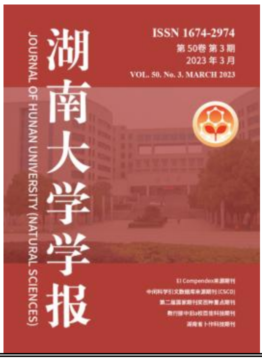

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Assessment of Raw Water Infrastructure Performance for the Performance Index Modeling

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Abstract: This research aimed at the performance assessment of raw water infrastructure. The performance of raw water infrastructure in this case is as the service function of the infrastructure for supplying the raw water. Generally, the benchmark for determining the infrastructure performance is seen from the ability of raw water infrastructure in distributing the raw water discharge according to the demand for the raw water acceptor service. This research is conducted in the Nusa Tenggara Barat (NTB) Province, one of the island provinces consisting of two big islands and several small islands surrounding them. The two big islands are Lombok and Sumbawa, with their uniqueness in the water use pattern, water availability, rainfall, and the economic matters of water user society. The methodology consists of the assessment of the monetary aspect, service aspect, operational aspect, and human resources aspect. The assessment result will be used as the validation standard in building the performance index modeling. However, the assessment of existing raw water infrastructure performance in NTB based on the PP 122, 2015. The result shows that the monetary aspect is increasing in several PDAM; the service aspect is decreasing; the operational aspect is increasing at the beginning, but by the time, it is decreasing; however, the human resources aspect shows an increasing condition.

Keywords: assessment, infrastructure, raw water, monetary aspect, service aspect, operational aspect, human resource aspect.

用于性能指标建模的原水基础设施性能评估

摘要：本研究旨在评估原水基础设施的性能。在这种情况下，原水基础设施的性能是作为供应原水的基础设施的服务功能。通常，确定基础设施性能的基准是原水基础设施根据原水接受服务的需求分配原水排放的能力。这项研究是在努沙登加拉巴拉特(非关税壁垒)省进行的，努沙登加拉巴拉特省是一个岛屿省份，由两个大岛和周围的几个小岛组成。两个大岛是龙目岛和松巴哇岛，它们在用水模式、可用水量、降雨量和用水社会的经济问题方面具有独特性。该方法包括对货币方面、服务方面、运营方面和人力资源方面的评估。评估结果将作为建立绩效指标模型的验证标准。然而，根据 2015 年聚丙烯 122 对非关税壁垒现有原水基础设施性能的评估。结果表明，几个 PDAM 的货币方面正在增加；服务方面正在减少；运

营方面一开始是增加的，到时候就减少了；然而，人力资源方面的情况有所增加。

关键词：评估、基础设施、原水、货币方面、服务方面、运营方面、人力资源方面。

1. Introduction

The performance of raw water infrastructure in this case is as the service function of the infrastructure for supplying the raw water. Generally, the benchmark for determining the infrastructure performance is seen from the ability of raw water infrastructure in distributing the raw water discharge according to the demand for the raw water acceptor service. The performance of infrastructure also reflects the ability to provide the service degree that is needed by the user. Generally, it can be measured from the reliability, availability [1], capacity, and fulfilling customer demand [2].

The model concept of sustainable raw water preparation can use the Domestic Water Mix method. This method shows the measuring of sustainable raw water; there are five stages: 1) Problem identification; 2) Determining the key attributes; 3) Analyzing the WTP; 4) Formulating the model by the system approach; 5) The mechanism of institution cooperation. However, every method that is used in the stage applies to each stage of aim [3].

Jiang [3] said that allocating complex raw water [4] can use the technology of topology analysis and graphical theory due to the decomposition principle and coordination of the raw water allocation system. This combination is applied for fulfilling the water supply guarantee by predicting the water demand and allocation model of water structure type [5, 6].

Some studies related to the performance index of some water resource infrastructure were carried out in the last five years. The modeling of infrastructure performance includes urban drainage, polders, sabo dams, groundwater, and rivers. The research aspects that are a part of the researched variable are the technical aspect, regulation aspect, and social aspect in the research of the river performance index [7], performance index of sabo dams [8], performance index of groundwater irrigation [9, 10], service performance index of polder systems [11], and service performance index of urban drainage [12]. However, this research intends to assess the raw water infrastructure performance in NTB based on the PP 122, 2015.

2. Materials and Method

2.1. Research Location

The research location is in the Nusa Tenggara Barat (NTB) province that consists of two islands that are Lombok Island and Sumbawa Island. The location selection is based on the following:

a. Lombok Island has topography tending to be flat, some areas are hilly and steep, the average rainfall per-year is 1,441 mm/year, has sufficient and constant water source distribution throughout the year, there is a fluctuation in water availability along year with a non-significant decreasing, and most of the flow pattern for raw water is gravitation. Fig. 1 presents a map of Lombok Island.

b. Sumbawa Island has topography as follows: most of it is filly and steep, the average rainfall per year is 1,176 mm/year, the distribution of water sources is uneven and to be fluctuated throughout the year, most of the raw water flow pattern uses a pump for reaching the raw water service area. Fig. 2 presents a map of Sumbawa Island.

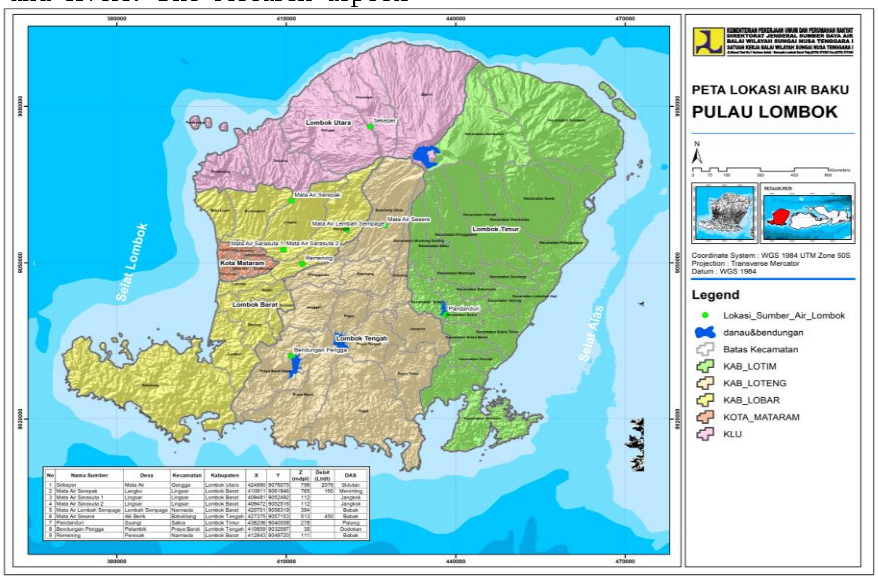
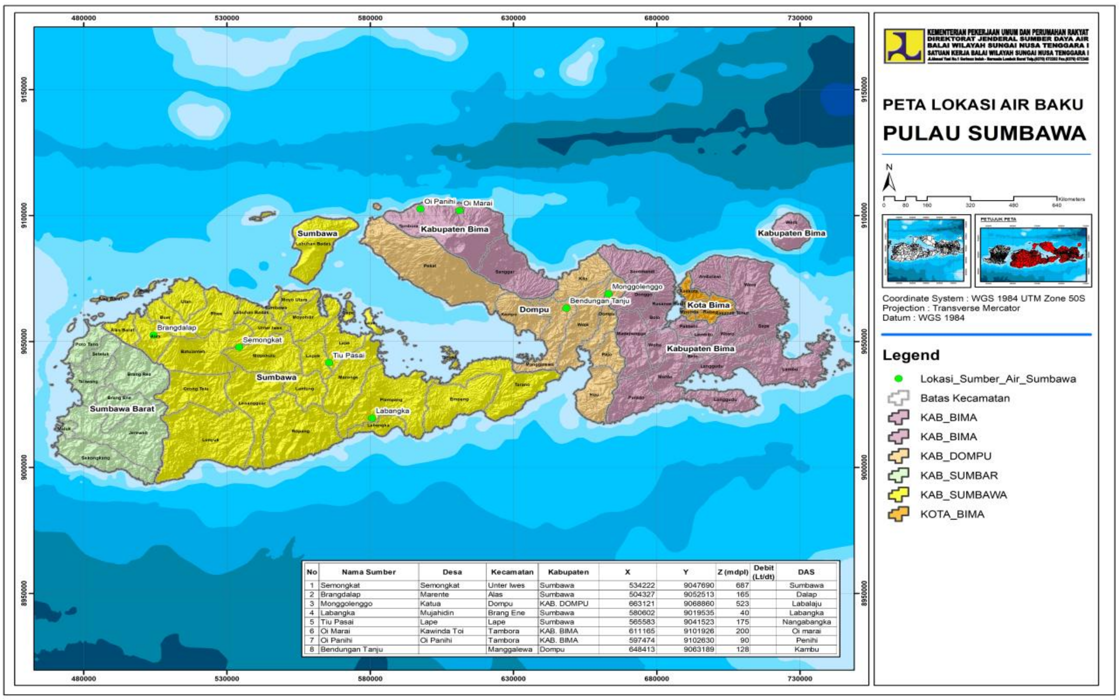


Fig. 1 Lombok Island location map



No	Nama Sumber	Desa	Kecamatan	Kabupaten	X	Y	Z (mdpl)	Debit (Lt/dt)	DAS
1	Semongkat	Semongkat	Unter Iwes	Sumbawa	534222	9047690	687		Sumbawa
2	Brangdalap	Marente	Alas	Sumbawa	504327	9052513	165		Dalap
3	Monggolenggo	Katua	Dompu	KAB. DOMPU	663121	9068860	523		Labalaju
4	Labangka	Mujahidin	Brang Ene	Sumbawa	580602	9019535	40		Labangka
5	Tiu Pasai	Lape	Lape	Sumbawa	565583	9041523	175		Nangabangka
6	Oi Marai	Kawinda Toi	Tambora	KAB. BIMA	611165	9101926	200		Oi marai
7	Oi Panihi	Oi Panihi	Tambora	KAB. BIMA	597474	9102630	90		Penihi
8	Bendungan Tanju		Manggalewa	Dompu	648413	9063189	128		Kambu

Fig. 2 Sumbawa Island location map

2.2. Raw Water

The water source is natural or artificial water storage over or under the soil surface (based on the PP No. 121, 2015-chapter 1 clause 3). Based on the PP No. 122, 2015-chapter 1 clause 1, raw water for household drinking water, which is mentioned further as raw water, is the water that comes from surface water source, groundwater, rainfall, and sea water, which conforms to the certain quality standard as the raw water for drinking water.

The Indonesia Republic Ministry Rule of General Work and Housing No 01/PRT/M/2016 about the licensing procedure of water resource exploitation and usage mentioned that the definition of water is all water in, over, or under the land surface, including in this meaning is surface water, groundwater, rainfall, and sea water in the land. The water source is natural or artificial water storage over or under the land surface. Based on the rule above, the water source is divided into 2 that are all of the water in the land surface; however, groundwater is all of the water in the soil layer or stone in the land sub-surface. Raw water is as the beginning of a process in preparing and processing clean water.

Based on the Indonesia Republic Rule No. 122, 2015 about the system of drinking water preparation, the raw water is for household drinking water which for the next is mentioned as raw water that is the water, which comes from surface water source, groundwater basin, and/or the rainfall that conforms to a certain quality standard for drinking water. The raw water can come from rivers, lakes, water wells, and rainfall and can also be made by curbing drainage water or sea water. The river water includes the surface water from rainfall and that flowing in the earth surface; then, they are collected in a relatively low place, according to the different local geomorphology. The usage of river water as the raw water is necessary to ensure that the water is not polluted and cannot be used continuously because it is dependent on the season. From the two types of water sources that are surface water and groundwater, the surface water source has the biggest availability to be used. However, the usage of groundwater is very helpful for fulfilling the water demand, but the usage of groundwater requires a very high operational cost.

2.3. Transmission System of Raw Water

The Indonesia Republic Ministry Rule of General Work and Housing No. 26/PRT/M/2014 mentioned that the system of drinking water preparation, which is mentioned further as SPAM, is a unity of physical (technical) and non-physical systems of infrastructure and drinking water means, which is implemented by designing, construction, maintaining, rehabilitating, monitoring, and/or evaluating the physical (technical) and non-physical drinking water preparation. The activity is carried out by the organizer of SPAM development that is state-owned enterprises/ local-owned enterprises, cooperation, public-owned enterprises, and or the society group who organize the SPAM development that consists of raw water unit, production unit, distribution unit, service unit, and management unit.

The raw water unit takes means and/or raw water provider that consists of a water storage structure, tapping structure, measurement and monitoring tools, pumping system, groundwater, and surface water

(Indonesian Republic Ministry Rule of General Work and Housing No. 27/PRT/M/2016).

Based on the basic place of the channel bed to the native land, the raw water channel is divided into two: stack and excavation channels. A stack channel building is implemented in the stacked area where the channel is over the native land, and the excavation material is brought from off-site channel area. However, the excavation channel bed is under the native land surface so it is necessary to conduct the excavation in building the channel.

2.4. Infrastructure of Water Resources

The infrastructure of water resources that is mentioned further as the infrastructure of SDA includes dams, reservoirs, small dams, weirs, irrigation channels, and raw water channels (Indonesia Republic Ministry Rule of General Work and Housing No. 09/PRT/M/2016). The water infrastructure does not consist only of a water source. This system is always comprehensive, consisting of at least some elements as follows: raw water source, raw water channel, water processing facility, water pump station, water tank, transmission network, water distribution network, etc. The inundated infrastructure is part of infrastructure that inter-dependent and inter-related. Specifically, the water resources can be seen as part and at a time outside the infrastructure.

2.5. Assessment Scale

In this research, for the assessment by respondents from the question points, we used the assessment scale. The scale is a set of assessments or scores that is determined for the subject, object, or behavior with the aim to measure the characteristics. The scale consists of a list of statements or questions, delivered to the respondents for being responded in a written form. Generally, the scale is used for measuring the behavior, perception, value, and interest. The scale does not present the success or failure of the measured object. Some measuring scales can be used in designing the measuring scale in the behavior research [13], for instance, the Thurstone scale, Guttman scale, and Likert scale. Among some measuring scales, the Likert scale as a data-collecting tool will be more practical than the other methods, saving time and energy. Additionally, the Likert scale has the odd scale range, so it is possible for the respondent has the middle assessment for being able to give the assessment. Based on the description above, this research used the Likert scale for collecting the respondent data that were analyzed.

3. Results and Discussion

3.1. Monetary Aspect Analysis

The analysis result of the monetary performance index is conducted in 7 BUMD in the research locations that are Lombok Barat Regency, Lombok Tengah Regency, Lombok Timur Regency, Sumbawa Regency, Dompu Regency, and Baima Regency. Table 1 presents the analysis result for each BUMD in the 5 years range (2017-2022). The result shows that in several PDAM is increasing and decreasing, however for PT Air Minum Giri Menang, the monetary performance is constant during 5 years. It marks that during the 5 years, on the 3 variables do not happen the increasing and tend to constant. The three variables are rentability, liquidity, and solvability.

Table 1 Monetary aspect, 2019-2021 ([14]; Own study, 2023)

No	Name of PDAM	Year				
		2017	2018	2019	2020	2021
1	PT. Air Minum Giri Menang (Perseroda)	1.030	1.030	1.030	1.030	1.030
2	PDAM Tirtha Ardhia Rinjani Kabupaten Lombok Tengah	0.920	0.865	0.920	0.700	0.810
3	PDAM Kabupaten Lombok Timur	0.700	0.920	0.920	0.700	0.920
4	PERUMDA Amerta Dayan Gunung Kabupaten Lombok Utara	1.030	0.700	0.865	0.865	0.920
5	PERUMDAM Batulanteh Kabupaten Sumbawa	0.700	0.975	0.865	0.590	0.920
6	PERUMDAM Tirta Rora Kabupaten Dompu	0.480	0.535	0.700	0.480	0.370
7	PDAM Kabupaten Bima	0.370	0.370	0.370	0.370	0.370

3.2. Service Aspect Analysis

Table 2 presents the service aspect performance analysis results. They show that the service aspect performance in most of the seven PDAMs decreases. This means that some aspects that affect the service aspects such as service scope, customer growth (%/year), solving the degree of complaints, customer water quality, and domestic water consumption are inter-related. In the PDAM Lombok Timur the decreasing in 2020 and increasing in 2021 happened, where the increasing happened in the customer growth.

Table 2 Service aspect, 2019-2021 ([14]; Own study, 2023)

No	Name of PDAM	Year				
		2017	2018	2019	2020	2021
1	PT. Air Minum Giri Menang (Perseroda)	0.950	0.950	0.900	0.700	0.725
2	PDAM Tirtha Ardhia Rinjani Kabupaten Lombok Tengah	0.800	0.450	0.450	0.000	0.450
3	PDAM Kabupaten Lombok Timur	0.750	0.650	0.525	0.450	0.600
4	PERUMDA Amerta Dayan Gunung Kabupaten Lombok Utara	0.700	0.600	0.650	0.700	0.550
5	PERUMDAM Batulanteh Kabupaten Sumbawa	0.850	0.500	0.500	0.500	0.450
6	PERUMDAM Tirta Rora Kabupaten Dompu	0.450	0.450	0.450	0.600	0.400
7	PDAM Kabupaten Bima	0.325	0.325	0.475	0.425	0.400

3.3. Operational Aspect Analysis

Table 3 presents the operational aspect analysis results. They show increasing at the beginning, by the time the operational condition is decreasing in the seven PDAMs in the research location.

Table 3 Operation aspect, 2019-2021 ([14]; Own study, 2023)

No	Name of PDAM	Year				
		2017	2018	2019	2020	2021
1	PT. Air Minum Giri Menang (Perseroda)	1.410	1.275	1.340	1.340	1.340
2	PDAM Tirtha Ardhia Rinjani Kabupaten Lombok Tengah	1.010	1.080	1.065	0.865	1.135
3	PDAM Kabupaten Lombok Timur	1.205	1.065	0.995	0.950	1.145
4	PERUMDA Amerta Dayan Gunung Kabupaten Lombok Utara	1.340	1.275	1.120	1.060	1.000
5	PERUMDAM Batulanteh Kabupaten Sumbawa	1.275	1.270	1.350	1.340	1.060
6	PERUMDAM Tirta Rora Kabupaten Dompu	0.930	0.780	0.860	0.650	0.660
7	PDAM Kabupaten Bima	0.430	0.430	0.430	0.350	0.350

3.4. Human Resource Aspect Analysis

Table 4 presents the human resource aspect analysis results. They show that the condition is increasing every year in the PT Air Minum Giri Menang (Perseroda); however, in the other PDAM, it tends to be constant every year.

Table 4 Human resource aspect, 2019-2021 ([14]; Own study, 2023)

No	Name of PDAM	Year				
		2017	2018	2019	2020	2021
1	PT. Air Minum Giri Menang (Perseroda)	0.590	0.590	0.630	0.630	0.630
2	PDAM Tirtha Ardhia Rinjani Kabupaten Lombok Tengah	0.430	0.470	0.430	0.430	0.430
3	PDAM Kabupaten Lombok Timur	0.470	0.430	0.430	0.430	0.430
4	PERUMDA Amerta Dayan Gunung Kabupaten Lombok Utara	0.470	0.430	0.510	0.430	0.470
5	PERUMDAM Batulanteh Kabupaten Sumbawa	0.360	0.360	0.360	0.360	0.360
6	PERUMDAM Tirta Rora Kabupaten Dompu	0.430	0.430	0.430	0.430	0.430
7	PDAM Kabupaten Bima	0.150	0.150	0.430	0.430	0.430

3.5. Recapitulation of All the Aspects

The recapitulation of the whole performance index analysis based on the PP 122/2015 can be seen in Table 5. This table is obtained from each PDAM of water source in the research location, for non-technical performance; PT Air Minum Giri Menang (Perseroda) was in a healthy condition during five years; however, the other PDAM changed from healthy to unwell, even PDAM Kabupaten Bima and Tirta Rora Kabupaten Dompu were unhealthy during five years.

The condition of PDAM Kabupaten Bima during five years did not increase from unhealthy to unwell; even the healthy condition is caused by the quality of water obtained from the water source, produced, and reaching the customer. Additionally, the water loss level is generally high enough, where the standard of water loss is 20%. The condition of human resources is also affected by increasing the status position of the PDAM. The three cases are affected enough, where each aspect has almost the same weight.

Table 5 Recapitulation of the performance based on the PP 122/2015 ([14]; Own study, 2023)

No	Name of PDAM	Year				
		2017	2018	2019	2020	2021
1	PT. Air Minum Giri Menang (Perseroda)	3.980	3.845	3.900	3.700	3.725
		Healthy	Healthy	Healthy	Healthy	Healthy
2	PDAM Tirtha Ardhia Rinjani Kabupaten Lombok Tengah	3.160	2.865	2.865	2.420	2.825
		Healthy	Healthy	Healthy	unwell	Healthy
3	PDAM Kabupaten Lombok Timur	3.125	3.065	2.870	2.530	3.095
		Healthy	Healthy	Healthy	unwell	Healthy
4	PERUMDA Amerta Dayan Gunung Kabupaten Lombok Utara	3.540	3.005	3.145	3.055	2.940
		Healthy	Healthy	Healthy	Healthy	Healthy
5	PERUMDAM Batulanteh Kabupaten Sumbawa	3.185	3.105	3.075	2.790	2.790
		Healthy	Healthy	Healthy	unwell	unwell
6	PERUMDAM Tirta Rora Kabupaten Dompu	2.290	2.195	2.440	2.160	1.860
		Not healthy	Not healthy	unwell	Not healthy	Not healthy
7	PDAM Kabupaten Bima	1.275	1.275	1.705	1.575	1.550
		Not healthy	Not healthy	Not healthy	Not healthy	Not healthy

Based on the results above, the PDAM Bima and Perumdan Tirta Rora Kabupaten Dompu should be attended for increasing the performance by eliminating the problem hindering increasing the position from unhealthy to healthy. Based on the analysis of PP 122/2015 above, the performance of service and operational affect the weight and indirectly affect the monetary aspect. Further analysis shows that the water sources in the two regencies are minimal, compared with the Lombok Barat and Lombok Utara regency that are supported by the natural conditions and water source.

The service scope and water loss are also reasons in institutional performance assessment as presented in Table 6.

Table 6 Aspects of the Service and Water Loss (Secondary data [15]; Own study, 2023)

No	Name of PDAM	Scope of service (%)	Number of customer	Water loss (%)
1	PT. Air Minum Giri Menang (Perseroda)	51.07	144,191	35.62
2	PDAM Tirtha Ardhia Rinjani Kabupaten Lombok Tengah	37.47	54,370	17.05
3	PDAM Kabupaten Lombok Timur	30.23	25,603	37.43
4	PERUMDA Amerta Dayan Gunung Kabupaten Lombok Utara	36.10	17,304	22.88
5	PERUMDAM Batulanteh Kabupaten Sumbawa	28.20	21,721	16.68
6	PERUMDAM Tirta Rora Kabupaten Dompu	22.90	8,511	61.90
7	PDAM Kabupaten Bima	14.41	20,472	64.48

4. Conclusion

Recapitulation of the whole performance index analysis based on the PP 122/2015 indicates that from each PDAM of water source in the research location, for non-technical performance; PT Air Minum Giri Menang (Perseroda) was in a healthy condition during five years; however, the other PDAM changed from healthy to unwell, even PDAM Kabupaten Bima and Tirta Rora Kabupaten Dompu were unhealthy during five years.

The monetary aspect analysis results for each BUMD in the five years' range (2017-2021) show that the monetary aspect in several PDAMs is increasing and decreasing; however, for PT Air Minum Giri Menang, the monetary performance is constant during five years. It marks that during five years, there is no increasing in the three variables; they tend to be constant.

The service performance analysis results show that the service aspect performance in most of the seven PDAMs is decreasing. This means that some aspects that affect the service aspects such as service scope, customer growth (%/year), solving the degree of complaints, customer water quality, and domestic water consumption are inter-related.

The operational aspect analysis results show increasing at the beginning; however, by the time, the operational condition is decreasing in the seven PDAMs in the research location. The human resource analysis results show that the condition is increasing every year in the PT Air Minum Giri Menang

(Perseroda); however, in the other PDAM, it tends to be constant every year.

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