of Public Works, 1996. The standard needs for mosques are 3000 (L / Unit / Day), 500 Mushola (L / Unit / Day), 300 Church (L / Unit / Day), Vihara 100 (L / Unit / Day) and Pura 100 (L / Unit / Day). The need for drinking water for worship facilities shows in the table below:

Table 15. Total Needs for Drinking Water for Worship Facilities

No.	Year	Total Water Requirements (Mosques, prayer rooms, churches, temples & temples) (L / sec)
1	2023	35.2
2	2028	35.3
3	2030	35.3

3) Health Facilities

The need for drinking water for health facilities is calculated based on the standards of the Department of Public Works, 1996. Standard Needs for Hospitals / Polyclinics are 200 (L / Unit / Day), Puskesmas 2000 (L / Unit / Day), Pharmacy 100 (L / Unit / Day) . The need for drinking water in health facilities can be seen in the table below:

Table 16. Total Need for Drinking Water in Health Facilities

No.	Year	Total Water Requirements (Hospital / Polyclinic, Puskesmas & Pharmacy) (L / sec)
1	2023	1.5
2	2028	1.6
3	2030	1.6

4) Industrial Facilities

The need for drinking water for industrial facilities is calculated based on the Directorate General of Human Settlements, Public Works, 1998. With a standard requirement of 10 L / person/day. The amount of water demand for industrial facilities is calculated based on the population of Palembang City who works in the industrial sector; the increase in the number of employees is calculated based on the projected population of Palembang City. The need for drinking water for industrial facilities can be seen in the table below:

Table 17. Total Need for Drinking Water in Industrial Facilities

No.	Year	Standard Needs (L / person / day)	Total Water Needs (L / sec)
1	2023	10	0.1
2	2028	10	0.1
3	2030	10	0.1

5) Public Facilities

The need for drinking water for facilities general is calculated based on the standards of the Ministry of Public Works, 1996. Standard office needs are 10 (L / Employee / Day), and the Sports Building 2000 (L / Unit / Day). The need for drinking water for public facilities can be seen in the table below:

Table 18. Total Need for Drinking Water for Public Facilities

No.	Year	Total Water Requirements (Office, Gymnasium) (L / sec)
1	2023	1.5
2	2028	1.6
3	2030	1.7

6) Trade and Service Facilities

The need for drinking water for public facilities is calculated based on the standards of the Ministry of Public Works, 1996 and the Director-General of Human Settlements, Public Works, 1998. Standard Terminal Needs are 2000 (L / Unit / Day), 500 Shops (L / Unit / Day), Market 12000 (L / Unit / Day), Restaurant 100 (L / Unit / Day), Hotel 150 (L / Unit / Day) and Cinema 2000 (L / Unit / Day). The need for drinking water for trade and service facilities can be seen in the table below:

Table 19. Total Need for Drinking Water for Trade and Service Facilities

No.	Year	Total Water Requirements (Terminals, Shops, Markets, Restaurants, Hotels, and Cinemas) (L / sec)
1	2023	299.3
2	2028	304.3
3	2030	306.2

Recapitulation Of Domestic And Non-Domestic Water Need

The total amount of Domestic and Non-Domestic Water needs in the planning area can be seen in the recapitulation table below:

Table 20. Total Domestic and Non-Domestic Water Needs

No.	Amenities	Requirement (L / sec)		
		2023	**2028**	**2030**
1	**Domestic**			
	Home Connection	3,846	4,081	4,174
	General Hydrant	607	644	659
	Amount (L / sec)	**4,454**	**4,725**	**4,833**
2	**Non Domestic**			
	Educational Facilities	59.51	63.13	64.58
	Worship Facilities	35.18	35.27	35.27
	Medical facility	1.52	1.57	1.58
	Industrial Facilities	0.07	0.08	0.08
	Public facilities	1.54	1.62	1.65
	Trade & Service Facilities	299.30	304.25	306.24
	Amount (L / sec)	397.11	405.92	409.40
	Total Amount (L / sec)	4850.67	5130.82	5242.84

Loss of Water

The total amount of water demand is the total amount of water demand minus water losses. The amount of water loss is estimated to be 20% of the total demand.

The amount of water loss from 2023-2030 can be seen in the table below:

Table 21. Water Loss

Year	Q (L / sec)	% Lost	Q (L / sec)
2023	4,850.67	20	970.13
2028	5,130.82	20	1,026.16
2030	5,242.84	20	1,048.57

Total Water Need

Total water demand is based on population projections, projections of domestic and non-domestic needs, as well as water losses, so it can be seen that the projected total water needs in 2023-2030 The total water requirement can be seen in the table below:

Table 22. Total Water Requirements

Year	Q Domestic & Non Domestic (L / sec)	Q Fire Hydrant (L / sec)	Q Lost (L / sec)	Q Total (L / sec)
2023	4850.67	485.07	970.13	6,306
2028	5130.82	513.08	1,026.16	6,670
2030	5242.84	524.28	1,048.57	6,816

CONCLUSION

The projection of the amount of water demand in Palembang City is calculated using statistical methods, namely the Arithmetic Method, the Geometry Method, and the Least Square Method. The data obtained from the

Central Bureau of Statistics are calculated using these three methods, of which the method chosen is the Least Square method. This is based on the correlation coefficient results, which is 1 or close to one and with the smallest Standard Deviation value. The calculation shows that the increase in the population of Palembang City in 2030 will increase by 1,898,221 people. So that with the projection of the people in 2030, the amount of domestic water demand can be obtained, namely 4,833 L / second in 2030.

Meanwhile, the amount of non-domestic water needs is obtained from the calculation of area facilities, namely: educational facilities, religious facilities, health facilities, industrial facilities, public facilities as well as trade and service facilities. The total non-domestic water demand in 2030 from the calculation of regional facilities is 409.4 L / second.

In addition, the amount of domestic and non-domestic water needs, to obtain the total demand, the amount of water loss is also calculated, the amount of water loss is as much as 20% of the total need. The calculation result of water loss in 2030 is 1,048.57 L / second.

Water demand for Palembang City in 2030 from the calculation of domestic, non-domestic, water needs. *Fire Hydrant* and the amount of water loss is 6,816 L / s.

REFERENCES

Afrianto, L. (2015). Proyeksi Kebutuhan Air Bersih Penduduk Kecamatan Indramayu Kabupaten Indramayu Sampai Tahun 2035. *Universitas Pendidikan Indonesia*, *1102794*.

Deny. (2010). Evaluasi Jaringan Pipa Distribusi Air Bersih PDAM Kab. Kampar. *Jurnal Perencanaan Wilayah Dan Kota*.

Heru Setiawan. (2014). Pencemaran Logam Berat Di Perairan Pesisir Kota Makassar Dan Upaya Penanggulangannya. *Info Teknis EBONI*, *11*(1), 1–13.

Juni, V. N., & Tujuan, M. (2018). *Air Bersih, Kebutuhan Air Bersih, Kapasitas Alat, Kapasitas Produksi, Standar Debit Minimum* . *6*, 79–84.

Kospa, H. S. D., & Rahmadi, R. (2019). Pengaruh Perilaku Masyarakat Terhadap Kualitas Air di Sungai Sekanak Kota Palembang. *Jurnal Ilmu Lingkungan*, *17*(2), 212. https://doi.org/10.14710/jil.17.2.212-221

Langi, B. V., & Mangangka, I. R. (2015). *Perencanaan Pengembangan Sistem Penyediaan Air Bersih Kelurahan Kayawu Kota Tomohon*. *3*(5), 303–312.

Nugraha Sadeli Utama. (2019). Proyeksi Kebutuhan Air Baku Kota Tasikmalaya Pada Tahun 2025. *Jurnal Infrastruktur*, *3*(2), 137–145. https://doi.org/10.35814/infrastruktur.v3i2.717

Suheri, A., Kusmana, C., Purwanto, M. Y. J., & Setiawan, Y. (2019). Model Prediksi Kebutuhan Air Bersih Berdasarkan Jumlah Penduduk di Kawasan Perkotaan Sentul City. *Jurnal Teknik Sipil Dan Lingkungan*, *4*(3), 207–218. https://doi.org/10.29244/jsil.4.3.207-218

Suriawiria, U. (1996). *Air dalam kehidupan dan lingkungan yang sehat*.

Suryani, A. S. (2016). Persepsi Masyarakat Dalam Pemanfaatan Air Bersih (Studi Kasus Masyarakat Pinggir Sungai Di Palembang). *Aspirasi*, *7*(1), 33–48.