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Feasibility Analysis of Decentralized Pressure Improvement in Peripheral Water Networks: Case Study of Zone 3, Surabaya, Indonesia

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Abstract. The study evaluates shifting Surabaya's low-pressure coastal area (Zone 3) from a centralized to a decentralized water treatment system. Current residual pressure is below 2 mH_2O, failing the 5–10 mH_2O standard, and Scenario 1 shows the existing system cannot meet 2030 demand. Scenario 2, following the utility's centralized expansion (Karang Pilang IV WTP, Putat Gede 3 Booster Pump, Mbah Ratu Reservoir), reaches 88% of customers at adequate pressure by 2030 but requires IDR 219.98 billion. A decentralized alternative with a local 500 L/s WTP and 900 m³ reservoir dedicated to Zone 3 achieves 98% coverage at the required pressure for only IDR 100.5 billion. The study concludes that decentralized systems can more effectively and cost-efficiently boost pressure and meet growing demand where raw water sources are limited and centralized expansion is insufficient.

1 Introduction

Surabaya City is the second most populous metropolitan area in Indonesia. The city's population reached 3,018,022 in 2024, with a corresponding population density of approximately 8990 people/km² [1]. This rapid urbanization places significant strain on public infrastructure, particularly water services. Surya Sembada Municipal Water Utility of Surabaya City (PDAM Surabaya) is guided by Surabaya Regional Medium-Term Development Plan (RPJMD) 2021-2026. Which mandates achieving universal and equitable access to safe drinking water by 2030 [2]. Therefore, PDAM Surabaya plans to develop a centralized massive-scale infrastructure to improve areas that are still not covered by water, namely, zone 3 [3].

The most critical challenge is found in the northernmost coastal peripheral region, where the city's highest population density is recorded at 35,271 people/km² [1]. Furthermore, spatial planning data indicate that this coastal zone has almost no vacant land available for new construction [4], which has historically hindered the utility from establishing local treatment facilities in the area. Despite the mandate for universal access to safe drinking water by 2030, a gap remains in optimal conditions, particularly in the Zone 3 distribution network, where the low residual high water pressure and its causes are discussed in this study.

Based on the residual pressure record data from the Surabaya City PDAM, this area still has a residual pressure level of below 0.5 mH2O, namely, Simokerto sub-district and 6 sub-districts currently suffer from an average residual water pressure head below 2 mH_2O in 2025 [3], failing to meet the Ministry of Public Works' standard (No.18/RT/M/2007) of 5–10 mH_2O [5], as shown in **Fig. 1**.

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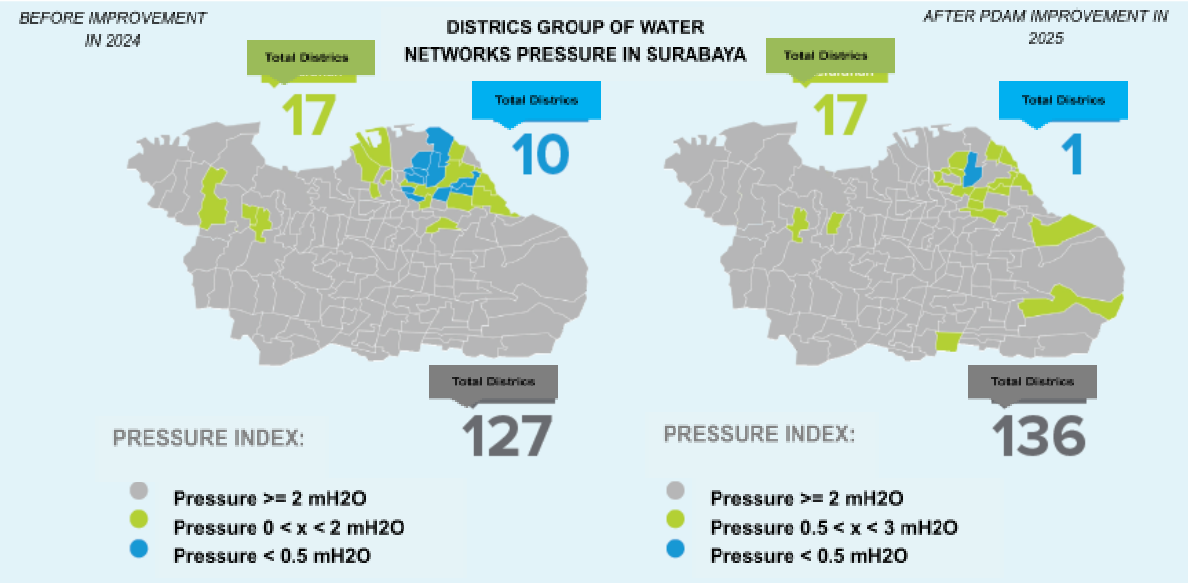


Fig. 1. Analysis of the Pressure Water Networks in Surabaya City [3].

This hydraulic failure is quantitatively validated by customer complaint data, where there is a frequent frequency of customer complaints in zone 3 per districts for the last 1 year in the form of water not flowing in Petemon, 220 complaints, Tambak Wedi, 30 complaints, Wonokusumo, as many as 28 complaints, Kapasan, 26 complaints, Kapas Krampung, 23 complaints, Bulak Banteng, 17 complaints, Bogen Baru, 1 complaint, which indicates widespread lack of water access in several coastal sub-districts.

The main cause of the low pressure in Zone 3 is its vast distance service from the main Water Treatment Plants (Karangpilang and Ngagel WTP), causing the development of centralization infrastructure to be less effective because which causes extreme frictional head loss across transmission lines [6], then This distance also increases water age within the pipes [7], leading to a decline in residual chlorine and a heightened risk of bacterial regrowth before reaching the customer [8].

The second cause, the current centralized system, is the increasing uncertainty of raw water availability. Surabaya's high-quality water supply of 4% comes from Umbulan springs and other springs in Pasuruan; however, this source is currently experiencing a significant decline in discharge quantity [3]. This reliance on a distant and diminishing source threatens the supply sustainability for peripheral zones. Moreover, local water resources in coastal areas are often non-viable due to poor surface water quality and brackish groundwater caused by extensive seawater intrusion [9].

The third cause is the high number of people in the area [1], so that the need for water is also large, and there is limited land to build clean water infrastructure in the northern coastal city of Surabaya [4] or the Zone 3 area.

While the utility's current mitigation plan focuses on centralized expansion—including the Mbah Ratu Reservoir and Putat Gede Booster with a high capital cost of IDR 219.98 billion [10]—a significant research gap remains. Comparative evidence evaluating whether this expensive centralized expansion can truly overcome the combined challenges of source uncertainty in Pasuruan and hydraulic bottlenecks in the coastal periphery is lacking. A decentralized "point-of-use" system located directly within the coastal service area could eliminate long-distance head loss and reduce dependency on diminishing external springs.

Consequently, this study aims to conduct a comparative feasibility analysis between the utility's centralized expansion plan and a proposed decentralized water treatment system. Specifically, this research aims to:

- Simulate hydraulic performance and service coverage projected for 2030.
- Evaluate technical compliance with regulatory pressure standards.
- The capital cost requirements are compared to determine the most viable and resilient solution for Surabaya's northernmost coastal peripheral water networks.

2 Materials and Methods

2.1 Study of Interest

The study was conducted in the city of Surabaya, Indonesia. More precisely, in the Zone 3 Service Unit of the Clean Water Distribution Network of Surabaya City. In the Zone 3 service unit of PDAM Surabaya City, further divided into several sub-zones, namely sub-zones 301-317, where the division of sub-zones can be seen in **Fig. 2**.

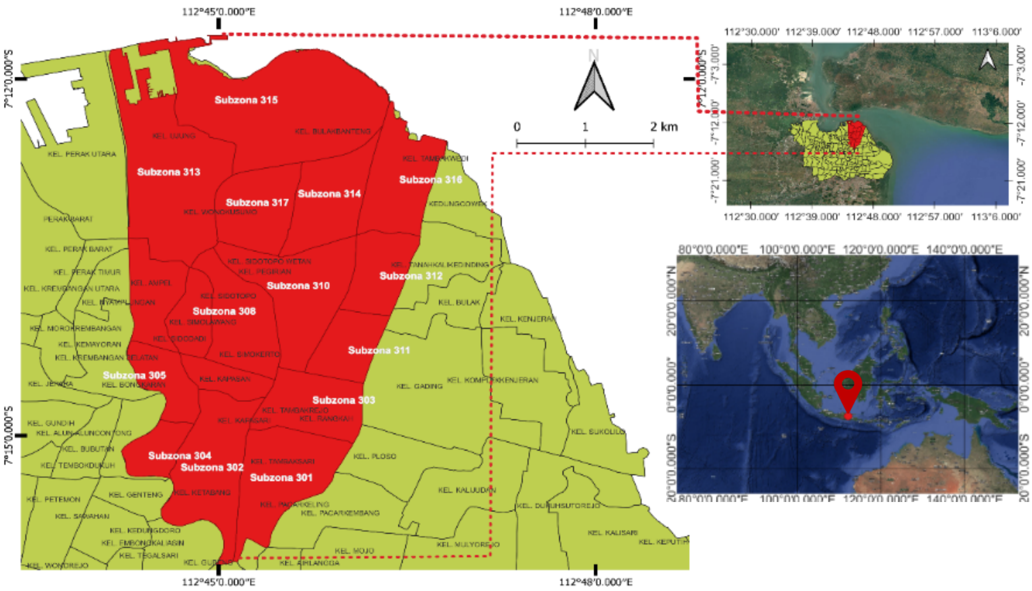


Fig. 2. Location of the Surabaya City Clean Water Distribution Network Zone 3 Services Unit.

2.2 Conceptual Study

This study was conducted by analyzing some of the problems that occur in the clean water distribution network in Surabaya, namely, being limited to peripheral areas (zone 3) that have low water head pressure only and then simulating the planned development, whether it is sufficient to meet or can be replaced by other alternatives. For more details, the conceptual diagram is found in **Fig. 3** as follows:

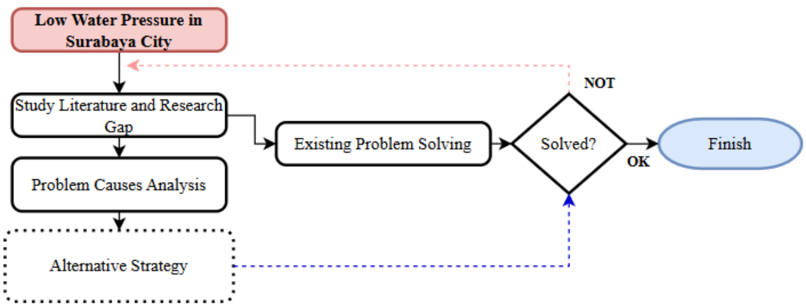


Fig. 3. Conceptual Diagram.

2.3 Methodology and Research Diagram

2.3.1 Data and analysis diagram

The data used for this study is limited to 2024, because the data from the annual book reporting has already preserved for that year, which can only be obtained at the end of 2024. The data used, sources, and usage are shown in **Table 1.**

Table 1. Data Sources and Their Uses

Data Item	Data Source	Use
City Population	Central Statistical Agency of Surabaya 2024	Calculating the amount of water per person in Surabaya, Indonesia
Total water consumption	Surabaya's Municipal Water Utility, Annual Book, 2024	Calculating the amount of water needed per person in Surabaya, divided by the total population
Water networks geospatial data	SIG Division, Surabaya Regional Water Supply	Obtaining Numerical Data on the Surabaya Pipeline
Sensor Pressure Recording	SIG Division, Surabaya Regional Water Supply	Low-pressure analysis and calibration of the numerical model
PDAM Book and E-procurement, Surabaya Infrastructure and Spatial Plan	Website/open source	To analyze the problems in the Surabaya network, the growth rate of Surabaya's population is determined, and a plan based on existing spatial conditions is chosen

For hydraulic simulation, use WaterGEMS Software recommended by Surabaya's Municipal Water Utility because it has more advanced features that make data analysis, including calibration, easier. For the research scheme and data processing to become the result of conclusions, as shown in **Fig. 4**.

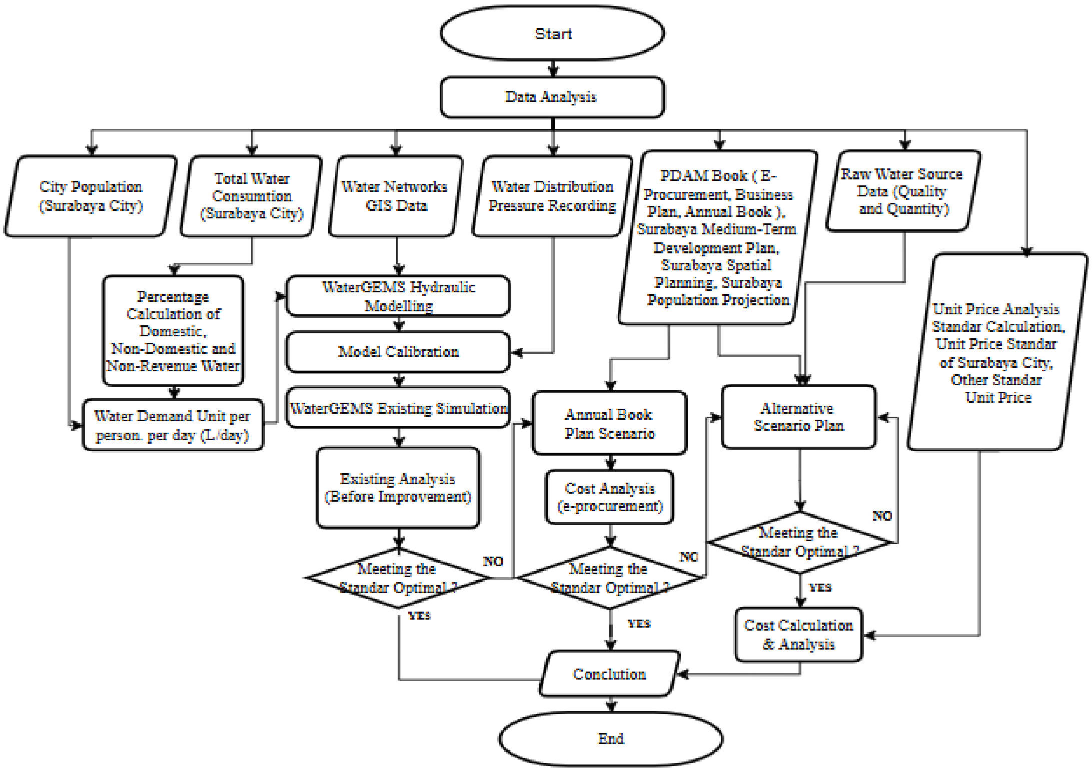


Fig. 4. Research Diagram

2.3.2 Demand Assumption

In the calculation of existing water needs using account billing data for each customer of PDAM Surabaya City in the last year, which is converted in the form of L/S, where the service coverage has reached 100%, the total water demand is the sum of domestic, non-domestic, and water loss needs, found in equation 1 by Kalensun [12] as follows:

$$Q_r = Q_d + Q_n + Q_a \tag{1}$$

Where:
Q_r = average water requirement (L/s),
Q_d = domestic water demand (L/s),
Q_n = non-domestic water needs (L/s),
Q_a = water loss (L/s).

Where the analysis of the demand approach in this planning uses the assumption that non-domestic water needs are 25% of domestic water needs according to urban clean water supply standards [11], and water loss of 31.05% in 2024 and decreases by 1% each year according to the PDAM business plan book, so that in 2030 water loss is 25.05%.

2.3.3 Hydraulic Simulation

In hydraulic analysis using WaterGEMS software, where the data needed for modeling is water demand, technical data of the clean water system of the City of Surabaya (primary and secondary pipelines, reservoirs, pumps, tanks, etc.), and field pressure data are used as calibration to adjust the simulation results to describe the actual conditions in the field. **Figure 3** shows more details of the simulation process. The hydraulic simulation itself is divided into 2 planning stages: the analysis stage of the existing year and the analysis of the projected year 2030. The demand used in the existing year is the demand from the existing billed account data. The 2030 projection uses population data multiplied by the average water usage from the existing billed account data.

2.3.4 Model calibration and validation

Data calibration aims to determine the difference between the data obtained from the simulation results and the actual data in the field. The root mean square error (RMSE) method is used to perform the calibration process [13]. The RMSE formula is as follows:

$$RMSE = \sqrt{\frac{\sum (X-Y)^2}{n}} \tag{2}$$

Where:
X = Observation value
Y = Predicted value
n = Amount of Data

2.3.5 Surabaya Regional Water Supply Utility and Service Improvement Planning

Surya Sembada Municipal Water Utility of Surabaya City is a drinking water company in Surabaya that has achieved 100% of the population of Surabaya City, with 630,491 customer connections. However, there are still areas that have small discharges with a pressure below 0.5 mH_2O, namely, in 10 villages in the north of Surabaya

City, besides a water loss of 31.06% above the regulatory standard of 25% [3], further new challenges of climate and population increase, so that the Water Utility of Surabaya City planning medium-term strategic development, and to realize the Surabaya City Regional Medium-Term Development Plan program Number 6 of 2021-2024, namely "By 2030, achieve universal and equitable access to drinking water"[2]. The rehabilitation of the pipeline network as far as 52.82 kilometers and the construction of the Karang Pilang IV Water Treatment Plant with a capacity of 1000 L/s at a cost of IDR 149,850,000,000 are among the developments planned for the medium term. Construction of the Mbah Ratu reservoir with a capacity of 6000 m^3 for IDR 36,299,552,556. Then, the Putat Gede III pump house was constructed with a capacity of 2 pumps of 375 L/s and one pump of 600 L/s, at a cost of IDR 33,834,747,495 [10].

2.3.6 Water Resources in Zone 3

Some of the raw water in Surabaya is from surface water (Surabaya River, Brantas River, and Bengawan Solo), Umbulan Springs, then used water such as Boezom Morokrembangan and Kali Mas, then groundwater but it is not recommended because the quality of Surabaya's groundwater is not good, especially in coastal areas where the city of Surabaya zone 3 has a rather brackish water condition according to groundwater salinity [10].

2.3.7 Ministry of Public Works' Water Distribution and Water Utility Services Standard

In raw water planning, there is a standard for piping distribution networks that regulates the speed of permitting and water pressure in the clean water distribution pipeline, regulated by the Ministry of Public Works' standard [5], which is found in **Table 2**. Piping distribution network standards,

Table 2. The Piping Distribution Network Standards [5].

Description	Notation	Requirements
Speed of water flow in the pipes		
a) Minimum speed	V min	0.3 - 0.6 m/s
b) Maximum speed		
PVC or ACP pipes	V max	3.0 - 4.5 m/s
Steel pipe or DCIP	Vmax	6.0 m/s
Pressure of water in the pipe		
a) Minimum pressure	h min	(0.5 – 1.0) atm at the farthest service coverage point.
b) Maximum pressure		
- PVC or ACP pipes	H Max	6 - 8 atm
- Steel pipes or DCIP	H Max	10 atm
- PE 100 pipe	H Max	12.4 MPa
- PE 80 pipe	H Max	9.0 MPa

Then, in the planning of clean water services, some standards are a reference in clean water services in urban areas regulated by the Ministry of Settlements and Regional Infrastructure [11], found in **Table 3** as follows:

Table 3. Urban Clean Water Service Standards [11].

Parameters	Metropolitan	Big Cities	Medium City	Small Town
Service Target	100%	100%	100%	80%
Water usage (l/person/day)				
Home Connection	150-210	100-150	90-100	60-100
General hydrant	30	30	30	30
Industrial Needs				
Heavy Industry (L/s)	0.5-1			
Medium Industry (L/s)	0.25-0.5			

15%-30% of the domestic needs

Parameters	Metropolitan	Big Cities	Medium City	Small Town
Light Industry (L/s)	0.15-0.25	15%-30% of the domestic needs		
Commercial				
Markets	0.1-1			
Local hotels (l/room/day)	400			
International Hotels	1000			
Social				
University (l/person/day)	22			
School	15			
Mosque (l/day)	1000-2000			
Hospital (l/room/day)	400			
Health center (l/day)	1000-2000			
Office (L/s)	0.01			
Military (l/day/ha)	10000			
Operating Hours (Hours)	24	24	24	24
Maximum water requirement	Average requirement x 1.35			
Water loss in new system	20 %			
Loss of the water legacy system	30%-40%			
Peak Hour Needs	1.65-2			

2.3.8 Calculation of Unit Price Analysis Standard

The BOQ calculation requires a detailed specification of the requirements per unit of work, which is derived from the engineering drawings during development analysis and planning. Material needs are considered based on the planning analysis results and adjusted to their market availability. Meanwhile, in the calculation of Capital Cost, the basis is the results of the BOQ calculation and Unit Price Analysis [14], using relevant cost data in the city of Surabaya [15] and referring to work standards.

3 Results and Discussion

3.1 Alternative scenario planning

From the problems in Zone 3, namely, low pressure and large population, the alternative planning chosen is the decentralization of production or the creation of a drinking water treatment plant in Zone 3, which is compared with the existing and planned Surabaya Municipal Water Utility. The scenarios compared are the existing conditions before improvement, the post-improvement conditions of the regional water supply utility planning/centralized scenario, and the post-Alternative planning conditions/decentralized scenario. Each scenario is analyzed with 2 stages or sub-scenarios, namely, demand in 2024 and the projected demand in 2030. The investments compared are as follows in **Table 4**:

Table 4. Scenario Planning

Scenario	Name	Sub-Scenario	Investment
1	Existing	a. Existing in 2024	- (without improvement)
		b. Existing in 2030	
2	Surabaya's Municipal Water Utility Plan	a. Surabaya's Municipal Water Utility Plan for 2024 (centralized improvement scenario)	1. Addition of a drinking water treatment plant for the Karang Pilang IV, with a capacity of 1000 L/s.

	Surabaya's Municipal Water Utility Plan	b. Surabaya's Municipal Water Utility in 2030 (centralized improvement scenario)	2. Addition of the Mbah Ratu Reservoir of 6000 m^3. 3. Addition of a Putat Gede III Boster Pump, 2 x 375 L/s + 600 L/s.
3	Alternative Plan	a. Alternative Plan for 2024 (decentralization improvement scenario)	1. Zone 3 drinking water treatment plant, Capacity 500 L/s;
		b. Alternative Plan for 2030 (decentralization improvement scenario)	2. Addition of 900 m^3 production reservoir.

3.2 Analysis of water supply and demand

In this section, the aim is to determine the water production supply and water needs compared in the existing conditions (Scenario 1) without additional supply, the conditions of adding centralized supply (Scenario 2), and adding decentralized (Scenario 3), **Table 5** shows the result of the comparison of the difference in water demand in the existing year and the projection of the three scenarios. Cumulation of water supply and demand.

Table 5. Cumulative Water Supply and Demand

Item	Explanation	Year		
		2024	**2025**	**2030**
Domestic (L/person/day)		185.76	210	210
Non-Domestic (L/person/day)	Domestic x 25 %	46.44	52.50	52.50
Normal Factor	F average = 1	232.20	262.50	262.50
Maximum day factor (MDF)	F max-day = 1.2	278.64	315.00	315.00
Peak Hour Factor	F peak = 1.8	417.96	472.50	472.50
Population (Person)		3,021,043	3,043,518	3,144,330
Non-Revenue	-1% per year	31.52%	30.52%	25.52%
Normal water demand	L/s	10,678.09	12,068.92	11,991.03
	m^3/s	10.68	12.07	11.99
Peak water demand hourly	L/s	19,220.57	21,724.06	21,583.86
	m^3/s	19.22	21.72	21.58
Production Capacity	L/s (water municipal plan)	-	1,000.00	1,000.00
	L/s (alternative plan)	-	500.00	500.00
	L/s (existing)	11,834.16	11,834.16	11,834.16
	m^3/s(existing)	11.83	11.83	11.83
	L/s (existing + water municipal plan)	11,834.16	12,834.16	12,834.16
	m^3/s (existing + water municipal plan)	11.83	12.83	12.83
	L/s (existing + alternative plan)	11,834.16	12,334.16	12,334.16
	m^3/s (existing + alternative plan)	11.83	12.33	12.33
Capacity Difference (Production and Demand)	m^3/s(existing)	1.16	-0.23	-0.16
	m^3/s (existing + water municipal plan)	1.16	0.77	0.84
	m^3/s (existing + alternative plan)	1.16	0.27	0.34

From the analysis results in **Table 5**. Water Supply and Demand Cumulation can be found that to deal with water needs in the projected year, existing conditions without additional water supply cannot face an increase in the number of population in 2025 and 2030 because water has a deficit of -0.23 m^3/s. Thus, an additional capacity of 500 L/s from Scenario 3 is sufficient and efficient to overcome water needs in 2025 and 2030 compared to an additional capacity of 1000 L/s from Scenario 2, which experiences idle capacity or excess water production and water production cost.

3.3 Hydraulic Analysis

3.3.1 Pressure calibration and validation

In the pressure calibration of the sensor records and simulations, as many as 34 points spread across the city of Surabaya were only used on primary and secondary pipes. The result of calibration pressure networks is shown in **Fig. 5**.

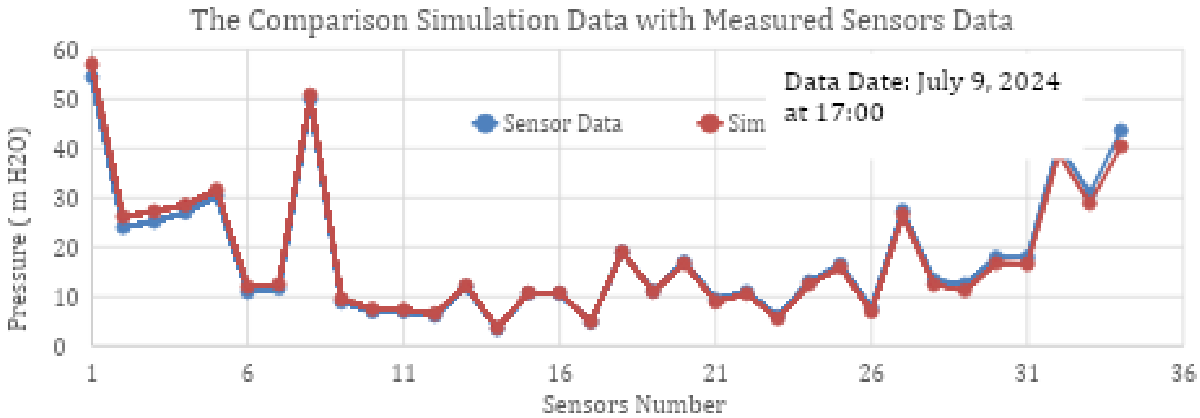


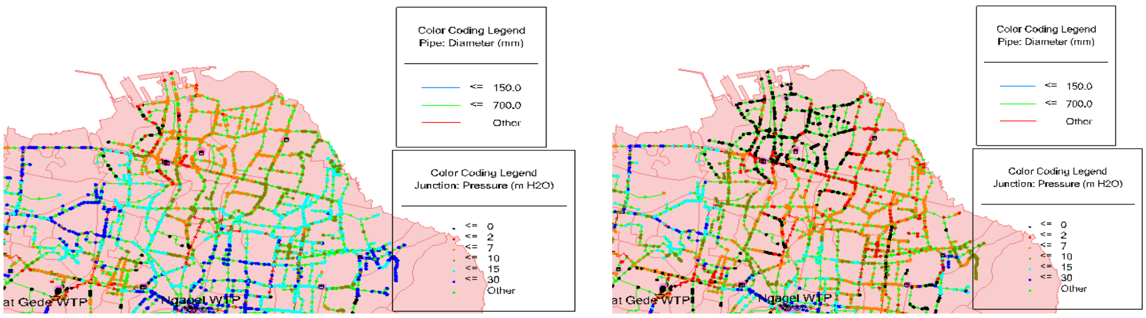
Fig. 5. Calibration pressure result on July 9, 2024, at 17:00.

Calibration is performed by adjusting the roughness value of the pipe so that the pressure can be in accordance with the field conditions. The results of the pressure adjustment indicated that the average pressure in the field data was 18.21 m H_2O, while in the simulation data, the average pressure was 18.18 m H_2O which had an average error of 0.91 m H_2O or 5% of the pressure conditions in the field with an RMSE value of 1.2 m H_2O, indicating that the error was still below 10% and valid to be used as a simulation of the actual situation.

3.3.2 Analysis of the Hydraulic Simulation Results

This hydraulics analysis is simulated at the peak hour (5:00 PM), into 3 scenarios that are Existing/without improvement in **Fig. 6**, government improvement plan/centralized scenario in **Fig. 7**, and alternative Improvement plan / decentralized scenario in **Fig. 8**, which are divided into sub-scenarios in 2024 and 2030 (Projected). Where the simulation results are explained whether the pressure is already optimal according to the regulations of the Ministry of Public Works, where the pressure is > 7 m H_2O, or not optimal, where the pressure is < 7 m H_2O [5].

1. Hydraulic analysis without improvement (Scenario 1)

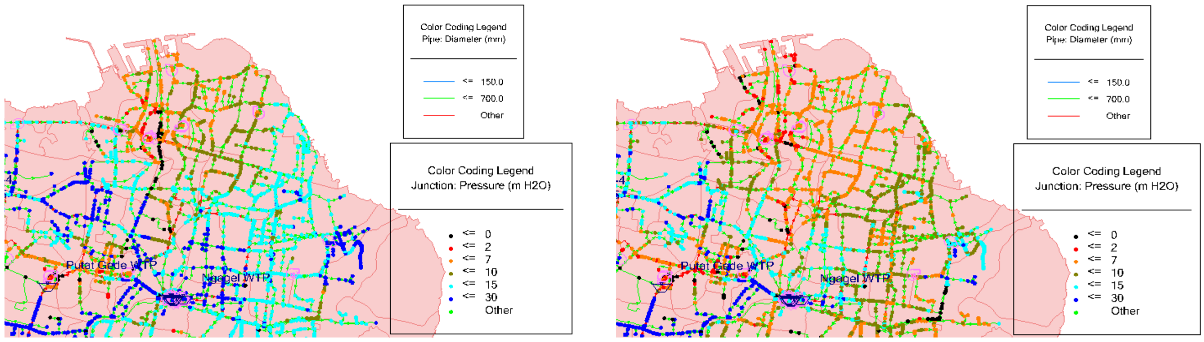


(a) (b)

Fig. 6. Hydraulic simulation of (a) 2024 year and (b) projected 2030 year without Improvement (scenario 1).

In the results of the hydraulic simulation scenario 1 or without improvement scenario in **Fig. 6**, from the analysis with a visual approach, it can be seen that in the current year 2024, the majority of nodes are orange or the pressure is below 7 mH_2O, indicating that the pressure is low but not water-off, However, there are many black nodes at the time of the 2030 projection year, indicating that the water pressure is 0 mH_2O.

2. Hydraulic Analysis with Centralized Improvement (Scenario 2)

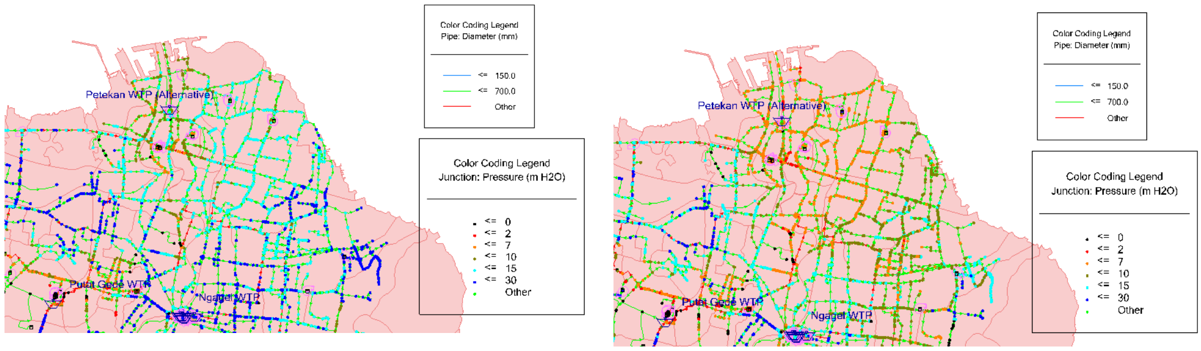


(a) (b)

Fig. 7. Hydraulic simulation of (a) 2024 year and (b) Projected 2030 year with Government Improvement Plan / Centralized Scenario

In the results of the hydraulic simulation scenario 2 / Centralized Scenario in **Fig. 7**, from the analysis with a visual approach, it can be seen that in the existing year 2024, the majority of nodes are green or the pressure is almost all optimal above 7 mH_2O, but at the time of the 2030 projection year, there are many orange nodes, indicating the water pressure is below 7 mH_2O and the red nodes indicate the pressure below 2 mH_2O This indicates that scenario 2 / centralization scenario is still not optimal to increase overall pressure in 2030.

3. Hydraulic Analysis with Decentralized Improvement (Scenario 3)



(a) (b)

Fig. 8. Hydraulic simulation of (a) 2024 year and (b) projected 2030 year with Government Improvement Plan / Decentralized Scenario

In the results of the hydraulic simulation scenario 3 / decentralized scenario in **Fig. 8**, from the analysis with a visual approach, it can be seen that in the current year 2024 the majority of nodes are light blue or the overall pressure is optimal above 15 mH_2O, but at the time of the 2030 projection year, there are many orange nodes, indicating a water pressure below 7 mH_2O and the red nodes indicate a pressure below 2 mH_2O but the pressure is not optimal compared to the previous scenario.

For more details of the output pressure per junction/node, a pressure percentage is calculated to determine the optimal amount of water pressure access, which is divided into optimal nodes with a pressure of > 7 m H_2O, non-optimal pressure < 7 m H_2O and > 2 m H_2O, and an area that cannot be watered with a low water pressure value of 2 m H_2O. The percentage of pressure calculation at the node in each scenario is shown in **Fig. 9**. Water Access Percentage per Scenario, as follows:

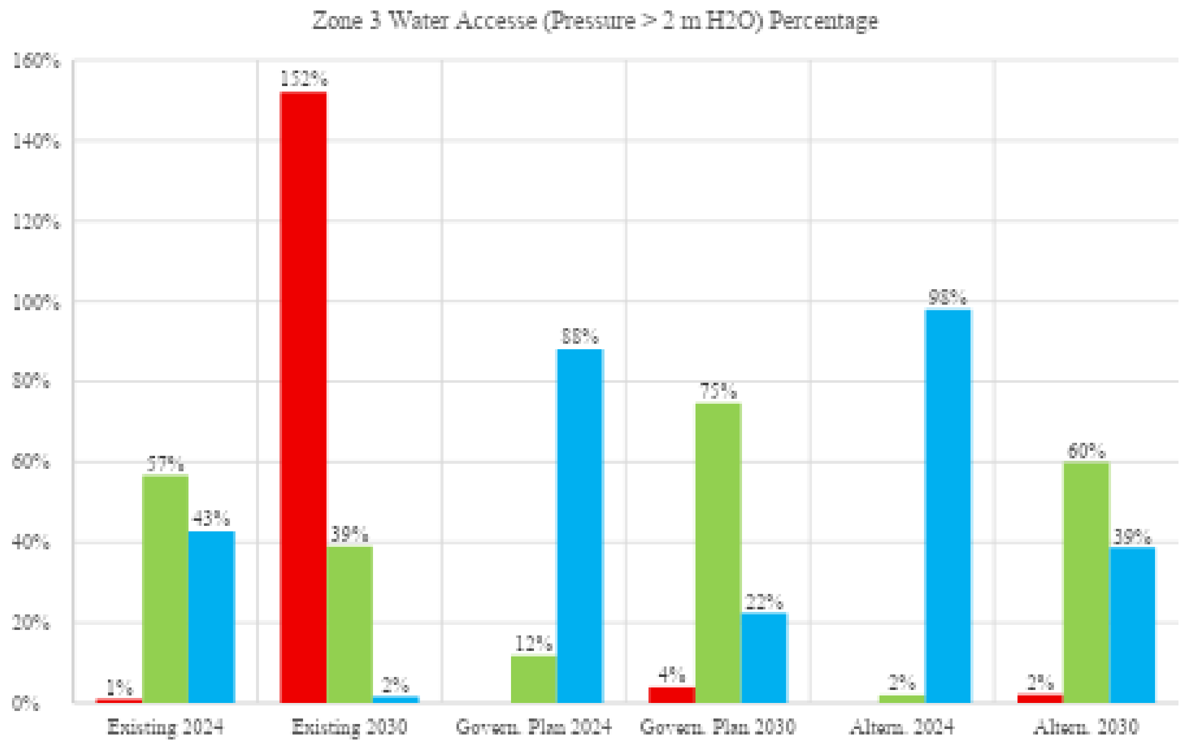


Fig. 9. Water access percentage per scenario

From the hydraulic analysis of **Figures 6, 7, and 8**, we know that the scenario without improvement cannot endure the water demand problem in 2030 at all. **Fig. 9** shows that the scenario of the government plan (centralized plan) improves to 100% water access for the existing, but 12% of the nodes still do not meet the optimal. And meet 96% accessed on the 2030 projection year. Conversely, the alternative scenario succeeds in accessing all areas for the existing year and 98% access on the 2030 projection. This indicates that in the decentralized scenario with the addition of 500 L/s supply, the optimal pressure is 12% greater than centralization with the addition of 1000 L/s supply for peripheral areas in zone 3, and the amount of water supply required in decentralization is 50% less than the centralization scenario in the case of this location.

3.4 Explanation of the Centralized Improvement Plan

Centralized planning is an alternative planned by the PDAM of Surabaya City because the main water production units, namely, Ngagel and Karang Pilang WTP, have been built, and land is still available to increase the central supply capacity. However, based on the results of the simulation using WaterGEMS in the analysis in the previous sub-chapter, complex planning and a large amount of water production are needed to meet the increased pressure in the peripheral area or Zone 3. The planning items and costs are listed in **Table 6,** with a total cost of IDR 219.98 billion.

Table 6. Cost of Centralized Improvement – PDAM's Plans

No.	Item	Total Cost (IDR)
1	Construction of the Putat Gede Pumpa House 3	33,834,747,495.00
2	Mbah Ratu Pump House and Supporting Buildings (reservoir and main distribution network)	36,299,522,566.00
3	Development of the IPAM Karang Pilang IV	149,850,000,000.00
Total Project Value		**219,984,270,061.00**

Total Project Value (Rounded)	**219,980,000,000.00**

3.5 Explanation of the alternative decentralized with WTP 500 L/s

3.5.1 Alternative Glass-Fused-to-Steel (GFS) WTP 500 L/s Preliminary Design

Based on the results of the simulation using WaterGEMS previously, it can be seen that the alternative decentralization in the form of making a water treatment plan with a capacity of 500 L/s has a significant influence on increasing pressure and saving total water compared to the centralization process by requiring a water capacity of 1000 L/s. However, in the existing conditions, there are limitations to building a decentralized WTP:

1. The quality of the existing raw water;
2. The availability of the existing land;
3. Higher cost for advanced units.

Then, the alternative is that it can save space, can treat existing river water well with low side effects, but requires slightly higher capital costs and maintenance costs than a conventional WTP structure. The Advanced Unit can be seen in **Table 7** and the layout in **Fig. 10** to determine the preliminary design of the land available.

Fig. 10. Petekan Glass-Fused-to-Steel (GFS) WTP 500 L/s (Decentralized Plan)

Table 7. Advanced WTP's Units and Dimensions

Unit	Dimension	Component
Drinking water treatment plant based on ultra-high-grade steel structure	Unit flocculation, clarifier, filtration, and reservoir	Ultra-high-grade glass-fused-to-steel
SCADA-setting system	1 set	Automatic bar screen, valve, and water level sensors
Direct Intake, Gravity Pipe	DN800, L = 15 m	Direct Intake-type intake and gravity intake
Submersible Pump	90 kW	Sewage submersible pump
Coagulation	DN500	In-Line Static Mixer

Unit	Dimension	Component
Flocculation	Dia. 8.5 m x 6 m	Vertical shaft mechanical flocculator
Clarify	Dia. 9 m x 5 m	Lamella Tube Settler
GAC Filtration	Dia. 5.5 m x 4 m	Granular Activated Carbon Filtration
Reservoir	Capacity 900 m^3	Structural concrete construction
Distribution Pump	3 x 250 L/s; 200 kW	Centrifugal Pump

Of the several units mentioned, the cost is calculated according to the standard of price calculation of the WTP capital cost per item package for 500 L/s from PDAM Surabaya. The total capital cost required for the Alternative Glass-Fused-to-Steel (GFS) WTP and the reservoir is IDR 100.5 billion. For details, see **Table 8** below:

Table 8. Capital Cost Package of the Alternative Glass-Fused-to-Steel (GFS) WTP (500 L/s)

No.	Item	Total cost (IDR)
I	Work preparation and occupational safety	900,000,000.00
II	Work of the intake unit (Vendor Estimate for 500 L/s)	5,000,000,000.00
III	Concrete foundation work for GFS WTP Structure	7,600,000,000.00
IV	Work of Process's Mechanicals	50,000,000,000.00
V	Interconnection Piping	3,000,000,000.00
VI	Electrical and Instrumentation Work	4,000,000,000.00
VII	Reservoir and Distribution Work	12,000,000,000.00
VIII	Supporting Building Work	8,000,000,000.00
Total construction cost (excluding VAT)		**90,500,000,000.00**
VAT 11%		**9,955,000,000.00**
Total Project Value		**100,455,000,000.00**
Total Project Value (Rounded)		**100,500,000,000.00**

3.5.2 Limitations and Advantages of Decentralized WTP Design

The limitation of decentralized WTP development is that the investment cost for a viable unit at this location is more expensive than conventional WTPs in general. Additionally, the existing water conditions are very poor, and even with advanced WTP technology to reduce the side effects of water quality, over time it can still result in high maintenance and repair costs. However, the advantage is that because it has a decentralized production system based on simulation results, it can meet lower water demands, making it more water-efficient and requiring less infrastructure, which results in a lower total capital cost for achieving higher water head pressure results compared to centralized planning.

3.6 Comparison of centralized and decentralized scenario results (offered)

Based on several analyses, both pressure results, capital costs, and the amount of water used were compared, with the comparison results are in **Table 9** and the comparison chart in **Fig. 11**.

Table 9. Capital Cost of the Alternative WTP

Scenario	Condition Networks	Result Comparisons			
		Addition of Water Production	Pressure		Capital cost (IDR)
			2024	2030	
1	Existing	-	43% Optimal	2% Optimal	-
2	Centralized	1000 L/s	88% Optimal	22% Optimal	219,980,000,000
3	Decentralized	500 L/s	98% Optimal	39% Optimal	100,500,000,000

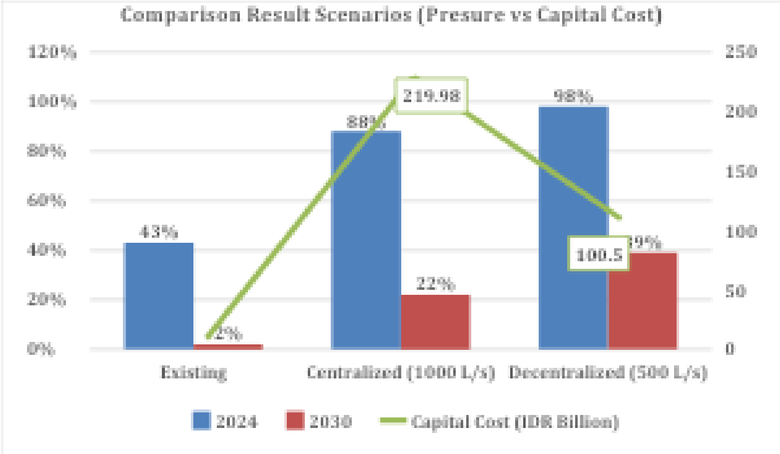


Fig. 11. Comparison of Scenario Result

From the analysis of the comparative graph of the scenario results in **Fig. 11**, it can be seen that in the existing conditions, no additional water with no cost is not able to face low pressure, both in 2024 conditions and in 2030 conditions. From the results of the analysis of the conditions of the Centralized scenario, an additional production of 1000 L/s is needed and a cost of IDR 219.98 Billion resulting in optimal pressure of 88% in 2024 and 22% in 2030, The Decentralized scenario conditions require an additional water of 500 L/s and a cost of IDR 100.5 Billion to achieve a more optimal pressure of 98% in 2024 and 39% in 2030. This indicates that the decentralized scenario has high effectiveness in increasing pressure, increasing water resistance with efficient use of the amount of water produced, and is efficient in investment costs. Therefore, increasing pressure with this decentralized concept is feasible on one hand, but on the other hand, the effect of poor raw water might still result in high maintenance and repair costs, although it does not exceed the maintenance and repair costs of a larger and more complex centralized production unit system.

4 Conclusion

From the topic of analysis of the low water pressure in Zone 3 of the clean water distribution network, it can be seen that the main cause of low water head pressure in the peripheral area in Zone 3 of the clean water distribution network of the city of Surabaya is the distance from the installation, so the alternative required is to decentralize unit water production or WTP where the water production capacity is half of the previous centralized planning by the Surabaya City PDAM or by 500 L/s, then an analysis is carried out with 3 scenarios, where it can be known that where in the analysis of scenario 1 (existing without improvement) it cannot overcome the problem of water pressure head for the projected year (2030) at all, then scenario 2 - the centralized unit production for 2024 clean water access of 100% nodes where pressure is above 2 mH_2O, but 12% of pressure head nodes is still below the optimal standard of minimum 7 mH_2O from regulations of the Ministry of Public Works, then in the 2030 projection year there will be only 88% who have access optimal drinking water or pressure above 2 mH_2O. Meanwhile, in the alternative scenario, it has managed to achieve 100% optimal water head pressure for existing and 98% optimal water head pressure for the 2030 projection year. Then, in the comparison of investment costs, improvement scenario 2 based on centralized unit production by PDAM plan of improvement data, where the investment made is the addition of the Karang Pilang IV WTP with a capacity of 1000 L/s, the addition of the Mbah Ratu Reservoir of 6000 m^3, and the addition of the Putat Gede III Boster Pump, 2 x 375 L/s + 600 L/s. Requires a total investment cost of IDR 219,984,300,051. Meanwhile, in Scenario 3, an alternative investment is made in the form of adding a Zone 3 drinking water treatment plant, a capacity of 500 L/s, and a production reservoir of 900 m^3 with a total investment of IDR 100,500,000,000, With the selection of an optimal Zone 3 installation alternative, it is hoped that, in addition, the alternative can save space, effectively treat existing river water with minimal side effects, but on the other hand, the impact of poor raw water may still result in high maintenance and repair costs, although not exceeding the maintenance and repair costs of a larger and more complex centralized production unit system.

Thus, this alternative is useful if the raw water source in the centralized unit experiences a significant decline, as it can effectively meet the increasing future water demand in an efficient and water-saving manner.

5 Future Study

There are limitations in the analysis that can be developed for further studies. First, regarding cost calculation, in addition to considering installation costs, maintenance and operational costs must also be considered. If water cannot be met in the future due to population increase or climate change, raw water can be used from other sources, namely seawater.

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