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The Effect of Quality, Quantity, Continuity, and Service of *Sistem Penyediaan Air Minum* (SPAM)/Drinking Water Supply System (DWSS) Products on Customer Satisfaction and Its Impact on Piped Water Absorption Using SEM-PLS Methods

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Abstract. This study is intended to analyze the influence of quality, quantity, continuity, and service of *Sistem Penyediaan Air Minum* (SPAM)/Drinking Water Supply System (DWSS) products on customer satisfaction, which has an impact on the amount of piped water absorption. This study uses a quantitative approach with a survey method and Structural Equation Modeling–Partial Least Squares (SEM-PLS). Data were obtained through the distribution of questionnaires by the company's QHSE Bureau to SPAM/DWSS customers, namely Perusahaan Daerah Air Minum (PDAM)/Drinking Water Regional Enterprise (DWRE). The respondents are PDAM/DWRE entities that have become partners of the company and cooperate in operating the water supply business. The variables studied include water quality (color, taste, odor, and pH), quantity (water capacity fulfillment and distribution), continuity (the ability to provide water at the required capacity and maintain its distribution processes), and service (ease of communication and responsiveness to the instructions given). The results of the study show that the X1 variable of product quality has a positive and significant influence on customer satisfaction, which also has a significant effect on the amount of piped water absorption. Product quality is the most dominant factor influencing satisfaction, and it increases the amount of piped water absorption. This indicates that customer considerations in SPAM/DWSS services are not only related to the quantity of water received and the consistency of distribution but also to the quality of the water consumed.

Keywords: SPAM/DWSS Products; Quality; Service; Customer Satisfaction; SEM-PLS.

INTRODUCTION

Indonesia is an archipelagic country with abundant natural resources, one of which is water. Water is a natural resource urgently needed by humans and other living beings to support daily life. Therefore, the provision of good-quality water, in sufficient quantity, with continuous distribution and supported by good service, is the main responsibility of *Sistem Penyediaan Air Minum* (SPAM)/Drinking Water Supply System (DWSS) operators (Mokan 2022; Widiati 2023). The success of a SPAM/DWSS is not only measured by its technical functionality but also by the level of customer satisfaction with the products and services provided. The level of customer satisfaction could reflect the extent to which the products and services provided have fulfilled people's needs and expectations (Baiomy 2021; Lee et al. 2016; Pakurár et al. 2019).

Perusahaan Daerah Air Minum (PDAM)/Drinking Water Regional Enterprise (DWRE) has a very important role in providing communities with clean water because this task can only be carried out by PDAM/DWRE as a representative of the state in accordance with the mandate of Article 33, paragraph (3), of the 1945 Constitution, which states, "The earth, water, and natural resources contained therein are controlled by the state and used for the greatest prosperity of the people." In Indonesia, there are still many areas that are unable to obtain clean water for their daily needs and therefore continue to rely on groundwater (Carrard et al. 2019; Umami et al. 2022; Zaidi et al. 2025). As is widely known, excessive groundwater consumption can cause environmental disasters. According to Gell et al, (2025) *Badan Riset dan Inovasi*

Nasional (BRIN)/National Research and Innovation Agency (NRIA), environmental disasters that may arise from excessive groundwater extraction include land subsidence, seawater intrusion, groundwater pollution, and building damage. Therefore, it is very important for communities to switch to piped water or PDAM/DWRE water while also playing an active role in protecting the environment. The use of PDAM/DWRE water provides greater assurance because people can obtain healthier water quality in accordance with the Minister of Health Regulation No. 2 of 2023 regarding drinking water quality standards.

However, in reality, there are still many obstacles in various aspects of SPAM/DWSS services, such as poor water quality, uneven water supply, supply disruptions, and slow service in handling complaints. These are important indications that need to be considered in order to conduct a thorough evaluation of SPAM/DWSS service dimensions. Evaluation of PDAM/DWRE performance is carried out regularly every year by Indonesia's *Badan Pengawasan Keuangan dan Pembangunan* (BPKP)/Financial and Development Supervisory Board (FDSB). In accordance with the Decree of the Head of *Badan Pendukung Pengembangan Sistem Penyediaan Air Minum* (BPPSPAM)/National Supporting Agency for Water Supply System Development (NSAWSSD) Number 002/KPTS/K-G/IV/2010 regarding Service Performance Assessment for the Development of Drinking Water Supply Systems in *Perusahaan Daerah Air Minum* (PDAM)/Drinking Water Regional Enterprises (DWRE), there are 18 (eighteen) indicators of PDAM/DWRE performance assessment across 4 (four) aspects, namely financial aspects, service aspects, operational aspects, and human resource aspects. The results of this performance assessment are divided into 3 (three) categories, namely healthy performance, unhealthy performance, and sick performance (Howarth et al. 2017; Jia et al. 2022; Maisharah 2025). Based on the 2023 *Badan Usaha Milik Daerah*(BUMD)/Regional-Owned Enterprise (ROE) Performance Book compiled by the *Kementerian Pekerjaan Umum dan Perumahan Rakyat*/Ministry of Public Works and Public Housing, in 2023 there were 257 (65.39%) healthy PDAM/DWREs, 88 (22.39%) unhealthy PDAM/DWREs, and 48 (12.21%) sick PDAM/DWREs. The results of the PDAM/DWRE performance evaluation concluded that most PDAM/DWREs have been classified as healthy. Therefore, PDAM/DWRE must implement strategic programs to resolve existing obstacles so that communities can enjoy and obtain clean water according to their needs. A scientific study is needed to measure the influence of these factors simultaneously on customer satisfaction and the level of piped water consumption (absorption) (Denantes et al. 2021; Romano et al. 2020).

The performance of PDAM/DWRE is greatly influenced by the performance of the SPAM/DWSS system. This is because the scope of SPAM/DWSS includes all stages involved in the provision of clean water, starting from the intake of raw water from rivers or other water bodies, followed by treatment and storage of treated water, and in some cases including the distribution of water to household and industrial customers. Therefore, improving SPAM/DWSS performance is also an important aspect that must be considered for the sustainability of PDAM/DWRE water services. One method to improve the performance of SPAM/DWSS operators is to accommodate customer aspirations through questionnaires in order to obtain recommendations for further improvement. Indicators used in surveys conducted by PDAM/DWRE are adopted as indicators in this study.

Among the indicators assessed in this study is water quality, which is an important factor in SPAM/DWSS services. Water quality consists of several aspects such as color, odor, taste, metal content such as iron and manganese, turbidity level, acidity level (pH), and residual chlorine. If the water quality does not meet applicable standards, it could be dangerous and may cause various health problems for consumers (Allaire et al. 2018; Dietrich et al. 2015; Organization 2022; Saleh et al. 2021; Uyttendaele et al. 2015).

Another indicator is the quantity of water, namely the sufficiency of clean water for consumers (Ogata et al. 2022; Tijjang et al. 2020). This is crucial to meet basic daily needs such as cooking, bathing, and other activities. If the daily sufficiency of clean water cannot be fulfilled, it may disrupt consumers' daily activities and reduce the level of consumer satisfaction. Therefore, the ability to meet water demand through the capacity of the *Instalasi Pengolahan Air* (IPA)/Water Treatment Plant (WTP) and its distribution to consumers is very important.

Another indicator is water continuity, which refers to the uninterrupted distribution of water to customers. If disruptions occur in water distribution, they may cause concern among consumers and reduce the level of trust in PDAM/DWRE services. Another indicator is customer service, which refers to after-sales responses including the handling of consumer complaints and the ease of administrative procedures. Customer service is one of the factors that must be considered in creating a positive perception among consumers regarding the quality of SPAM/DWSS services. Ease of communication and swift responses to complaints are important indicators that must be implemented by SPAM/DWSS operators. Thus, existing problems can be resolved promptly and do not interfere with the availability of water for consumers.

The urgency of this research stems from multiple converging factors. Environmentally, the continued reliance on groundwater extraction threatens urban sustainability through land subsidence and seawater intrusion, making the transition to piped water systems imperative. Socially, access to quality drinking water represents a fundamental right affecting public health outcomes. Economically, water service providers require evidence-based guidance for resource allocation and service improvement strategies. The declining consumption trend despite high satisfaction ratings suggests a potential misalignment between PDAM assessments of SPAM services and community responses to those services, requiring urgent investigation to prevent further deterioration of water access.

In this study, the independent variables (X) are quality, quantity, continuity, and SPAM/DWSS service, while the dependent variables (Y) are customer satisfaction and the level of piped water consumption. Variable X was analyzed for its influence on customer satisfaction and the level of piped water consumption using the Structural Equation Modeling–Partial Least Squares (SEM-PLS) method. This method was chosen because of its ability to test latent relationships between variables with high complexity and because it is suitable for theoretical models based on consumer behavior. It is expected that the results of this research will contribute positively to the development of SPAM/DWSS services so that SPAM/DWSS operations become more effective and efficient and more oriented toward customer satisfaction.

Over the past five years, the average consumption of SPAM/DWSS water has continued to decline. This trend contrasts with the high customer satisfaction ratings of SPAM/DWSS providers as assessed by PDAM/DWRE. Based on these conditions, this study examines the influence of quality, quantity, continuity, and service on customer satisfaction and its impact on piped water consumption.

The purpose of this study is to analyze the variables that affect customer satisfaction with SPAM/DWSS services. By understanding the results of this study, SPAM/DWSS operators are expected to improve their performance so that the customer satisfaction of PDAM/DWRE services can increase, while also identifying the variables that influence customer satisfaction in relation to the level of piped water consumption of PDAM/DWRE.

MATERIALS AND METHODS

This research was a quantitative study employing a survey method conducted regularly by the company's QHSE Department every six months, typically in June and December. The research locations were six SPAM/DWSS *Badan Usaha Pelaksana* (BUP)/Business Entity (BE) facilities located in several cities, namely Jakarta, Bekasi, Tangerang, Gresik, and Pekanbaru. The customer satisfaction survey data used in this study were derived from surveys conducted between 2022 and 2024. In this study, the customers were *Perusahaan Daerah Air Minum* (PDAM)/Drinking Water Regional Enterprises (DWREs) that served as clients of the SPAM/DWSS companies. The number of customers included in the sample was six PDAM/DWREs. Meanwhile, piped water absorption depended on the amount of piped water used by the community and the piped water absorption monitored by PDAM/DWREs. The focus of this study was to identify the most influential and significant variables affecting SPAM/DWSS customer satisfaction and the level of piped water absorption in PDAM/DWREs.

The sampling technique used in this study was a questionnaire distributed to customers to collect data on product quality, product quantity, product continuity, and the services provided by SPAM/DWSS companies. This study used the Structural Equation Modeling–Partial Least Squares (SEM-PLS) approach. SEM-PLS analysis is a multivariable statistical analysis method used to test and confirm theoretical models, particularly models with complex relationships between latent variables (unobserved variables) and manifest variables (observed variables). For the collection of data on customer piped water absorption, the data were obtained from the amount of water distributed to the community by the SPAM/DWSS companies. The following are the variables and indicators used in this study.

Table 1. Research Variables and Indicators

Variable	Indicators
Product Quality (X1)	Water color (X1.1)
	Water flavor (X1.2)
	Water smell (X1.3)
	Degree of acidity (pH) (x1.4)
Product Quantity Yield (X2)	Water capacity fulfillment (X2.1)
	Fulfillment of distribution water capacity (X2.2)
Product Continuity of Results (x3)	Ability to meet water capacity needs (X3.1)
	Fulfillment of distribution water capacity needs (X3.2)
Service (X4)	Ease of communication (X4.1)
	Fast and Responsive to instructions given (X4.2)
Customer Satisfaction (Y1)	The value of customer satisfaction
Piped water absorption of SPAM/DWSS (Y2)	Total customer piped water absorption

Before analyzing the application of Structural Equation Modeling-Partial Least Squares (SEM-PLS), the above indicators must be checked for outer loading. For outer loading valued > 0.6, the indicator is valid and could be used for the next stage of analysis. Invalid indicators will be removed, after which they will continue using the SEM-PLS application. The results of the SEM-PLS analysis will produce the following equations:

$$\mathbf{Y = \beta 1.\ X1 + \beta 2.\ X2}$$

Information:

Y = Dependent variable

β1 = Variable regression coefficient X1

β2 = Variable regression coefficient X2

X1 = Independent variable 1
X2 = Independent variable 2

RESULTS AND DISCUSSION

From the variables and indicators specified in table 1 above, the author conducted an analysis with SEM-PLS to test and to develop a relationship model between variables quantitatively. The diagram of the analysis results is as follows:

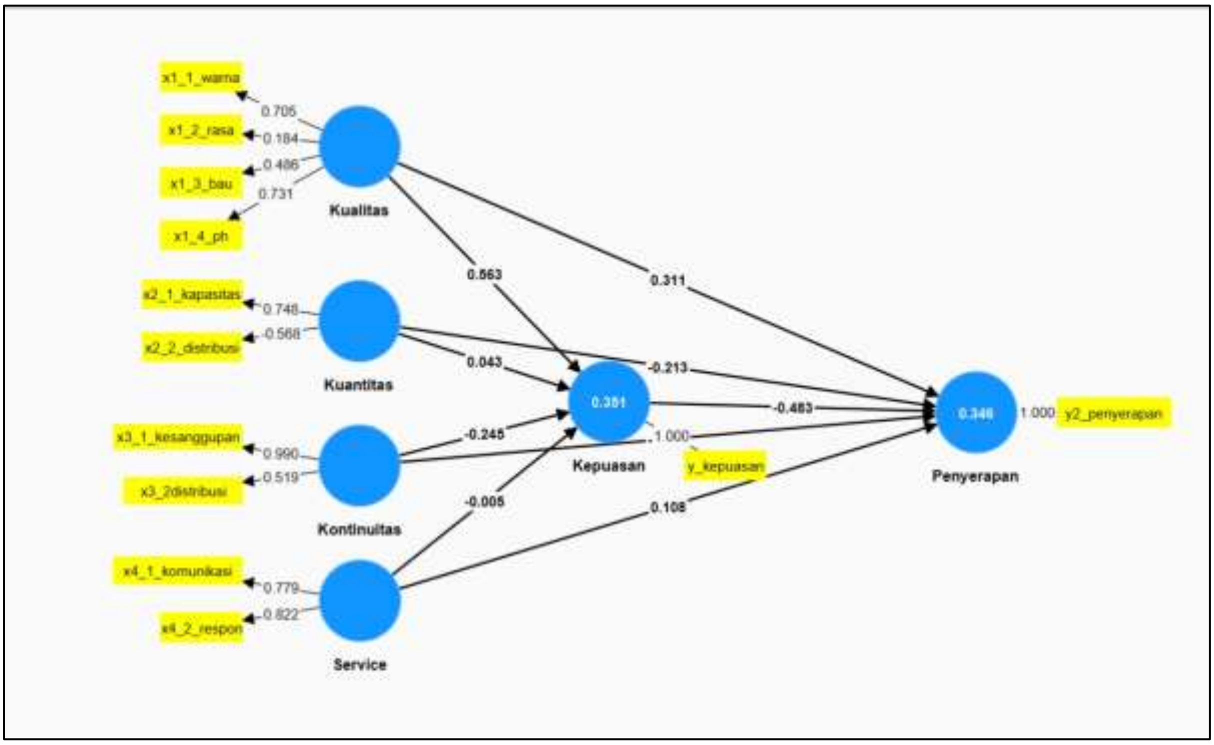

Figure 1 Path Diagram 1

Based on the image above, an Outer Model Assessment has been applied by conducting a construct validity test. Outer loading will be valid if the outer model value > 0.6. Based on the image above, the valid indicators are colour (outer loading 0.705), pH (outer loading 0.731), distribution capacity (outer loading 0.748), distribution capacity (outer loading 0.568), continuity capability (outer loading 0.990), continuity distribution (outer loading 0.519), ease of communication (outer loading 0.779) and fast responsive to complaints (outer loading 0.822). For invalid indicators, they will be removed and then bootstrapping calculations are carried out with the results in Figure 2, Table 2 and Table 3 below. The variables that have a significant influence could be seen from the P value < 0.05 and the statistical T value > 1.3 in Table 3.

The results of the analysis could also be seen in the results of the construct reliability and validity test. The quality criteria will be accepted if Cronbach's Alpha, rho_A and Composite Reliability are ≥ 0.7 and the Average Variance Extracted (AVE) value is ≥ 0.5. From the test results, there was a rho_a ≥ value of 0.7 which was 2.231, rho_c ≥ 0.7 which was 0.752 and 0.782 and AVE ≥ 0.5 which was 0.625 and 0.642 so that it could be concluded the quality requirement of data has been fulfilled.

Table 2. Construct Reliability and Validity Test Results

Construct	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
Continuity	0,567	2,231	0,752	0,625
Quality	0,251	0,345	0,622	0,326
Quantity	0,216	-0,281	0,028	0,441
Service	0,443	0,445	0,782	

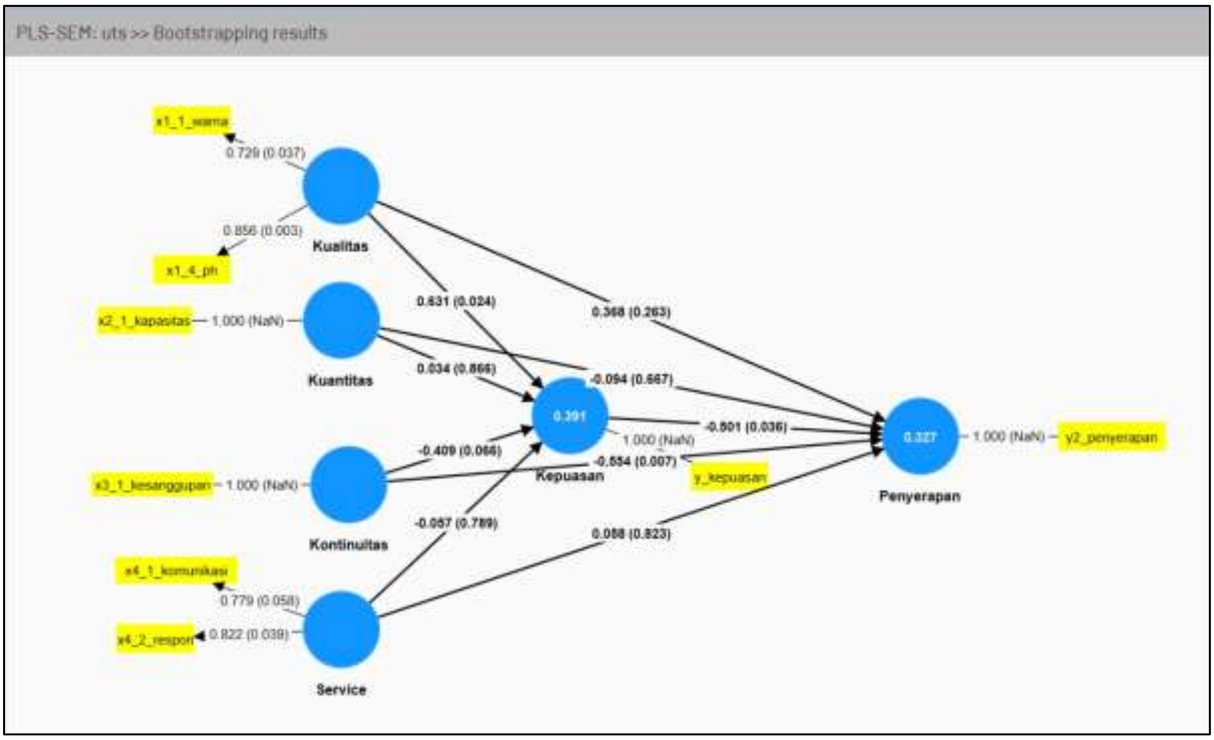

Figure 2. Path Diagram 2

Table 3. Total Effect Results

Effect	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (IO/STDEVI)	P Values
Satisfaction -> Absorption	-0.501	-0.446	0.238	2.102	0.036
Continuity -> Satisfaction	-0.409	-0.406	0.223	1.836	0.066
Continuity -> Absorption	-0.349	-0.314	0.179	1.949	0.051
Quality -> Satisfaction	0.631	0.581	0.279	2.258	0.024
Quality -> Absorption	0.052	0.041	0.269	0.194	0.846
Quantity -> Satisfaction	0.034	0.045	0.200	0.168	0.866
Quantity -> Absorption	-0.111	-0.106	0.234	0.475	0.635
Service -> Satisfaction	-0.057	0.001	0.211	0.268	0.789

Service -> Absorption	0.087	0.081	0.273	0.317	0.751

Table 3 above explained that the regression equation occurred is as follows:

Y Customer Satisfaction = 0.631*XQuality + 0.034*XQuantity - 0.409*XContinuity – 0.057*XService

Y Piped Water Absorption = -0.501*YCustomer Satisfaction + 0,052*Quality - 0.111*XQuantity – 0.349*XContinuity + 0.087*XService

The results of bootstrapping analysis in Figure 2 and Table 3 above could be explained as follows:

1. Variable Y Customer Satisfaction of SPAM/DWSS

a. The variable that has a significant effect on customer satisfaction is the quality of product (P value: 0.024). This shows that the quality of product results is very important to be considered to get an increasing customer satisfaction value.

b. The quality of product also has the largest original value and a positive value of 0.631. This means that the quality of product has positive effect on customer satisfaction. With every improvement in the quality of product results of 1 (one) unit, it will be able to increase 0.631 customer satisfaction. The quality of product that have positive effect on customer satisfaction shows that the better quality of product results the more customer satisfaction.

c. A valid indicator that affecting customer satisfaction is color and degree of acidity of SPAM/DWSS water provided to customers.

2. Variable Y SPAM/DWSS piped water absorption

a. The variable that has a significant effect on the amount of SPAM/DWSS piped water absorption is customer satisfaction (P value: 0.036). This shows that customer satisfaction is a very important aspect to be considered in order to affect the amount of customer satisfaction.

b. In the equation for Y SPAM/DWSS piped water absorption, it shows original negative value of 0.501. This shows that customer satisfaction has a negative effect on the amount of piped water absorption. Negative values indicate that the more satisfied customers are, the less amount of SPAM/DWSS piped water absorbed.

3. Variable X

Indicators which significantly affecting quality are color and acidity level (pH). The indicator that has significant effect on quantity is the fulfilment of water capacity. The indicator that has significant influence on continuity is the ability to fulfil water capacity needs. Indicators that have significant effect on services are ease of communication and quick response to complaints.

In previous studies, it was stated that if customer satisfaction increases, the number of products purchased by the public is also increasing. This does not apply to SPAM/DWSS companies. In assisting water management for public, PDAM/DWRE made contracts with the SPAM/DWSS companies in the water treatment plant and sometimes further in distribution to the public too, so in this study the customer of the SPAM/DWSS companies is PDAM/DWRE. However, the amount of piped water absorption depends on the amount of water used by the public. Meanwhile the public is making contracts with PDAM/DWRE so that the increased satisfaction of PDAM/DWRE with SPAM/DWSS companies performance does not have a positive correlation or does not increase the amount of piped water absorption. The amount of piped water absorption depends mostly on the performance of the PDAM/DWRE as they are the ones assessed by the community.

CONCLUSIONS

The study found that product quality had a significant positive effect on PDAM/DWRE customer satisfaction, while customer satisfaction showed a significant negative effect on SPAM/DWSS water absorption. Among the quality indicators, water color and acidity (pH) were identified as the most influential factors affecting satisfaction. Based on these findings, strategies to improve both satisfaction and water consumption include maintaining water color below 10 PtCo and stable pH levels between 6.5–8.5 in accordance with Minister of Health Regulation No. 2 of 2023 through routine laboratory testing and transparent reporting, ensuring consistent compliance with quality standards, implementing effective marketing and promotional initiatives to encourage communities to transition from groundwater to piped water, and strengthening government support through public education and regulatory policies that promote the use of SPAM/DWSS services. Future research is recommended to incorporate additional variables—such as tariff structures, service reliability, and consumer behavioral factors—and to expand the study to a larger number of PDAM/DWREs or regions in order to obtain a more comprehensive understanding of the factors influencing customer satisfaction and piped water consumption.

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