Evaluation of PDAM Performance Using Dynamic Models

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Abstract. *In the area of Public Works, one of the Minimum Service Standards under the authority of the Regional Government is the fulfillment of basic needs of daily drinking water. However, the service by PDAM is still not optimal. It can be seen from the PDAM's performance that was "unhealthy from year to year according to BPPSPAM data. Some of the research methods used in analyzing PDAM performance are problem identification, identification of variables and conceptual models, dynamic model simulations, analysis and interpretation as well as drawing conclusions and suggestions. From the simulation result of dynamic models using Vensim PLE plus software, alternative scenarios were obtained, that will increase domestic water consumption and customer connections by 12.5% per year, increasing the repair and replacement of distribution piping systems and customer meters by 20% per year, and increasing rate to 15% per year.*

Keywords: *PDAM Performance, Dynamic Models, Minimum Service Standards, PLE plus Venses*

1. Preliminary Study Overview

Drinking water is a basic need that is indispensable for human life in a sustainable manner in order to improve the degree of public health. To meet these basic needs, a quality, healthy, efficient and effective drinking water supply system is needed, integrated with other sectors, especially the sanitation sector so that people can have healthy and productive life. So, we need the presence of the government to ensure that public drinking water is assured, good quality, quantity and continuity [1]. Populationgrowth, coupled with declining water availability and changing climatic conditions undescore the need for sustainable and responsive water management instruments.

In the Government Regulation Number 2ndof year 2018 stated that the Minimum Service Standards or abbreviated as MSS is a provision regarding the type and Quality Basic Service which is a compulsory Government Affairs obtained every citizen is entitled to a minimum. Basic services in the Minimum Service Standards is mandatory held by government affairs, both provincial government and the local government. In the area of Public Works and Spatial Planning, one of the MSS under the authority of the Provincial Government is the fulfillment of bulk potable water inter-district / city. While the MSS under the authority of the District / City is the fulfillment of basic needs of daily drinking water. Due to the importance of MSS, City Government forms a special business entity, namely the PDAM [2,3].

However, the service of public drinking water by PDAM is still not optimal. It can be seen from the performance of PDAM that are still "unhealthy" from year to year according to the data of Water Supply System Development Support (BPPSPAM). In East Java, there are several PDAM that are still in the category "unhealthy", such PDAM in Probolinggo, PDAM in Ngawi, PDAM in Bangkalan, Pamekasan and PDAM in Blitar and PDAM Maja Tirtain Mojokerto. Those PDAMs have "unhealthy" performance or has a value below 2.8 as limit value due to be labeled as "healthy" performance [4,5]. This condition must be addressed immediately in order to increase the performance of PDAM to be labeledas "healthy" rather than "unhealthy". Water plant siwalanpanji used nanofiltration but could not treat raw water it is mean that technology not yet enhance water consumption [6,7].

2. Research Method

Some of the research methods used in analyzing the performance of PDAM areproblem identification, identification of variables and conceptual models, dynamic model simulations, and analysis and interpretation as well as drawing conclusions and suggestions.

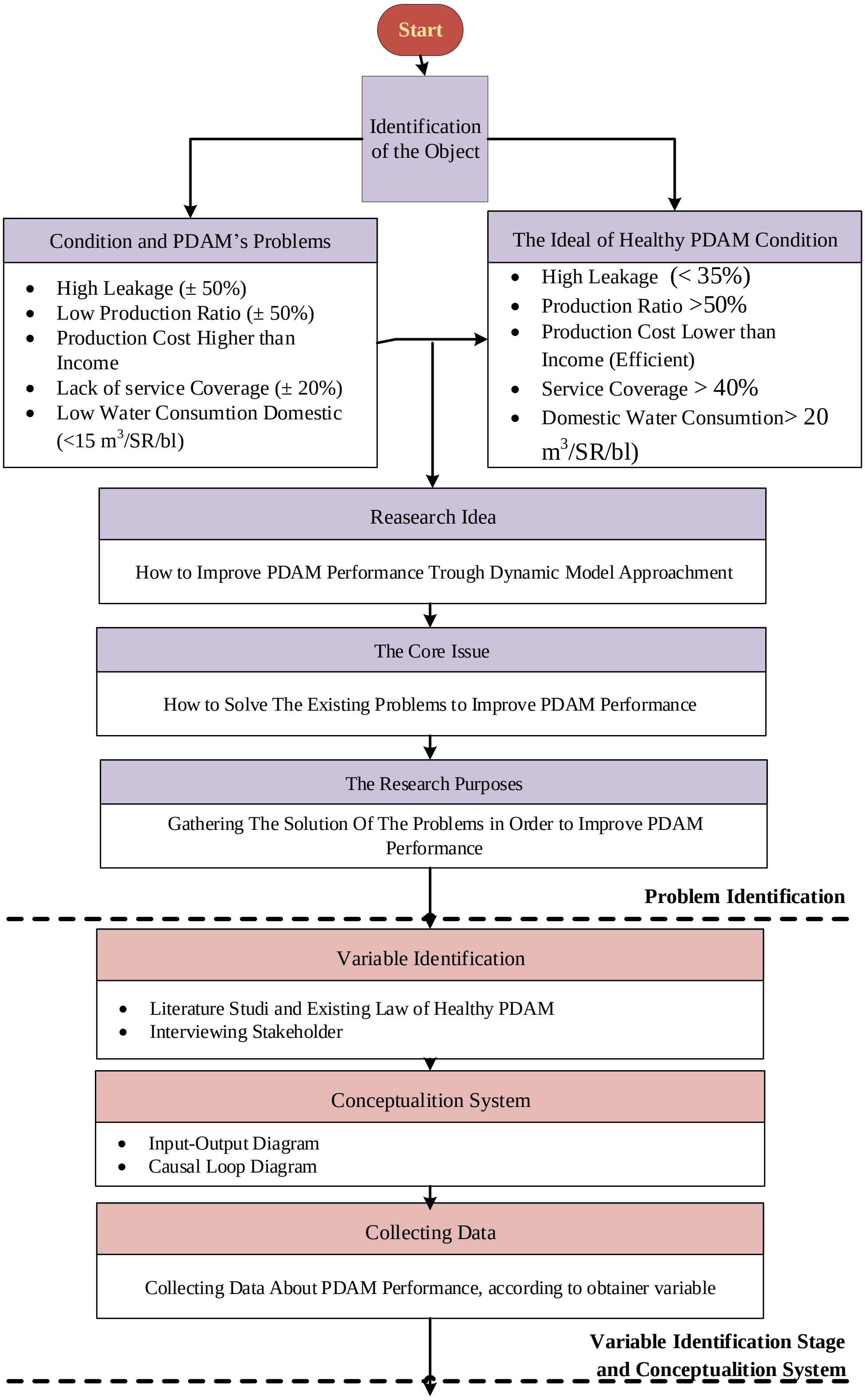

Figure 1. Flowchart of Research Methods

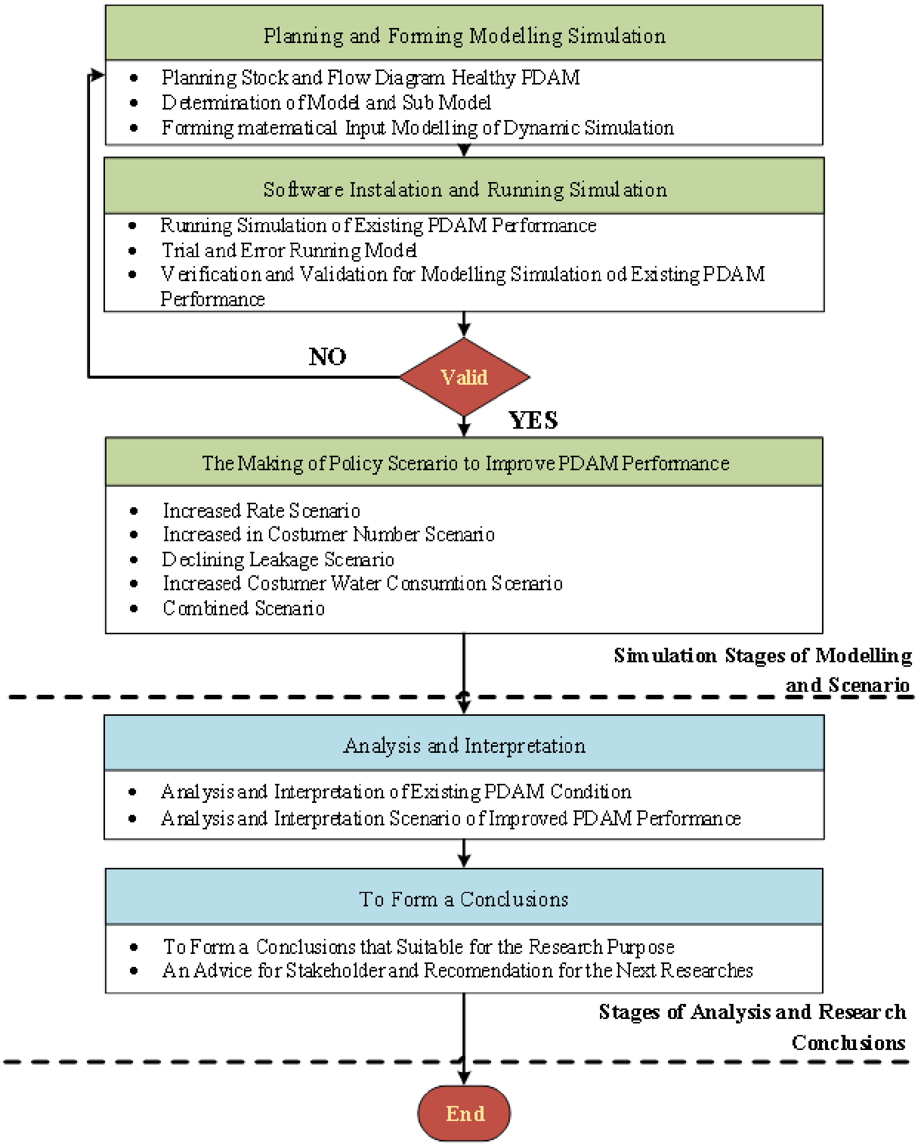

Figure 2. Flowchart of Research Methods – Continoued

2.1. Problem Identification and Formulation

At this stage, finding the facts that support information about the condition of PDAM management, both in terms of financial aspects and technical aspects related to the performance of PDAM. From the findings against the PDAM performance problems, then we do a comparison between the ideal conditions in accordance with the standards and regulations regarding good PDAM governance. With the deviation or variance between existing conditions and ideal conditions, then made the formulation of the problem that will be solved in the study. Previous study by Prima (2017) explained that water supply is the most important thing in daily home activities especially for washing, cleaning and bathing. Indonesian villagers usually supply water by pumping ground water to fill water tanks [8].

2.1. Identification System Variables and Conceptualization

2.1.1. Variable identification

Variable identification is carried out on the variables involved as well as other parameters that influence the PDAM management system, as appraisal data base. PDAM performance assessment that is used as reference in this study using a combination of criteria (Composite Criteria), according to the PDAM Performance Assessment Technical Guidelines issued by the Minister of Public Works Regulation Number 18thof year 2007 concerning the Implementation of Development of Drinking Water Supply Systems. The performance evaluation consists of four aspects including: the financial aspect, service aspects, operational aspects and human resources aspects. Where every aspect consists of several performance indicators that influence each other.Water loss or in foreign terms Non-Revenue Water (NRW) has become a classic problem of the Perusahaa Daerah Air Minum (PDAM) [9].

According to MacGillivray (2006), financial pressures, regulatory reform and sectoral restructuring require water companies to move from a management approach that tends to be technical to avoid risk to commercial and business-oriented practices [10]. Another research study conducted by Danielaini (2019) impressed to a water security in the Metropolitan Area of Cirebon under the threat of routine flooding and drought, rapid urbanization and climate change [7].

2.1.2. Conceptualization System

Conceptualization system is done through designing a conceptual model of the existing system. Conceptual modelsare designed in the form of input-output diagrams and causal diagrams or called causal loop diagrams. In this study, the factors that influence each parameter and those that affect other parameters will be examined, as well as the relationship with the variation of each parameter sought.

2.2. Identification System Variables and Conceptualization

2.2.1. Formulation Design and Simulation Models

At this stage, a simulation model of the PDAM performance system is designed, after designing a simulation model was completed, a formulation of the model is done. This research phase begins with the creation of dynamic models with the help of software (software) that is accuratelysee the behavior of the model [11]. The Dynamic System (System Dynamics, hereinafter abbreviated as SD) was originally developed at the Massachusetts Institute of Technology in 1956, developed by Forrester (1998) wich implied the computer simulation application used is VensimPle plus. TheVensimPle Plus application was chosen because it allows the handling mechanism of dynamic systems with little complexity, the model was designed and formulated in form of systematic formulation of variables based on the correlation. A dynamic system model built by variables which is categorized as a stock variable, variable flow, connectors, and converters. Stock (level) and flow (rate) are used to represent activities in a feedback loop [12].

Lin (2015) in this study with a causal feedback loop diagram of system dynamics, a casual interactive relationship between model variables and parameters can be expressed to explain the dynamic nature of impacts and feedback, illustrating information feedback in a system [13]. Wingo (2017) also informed that SD can be run as a auto simulation or as a plugin for a larger simulation framework, and can import models from several SD model formats, including Simile, Vensim model file models, and XMILE exchange formats [14]. The concept of a dynamic system is to connect all objects that interact with each other to create trends in the future from 3 policy scenarios regarding changes in land cover policy. Sherwood (2002) provided the same important clues in understanding CLD for a problem, namely: Know the boundaries and scope of the problem; Starting from something (variable) that is interesting [15]. Another input verivied by Vennix (1996) explained CLD model is a model that emphasizes his attention to the causal relationship between system variables (components) depicted in a diagram in the form of curved lines that lead to arrows connecting one system component to another [16].

2.2.2. Making Policy Scenario

The criteria of assessment policy scenarios to be applied is determined based on the variable that measure the success of the destination system. In improving PDAM performance, some of the assessment criteria policy scenario are the financial performance, operational performance and service performance. Variables used as factor in the policy-making scenario consists of four factors, namely rates, customers numbers (SR), customer water consumption and leakage control.

3. Result and Discussion

PDAM MajaTirta an institution that has the responsibility to manage water resources in the city of Mojokerto, which is expected to help create the output in the form of the use of clean and healthy water for the community. Variable identification shown in the input-output diagram.

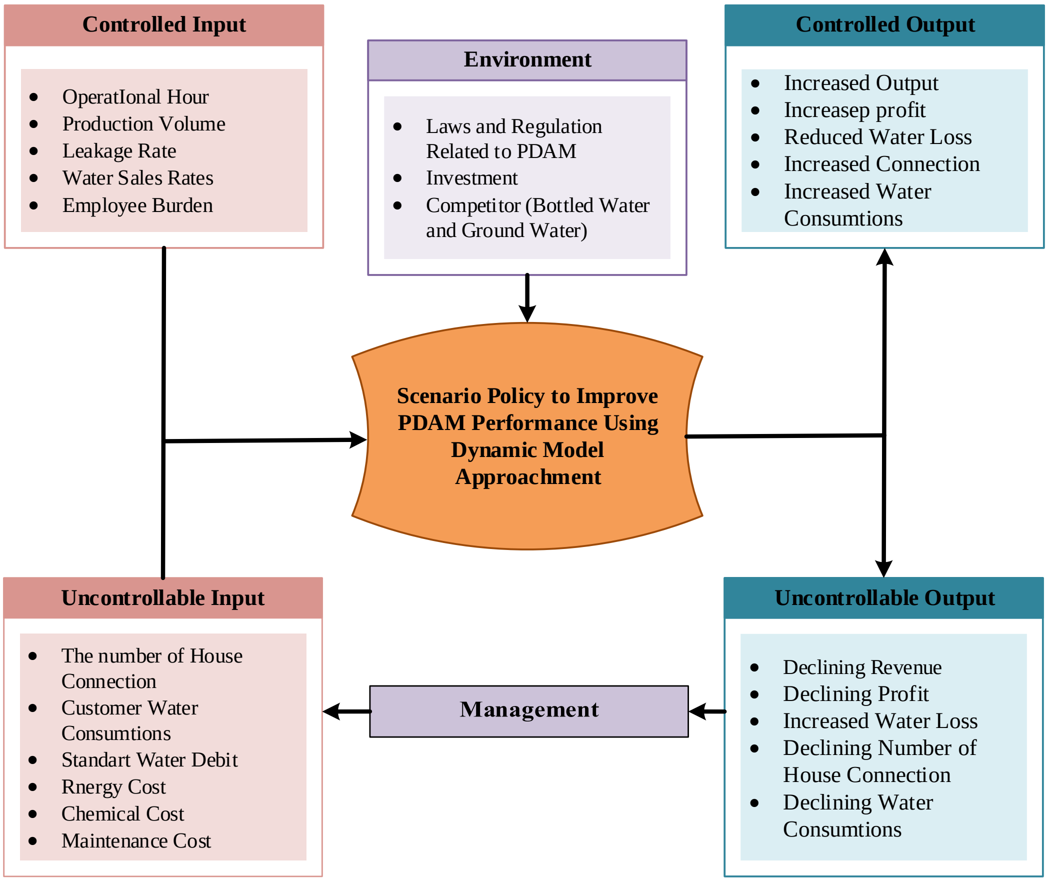

Figure 3. Input-Output Diagram

From Figure 3, it can be seen the input of the issues to be resolved in this study consists of two inputs, namely inputs the desired and undesired inputs. By using the PDAM's point of view, controllable inputs are inputs in relation to the performance of PDAM that can be controlled by PDAM, namely water quality distribution, customers water pressure, leakage rates, water sales rates and also costs or employee expense. Whereas input that can not be controlled are the number of connections (SR), customer water consumption, raw water debit, raw water quality, energy costs and chemicals cost.

For the desired output of problem solving in this study is also divided into two, namely the desired output and undesired output. The desired output is increased revenue, increased profits, reduced water loss, increased number of connections and increased water consumption. Whereasthe undesired output are the reduction in income, loss of profits, increased water loss, a number of downward connections and decreased water consumption. These undesirable outputs can be minimized by conducting good management or management of controllable inputs. In addition to environmental factors also becomesupportingr input in this problem, namely government regulation, private investment and the presence of competitors, namely the presence of bottled drinking water (AMDK) and shallow groundwater quality.

To achieve the final result of goodPDAM performance then the scenario created by combining the scenario of increased revenue and leakage control, almost all variables are simulated including rates. It is intended to determine the extent to which these variables are attempted to improve performance to become a good PDAM performance.

Variables that made changes, among others: water consumption increased to 12.5% per year, increasing the quality of clean water to increase the ratio of domestic water consumption ± 67% (80 l / or / day from the standard 120 l / or / day), increased repair customer meter at 20% per year and the improvement of distribution pipes by 20% per year and the increase rate of 15% per year.

From the simulation results, the variable observations that changes are the variable increase in PDAM revenue followed by a significant increase of the variable accumulation of profits, the ratio of water loss, the ratio of the meter change and PDAM performance. The variables that did not change were the operating ratio, water consumption and production efficiency. This may be caused by the increase that is still less than the existing target, so it has not been able to cover or the existing backlog.

The result of this scenario are:

- Customer growth increased starting in 2013 from 5% to 25%
- Performance service coverage increased in 2014 from 5% to 10%
- Performance Water Loss ratio increased in 2015 up to 2017 from 14% to 28%
- Performance Meter Change ratio increased in 2015 up to 2017 from 6.5% and 13% to 13%, 19.5% and 26%

Thus the performance of PDAM can be increased and had become a "healthy" in 2015, though gradually declining but remains in the category of "healthy".

Tabel 1. Scenario Simulation Results Combined with Leakage Control Scheme, Increasing Number of Connections (SR), Water Consumption and Rates

Time Years/Water performance	Base Model - Water Loss Ratio	Water Loss ratio: Combined Without Rates	Base Model – PDAM Performance	Base model - Category PDAM Sanitary	PDAM Performance: Combined Without Rates	PDAM Restructuring Category: Combined Without Rates
2013	54.41%	51.59%	2:50	unhealty	2:50	unhealty
2014	54.99%	47.26%	2:55	unhealty	2.6	unhealty
2015	45.05%	33.71%	2:58	unhealty	2.79	unhealty
2016	47.14%	32.43%	2:56	unhealty	2.69	unhealty
2017	48.70%	31.18%	2.66	unhealty	2.86	healthy
2018	49.41%	29.57%	2.66	unhealty	2.93	healthy
2019	49.99%	28.10%	2.66	unhealty	3:00	healthy
2020	50.43%	26.63%	2.73	unhealty	3:00	healthy
2021	50.73%	25.08%	2.73	unhealty	3:00	healthy
2022	50.88%	23:39%	2.73	unhealty	3:07	healthy

5. Conclusion

Based on the analysis of simulation results of existing conditions and policy scenarios that have been presented, it can be drawn some conclusions as follows:PDAM problems consist of two aspects, namely aspects related to management effectiveness which includes domestic water consumption (distributed volume vs. standard needs per person per day), customer growth, the scope of technical services (coverage area of service PDAM) as well as aspects related to PDAM operational efficiency that include operating ratios (efficiency between revenue and operating expenses), production efficiency (efficiency between operating capacity and installed capacity), water loss ratio

(ratio between water consumed and water production), water loss ratio. To be able to provide the proposed system improvements in order to improvePDAM performance, efforts are made to improve effectiveness and efficiency through schemes consisting of: Rates increased, increased customer water consumption, increased number of connections, improved repairs and replacements customer meters and distribution pipe. These schemes were then grouped into three scenarios, income improvement scenarios, leakage control scenarios and combined scenarios.

From the results of modeling simulations conducted to obtain an improvement of PDAM performance scenarios into the healthy category through simulation of leakage control scenarios and combined scenarios without increasing rates or by increasing customer rates. Of the three simulation scenarios that demonstrate improved performance of less healthy taps into healthy, scenario combined with increasing customer rates selected to maintain continuity (sustainability) of PDAM performance with the reasons for this scenario, accumulated profits already had a positive performance. Hopefully, by the positive performance of the accumulated profit, the PDAM is able to finance the development of the system and improving quality of service to customers.

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