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Analysis of Clean Water Supply Needs in Penajam Paser Utara Regency

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A R T I C L E I N F O

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A B S T R A C T

The clean water service coverage in Penajam Paser Utara (PPU) Regency reached only 26% in 2023, comprising 14.75% through piped water supply systems (SPAM-JP) and 11.25% through non-piped systems (SPAM-NJP). Meanwhile, Indonesia's national target for 2024 aims for 100% access to safe drinking water. This study aims to analyze service coverage, maximum water demand, and the water balance in Penajam Paser Utara Regency. The analysis involves population projections, customer projections, and estimations of water demand and production capacity. The findings indicate a projected increase in service coverage as infrastructure capacity expands. The previously existing water supply deficit is expected to gradually shift to a surplus, facilitating a more equitable and sustainable water supply system

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INTRODUCTION

The availability of clean water in urban areas is a fundamental necessity that must be fulfilled to support daily human activities. Water is a primary resource required for various essential activities such as bathing, drinking, washing, cooking, and other domestic uses. In this study, Kabupaten Penajam Paser Utara (PPU) is selected as the case study for analyzing clean water needs. The region exhibits a growing population trend each year, necessitating an increased demand for clean water. Several factors influence the demand for clean water, including population growth, the number of household connections, and the number of individuals per household.

Perumda Air Minum Danum Taka plays a vital role in meeting the clean Water Demands of Kabupaten Penajam Paser Utara. However, the current water supply infrastructure has not yet been able to fulfill the total demand for clean water in the region. This issue is evident from the significant number of new service connection requests that remain unprocessed. Additionally, the coverage of clean water services in 2023 only reached 26%, with 14.75% coming from the piped water supply system (SPAM-JP) and 11.25% from non-piped water supply systems (SPAM-NJP). This situation, if left unaddressed, is expected to worsen due to the continuous increase in water demand in line with population growth. The disparity between water demand and supply has resulted in a declining service coverage rate, leading to a greater number of residents who lack access to clean water services. One potential solution to mitigate this issue is increasing production capacity. To plan for such an increase effectively, a comprehensive analysis of clean water demand is required to determine the necessary supply levels, ensuring that capacity expansion is well-planned and aligned with future needs.

Previous studies have extensively examined clean water demand analysis in various urban areas in Indonesia, such as the Clean Water Development Study for PDAM Tirta Barito in Buntok City, the Clean Water Demand Analysis for Batam City, and the Clean Water Demand Projection for Pulang Pisau City. These studies generally utilize standards from the Ministry of Public Works to estimate water consumption based on city classification by population size. However, a limitation of this method is that it assumes a generalized water consumption rate without considering specific urban consumption characteristics, despite the fact that each city has distinct water use patterns.

To address this limitation, this study employs an approach based on the actual water consumption rate in Kabupaten Penajam Paser Utara, derived from historical consumption data from Perumda Air Minum Danum Taka. This method has been successfully applied in other countries, such as Turkey, where water demand analysis is based on real historical consumption data. The adoption of this approach is expected to provide a more accurate representation of actual water demand in the study area.

LITERATURE REVIEW

Furthermore, this study includes projections of service coverage and water balance as supplementary parameters in the clean water demand analysis. Therefore, the primary objectives of this research are to assess service coverage, determine maximum water demand, and analyze the water balance. The findings from this study are expected to serve as key parameters for future clean water planning in Kabupaten Penajam Paser Utara and provide valuable insights for Perumda Air Minum Danum Taka in formulating strategic decisions to achieve optimal service delivery in the coming years.

METHODOLOGY

This research consists of several essential stages that must be carried out systematically. A summary of these stages is presented in the research flowchart in Figure 1 below.

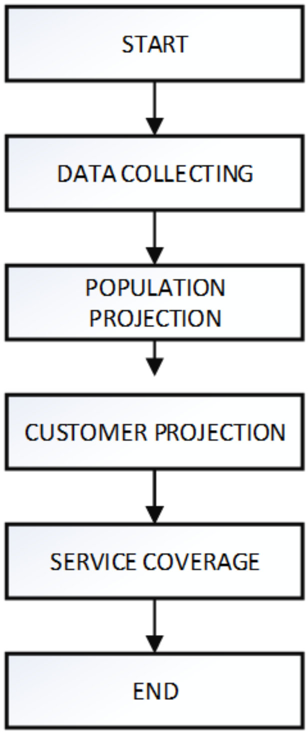

Figure 1. Research Method

A. Study Location

Penajam Paser Utara (PPU) Regency is located at approximately 1.2686°S latitude and 116.7081°E longitude, covering an area of 3,333.06 km². As of 2024, the district has a population of 196,566 people, with a distribution concentrated in urban centers such as Penajam, Babulu, Waru, and Sepaku. The region's water resources are influenced by several major rivers, including the Kelai, Paser, and Tunan Rivers, which serve as potential raw water sources. Additionally, PPU has several small reservoirs and groundwater sources that contribute to local water supply. However, access to clean water remains a significant challenge, with only 22.43% of the population receiving piped water services from Perumda Air Minum Danum Taka, while 0.66% is served by non-municipal piped systems. The remaining population relies on alternative sources such as wells, rainwater harvesting, and surface water, which are highly susceptible to seasonal variations and contamination risks. Rapid urbanization, industrial development, and the establishment of Indonesia's new capital (IKN Nusantara) in the neighboring region have further intensified the demand for clean water, highlighting the urgent need for infrastructure improvements and sustainable water resource management in PPU.

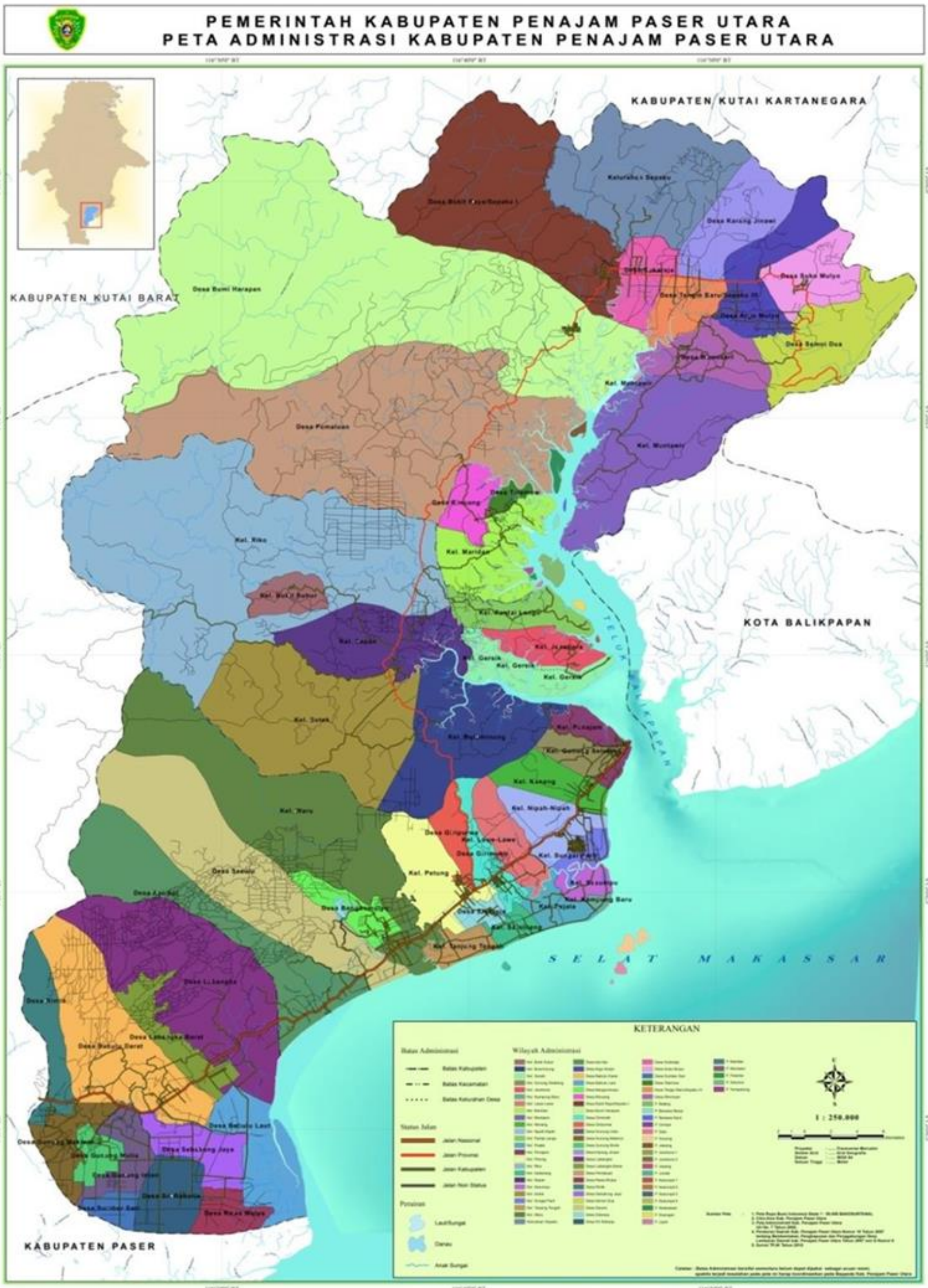

Figure 2. Penajam Paser Utara (PPU) Regency Map

B. Population Projection

To determine the projected drinking water demand, it is first necessary to estimate the population of the planning area up to the end of the design period (2039). The population projection is carried out using the following methods:

1. Arithmetic Method

This method assumes a constant absolute increase in population over time. It is suitable for regions with relatively stable growth patterns and is expressed mathematically as:

Pt=P0+(r×t)P_t = P_0 + (r \times t)Pt=P0+(r×t)

where Pt is the projected population in year ttt, P0P_0P0 is the base year population, rrr is the annual population increase, and ttt is the projection period.

2. Geometric Method

This method assumes a constant percentage growth rate and is suitable for areas experiencing exponential population growth. The formula used is:

Pt=P0×(1+r)tP_t = P_0 \times (1 + r)^tPt=P0×(1+r)t

where rrr represents the annual growth rate as a decimal.

3. Least Square Method

This method analyzes past population trends and determines the best-fitting linear equation through statistical regression. It minimizes the sum of squared differences between observed and estimated values, providing a more refined projection model.

4. Water Demand Calculation

After projecting population growth, the next step is to calculate the water demand using the following equations:

Qmd = Population □ q
Qmdmax = Qmd □ F (maxday)
Qmdpeak hour = Qmd □ F (peak hour)

Where:

Qmd = Water Demand (l/day)
Q = Water Consumption per Person per Day
Qmdmax = Maximum Daily Water Demand
Fpeak hour = Peak Hour Factor

RESULTS AND DISCUSSION

A. Population Projection

To estimate the population, previous population data is used. The population data of Penajam Paser Utara Regency used for projection is from the years 2013 to 2023. This can be seen in the following table.

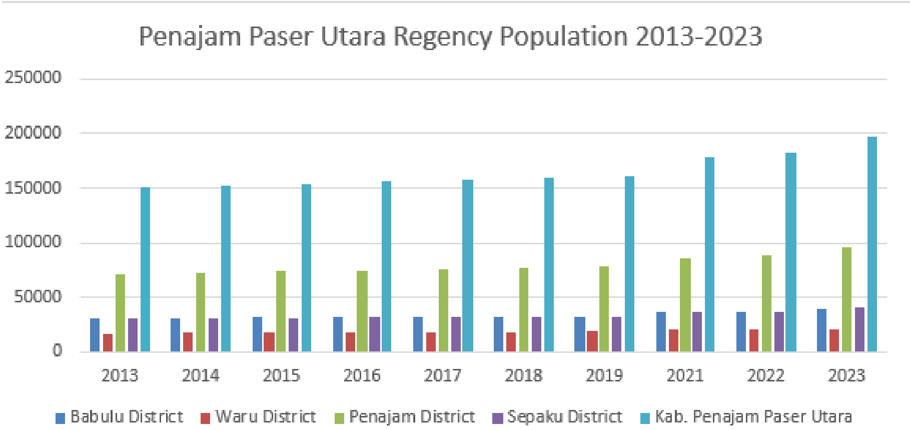

Figure 3. Penajam Paser Utara Regency Population 2013-2023

In calculating the population growth ratio in Penajam Paser Utara Regency using the least square method, the results of the population estimation in Penajam Paser Utara Regency using this method are presented in the following figure**.**

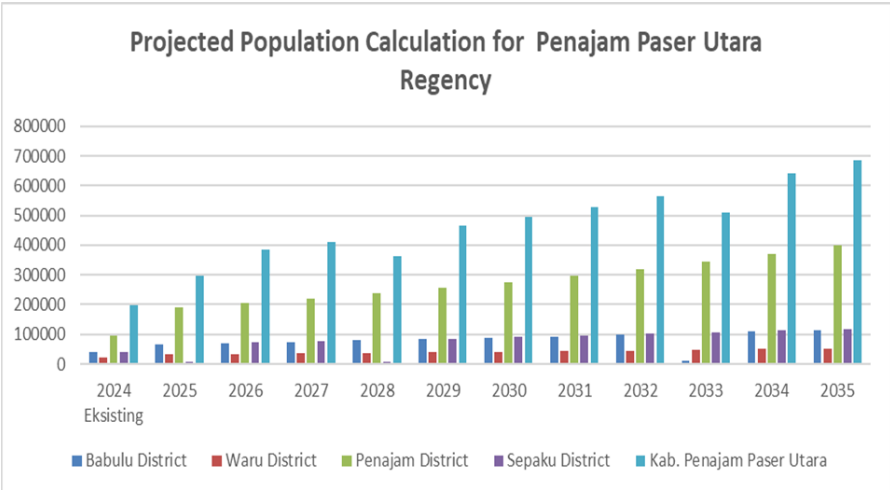

Figure 4. Projected Population Calculation for Kabupaten Penajam Paser Utara

B. Water Demand Projection

The projection of clean water demand is planned until the year 2035, calculated based on the population and planning criteria.

Table 1. Penajam Paser Utara Regency Average Total Water Demands in a Year

No	Water Demands	Unit	Average Total Water Demands in a Year							
			2025	2026	2027	2028	2029	2030	2035	2039
1	Regency Capital	(l/s)	388	405	412	419	427	549	613	717
2	District Capital	(l/s)	162	171	177	182	189	237	287	345
3	Service Unit	(l/s)	5.77	7.5	11.12	11.85	11.87	18.35	25.76	31

Table 2. Penajam Paser Utara Regency Average Total Water Demands in a Year

No	Water Demands	Unit	Total Maximum Daily Water Requirement (Qmax)							
			2025	2026	2027	2028	2029	2030	2035	2039
1	Regency Capital	(l/s)	466	486	495	503	512	658	735	861
2	District Capital	(l/s)	193	205	212	219	226	285	345	413
3	Service Unit	(l/s)	6.91	9.03	13.35	13.73	14.11	21.77	30.75	37.33

Table 3. Penajam Paser Utara Regency Total Peak Hour Water Requirement (Q Peak)

No	Water Demands	Unit	Total Peak Hour Water Requirement (Q peak)							
			2025	2026	2027	2028	2029	2030	2035	2039
1	Regency Capital	(l/s)	583	607	618	629	640	823	919	1.076
2	District Capital	(l/s)	242	257	265	274	283	357	431	516
3	Service Unit	(l/s)	8.16	11.2	16.23	17.27	17.31	27.03	38.64	47.01

C. Water Balance

The water balance consists of the potential surface water that will be utilized as a raw water source. This potential can be calculated by subtracting the utilized discharge from the reliable surface water/river discharge data.

Table 4. Penajam Paser Utara Regency Water Balance

PAM	Installed Capacity (l/s)	Production Volume (m^3/year)	Production Volume (l/s)	Idle Capacity (l/s)	Raw Water Source	Raw Water Capacity (l/s)
Spam Lawe-Lawe	280	5,598,720	180	100	Lawe-Lawe River	300
Spam Unit Waru	20	528,768	17	3	Waru Reservoir	200
Spam Unit Sepaku	30	933,120	30	0	Tangin Baru River	15
Spam Unit Maridan	10	211,507	6.8	3.6	Maridan Reservoir	20
Spam Unit Sotek	10	248,832	9	1	Sotek Reservoir	15

D. Existing Conditions

In 2024, the piped water service (JP) managed by Perumda Air Minum Danum Taka in Kabupaten Penajam Paser Utara covers approximately 22.43% of the total administrative population, equivalent to 44,094 residents out of 196,566. Meanwhile, the piped water service (JP) managed by non-Perumda providers remains significantly lower, reaching only 0.66% or 1,305 residents. These figures indicate that a substantial portion of the population still relies on alternative water sources, highlighting the urgent need for infrastructure expansion and service improvements to ensure broader access to clean water in the region.

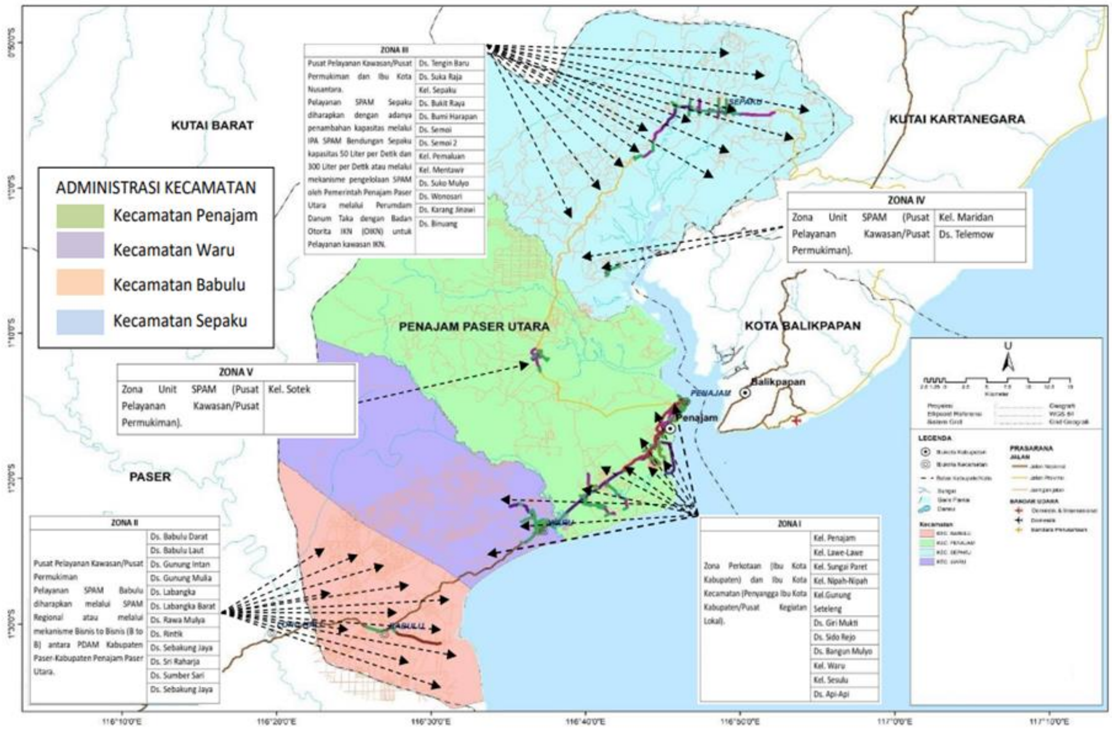

Figure 5. Penajam Paser Utara Regency SPAM Service Zone Map

Based on the analysis comparing the current water production capacity with the projected water demand in Penajam Paser Utara Regency, it can be concluded that the existing production capacity is significantly insufficient. The total current water production capacity from all SPAM (Regional Drinking Water Supply Systems) is 242.8 l/s, while the projected peak hour water demand in 2025 is expected to reach 833.16 l/s, resulting in a deficit of 590.36 l/s. This shortage is anticipated to worsen by 2035, when the water demand is projected to increase to 1,473.64 l/s, while the production capacity remains unchanged, leading to a deficit of 1,230.84 l/s.

Although there is an idle capacity of 100 l/s, particularly in SPAM Lawe-Lawe, optimizing this capacity alone will still be insufficient to bridge the existing gap. Therefore, strategic measures must be taken to enhance water production capacity, either by optimizing the currently unused installed capacity or by developing new raw water sources. Additionally, improvements in water distribution infrastructure are necessary to ensure broader and more efficient access to clean water. If these measures are not promptly implemented, the region may face a severe water crisis in the coming years.

CONCLUSIONS AND RECOMMENDATIONS

The current water production capacity is significantly insufficient to meet the projected water demand for both 2025 and 2035. While there is some idle capacity that can be optimized, it remains inadequate to bridge the substantial deficit. To prevent a future water crisis, a significant increase in both water production and distribution capacity is necessary. Strategic measures should include enhancing the production capacity of existing SPAM units, maximizing the utilization of idle capacity, developing new raw water sources to expand production, and extending the distribution network to improve clean water service coverage. Without these efforts, the region may face severe water shortages in the coming years.

FURTHER STUDY

This research still has limitations so that further research is needed on the topic of Analysis of Clean Water Supply Needs in Penajam Paser Utara Regency in order to perfect this research and increase insight for readers and writers.

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