Application of Analytical Hierarchy Process Method for SQM on Customer Satisfaction

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Abstract. The research objective was to analyze service quality management on customer satisfaction by utilizing decision support system (DSS) techniques in the completion process. The research data source is the Regional Drinking Water Company (abbreviated as PDAM) "Tirtauli" in Pematangsiantar city. The object of the research is the customers/users of PDAM services which are carried out by means of random observations and questionnaires. The DSS technique used is the analytic hierarchy process (AHP) method. The result of the method is a recommendation in the form of a ranking of service quality management on customer satisfaction. The criteria used to measure customer satisfaction in research are physical evidence (K1), reliability (K2), responsiveness (K3), assurance (K4), care (K5). The calculation results of the AHP method state that two very influential criteria in improving service quality management on customer satisfaction are assurance (K4) with a final value of 0.1929 and reliability (K2) with a final value of 0.1912. The results of the research are expected to provide information and input to the management of PDAM Tirtauli in improving service quality management in order to achieve customer satisfaction.

1. Introduction

Much of the most widely researched research in the world deals with the most widely researched variables in the world which are competitiveness, product knowledge, customer satisfaction and loyalty. From these studies, customer satisfaction is the most widely conducted research [1]. Customer satisfaction is one of the assessments of services that have been provided in accordance with what is expected [2]. Customer satisfaction is the benchmark for companies in running their business. If the quality of service provided by the company to customers is good, the customer thinks the company is professional in providing its services. Vice versa, if customers think the quality of service provided to customers is bad, then the customer thinks the company is less professional in providing service [3]–[5]. Therefore, in an effort to improve or maintain the quality of service it is necessary to conduct research based on customer assessment. Many artificial intelligence techniques can be used to solve complex problems [6] such as decision support systems [7]–[14], data mining [15]–[17], artificial neural networks [18] and others. There are various techniques to resolve inaccuracies in company
performance appraisals, one of which is a decision support system [19]. The method used is the analytic hierarchy process (AHP). The AHP method is a comprehensive decision-making model by taking into account qualitative and quantitative matters [20] so that it can measure and regulate the impact of an interacting component in a system on system errors [21]. Several studies were conducted on the level of customer satisfaction with service quality [22] using five criteria and fourteen sub criteria. The difference with the research that the author is currently doing is in the use of methods and sub-criteria. The method that I use is the AHP method. Where the advantages of the AHP Method are quite effective in simplifying and speeding up the decision making process by solving problems into their parts [23]. And the criteria that the authors use to determine the level of customer satisfaction with service quality, namely using five criteria and twenty five sub criteria. Based on these problems, we need a system that can solve problems of service quality management on customer satisfaction by utilizing the AHP method so that we can find out the priority criteria in improving service management to customers.

2. Methodology

The application of service quality management to customer satisfaction by utilizing the AHP method in the process of completion is a study whose data is sourced from PDAM Tirtauli, Pematangsiantar city. The data were obtained by making observations and questionnaires given randomly to customers or users of PDAM Tirtauli services. The results of observations and interviews were obtained using Microsoft Excel software before the analysis was carried out using the analytic hierarchy process method. Following are the customer satisfaction criteria used in the study, namely physical evidence (K1), reliability (K2), responsiveness (K3), assurance (K4) and care (K5). The following are the results of the customer satisfaction criteria values that have been processed with Microsoft Excel as shown in the following table:

| criteria | K1  | K2  | K3  | K4  | K5  |
|----------|-----|-----|-----|-----|-----|
| K1       | 82  | 80  | 79  | 81  | 80  |
| K2       | 80  | 81  | 79  | 82  | 78  |
| K3       | 81  | 81  | 77  | 79  | 79  |
| K4       | 82  | 81  | 81  | 79  | 79  |
| K5       | 81  | 78  | 79  | 79  | 79  |

Source: processed data

The following is a flowchart of the analytic hierarchy process (AHP) method as shown in the following figure:

![Flowchart](image-url)

**Figure 1.** flowchart analytic hierarchy process (AHP) method
3. Results and Discussion

After determining the criteria and getting the average value of each criterion as shown in table 1, the next steps are:

a) Calculating the Pairwise Matrix Value (Pairwise Comparison Matrix) of each criterion as shown in the following table:

| Table 2. Pairwise Comparison Matrix |
|-----------------|
| criteria | K1 | K2 | K3 | K4 | K5 |
|---|---|---|---|---|---|
| K1 | 1  | 1/2| 1/2| 1/3| 2/1|
| K2 | 2/1| 1  | 2/1| 1/2| 2/1|
| K3 | 2/1| 1/2| 1/1| 1/2| 2/1|
| K4 | 3/1| 2/1| 2/1| 1  | 3/1|
| K5 | ½  | 0.5| 1/2| 1/3| 1  |

The scale in table 2 is a comparison value between the criteria where the value of the scale can be seen from the following explanation:

1) Scale 1 = equal importance to one another.
2) Scale 3 = moderate category compared to other interests.
3) Scale 5 = strong category compared to other interests.
4) Scale 7 = very strong category compared to other interests.
5) Scale 9 = one interest is extremely stronger than the other.
6) Scale 2, 4, 6, 8 = The values between two values of adjacent considerations, this value is given when there are two compromises between the 2 options.

b) Calculate the weight of the criteria (priority vector) by normalizing the value of each pairwise comparison matrix column by dividing each number of adjusted column values and calculating the average value of the sum of each row matrix. The following is the normalization of the values for each column of the pairwise comparison matrix.

| Table 3. Normalization of the pairwise comparison matrix |
|-----------------|
| criteria | K1 | K2 | K3 | K4 | K5 |
|---|---|---|---|---|---|
| K1 | 1,000| 0,500| 0,500| 0,333| 2,000|
| K2 | 2,000| 1,000| 2,000| 0,500| 2,000|
| K3 | 2,000| 0,500| 1,000| 0,500| 2,000|
| K4 | 3,000| 2,000| 2,000| 1,000| 3,000|
| K5 | 0,500| 0,500| 0,500| 0,333| 1,000|
| total | 9,000| 5,000| 6,000| 3,000| 10,000|

In table 3, the normalization of the matrix is by calculating the number of values for each predetermined criterion column.

In table 4, the average is obtained from the results of the normalization of the value of each pairwise comparison matrix column then the average results are added. Then the criterion weight value (Wj) = (0.1211; 0.2244; 0.1711; 0.3400; 0.0900).
c) Find the Lambda Max ($\lambda_{\text{max}}$) by switching the pairwise comparison matrix with the average priority value.

$$(1,000*0,1211 + 0,500*0,2244 + 0,500*0,1711 + 0,333*0,3400 + 2,000*0,0900) = 0,6121.$$ 

Then the following results are obtained:

$$\begin{bmatrix}
1,000 & 0,500 & 0,500 & 0,333 & 2,000
2,000 & 1,000 & 2,000 & 0,500 & 2,000
2,000 & 0,500 & 1,000 & 0,500 & 2,000
3,000 & 2,000 & 2,000 & 1,000 & 3,000
0,500 & 0,500 & 0,500 & 0,333 & 1,000
\end{bmatrix} \begin{bmatrix}
0,1211
0,2244
0,1711
0,3400
0,0900
\end{bmatrix} = \begin{bmatrix}
0,6121
1,1588
0,8755
1,7643
0,4615
\end{bmatrix}$$

After getting the results of the average value, then look for the Lambda Max results:

$$\lambda_{\text{max}} = \frac{1}{5} \left( 0,6121 + 1,1588 + 0,8755 + 1,7643 + 0,4615 \right) = 5,1305$$

d) Check that the decision maker is consistent in making comparisons. Since the matrix is of order 5 (5 columns), the Consistency Index (CI) value is:

$$\text{CI} = \frac{5,1305 - 5}{4} = 0,0326$$

e) In looking for the Consistency Ratio (CR), if CR ≤ 0.1 then the pairwise comparison value on the given criteria matrix is consistent, and if CR ≥ 0.1 then the pairwise comparison value on the given criteria matrix is inconsistent.

CR = $0,0326/1,12 = 0,0291$

CR = 0,0291 ≤ 0,1 (Consistent)

f) Then calculate and determine the weighted value of the Comparison matrix based on each Criterion. The following are the results of the weighted comparison matrix for each criterion as shown in the following table:

| Criteria | K1 | K2 | K3 | K4 | K5 |
|----------|----|----|----|----|----|
| K1       | 1  | 82/80 | 82/81 | 82/82 | 82/82 |
| K2       | 80/82 | 1 | 80/81 | 80/82 | 80/81 |
| K3       | 81/82 | 81/80 | 1 | 81/82 | 81/81 |
| K4       | 82/82 | 82/80 | 82/81 | 1 | 82/81 |
| K5       | 81/82 | 81/80 | 81/81 | 81/82 | 1 |

| Criteria | K1 | K2 | K3 | K4 | K5 |
|----------|----|----|----|----|----|
| K1       | 0,2020 | 0,2020 | 0,2020 | 0,2020 | 0,2020 |
| K2       | 0,1970 | 0,1970 | 0,1970 | 0,1970 | 0,1970 |
| K3       | 0,1995 | 0,1995 | 0,1995 | 0,1995 | 0,1995 |
| K4       | 0,2020 | 0,2020 | 0,2020 | 0,2020 | 0,2020 |
| K5       | 0,1995 | 0,1995 | 0,1995 | 0,1995 | 0,1995 |

Then the weight value of physical evidence (K1) is known, namely: W {0.202; 0.197; 0.199; 0.202; 0.199}. 

Table 5. Normalization of Pairwise Comparison Matrices

| Criteria | K1 | K2 | K3 | K4 | K5 |
|----------|----|----|----|----|----|
| K1       | 0,2020 | 0,2020 | 0,2020 | 0,2020 | 0,2020 |
| K2       | 0,1970 | 0,1970 | 0,1970 | 0,1970 | 0,1970 |
| K3       | 0,1995 | 0,1995 | 0,1995 | 0,1995 | 0,1995 |
| K4       | 0,2020 | 0,2020 | 0,2020 | 0,2020 | 0,2020 |
| K5       | 0,1995 | 0,1995 | 0,1995 | 0,1995 | 0,1995 |
2) Criteria for Reliability (K2)

| Criteria | K1 | K2 | K3 | K4 | K5 |
|----------|----|----|----|----|----|
| K1       | 1  | 80/81 | 80/81 | 80/81 | 80/78 |
| K2       | 81/80 | 1  | 81/81 | 81/81 | 81/78 |
| K3       | 81/80 | 81/81 | 1  | 81/81 | 81/78 |
| K4       | 81/80 | 81/81 | 81/81 | 1  | 81/78 |
| K5       | 78/80 | 78/81 | 78/81 | 78/81 | 1  |

Then it is known the weight value of reliability (K2), namely: W (0.199; 0.202; 0.202; 0.202; 0.194).

3) Criteria for Responsiveness (K3)

| Criteria | K1 | K2 | K3 | K4 | K5 |
|----------|----|----|----|----|----|
| K1       | 1  | 79/79 | 79/77 | 79/81 | 79/79 |
| K2       | 79/79 | 1  | 79/77 | 79/81 | 79/79 |
| K3       | 77/77 | 77/77 | 1  | 77/81 | 77/77 |
| K4       | 81/79 | 81/79 | 81/77 | 1  | 81/79 |
| K5       | 79/79 | 79/79 | 79/77 | 79/81 | 1  |

Then we know the weight value of responsiveness (K3), namely: W {0.20; 0.20; 0.19; 0.20; 0.20}.

4) Criteria for Assurance (K4)

| Criteria | K1 | K2 | K3 | K4 | K5 |
|----------|----|----|----|----|----|
| K1       | 1  | 81/82 | 81/79 | 81/82 | 81/79 |
| K2       | 82/81 | 1  | 82/79 | 82/82 | 82/79 |
| K3       | 79/81 | 79/82 | 1  | 79/82 | 79/79 |
| K4       | 82/82 | 82/82 | 82/79 | 1  | 82/79 |
| K5       | 79/82 | 79/82 | 79/79 | 79/82 | 1  |

Then it is known the weight value of the guarantee (K4), namely: W {0.20; 0.20; 0.19; 0.20; 0.196}.

5) Criteria for Care (K5)

| Criteria | K1 | K2 | K3 | K4 | K5 |
|----------|----|----|----|----|----|
| K1       | 1  | 80/78 | 80/79 | 80/79 | 80/79 |
| K2       | 78/80 | 1  | 78/79 | 78/79 | 78/79 |
| K3       | 79/80 | 79/78 | 1  | 79/79 | 79/79 |
| K4       | 79/80 | 79/78 | 79/79 | 1  | 79/79 |
| K5       | 79/80 | 79/78 | 79/79 | 79/79 | 1  |

Then it is known the weight value of care (K5), namely: W (0.20; 0.198; 0.200; 0.200; 0.200).
Then the following results are obtained:

\[
\begin{bmatrix}
0.202 & 0.199 & 0.200 & 0.201 & 0.202 \\
0.197 & 0.202 & 0.200 & 0.206 & 0.198 \\
0.199 & 0.202 & 0.195 & 0.196 & 0.200 \\
0.202 & 0.202 & 0.205 & 0.206 & 0.200 \\
0.199 & 0.194 & 0.200 & 0.196 & 0.200 \\
\end{bmatrix}
\begin{bmatrix}
0.1211 \\
0.2244 \\
0.1711 \\
0.3400 \\
0.0900 \\
\end{bmatrix}
\]

Then the following results are obtained:

\[
\begin{bmatrix}
0.0245 & 0.0447 & 0.0342 & 0.0683 & 0.0182 \\
0.0239 & 0.0453 & 0.0342 & 0.0700 & 0.0178 \\
0.0241 & 0.0453 & 0.0334 & 0.0666 & 0.0180 \\
0.0245 & 0.0453 & 0.0351 & 0.0700 & 0.0180 \\
0.0241 & 0.0435 & 0.0342 & 0.0666 & 0.0180 \\
\end{bmatrix}
\begin{bmatrix}
0.1899 \\
0.1912 \\
0.1874 \\
0.1929 \\
0.1864 \\
\end{bmatrix}
\]

Then the following is a ranking table as follows:

| No | Criteria                   | Final score | Rank |
|----|----------------------------|-------------|------|
| 1  | Physical Evidence (K1)     | 0.1899      | 3    |
| 2  | Reliability (K2)           | 0.1912      | 2    |
| 3  | Responsiveness (K3)        | 0.1874      | 4    |
| 4  | Assurance (K4)             | 0.1929      | 1    |
| 5  | Care (K5)                  | 0.1864      | 5    |

From the results of the analysis in table 16, each criterion has its final value. According to calculations carried out by AHP that the highest value on customer satisfaction with service quality at PDAM Tirtauli is Guarantee (K4) with a final score of 0.1929 and reliability (K2) with a final value of 0.1912.

4. Conclusion

Based on the research results, it can be concluded that the application of the AHP (Analytical Hierarchy Process) method in improving service quality management towards customer satisfaction can be applied and used as a solution. The calculation results of the five assessment criteria obtained by two criteria that are very influential on customer satisfaction, namely Guarantee and reliability. This proves the applicability and potential of the AHP (Analytical Hierarchy Process) method to solve complex problems.

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