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The Effect of Service Coverage and Water Loss Rate on the Performance of Tirta Giri Nata

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ABSTRACT

The performance of the Regional Public Drinking Water Company is an essential indicator in ensuring public access to efficient and sustainable clean water services. This study aims to analyze the influence of service coverage and the rate of water loss (Non-Revenue Water/ NRW) on the performance of Tirta Giri Nata Cirebon City, Indonesia. The approach is quantitative with multiple linear regression methods, based on monthly data from 2021 to 2023. The results showed that the coverage of services had a significant positive effect on performance, while NRW had a significant adverse impact. The determination coefficient (R^2) value of 42.1% indicates that both variables explain a large proportion of variations in company performance. These findings affirm the importance of strategies to expand the coverage and control of NRW as a crucial step in improving regional drinking water services' operational efficiency and sustainability.

Keywords
Drinking Water
NRW
Performance
Service Coverage
Water Loss

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Introduction

The availability of clean water is one of the leading indicators of community welfare and sustainable development. In Indonesia, the primary responsibility for providing drinking

water services to the public generally falls under the Regional Public Drinking Water Company (owned by the local government), which operates as a Regionally Owned Enterprise (*Badan Usaha Milik Daerah* or BUMD). As a public service entity, it is required to ensure the affordability and feasibility of drinking water services and demonstrate efficient and accountable operational and financial performance.

Tirta Giri Nata, Cirebon, is one of the BUMDs that has a strategic role in supporting the fulfillment of the community's fundamental rights to clean water. However, the company's performance has shown significant challenges in recent years. Data collected from the performance evaluation report shows that the coverage of services has decreased from 46.11% in 2021 to only 33.94% in 2023, despite the continued growth of the population. This phenomenon reflects an imbalance between the available service capacity and the community's actual needs in the service area.

In addition, the level of water loss or Non-Revenue Water (NRW) is also a crucial problem. NRW reflects the proportion of water lost or does not contribute to a company's revenue due to technical leaks, theft, or weaknesses in the recording and billing system. In 2023, Tirta Giri Nata's NRW was recorded at 37.97%, which, although it has decreased slightly compared to the previous year, is still far from the national efficiency limit set at 30%. The high level of NRW not only impacts the loss of potential income but also leads to the waste of production resources and increases the risk of infrastructure damage.

Various previous studies have indicated that the scope of services and the rate of water loss directly or indirectly influence the performance of drinking water supply companies [1]-[3]. The broad scope of services reflects the company's capacity to reach more customers and increase revenue. On the other hand, a high water loss rate indicates technical inefficiencies that can reduce operational performance and customer satisfaction [4][5]. Therefore, evaluating the relationship between these two technical variables and company performance is a strategic step in strengthening the governance of BUMD.

This study aims to analyze the influence of service coverage and water loss rate on the performance of Tirta Giri Nata. Using a quantitative approach and multiple linear regression analysis methods, this study seeks to provide empirical contributions that can be used as a basis for formulating strategies to improve operational and service performance. The research results will benefit the company's internal management, local governments, and other stakeholders in designing more effective and sustainable interventions in the drinking water sector.

Literature Review

Service coverage is one of the primary indicators used to assess the performance of Drinking Water Supply Systems (DWSS) managed by BUMD. It reflects the percentage of the population served through active household connections within the utility's technical service area [6]. A high level of service coverage indicates the institution's capability to ensure access to clean water as a fundamental right, whereas low coverage suggests infrastructure, production, and distribution limitations. At the national level, technical service coverage in Indonesia remains relatively low, with only 26.77% of the population served in 2023. It is far below the national benchmark of 60% required for optimal performance [6]. In parallel, NRW continues to pose a critical challenge for water utilities. NRW refers to the difference between water produced and billed, encompassing physical losses due to leaks, commercial losses such as meter inaccuracies or illegal consumption, and authorized but unbilled usage [7]. The national average NRW stood at 33.51% in 2023, exceeding the efficiency threshold of 30%. This suggests persistent system control and technical management inefficiencies that can adversely impact operational and financial performance. The problem of NRW is not limited to Indonesia. Globally, Jabari [8] highlighted significant water losses across the supply chain, from treatment to end-use. The World Bank estimates annual global losses of around 32 billion cubic meters, leading to severe economic impacts [9]. Social and technical factors, such as unauthorized connections, inaccurate metering, and poor tariff policies, further exacerbate NRW issues [10]. Pipe material, soil conditions, and hydraulic pressure also play a role; for instance, Jones et al. [11] found HDPE and mild steel pipes more susceptible to leakage than ductile iron, especially under unstable soil or high-pressure conditions.

Reducing NRW requires a multidimensional approach combining advanced technologies and strategic management. Implementing SCADA systems, District Meter Areas (DMA), digitized metering, and real-time pressure monitoring have been identified as practical tools. Tabesh et al. [12] emphasized the need for integrated solutions that align technical interventions with institutional policies. Benchmark examples such as Singapore demonstrate how NRW can be reduced to below 5% through intelligent systems, progressive tariffs, and community engagement [13], highlighting that NRW management is as much about governance as it is about engineering.

The interrelationship between service coverage, NRW, and utility performance is well documented. More exhaustive coverage can increase revenue potential and economic scale, yet requires strong financial and operational foundations. According to the Service-Profit Chain Theory [14], service quality directly influences customer satisfaction, loyalty, and revenue. Farley and Liemberger [15] noted that physical losses raise production costs, while commercial losses diminish income, thus constraining investment in network expansion. From

an operational efficiency perspective, Stevenson [16] argues that utilities minimizing input to maintain or improve output gain long-term competitiveness. Empirical evidence by Jones et al. [11] supports this, finding that utilities with low NRW levels exhibit better expansion capability and service quality. In the Indonesian context, performance evaluation results confirm that utilities with lower NRW tend to score higher in efficiency and solvency ratios [7], making NRW control a central strategy for sustainable utility development.

Material and Methods

This study adopts a quantitative approach to empirically examine the influence of service coverage and NRW on the performance of Tirta Giri Nata, a regional drinking water company. The research design is associative, aiming to determine the relationship and influence between the independent variables (service coverage and NRW) and the dependent variable (company performance), within the context of regional water utility management. Secondary data were obtained from internal company reports and official sources such as the Ministry of Public Works and Public Housing and Drinking Water Regulator (*Badan Peningkatan Penyelengaraan Sistem Penyediaan Air Minum* or BPPSPAM). The dataset spans 36 months from January 2021 to December 2023.

Service coverage (X_1) is defined as the percentage of the population served relative to the total population in the technical service area. NRW (X_2) represents the percentage of water loss, calculated as the difference between the volume of water produced and the volume billed. The dependent variable (Y), company performance, is measured using the national evaluation framework for regional water utilities, which includes four dimensions: finance, service, operations, and human resources. Multiple linear regression analysis was employed to assess the simultaneous and partial effects of the independent variables on performance. Before regression analysis, classical assumption tests were conducted to ensure the robustness of the model. It includes tests for normality, multicollinearity, heteroscedasticity, and autocorrelation.

All statistical analyses were performed using SPSS version 26. The strength and significance of the relationships between variables were evaluated using regression coefficients, p-values, and the coefficient of determination (R^2), which indicates how much variance in performance can be explained by service coverage and NRW. The quantitative methodology provides objectivity and enhances generalizability, offering practical insights into the technical factors influencing utility performance and informing policy decisions to improve operational efficiency and water service delivery in regional water utilities.This study adopts a quantitative approach to empirically examine the influence of service coverage and NRW on the performance of Tirta Giri Nata, a regional drinking water company. The research

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Results and Discussions

A. Classic Assumption Test

Before multiple linear regression analysis was performed, a series of classical assumption tests was performed to ensure the validity and reliability of the model. The results of the normality test using Kolmogorov-Smirnov showed the value of Asymp. Sig. is 0.200, usually distributed data (greater than 0.05). The multicollinearity test showed that the VIF value of each independent variable was below 10 and the tolerance value was above 0.1, indicating the absence of symptoms of multicollinearity.

The heteroscedasticity test using the Glejser method showed that the significance value of all independent variables was greater than 0.05, meaning there were no symptoms of heteroscedasticity. Meanwhile, the autocorrelation test using the Durbin-Watson yielded a value of 2.021, which is in the range of no autocorrelation (1.55–2.46).

B. Multiple Linear Regression Test

Based on the results of multiple linear regression analysis, the following regression equations are obtained:

$$\mathbf{Y = 4.302 + 0.567X_1 - 3.016X_2 + e} \quad (1)$$

where:

Y = Performance
X_1 = Service Coverage (%)
X_2 = Water Loss Rate / NRW (%)
e = Error term

Table 1. Multiple Linear Regression Test Results

Coefficients[a]

	Unstandardized Coefficients (B)	Std. Error	Standardized Coefficients (Beta)	t	Sig.
(Constant)	4.302	0.333	–	12.929	<.001
Service Coverage	0.567	0.228	0.281	2.485	0.016
Water Loss Rate	-3.016	0.672	-0.506	-4.486	<.001

a. Dependent Variable: Performance

From Table 1 above, the values listed are used to illustrate the following regression equation:

Y = 4.302 + 0.567(X1) - 3.016(X2) + e

Performance Value = 4.302 + 0.567*(Service Coverage) - 3.016*(Water loss rate) + e

Based on the above equation, it can be explained that:

- Constant 4.302 states that if the variable of all independent variables is considered Constant (fixed), then the value of the Performance Value will increase by 4.302 units.
- The Service Coverage regression coefficient (X1) of 0.567 states that every increase in one unit of Service Coverage will increase the Performance Value by 0.567 per unit. Moreover, vice versa, a decrease of one unit of Service Coverage will reduce the Performance Value by 0.567 units.
- The regression coefficient of the Water Loss Rate (X2) of -3.016 states that every one unit increase in the Water Loss Rate will decrease the Performance Value by 3.016 per unit. Moreover, vice versa, a decrease of one unit in the Water Loss Rate will increase the Performance Value by 3,016 units.

C. Coefficient Determination Test

Based on the results of the determination coefficient test in Table 2, the value of the determination coefficient in R-Square is 0.421, which means that the ability of the explanatory

variable to explain the response variable is 42.1%. In comparison, other variables outside the regression model influence the remaining 57.9%.

Table 2. Determination Coefficient Test Results

Model Summary[b]

R	R Square	Adjusted R Square	Std. Error of the Estimate
0.649[a]	0.421	0.398	0.25340

a. Predictors: (Constant), Water Loss RateService Coverage
b. Dependent Variable: Performance

D. Test F

The F-statistical test is used to measure the influence of independent variables together on the movement of the dependent variable. Thus, the following tests apply: Ho is accepted if F-stat < F table. Table 3 shows the results.

Table 3. Simultaneous Test Results of Service Coverage and Water Loss Rate on Performance

ANOVA[a]

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	2.337	2	1.169	18.197	< .001[b]
Residual	3.211	50	0.064		
Total	5.548	52			

a. Dependent Variable: Performance
b. Predictors: (Constant), Water Loss RateService Coverage

The regression model equation of the Effect of Service Coverage and Water Loss Rate on the Performance Value has an F-calculated value of 18.197, and this equation is proven to be significant at the confidence level of 5% because it is larger than the F-table, which is 4.0343. In other words, Service Coverage and Water Loss Rate variables significantly affect the direction of the Performance Value at $\alpha = 0.05$.

E. T test

The partial significance test is used to see the effect of each independent variable individually on its dependent variable. For this reason, the test statistics used are the t-test or the t-statistic. The criteria for decision-making are:

- if the t-calculation < t-table, then the independent variable does not have a significant effect on the dependent variable;
- if t-calculation > t-table, then the independent variable has a significant effect on the dependent variable.

Alternatively, it can also be by looking at the p-value,

- if the Sig > 0.05, then the hypothesis is not tested;
- if the Sig < 0.05, then the hypothesis is tested.

See Table 4 for the results.

Table 4. Partial Test Results of Service Coverage and Water Loss Rate on Performance

Variabel	Regression Coefficients	t-count	t-table	Conclusion
Scope of Service	0.567	2.485	2.0085	**H0 is rejected**; the Scope of Service significantly influences the performance value
Water Loss Rate	3.016	-4.486	2.0085	**H0 is accepted**; there is no significant effect of the level of water loss on the Performance Value

For the coefficient of the path X_1 to Y = 0.567, a t-calculation value of 2.485 is obtained by taking a significance level of α of 5%, then the t-value of the t-table = 2.0085, so that because t-calculation = 2.485 is greater than t-table, H0 is rejected or in other words the Service Coverage affects the Performance Value by 0.567 so that every increase in Service Coverage will increase the Performance Value by 0.567 units.

For the coefficient of the line X_2 to Y = -3.016, the calculated t-value of -4.486 is obtained by taking the significance level of α of 5%, then the value of t-table = -2.0085, so that because t-calculation = -4.486 is smaller than t-table, H0 is accepted or in other words the Water loss Rate has a significant effect on the Performance Value by -3.016 so that every increase in the Water Loss Rate will decrease the Performance Value by 3.016 units.

Discussion

The results of this study confirm that the scope of services has a positive and significant relationship with the performance. This is in line with the framework of the Service-Profit Chain theory, which states that the quality and reach of public services drive customer growth and revenue [14]. With the broader scope of services, the potential for increasing customers and company revenue is greater, impacting operational and financial performance.

On the other hand, the study's results also demonstrate that NRW exerts a negative and statistically significant effect on company performance. A consistently high rate of water loss not only reflects technical inefficiencies within the distribution network but also exposes deeper structural weaknesses in both infrastructure maintenance and administrative management. Such inefficiencies may arise from physical leaks due to aging pipelines, inadequate monitoring systems, or poor investment in modern technologies that ensure accurate measurement and control. On the administrative side, insufficient record-keeping, weak billing systems, and limited capacity for detecting illegal connections contribute to the persistence of NRW, further compounding the company's operational challenges.

These conditions ultimately undermine financial sustainability by reducing billable water volume, weakening cash flow, and straining resources that could otherwise be allocated to service improvements. The detrimental impact of NRW is well documented in the literature.

Farley and Liemberger [15] emphasize that uncontrolled water losses directly erode revenue streams, while Murugan and Chandran [9] add that increased production costs associated with replacing lost water place an additional burden on utilities. Together, these findings highlight that reducing NRW is not merely a technical necessity but a strategic imperative for improving efficiency, ensuring customer satisfaction, and safeguarding long-term organizational viability.

Although the regression model in this study was able to explain the influence of two main variables significantly, the R^2 value that has not reached 0.5 indicates that other variables also affect the performance, such as the quality of human resources, the tariff system, operational costs, and internal policies. Therefore, it is necessary to conduct further studies to develop a more comprehensive model.

Conclusion

This study proves that the scope of services and the level of water loss significantly influence the performance of Tirta Giri Nata. The multiple linear regression analysis results showed that the scope of services contributed positively to improving company performance, while NRW had a significant negative impact. The value of the determination coefficient (R^2) of 42.1% indicates that the two independent variables simultaneously explain a large proportion of the variation in the company's performance. These findings reinforce the view that operational efficiency and service coverage are the main pillars of the success of drinking water company.

The implications of these results emphasize the importance of managerial strategies in expanding the scope of services through planned infrastructure development and controlling NRW through technical approaches and digitalization of distribution systems. Perumda's management is expected to strengthen network capacity, monitor leaks, and optimize customer consumption records. In addition, policy interventions from local governments are needed to support performance improvement through financing, training, and a data-based performance evaluation system. Thus, the performance of drinking water companies can continue to be improved sustainably to answer the challenges of public services in the clean water sector.

Conflict of Interest

The authors declare no conflict of interest.

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