ANALYSIS OF DRINKING WATER SUPPLY SYSTEM IMPROVEMENT USING FUZZY AHP

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1. Introduction

There are 386 local water companies (PDAM) in 542 regional autonomy in Indonesia. Among them, only 53% were included in "Healthy" category (BPPSPAM, 2015). Drinking water supply in 2015 has not yet reached the target, resulting in 68.87% of proper drinking water access. The improvement of water infrastructure and tools is needed to accomplish 100% proper drinking water universal access, expected by Sustainable Development Goals (SDGs) in 2019.

Fuzzy analytic hierarchy process (AHP) approach is often used in research aiming to improve drinking water supply. The approach is characterized by the uncertainly of both the problem and the decision maker's expertise and cognitive abilities and recommended as a reliable support tool by decision makers in real situation (Sradjevic and Medeiros , 2008). For example, Okeola (2012) applied the fuzzy AHP to evaluate the distribution of urban drinking water in Nigeria. Thungngern (2015), applied multi-criteria decision analysis (MCDA) with AHP to water resources management in Thailand. Ayunda (2013) utilized fuzzy AHP to determine policy priorities in order to improve the performance of local water company. This paper presents a case study in Subang District, Indonesia, where drinking water is served by local water company, PDAM Tirta Rangga. The fuzzy AHP approach was applied in order to improve drinking water supply.

2. Methods

This research was conducted in Subang District, West Java, Indonesia. We used fuzzy AHP approach to analyze and improve water supply system. The AHP was developed as an alternatives for solving complex problems and to meet the variety of decision making conflicting situations (Saaty, 1980). The initial stage was to determine the factors and sub-factors of water supply system. These factors consist of operational technique, financial, environmental, and management capacity. Each of factors is included in the questionnaires for weighting factors assessment. Slovin formula was used to determine the number of expertise respondents. Respondents consisted of stakeholders, who are considered capable in the different point of view, following the research conducted by Prince et al. (2012). In addition, community group leaders were also included as respondents to complement the linguistic scale presentations (Okeola, 2012). Weighting results were processed using Expert Choice 11 application, by considering the inconsistency level.

The next step was an attempt to develop analysis model to improve drinking water supply with a fuzzy logical approach. The modeling studied with Matlab Fuzzy Toolbox 7.11 software application was used in the modelling. Rule base of each factors and each sub-factors obtained AHP results. The weighting of drinking water supply improvement was validated between the results of sub-factors. Modeling simulation vectors were analyzed with ''If'' and ''Then'' logical rule base. The transformation process from input to output converted each result of fuzzy inference.

Rule base design of water supply improvement analysis model was the most important stages before performing fuzzy rule base. Rule base informed to the respondents, and there were only four (4) options on the outputs, those were low, medium, high, or very high. If it was affected by the sub-factors condition, further it will (then) have an effect on the improvement of water supply system. Modeling result projection was expressed in fuzzy set form. Finally, simulation was verified to ensure model capability for water supply system improvement.

3. Result and Discussion

Subang District is an area in the northern districts of West Java Province. Drinking water supply system serviced by Subang local water company in 2015 was 16.97% of the total house connections. In only 52.48% from 33 sub-districts were supplied by water company showed in (Fig 1). The final results of the paired comparison questionnaire were input into AHP model with Expert Choice 11 Program, which began by describing paired comparisons matrix. The most influential factor in improving the water supply system was operational technique (weight value: 0.34), followed by the environment, financial, and the management capacity (Fig 2). Factor inconsistencies rate was 0.08, smaller than 0.1, showing that results are accountable and expertise are reliable (Ramdoni, 2013).

The water production capacity will continue to improve the operational technique of drinking water supply (Fig 3). Improvement of operational technique was initially influenced by water treatment process, but that pattern change to be declivous after entering the fulfillment of the 30% water quality standards. Drinking water supply system improvement model has been designed, simulated with existing data and applied to improve planning in Subang District Local Water Company.

Improvement of operational techniques could achieve optimal score at 3.6 of 0 to 4, if drinking water supply system utilizes water resource from river, producing water in a large capacity, achieving 80% quality standards from water treatment, using gravity on water distribution, and without water losses (Fig 4).

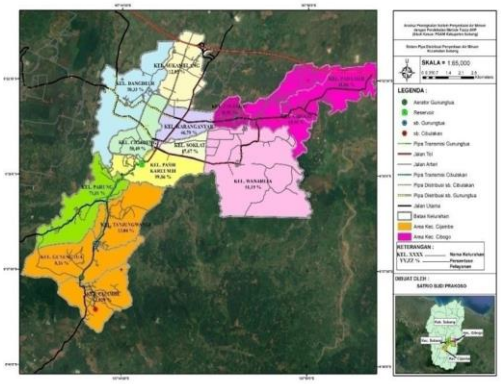

Fig 1 Drinking water supply system
Source: RISPAM 2016

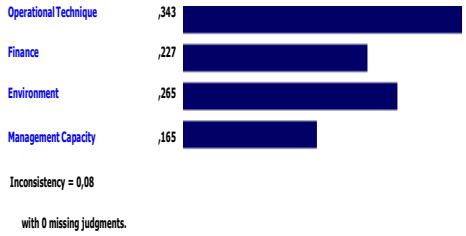

Fig 2 The value of weighting among factors

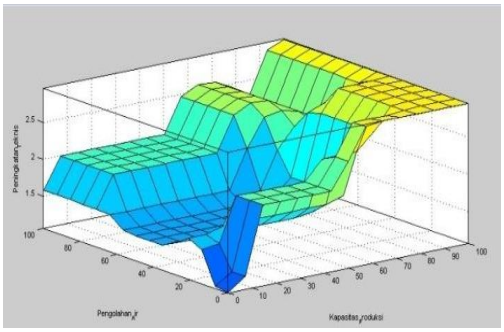

Fig 3 3D graphic of water supply of improved operational technique

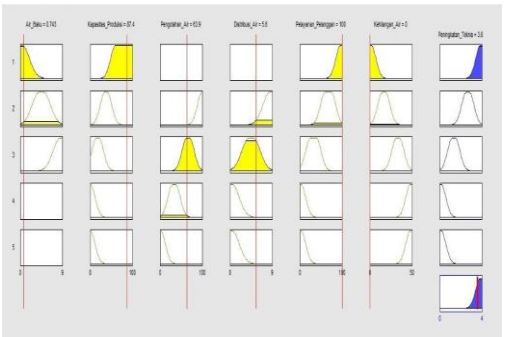

Fig 4 Operational technique improvement model simulation

4. Conclusion

Until 2015, PDAM Tirta Rangga Subang District reached 52.48% service coverage, and experience high level of water losses, although it has high potential sources of raw water. Operational technique factors with a value of 0.3 was considered as the most influential factor in the improvement of water supply system, followed by environmental, financial and management capacity. Fuzzy method with rule base inputs will affect the output of the drinking water supply improvement alternative.

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