Development of a Supply-Demand Model at PERUMDAM Tirta Kahuripan Bogor Regency to Improve Service Coverage

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DOI: 10.29322/IJSRP.13.11.2023.p14302
https://dx.doi.org/10.29322/IJSRP.13.11.2023.p14302

Paper Received Date: 15th September 2023
Paper Acceptance Date: 24th October 2023
Paper Publication Date: 6th November 2023

Abstract- Bogor Regency is the regency with the largest population in Indonesia. There is an issue with the provision of drinking water in Bogor Regency, as the expansion of drinking water services by PERUMDAM Tirta Kahuripan cannot keep up with the growth rate of the Bogor Regency population. This study aimed to identify factors that influenced the increase in service coverage. The instruments used in this study were expert questionnaires and respondent questionnaires, and they were analyzed with SPSS software. The results of the study showed that all variables examined had an effect on the increase in service coverage and were declared homogeneous, valid, and reliable. The most influential variable was then used as a reference for developing a supply-demand model to improve service coverage at PERUMDAM Tirta Kahuripan in Bogor Regency.

Index Terms- Drinking Water Supply, Drinking Water Demand, Service Coverage

I. INTRODUCTION

Acknowledging the importance of drinking water for human life, the SDGs set a target for universal access to drinking water (100%) by 2030 in order to ensure the availability and sustainable management of water for everyone [21]. Fulfilling the demand for drinking water is the responsibility of both the central and local governments through State-Owned Enterprises or Regionally Owned Enterprises, as stipulated in Article 40, paragraph (3) of Law Number 7 of 2004 regarding Water Resources Management. Efforts to increase access to safe drinking water in Indonesia should focus on piped water for several reasons; 1) Well water, as the largest source of drinking water for the population, has seen a decline in quality and quantity due to population growth and economic activity, 2) Piped water is relatively less contaminated compared to well water and other sources, 3) The achievement of access to piped water is very low (the proportion of piped water access in Indonesia in 2019 was only 20%) [3].

Provinces on Java Island, except DKI Jakarta, have below-average access to piped drinking water, even lower than the national average. One reason is that the provinces on Java generally have a large number of households, as is the case in Bogor Regency, West Java. Bogor Regency has the largest population in Indonesia, with as many as 5,566,838 individuals [6].The Drinking Water Supply System (SPAM) that serves the population in Bogor Regency is managed by the Regionally Owned Drinking Water Company (PERUMDAM) Tirta Kahuripan. PERUMDAM Tirta Kahuripan of Bogor Regency is categorized as “HEALTHY” based on the Ministry of Public Works indicators with a performance value of 4.09 [4].

Demographic data shows that out of the total population of Bogor Regency of 2,931,084 individuals, only 703,488 individuals or about 28.01% received services from PERUMDAM Tirta Kahuripan in 2022 [4]. Administratively, the service area of PERUMDAM Tirta Kahuripan in Bogor Regency is divided into nine zones, including Babakan Madang, Ciawi, Cibinong, Cileungsi, Ciomas, Jonggol, Kemang, Leuwiliang, and Parungpanjang.

The prevalence of drinking water service coverage by PERUMDAM Tirta Kahuripan in Bogor Regency from 2013-2022 did not meet the performance assessment standards according to the technical guidelines for PDAM performance assessment

issued by BPPSPAM Ministry of Public Works and only received a score of 2. Technical service coverage according to BPPSPAM is expected to reach or exceed 80%, so the customer growth variable indicator will receive a score of 5, and no addition is needed related to the use of alternative water sources [5].

However, the expansion of drinking water service coverage by PERUMDAM Tirta Kahuripan during that period could not match the demographic growth dynamics of Bogor Regency. Therefore, the disparity between drinking water service coverage and population growth became one of the "physical gaps" that was the focus of this study. Hence, this study was conducted to identify factors affecting the increase in service coverage on the supply-demand aspect at PERUMDAM Tirta Kahuripan in Bogor Regency.

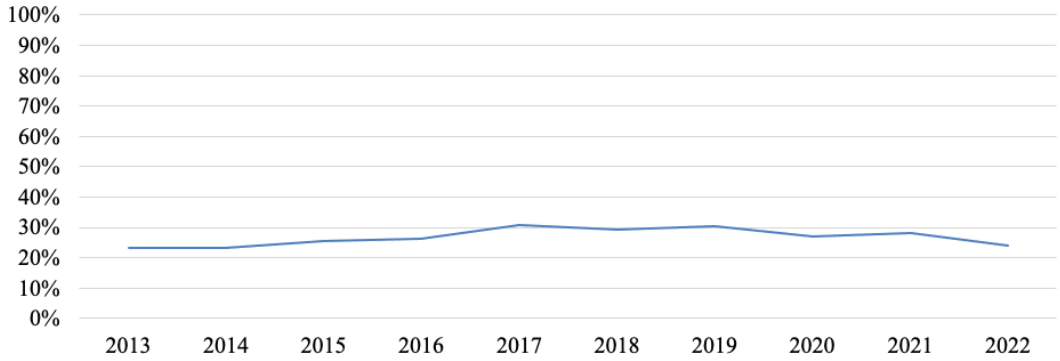

Figure 1. Technical Service Coverage of PERUMDAM Tirta Kahuripan 2013-2022
Source: BPKP (2014-2023)

II. LITERATURE REVIEW

Literature was obtained from various prior studies with topics relevant to the drinking water supply system at the Regional Public Drinking Water Company (PERUMDAM). 1) A case study of community-based rural drinking water supply program (PAMSIMAS) in Magelang Regency, Indonesia used a dynamic systems approach. Five aspects selected for sustainability and development of modeling and simulation included: financial, institutional, environmental, technical, and social aspects [7], 2) Dynamic Systems could provide a unique framework to integrate different physical and social systems crucial for water resource management, while offering an interactive environment for public engagement [20], 3) Dynamic Systems is a model capable of depicting the relationship between impact factors and the support power of water resources and is suitable for performing simulations and predictions under various scenarios [9], 4) Setyawati et al. (2015) concluded that the drinking water supply-demand model developed using a system dynamics approach is highly relevant to be implemented in PDAM Tirtawening as a tool for establishing, changing, integrating between projects and determining project priorities, aiming to achieve company strategies [15].

However, the novelty of this research is the choice of study locus, namely PERUMDAM Tirta Kahuripan in Bogor Regency.With a focus on this specific region, the research produced a characteristic model of the drinking water supply system for PERUMDAM Tirta Kahuripan, reflecting the unique characteristics and challenges faced by the regency. In this research, various pieces of literature about the drinking water supply system in PERUMDAM Bogor Regency were used to support and assist the writing process (BPKP, 2014-2023; Bogor Regency Government, 2018; Setyawati, 2015; Maryati, 2017; Soebagyo, 2013; Andani, 2012; Jaya, 2013; Pirngadi and Nurwulandari, 2018). Generally, regarding the scope of the drinking water supply system at PERUMDAM Bogor Regency, the author described that there are several influential factors,namely:

a. Drinking Water Demand: The drinking water demand subsystem includes the number of populations, served population, customers, water consumption, consumption rate, tariff, tariff rate, and domestic income at PERUMDAM Tirta Kahuripan Bogor Regency.

b. Drinking Water Supply: The drinking water supply subsystem encompasses installed capacity, production capacity, production volume, NRW production, distribution volume, NRW distribution, volume of water sold, leakage,availability of raw water, and investment.

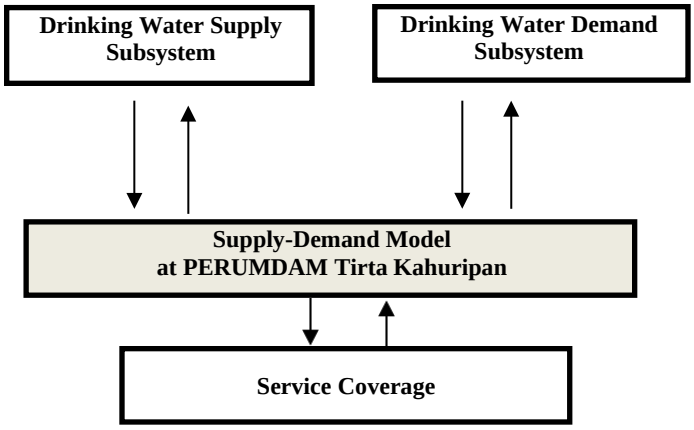

Figure 2. Research Conceptual Framework

III. METHODOLOGY

The study conducted a case study at PERUMDAM Tirta Kahuripan, Bogor Regency, using both primary data (from questionnaires during content/construct validation and respondent survey phases) and secondary data (from literature studies). Questionnaires were distributed to experts in the drinking water field, to validate planning and controlling processes. These experts had to meet set criteria: practitioners required a minimum of 10 years' work experience in the sectorand at least a bachelor's degree, while academics needed a minimum of 10 years' field experience and a master's degree. During the survey phase, feedback was collected from 30 respondents who had at least a bachelor's degree and 2 years of work experience in the field.

Expert opinions were measured with the Guttman Scale, per Sugiyono (2011), generating data with scores ranging from 0 (lowest) to 1 (highest), with effectiveness determined by percentage scores. Respondent perceptions were assessed using the Likert Scale, as described by Taherdoost (2019), where they expressed their level of agreement or disagreement on a one-to-five scale, adjusted according to predetermined indicators.

The study's results were analyzed using SPSS software through the following stages:

1. Homogeneity Test [14]: To evaluate opinion uniformity among respondents on risk variables, the Kruskal-Wallis and Mann-Whitney tests were used, depending on the number of categories. Uniformity was indicated by a p-value in the Asymp.Sig (2-tailed) column exceeding 0.05.
2. Validity and Reliability Test [16]: A questionnaire item was valid if the r calculation was greater than the r table value. Instruments with an alpha value above 0.60 were deemed reliable.
3. Correlation Test [11]: Spearman Rank Correlation was used to identify relationships between independent and dependent variables with ordinal data, without needing normal distribution. A significance value below 0.05 indicated a correlation.

IV. RESULTS AND DISCUSSION

Content and Construct Validation

At this stage, expert validation was conducted to identify factors influencing the service coverage at Perumda Air MinumTirta Kahuripan in Bogor Regency. The data source for this validation came from 9 experts.

Table 1. List of Experts for Expert Validation

No	Position	Organization	Work Experience (Years)	Highest Education
P1	Manager	Perumda Air Minum Tirta Kahuripan Kabupaten Bogor	17	Bachelor's Degree (S1)
P2	Executive Director	Indonesian Drinking Water Company Association (PERPAMSI)	32	Bachelor's Degree (S1)
P3	Lecturer	Department of Civil and Environmental Engineering, Faculty of Engineering, University of Indonesia (FT-UI)	34	Doctorate (S3)
P4	Government Official	Head of Section for Regional Owned Enterprises (BUMD) for Drinking Water, Waste, and Sanitation at the Directorate General of Regional Financial Development, Ministry of Home Affairs	24	Master's Degree (S2)
P5	Specialist	Water Specialist, World Bank	14	Master's Degree (S2)
P6	Board of Supervisors	PERUMDA PAM JAYA Board of Supervisors	30	Doctorate (S3)
P7	Director	PDAM Kota Mojokerto Director	15	Master's Degree (S2)
P8	Commissioner	Commissioner, PDAM Tirta Asasta Depok	>10	Doctorate (S3)
P9	Senior Operations Officer	International Finance Corporation, World Bank Group (Former Head of Sub-directorate for Region III, Directorate for Development of Drinking Water Supply Systems)	20	Master's Degree (S2)

Table 2. Recapitulation of Content and Construct Validation Data

Code	Factor influencing Service Coverage in Drinking Water Supply System	Do You Agree that This Factor Influences Service Coverage at PERUMDAM Tirta Kahuripan?									Result
		P1	P2	P3	P4	P5	P6	P7	P8	P9	
X1.1	Population	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
X1.2	Served Population	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
X1.3	Population Growth Rate	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
X1.4	Customers	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
X1.5	Customer Growth Rate	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
X1.6	Domestic Customers	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
X1.7	Water Consumption	No	Yes	No.	Yes	Yes	Yes	No.	Yes	Yes	Yes
X1.8	Consumption Rate	No.	Yes	No.	Yes	Yes	Yes	No.	Yes	Yes	Yes

X1.9	Tariff	No.	No.	No.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
X1.10	Tariff Rate	No.	No.	No.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
X1.11	Domestic Income	No.	No.	No.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
X2.1	Installed Capacity	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
X2.2	Production Capacity	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
X2.3	Production Volume	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
X2.4	NRW Production	No.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
X2.5	Distribution Volume	Yes	Yes	No.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
X2.6	NRW Distribution	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
X2.7	Volume of Sold Water	No.	Yes	Yes	Yes	Yes	Yes	No.	Yes	Yes	Yes
X2.8	Leakage	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Based on the analysis of content and construct validation data conducted by experts using the Guttman scale approach, it can be concluded that all factors have an influence on service coverage at Perumda Air Minum Tirta Kahuripan Kabupaten Bogor. Furthermore, through intensive discussions with the experts, two additional factors were identified, namely the availability of raw water and investment. Therefore, this research will consider a total of 21 factors that influence service coverage at Perumda Air Minum Tirta Kahuripan Kabupaten Bogor.

Respondent Survey

After the questionnaire was revised, the next stage of data collection involved distributing questionnaires regarding the factors influencing service coverage at Perumda Air Minum Tirta Kahuripan Kabupaten Bogor. A total of 30 respondents were obtained to fill out the questionnaire for this study. Then, the acquired data will be processed using the SPSS application version 27.

Table 3. List of Research Respondents

No	Position	Organization	Work Experience	Highest Education
R1	Staff	Consultant at National Urban Water Supply Project (NUWSP)	> 10 years	Bachelor's Degree (S1)
R2	Staff	Water Auditor at BPKP DKI Jakarta	< 5 years	Bachelor's Degree (S1)
R3	Staff	Directorate of Drinking Water, Ministry of PUPR	< 5 years	Bachelor's Degree (S1)
R4	Staff	Directorate of Drinking Water, Ministry of PUPR	< 5 years	Bachelor's Degree (S1)
R5	Staff	Directorate of Drinking Water, Ministry of PUPR	< 5 years	Bachelor's Degree (S1)
R6	Staff	Directorate of Drinking Water, Ministry of PUPR	< 5 years	Bachelor's Degree (S1)
R7	Staff	Directorate of Drinking Water, Ministry of PUPR	< 5 years	Bachelor's Degree (S1)
R8	Staff	Directorate of Drinking Water, Ministry of PUPR	< 5 years	Bachelor's Degree (S1)

R9	Supervisor	PAM JAYA, DKI JAKARTA	> 10 years	Bachelor's Degree (S1)
R10	Manager	Water Operation and Maintenance Manager at SUEZ Arabia, Makkah City (Former Head of Technical Standardization & Development at PT PAM Lyonnaise Jaya)	> 10 years	Master's Degree (S2)
R11	Manager	PDAM PT. Tirta Sriwijaya Maju (Perseroda)	> 10 years	Bachelor's Degree (S1)
R12	Staff	PDAM KOTA SURABAYA	< 5 years	Bachelor's Degree (S1)
R13	Manager	Perumda Air Minum Tirto Negoro Sragen	> 10 years	Bachelor's Degree (S1)
R14	Supervisor	Perumda Air Minum Tirta KahuripanKab Bogor	> 10 years	Bachelor's Degree (S1)
R15	Supervisor	Perumda Air Minum Tirta KahuripanKab Bogor	5 - 10 years	Bachelor's Degree (S1)
R16	Supervisor	Perumda Air Minum Tirta KahuripanKab Bogor	5 - 10 years	Bachelor's Degree (S1)
R17	Supervisor	Perumda Air Minum Tirta KahuripanKab Bogor	> 10 years	Bachelor's Degree (S1)
R18	Supervisor	National Urban Water Supply Project (NUWSP), Ministry of Home Affairs	> 10 years	Master's Degree (S2)
R19	Supervisor	Head of Public Works, Spatial and Transportation Planning DevelopmentSub Division, Bappedalitbang Kab Bogor	> 10 years	Master's Degree (S2)
R20	Supervisor	Directorate of Drinking Water, Ministry of PUPR	5 - 10 years	Bachelor's Degree (S1)
R21	Supervisor	Perumda Air Minum Tirta KahuripanKab Bogor	> 10 years	Bachelor's Degree (S1)
R22	Supervisor	Perumda Air Minum Tirta KahuripanKab Bogor	> 10 years	Bachelor's Degree (S1)
R23	Staff	Perumda Air Minum Tirta KahuripanKab Bogor	5 - 10 years	Bachelor's Degree (S1)
R24	Supervisor	Perumda Air Minum Tirta KahuripanKab Bogor	> 10 years	Bachelor's Degree (S1)
R25	Supervisor	Perumda Air Minum Tirta KahuripanKab Bogor	> 10 years	Bachelor's Degree (S1)
R26	Manager	Perumda Air Minum Tirta KahuripanKab Bogor	> 10 years	Bachelor's Degree (S1)
R27	Supervisor	Perumda Air Minum Tirta KahuripanKab Bogor	> 10 years	Bachelor's Degree (S1)
R28	Supervisor	Drinking Water Sector Trainer, Institut Sinau Indonesia	< 5 years	Bachelor's Degree (S1)
R29	Supervisor	Drinking Water Sector Trainer, Institut Sinau Indonesia	5 - 10 years	Master's Degree (S2)
R30	Staff	Environmental Consultant and Drinking Water Supervisor at Perumdam Tirta Kahuripan PT. Gema Reksa Persada	< 5 years	Bachelor's Degree (S1)

Homogeneity Test

The purpose of the homogeneity test is to understand the perceptions of respondents based on certain categories. Homogeneity analysis is conducted non-parametrically based on the results of the respondent survey data, focusing on three main aspects, namely: Homogeneity Test Based on Educational Background, Position, and Work Experience. To test homogeneity based on the level of education, the Mann-Whitney U Test is used with the assistance of the SPSS application. The Kruskal Wallis H Test is used to test homogeneity based on position and work experience.

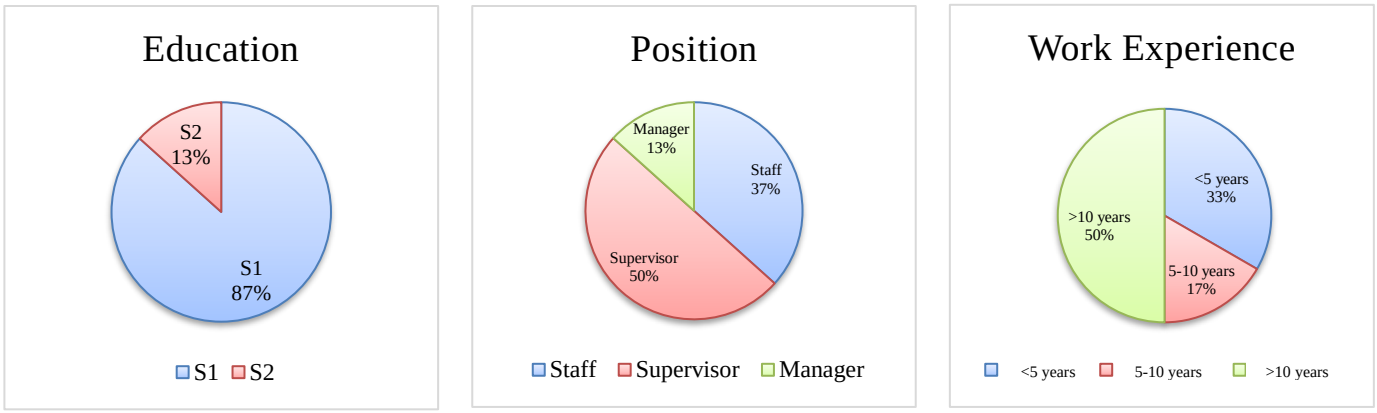

Figure 3. List of Respondent Groups by Education, Position, and Work Experience

Table 4. Results of Homogeneity Test Based on Education, Position and Work Experience

Code	Factor	Asymp. Sig. (2-tailed)	Code	Factor	Asymp. Sig.	Code	Factor	Asymp. Sig.
X1.1	Population	0,088	X1.1	Population	0,520	X1.1	Population	0,538
X1.2	Served Population	0,124	X1.2	Served Population	0,570	X1.2	Served Population	0,483
X1.3	Population Growth Rate	0,065	X1.3	Population Growth Rate	0,482	X1.3	Population Growth Rate	0,413
X1.4	Customers	0,681	X1.4	Customers	0,373	X1.4	Customers	0,619
X1.5	Customer Growth Rate	0,785	X1.5	Customer Growth Rate	0,220	X1.5	Customer Growth Rate	0,401
X1.6	Domestic Customers	0,736	X1.6	Domestic Customers	0,127	X1.6	Domestic Customers	0,399
X1.7	Water Consumption	0,247	X1.7	Water Consumption	0,222	X1.7	Water Consumption	0,431
X1.8	Consumption Rate	0,238	X1.8	Consumption Rate	0,193	X1.8	Consumption Rate	0,424
X1.9	Tariff	0,470	X1.9	Tariff	0,963	X1.9	Tariff	0,920
X1.10	Tariff Rate	0,470	X1.10	Tariff Rate	0,963	X1.10	Tariff Rate	0,920
X1.11	Domestic Income	0,174	X1.11	Domestic Income	0,449	X1.11	Domestic Income	0,552
X2.1	Installed Capacity	0,651	X2.1	Installed Capacity	0,864	X2.1	Installed Capacity	0,823
X2.2	Production Capacity	0,630	X2.2	Production Capacity	0,939	X2.2	Production Capacity	0,380
X2.3	Production Volume	0,735	X2.3	Production Volume	0,393	X2.3	Production Volume	0,149
X2.4	NRW Production	0,870	X2.4	NRW Production	0,677	X2.4	NRW Production	0,755
X2.5	Distribution Volume	0,584	X2.5	Distribution Volume	0,341	X2.5	Distribution Volume	0,509
X2.6	NRW Distribution	0,553	X2.6	NRW Distribution	0,907	X2.6	NRW Distribution	0,882
X2.7	Volume of Sold Water	0,180	X2.7	Volume of Sold Water	0,873	X2.7	Volume of Sold Water	0,858
X2.8	Leakage	0,689	X2.8	Leakage	0,744	X2.8	Leakage	0,954
X2.9	Availability of Raw Water	0,785	X2.9	Availability of Raw Water	0,759	X2.9	Availability of Raw Water	0,302
X2.10	Invesment	0,504	X2.10	Invesment	0,778	X2.10	Invesment	0,253
a. Grouping Variable: Education			a. Kruskal Wallis Test			a. Kruskal Wallis Test		
b. Not corrected for ties.			b. Grouping Variable: Position			b. Grouping Variable: Work Experience		

Based on the analysis results, it is known that the significance value (Asymp. Sig 2-tailed) for all variables is more than 0.05. Therefore, all variables are considered homogeneous. This indicates that there are no significant differences in opinions regarding the factors under review when viewed based on the education, position, and work experience of the respondents.

Data Adequacy Analysis

The data adequacy test is conducted to determine whether the obtained data is sufficient. Initially, the questionnaire was distributed to 30 respondents, and all were completely filled out by the respondents. This test is crucial to ensure that the collected data comes from a consistent and uniform system. To perform the data adequacy test, Slovin's formula is used as explained by Amirin, (2011):

$$n = \frac{N}{1 + Ne^2}$$

Where:

n = Sample size
N = Population size
e = Margin of error percentage

Thus, it is obtained:

$$n = \frac{30}{1 + 30*0{,}05^2} = 27$$

Based on the calculation, the minimum number of respondents needed to fill out the questionnaire is 27 people. However, in this study, a total of 30 respondents participated in filling out the questionnaire. The decision to involve more respondents was made to improve the quality of the research results.

Validity & Reliability Analysis

The validity test aims to determine to what extent the instrument used can measure according to its purpose. The expected result of this test is to obtain a valid and legitimate instrument. In the context of questionnaires, validity can be tested by looking at the correlation between the scores of each statement and the overall score from the respondents' responses to all information in the questionnaire. Components used in this validity testing include:

- Two-sided test
- 95% confidence level (5% significance)
- N = 30
- Df = N – 2 = 30 – 2 = 28
- R table= 0.3610

Next, a validity test is conducted on the factors affecting service coverage at Perumda Air Minum Tirta Kahuripan. This testis done with the help of Ms. Excel and SPSS version 27 applications. The results of the tests can be seen in the following table:

Table 5. Validity Test Results

Code	Factor	Rcalculated	Rtable	Remark
X1.1	Population	0.563	0.3610	Valid
X1.2	Served Population	0.549	0.3610	Valid
X1.3	Population Growth Rate	0.585	0.3610	Valid
X1.4	Customers	0.598	0.3610	Valid
X1.5	Customer Growth Rate	0.480	0.3610	Valid
X1.6	Domestic Customers	0.458	0.3610	Valid
X1.7	Water Consumption	0.725	0.3610	Valid

X1.8	Consumption Rate	0.685	0.3610	Valid
X1.9	Tariff	0.712	0.3610	Valid
X1.10	Tariff Rate	0.712	0.3610	Valid
X1.11	Domestic Income	0.729	0.3610	Valid
X2.1	Installed Capacity	0.494	0.3610	Valid
X2.2	Production Capacity	0.551	0.3610	Valid
X2.3	Production Volume	0.412	0.3610	Valid
X2.4	NRW Production	0.602	0.3610	Valid
X2.5	Distribution Volume	0.495	0.3610	Valid
X2.6	NRW Distribution	0.568	0.3610	Valid
X2.7	Volume of Sold Water	0.626	0.3610	Valid
X2.8	Leakage	0.590	0.3610	Valid
X2.9	Availability of Raw Water	0.490	0.3610	Valid
X2.10	Invesment	0.502	0.3610	Valid

Based on the validity test results shown in the table, it is observed that the Rcalculated for each variable is greater than the Rtable (Rcalculated> Rtable), hence all variables are deemed valid. Following the validity test, a reliability test is conducted to assess the consistency of measurements obtained from the instrument used. The results of the reliability testing show a Cronbach's Alpha value greater than 0.6, indicating that the instrument used in this study has good reliability.

Table 6. Reability Test Results

	Item-Total Statistics				
Code	Factor	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
X1.1	Population	167,00	435,793	0,536	0,739
X1.2	Served Population	166,87	439,085	0,526	0,741
X1.3	Population Growth Rate	167,03	435,413	0,560	0,738
X1.4	Customers	166,77	439,495	0,579	0,741
X1.5	Customer Growth Rate	166,73	442,478	0,457	0,743
X1.6	Domestic Customers	166,77	442,185	0,433	0,743
X1.7	Water Consumption	167,43	424,254	0,701	0,731
X1.8	Consumption Rate	167,47	424,947	0,657	0,732
X1.9	Tariff	167,80	418,648	0,682	0,728
X1.10	Tariff Rate	167,80	418,648	0,682	0,728
X1.11	Domestic Income	167,50	420,121	0,702	0,729
X2.1	Installed Capacity	166,63	443,068	0,474	0,743
X2.2	Production Capacity	166,67	440,437	0,530	0,741
X2.3	Production Volume	166,73	442,616	0,383	0,743

X2.4	NRW Production	167,00	429,931	0,571	0,735
X2.5	Distribution Volume	167,03	441,275	0,471	0,742
X2.6	NRW Distribution	166,97	431,895	0,536	0,737
X2.7	Volume of Sold Water	167,53	428,189	0,595	0,734
X2.8	Leakage	166,87	432,809	0,561	0,737
X2.9	Availability of Raw Water	166,73	442,202	0,468	0,743
X2.10	Invesment	166,90	438,852	0,474	0,741

Correlation Analysis

The Spearman correlation test is used to determine the relationship between two or more variables with an ordinal scale [22]. The basic assumption of this test is that the data is not normally distributed, and the variables are measured on an ordinal scale. The purpose of this correlation test is to evaluate whether there is a significant relationship between the two variables and assess the strength level of the relationship.

Table 7. Correlation Test Results

Code	Factor		Y	Result	Strength of Relationship
X1	Drinking Water Demand				
X1.1	Population	Correlation Coefficient	.520**	Correlated	Strong
		Sig. (2-tailed)	0,003		
X1.2	Served Population	Correlation Coefficient	.503**	Correlated	Strong
		Sig. (2-tailed)	0,005		
X1.3	Population Growh Rate	Correlation Coefficient	.550**	Correlated	Strong
		Sig. (2-tailed)	0,002		
X1.4	Customers	Correlation Coefficient	.593**	Correlated	Strong
		Sig. (2-tailed)	0,001		
X1.5	Customer Growth Rate	Correlation Coefficient	.488**	Correlated	Moderate
		Sig. (2-tailed)	0,006		
X1.6	Domestic Customers	Correlation Coefficient	.482**	Correlated	Moderate
		Sig. (2-tailed)	0,007		
X1.7	Water Consumption	Correlation Coefficient	.670**	Correlated	Strong
		Sig. (2-tailed)	0,000		
X1.8	ConsumptionRate	Correlation Coefficient	.634**	Correlated	Strong
		Sig. (2-tailed)	0,000		
X1.9	Tariff	Correlation Coefficient	.696**	Correlated	Strong
		Sig. (2-	0,000		

		tailed)			
X1.10	Tariff Rate	Correlation Coefficient	.696**	Correlated	Strong
		Sig. (2-tailed)	0,000		
X1.11	DomesticIncome	Correlation Coefficient	.705**	Correlated	Very Strong
		Sig. (2-tailed)	0,000		
X2	Drinking Water Supply				
X2.1	InstalledCapacity	Correlation Coefficient	.504**	Correlated	Strong
		Sig. (2-tailed)	0,005		
X2.2	ProductonCapacity	Correlation Coefficient	.558**	Correlated	Strong
		Sig. (2-tailed)	0,001		
X2.3	ProductionVolume	Correlation Coefficient	.417*	Correlated	Moderate
		Sig. (2-tailed)	0,022		
X2.4	NRW Production	Correlation Coefficient	.543**	Correlated	Strong
		Sig. (2-tailed)	0,002		
X2.5	DistributionVolume	Correlation Coefficient	.552**	Correlated	Strong
		Sig. (2-tailed)	0,002		
X2.6	NRW Distribution	Correlation Coefficient	.500**	Correlated	Strong
		Sig. (2-tailed)	0,005		
X2.7	Volume ofWater Sold	Correlation Coefficient	.618**	Correlated	Strong
		Sig. (2-tailed)	0,000		
X2.8	Leakage	Correlation Coefficient	.474**	Correlated	Moderate
		Sig. (2-tailed)	0,008		
X2.9	Raw Water Availability	Correlation Coefficient	.479**	Correlated	Moderate
		Sig. (2-tailed)	0,007		
X2.10	Investment	Correlation Coefficient	.523**	Correlated	Strong
		Sig. (2-tailed)	0,003		
**. Correlation is significant at the 0.01 level (2-tailed).					
*. Correlation is significant at the 0.05 level (2-tailed).					

Based on the correlation test results conducted, there are 30 variables that show a significant relationship, with a significancevalue of less than 0.05. Among these 30 variables, when categorized based on the strength of their relationship:

1. One variable shows a very strong relationship.
2. Sixteen variables show a strong relationship.
3. Four variables show a moderate relationship.

V. CONCLUSION

The results of the study showed that all variables examined had an effect on the increase in service coverage and were declared homogeneous, valid, and reliable. The most influential variable was then used as a reference for developing a supply-demand model to improve service coverage at PERUMDAM Tirta Kahuripan in Bogor Regency.

REFERENCES

[1] Amirin, T. 2011. *Populasi dan Sampel Penelitian* 4: Ukuran Sampel Rumus Slovin. Jakarta: Erlangga.
[2] Andani, A. 2012. Peningkatan Penyediaan Air Bersih Perpipaan Kota Bandung Dengan Pendekatan Pemodelan Dinamika Sistem. *Jurnal Perencanaan Wilayah dan Kota SAPPK*. 1(1): 69-78
[3] Bappenas. 2019. *Meta Data Target Indikator Air Minum*
[4] BPKP (Badan Pengawasan Keuangan dan Pembangunan). 2014-2023. *Laporan Hasil Evaluasi Kinerja PDAM Tirta Kahuripan Kabupaten Bogor Tahun 2013-2022*
[5] BPPSPAM (Badan Peningkatan Penyelenggaraan Sistem Penyediaan Air Minum). 2014. *Petunjuk Teknis Penilaiaan Kinerja PDAM.* Kementerian PUPR
[6] BPS (Badan Pusat Statistik). 2022. *Kabupaten Bogor Dalam Angka Tahun 2022*.
[7] Daniel, D., Prawira, J., Djono, TPA., Subandriyo, S., Rezagama, A., & Purwanto, A. 2021. A System Dynamics Model of the Community-Based Rural Drinking Water Supply Program (PAMSIMAS) in Indonesia. *Water* 2021, 13, 507. https://doi.org/10.3390/w13040507
[8] Jaya, I. 2013. Model Sistem Distribusi Air Minum PDAM Tirtawening Kota Bandung Untuk Meningkatkan Cakupan Pelayanan Dengan Pendekatan Sistem Dinamis. *Tesis.* Fakultas Teknik Sipil, Universitas Indonesia.
[9] Liu, B., Qin, X., & Zhang, F. 2022. System-dynamics-based scenario simulation and prediction of water carrying capacity for China. *Sustainable Cities and Society*, 82. https://doi.org/10.1016/j.scs.2022.103912
[10] Maryati, S., Humaira, A. N. S., & Hudiary, K. R. 2017. Faktor-Faktor Yang Mempengaruhi Cakupan Pelayanan Air Bersih Di Kawasan Metropolitan di Indonesia. *Prosiding Simposium II* – UNIID. 248-253
[11] Muniarti, Palupi, M. 2013. *Alat-alat Pengujian Hipotesis*. Semarang: Penerbitan Unika Soegijapranata
[12] Pemerintah Kabupaten Bogor. 2018. *Business Plan Kabupaten Bogor Tahun 2018-2022*
[13] Pirngadi, B.H. & Nurwulandari, F.S. 2018. Analisis Statistik Variabel Internal Perusahaan Daerah Air Minum Di Indonesia Yang Berpengaruh Pada Peningkatan Cakupan Pelayanan. *Infomatek*. 20(2): 69-78
[14] Prayitno, D. 2010. *Paham Analisa Statistik Data dengan SPSS*. Yogyakarta: MediaKom
[15] Setyawati, R. 2015. Manajemen Portfolio Proyek Peningkatan Cakupan Air Minum PDAM Tirtawening Kotamadya Bandung. *Disertasi.* Fakultas Teknik Universitas Indonesia
[16] Singarimbun, M. 1989. *Metode Penelitian Survey*. Jakarta: LP3ES.
[17] Soebagyo, S., Rachmaningtyas, L., Kusumawardani, D., & Utami, R. B. (2013). Akses Terhadap Air Perpipaan Di Indonesia: Kajian Sosio-Ekonomi. *Jurnal Ekonomi Dan Bisnis Airlangga*, 23(1). https://doi.org/10.20473/jeba.V23I12013.%p
[18] Sugiyono. 2011. *Metode Penelitian Kuantitatif, Kualitatif dan R&D*. Bandung: Afabeta.
[19] Taherdoost, H. 2019. What Is the Best Response Scale for Survey and Questionnaire Design; Review of Different Lengths of Rating Scale, Attitude Scale, Likert Scale. *International Journal of Academic Research in Management*.
[20] Tidwell V, Passell H, Conrad S, &Thomas R. 2004. System Dynamics Modeling for Community-Based Water Planning: Application to the Middle Rio Grande. *Aquatic Sciences* 66: 357-372.
[21] UN (United Nations). 2016. *Transforming Our World: The 2030 Agenda for Sustainable Development*
[22] Wiratman. 2015. *Teknik Uji Instrument*. Jakarta: PT Rineka Cipta

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