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The Selection of Infrastructure Aspect for Performance Assessment in Indonesian PDAM

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Abstract: ***Performance assessments of Indonesian PDAM (the Indonesian acronym for Regional Drinking Water Companies) are crucial in ensuring optimum supply systems of drinking water in the communities. Since 2010, the Indonesian Government has based the performance assessment on the procedures set by BPPSPAM (the Indonesian acronym for Supporting Agency for Development of Drinking Water Supply System) under the Ministry of Public Works and Housing. The overall assessment has consisted of 25% of the financial, 25% of the service, 35% of the operational, and 15% of the human resource aspects. In their assessment of drinking water companies' performances, other countries have already employed the physical/infrastructure aspect in addition to these four.***

This research, therefore, aims at finding influential sub-aspects under the infrastructure aspect that contribute best in assessing PDAMs' performances. Influential aspect measured with Partial Least Squares algorithm. Partial Least Squares is chosen because they are using quick, efficient and optimal regression method based on covariance. Parameter that used in assessment can be correlated using regression when the number of explanatory variables is high. From the correlation we could get the influential aspect positively influent by what sub aspect.

The Partial Least Squares Structural Equation Modelling (PLS-SEM) algorithm is applied on 35 PDAMs in the regencies/municipalities in Central Java Province has separated 3 of 10 infrastructure sub-aspects to be the most influential, namely: network density, raw water resource, and pumping system. The result show that assessment of drinking water company positively influenced by network density (β=0.378, $p<0.05$), raw water resources (β=0.899, $p<0.05$), and also pumping system (β=0.631, $p<0.05$).

Keywords : ***PDAM performance assessment, water utility supply system, infrastructure aspect.***

I. INTRODUCTION

The management of SPAM (the Indonesian acronym for Drinking Water Supply Systems) in Indonesia has long been under maintenance of PDAM company. PDAM has reached 374 of total branch all over the regencies/municipalities in Indonesia until now. There are 223 PDAMs (60% of the total) that have earned the category of healthy performances, 99 PDAMs (26% of total) which are less healthy,

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and 52 PDAMs (14% of total) which are unhealthy based on the assessment of BPPSPAM in 2018. PDAM's performances need to be assess comprehensively to measure the quality of the services for further improvement. PDAM's services have to fulfill the main objective, which is to provide high quality, reliable, services for the customers to fulfill their needs for clean water [1].

The previous guide to assess PDAMs performances came from The Decree of Chief of BPPSPAM Number 002/KPTS/K-6/2010 on Performance Assessment of Service and Development of Drinking Water Supply Systems of PDAMs, which used 3-criteria for classification: healthy, less- healthy, and unhealthy performances. The BPPSPAM-based performance assessment has been applied since 2010, and until now still open the chance for correcting and study for the improvements of the influential factors. Some researchers [2] claimed that periodical monitoring, evaluation, and improvement to the performance indicators are essential in ensuring continuous, satisfactory, performance level of Drinking Water Supply Systems. Quantitative-based indicators reflecting each component performances are used to monitor and evaluate the success or failure of a Drinking Water Supply System and help the Government, i.e. the companies owner, make decisions [3].

Influential factors of hydraulic performances including reliability, availability, serviceability needed to be considered such as in Jalal research [4]. As quoted from International Water Association (IWA), countries that have adopted the IWA-based performance assessments for Regional Drinking Water Companies, includes service quality, human resources, finance, water sources, physical, and operational aspects for their indicators [5]. The U.K.'s OFWAT (Office of Water Services) employs indicators such as customer's billing, customer's service level, water quality and environmental performance, water distribution, leakage, water efficiency, unit cost and relative efficiency, and networking and financial performances [6]. The new indicators put at work in the Malaysian case have incorporated management of water resources, human resources, physical assets, operational assets, service quality, and finance [2]. It is visible that physical (infrastructure) sub-aspects are becoming more frequent to be adopted as influencing indicators in assessesment of drinking water company performance.

However, the performance of PDAM gained from Indonesian BPPSPAM score has been considered only four aspects, which is finance, service, operation, and human resources, while not fully embracing the infrastructure aspect of the systems.

Sub aspect that can be considered for infrastructure are raw water source, pipe networking, water treatment installation, water reservoir, and also the customer density.

Thirty-five PDAM in Central Java Province was assessed by BPPSPAM in 2017. From the scoring system, two districts were declared less healthy in their performance: from Banjarnegara Regency, the score was 2.78, and from Grobogan Regency, the score was 2.36. The highest score achieved in the 2017 assessment was 4.17 by Batang Regency. Nonetheless, this classification and scorings are not considered the criteria from infrastructure sub aspect. Infrastructure sub aspect can show more comprehensively condition around PDAM in Indonesia like in the other country.

For example, PDAM of Magelang Municipality is classified as healthy with a score of 3.07, similar to that of the Surakarta Municipality whose score is 3.03. Higher scores should have been given as a result if the district considers surrounding natural springs as dominant raw water sources and high ratios of network densities to the service areas dan customers [2-3,7-8].

The audit from BPKP (the Indonesian acronym for Finance & Development Supervisory Agency) of Central Java Representative (2017) shows that the parameter in assessment was not sufficiently shown network performance results. There was also a recommendation to re-formulate network performance indicators in assessing PDAMs performances. These directed the research towards finding sub-aspects under the infrastructure domain which are influential to PDAMs performance appraisals. The contribution of this research is to give a proper model for selecting PDAM criteria before comparing the result from new parameter model gained from the ANP questionnaire. Proper model checks the parameter needed to be consider which give a positive beta from SMART-PLS software. As stated above, the objective of this research is to decide what infrastructure sub-aspects can be influential to a PDAM's performance score.

II. METHODOLOGY

A. Location

The research has taken Central Java Province as the scope of location. Central Java Province was chosen as the alternative scoring criteria because of this several factor:

a. It has the second most (35) PDAMs among the entire 34 Provinces in Indonesia – East Java Province has the first most with a total of 38.

b. It has the second most RP (Residential Pickups) with a total of 1,6 million – again, East Java Province has the first most with a total of 1,8 million.

c. The PDAMs' performances vary from healthy to less-healthy.

d. The geographical conditions comprise mountainous and plain areas, making the Drinking Water Supply Systems of the PDAMs also vary – either gravitational, pumping or combination of both.

e. The population densities vary, with the range of 400-12.000 people/km2.

B. Operational definitions of BPPSPAM-based, PDAMs performance assessment

BPPSPAM calculation of a PDAM's performance is:

PP = 0,25 FA + 0,25 SA + 0,35 OA + 0,15 HA

where : PP = PDAM Performance

FA = Financial Aspect

SA = Service Aspect

OA = Operational Aspect

HA = Human Resource Aspect

while in explanatory notes:

1) Financial Aspect includes sub-aspects of:

FA1 = Return On Equity (ROE), i.e. the ability to generate back profits from equity

FA2 = Operational Ratio, i.e. the expenses efficiencies to revenues

FA3 = Cash Ratio, i.e. the ratio of the total cash and its equivalent to current liabilities.

FA4 = Billing effectiveness, i.e. the effectiveness of billing activities on water sales.

FA5 = Solvability, i.e. the ability of a PDAM to pay its debts using its assets.

2) Service Aspect includes sub-aspects of:

SA1 = Range of technical service, i.e. the percentage of the served to the whole population within the range of service.

SA2 = Customer growth, i.e. the annual rate of growth of the number of customers.

SA3 = Rate of complaint follow-ups, the extent a PDAM can make followups to complaints yearly.

SA4 = Water quality, i.e. the quality measurement of distributed drinking water, as specified in the Decree of Minister of Health Number 492/MENKES/PER/V/ 2010 on Specifications of Drinking Water Quality.

SA5 = Domestic water consumption, i.e. the description of the level of domestic customers' use of the water.

3) Operational Aspect includes sub-aspects of:

OA1 = Production efficiency, i.e. the measurement of the efficiency of the production system.

OA2 = Water loss, i.e. the measurement of the efficiency of the distribution system against water sales.

OA3 = Operational hours, i.e. the measurement of the efficiency of the whole system and service continuity.

OA4 = Water pressures in residential pickups, i.e. the standardized, minimum levels of water pressure to the number of customers.

OA5 = Replacements of water meters of the customers to ensure the accuracy of customers' water meter age.

4) Human Resource Aspect includes sub-aspects of:

HA1 = Employee Ratio to 1000 customers; it measures the efficient use of labor in serving 1000 customers.

HA2 = Employee Education and Training Ratio to Competence Improvement; it measures the company's concern to improve employee competency.

HA3 = Ratio of Education and Training Cost to Employee Cost; it measures the company's concern to fund employee competency improvement.

C. Operational definitions of the infrastructure aspect

Several sub-aspects under infrastructure, which can influence a PDAM's performance score, are compiled from preceding journals on drinking water supply systems, such as:

IA1 = Network density, i.e. ratio of the piping length to the service range (in km/km2) [7].

IA1a = Customers density, i.e. ratio of the piping length to Residential Pickups (in km/1000RP) [7,8].

IA2 = The total installed capacity of dominant raw water sources [2,3].

IA2a = The installed capacity of dominant raw water sources, after weighted [2,3].

IA3 = The total installed capacity of a WTP (in L/s) [9].

IA3a = The percentage of actual WTP production to the installed capacity (in %) [9].

IA4 = The total installed capacity of a pumping system (in L/s) [9].

IA4a = The ratio of actual production volume (m3/yr) to the total installed capacity of a pumping system (m3/yr) [9].

IA5 = The total installed capacity of the reservoir (m3) [9].

IA5a= The percentage of actual daily usage of reservoir volume (m3) to the total installed capacity of the reservoir (m3) [9].

D. PLS-SEM Method

Two methods are available to analyze relationships using structural equation modeling: the Covariance-Based Structural Equation Modelling (or CB-SEM) and Partial Least Squares Structural Equation Modelling (or PLS-SEM) [10]. This research is using PLS-SEM on the basis that:

1. PLS-SEM is applicable for testing predictive relationships between constructs and so impeccable for theory-developmental researches – hence its application in developing our theory on PDAM performance assessment.
2. The main assumption of using PLS-SEM is that it doesn't impose normality assumptions, and the data doesn't have to be normally distributed.
3. PLS-SEM is preferable for small-sized samples, which is only 35 PDAMs in this research.

SEM with PLS is an alternative technique in SEM analysis, where the data used do not have to be multivariate in normal distribution. In SEM with PLS the value of latent variables can be estimated according to a linear combination of manifest variables associated with a latent variable and treated to replace the manifest variable. SEM with PLS is consists of three component which is:

a. Structural models or inner models describe the relationship model between latent variables that are formed based on the substance of the theory. Equation for structural models for SEM PLS:

$$\eta_j = \Sigma\beta_j\eta_i + \Sigma\gamma_j\xi_b + \xi_j$$

where:

i. b states the range index along i and b

j represents the number of endogenous latent variables

βji represents the path coefficient that connects endogenous latent variables

(η) with endogenous (η)

γjb states the path coefficient that connects endogenous latent variables

(η) with exogenous (ξ)

ζ represents the measurement error rate (inner residual variable)

b. Measurement models or outer models describe the relationship between latent variables and their manifest variables (indicators). In the outer model there are two types of models namely the formative indicator model and the reflexive indicator model. The reflexive model occurs when the manifest variable is influenced by latent variables, while the formative model assumes that the manifest variable influences the latent variable with the direction of causality flowing from the manifest variable to the latent variable. Equation for the SEM PLS reflexive indicator model:

$$x = \lambda_x\xi + \varepsilon_x$$

$$y = \lambda_y\xi + \varepsilon_y$$

where:

x represents the indicator for the exogenous latent variable (ξ)

y states the indicator for endogenous latent variables (η)

λx, λy states the loading matrix which describes such a simple regression coefficient which connects the latent variable with the indicator

While the equation for the formative indicator model:

$$\xi = \Pi x \xi x_i + \delta_\xi$$

$$\eta = \Pi y \xi y_i + \varepsilon_\eta$$

where:

Πx, Πy states like multiple regression coefficients of the latent variable with respect to the indicator

δ_ξ, ε_η states the level of measurement error (residual error)

c. This third part is a special feature of SEM with PLS and is not present in covariant-based SEM. The weight relation score shows the relationship between variance values between indicators and their latent variables. The equation for weight relation is:

$$\xi b = \Sigma_k w_k x_k$$

$$\eta i = \Sigma_k w_k y_k$$

where:

w_{kb}, w_{ki} states the weight k used to estimate latent variables ξ_b and η_i

E. Research flowchart

The research process begins with finding gaps between PDAMs' field-conditions with the references on the researchers' field of study. The infrastructure aspect has been employed widely across worldwide in assessing the performance of drinking water supply companies, yet there is no evidence that it has specifically addressed in any research on the Indonesian PDAMs case. Therefore a literature study, as well as theoretical, is performed on the infrastructure sub-aspects, by which 10 sub-aspects are derived (i.e. IA1, IA1a, IA2, IA2a, IA3, IA3a, IA4, IA4a, IA5, and IA5a). The following data collection secures the BPPSPAM's results on PDAMs performance appraisals and technical data of PDAMs' infrastructure sub-aspects in the field. All this data is analyzed using PLS-SEM until all infrastructure sub-aspects most influential to PDAMs performance score gained.

The complete procedures of this research follow the steps in Fig. 1.

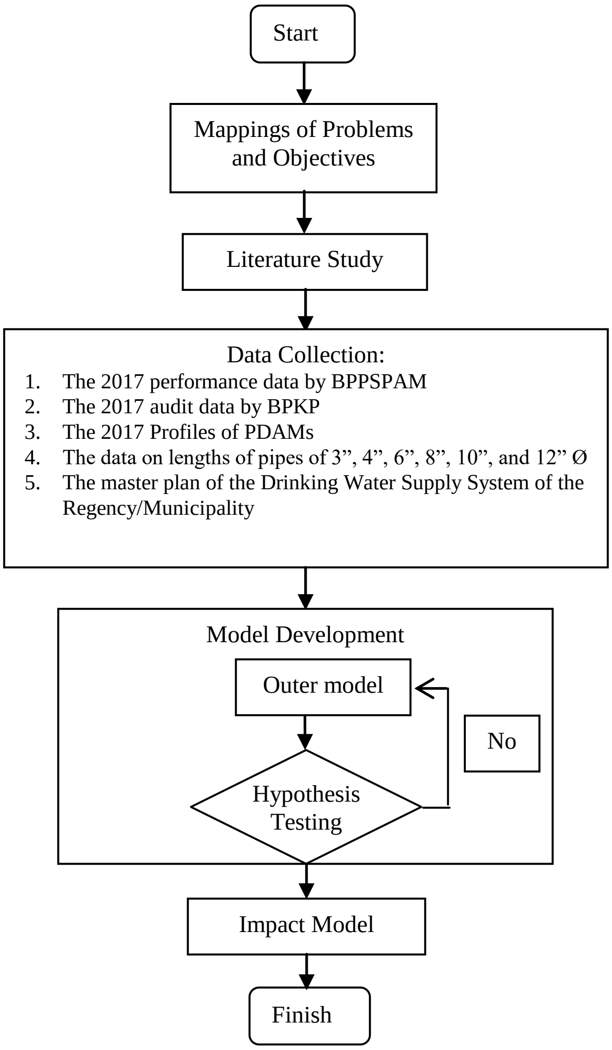

Fig. 1.Research Flow Chart

III. RESULT AND DISCUSSION

There should be minimum 01 to 02 week time window for it. The scores of the entire sub-aspects as well as of the PDAMs performances are taken as PLS-SEM input data. For infrastructure sub-aspects, a normal distribution formula is used to determine scoring 1 to 5. The first test of the PLS-SEM model was the outer model testing. The outer models were assessed using reliability (with composite reliability > 0.6) and validity (with √ AVE> 0.5) [10,11]. The results are presented in Table- I. The influential values of all aspects and sub-aspects of the tested model can be seen in Fig. 2.

Table- I: Results on Reliability and Validity Tests

Constructs	Composite Reliability	√Average Variance Extracted (√AVE)
Infrastructure Aspect	0,416	0,618
Financial Aspect	0,666	0,568
Operational Aspect	0,551	0,516
H.R. Aspect	0,023	0,581
Service Aspect	0,559	0,537
PDAM Performance	1,000	1,000

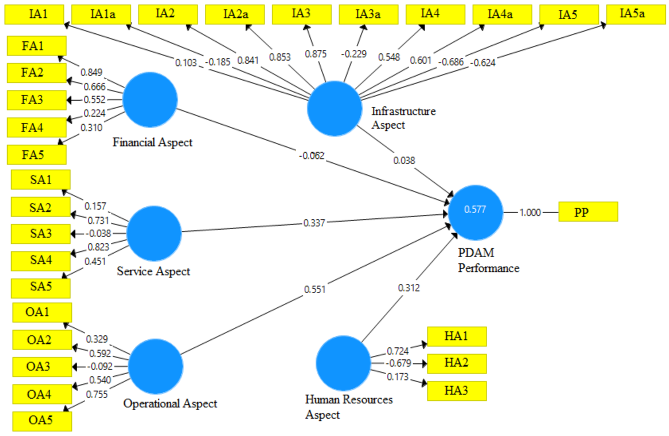

Fig. 2.The Resulting Model of Outer Loadings Tests of all Aspects and Sub-Aspects

The results of outer model testing as shown in Table- I still indicated several values of composite reliability < 0,6 and of √ AVE < 0,5. To achieve positive influential values in all aspects and sub-aspects, iteration was then performed by eliminating the negatively valued sub-aspects and/or other sub-aspects. Table- II presents the non-eligible sub-aspects to drop out. After dropping out invalid sub-aspects, testing on rerun outer loading will result in a model shown in Fig. 3.

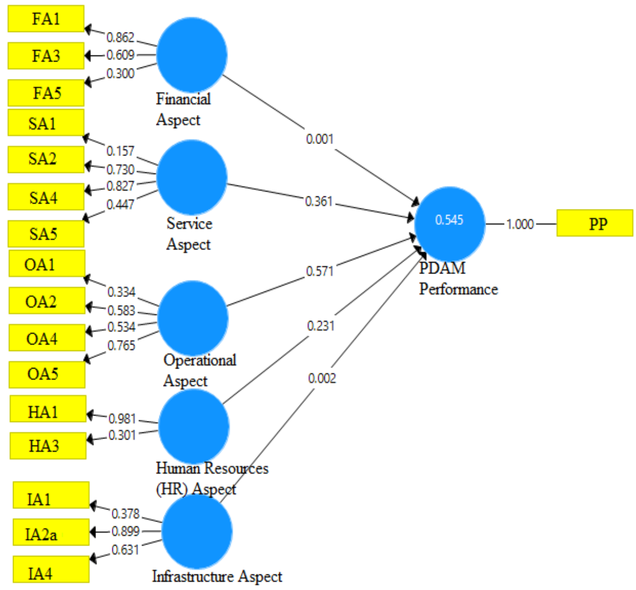

Fig. 3.The Resulting Model of Rerun Outer Loading Tests.

Table- II: The Sub-Aspects Dropped Out

Sub-Aspects	Influential Values
FA2	0,666
FA4	0,224
SA3	-0,038
OA3	-0,092
HA2	-0,679
IA1a	-0,185

IA2	0,841
IA3	0,875
IA3a	-0,229
IA4a	0,601
IA5	-0,686
IA5a	-0,624

The results of the reliability and validity testings of the rerun outer loading model are presented in Table- III. The results of the impact model in Fig. 3 and reliability-validity testings in Table- III have justified the model applicability, with the R2 value of 0,545 which is interpreted as moderate. R2 is interpreted as substantial at 0,67; moderate at 0,33; and weak at 0,19 [10].

Table- III: Results of Rerun Reliability and Validity Tests

Constructs	Composite Reliability	√AVE
Infrastructure Aspect	0.688	0,671
Financial Aspect	0.636	0,633
Operational Aspect	0.647	0,574
Service Aspect	0.646	0,557
H.R. Aspect	0.634	0,725
PDAM Performance	1.000	1.000

Network densities sub-aspect was involved, because research previously indicated that there is an important factor that deserves consideration in the performance of a drinking water supply system [7]. At high population densities, high network densities will lower distribution costs and result in high-performance scores.

The addition of water sources sub-aspects has followed the water supply system performance indicators from IWA (International Water Association). IWA is the main reference for the world water supply system industry because the indicators are diverse and have accommodated various geographical conditions [3]. Also, it is in line with the research that included new indicators [2], one of which was the management of water sources.

The involvement of the pumping system sub-aspect has been in line with the previous research where the pumping system sub-aspect is influential in the performance assessment of a PDAM [9]. Pumping is an influential part of the water distribution system of which aim is to meet the demand for the appropriate quantity and pressure [12].

IV. CONCLUSION

From the discussions above, it can be concluded that: The rerun test model has indicated three infrastructure sub-aspects that are influential to PDAMs performance score. These are network densities, water sources, and pumping systems. These aspect shows that assessment of drinking water company positively influenced by network density (β=0.378, p<0.05), raw water resources (β=0.899, p<0.05), and also pumping system (β=631, p<0.05).

Network density, raw water resources, and pumping system could be included as parameter that influence the PDAM performance. The further research would be use an Analytical Network Process to ensuring the capacity and consistency of three additional parameter in affecting PDAM performance.

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