

**SALT QUALITY DETERMINATION USING SIMPLE ADDITIVE WEIGHTING (SAW)  
AND ANALYTICAL HIRARKI PROCESS (AHP) METHODS**

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***Abstract***

*Salt has a salty taste obtained by drying seawater into mineral crystals. However, the quality of industrial salt in Indonesia is still an obstacle, so the need for industrial salt still relies on imported salt. The quality of salt is shown from physical and chemical appearance. Good salt is shown by the crystal form which is smooth and has a clear white color. Good salt quality knowledge must be known so that it can meet Indonesia's national standards and can distinguish salt designation based on its quality category. This study compares the Simple Additive Weighting (SAW) and Analytical Hierarchy Process (AHP) methods to determine the highest quality salt. The SAW method gives weight to each of its attributes, the total score finally produces an alternative decision in accordance with the criteria so that it produces a quality salt. The AHP method starts by creating a hierarchical structure that has the main objectives, criteria and alternatives to be discussed. Pairwise comparisons are used to form relationships in the structure. So, it will form a matrix where the ratio scale is derived in the form of the main vector eigen or function-eigen. The accuracy of the test results showed that the SAW method is better with an accuracy of 80% compared to the AHP method of 76%*

*Key words: decision support systems, salt, quality, SAW, AHP.*

## INTRODUCTION

Salt is an important commodity for people's life. In addition to consumption, salt is also needed in many industries, such as preservatives, cosmetics, medicines and as a mixture of other chemicals [1]. Indonesia consists of many islands, so it should be able to meet the needs of national salt, but in reality Indonesia is still importing salt to meet national salt needs [2]. In other countries, salt can be produced through underground mining deposits and also through the process of seawater crystallization [3].

Madura is one of the largest salt producing and supplying island in Indonesia with an area of 15,000 hectares [3], that makes this island is known as a salt island. In Madura, there is also the Salt Science and Technology Center of Excellence which was initiated by the University of Trunojoyo Madura (UTM) [3]. In addition, UTM also makes salt as one of the focuses of its studies. Various kinds of salt quality are produced in Madura, but so far it is not well recorded.

NaCl content, water content, and color of salt can determine the salt quality into three types, they are KP I, KP II and KP III [4]. In this research, a decision support system for determining the quality of salt will be built using a simple additive weighting (SAW) method with a case study of salt produced by Madura salt farmers. The Simple Additive Weighting (SAW) method is a method of Multi-Attribute Decision Making (MADM) [5]. This method is also often known as the weighted sum method [6]. The basic concept of the Simple Additive Weighting (SAW) method is to find the weighted sum of the performance ratings for each alternative on all attributes [7].

Seeing the existing problems, the purpose of this study is to offer a solution to choose the best salt with the parameters that based on salt content in the form of NaCl, H<sub>2</sub>O, Ca and Mg.

## MATERIAL AND METHODS

Salt is not only for consumption materials, but also as raw material for various industries [8]. Madura is a salt producing area. The government through the ministry of

technology research and higher education has made Madura as a place of Excellence for Salt Innovation [9]. University of Trunojoyo Madura (UTM) as one of the State Universities in Madura makes salt as one of its study focuses [10]. NaCl content, water content, and color of salt can determine the salt quality into three types, they are KP I, KP II and KP III [4].

## *SIMPLE ADDITIVE WEIGHTING*

Simple Additive Weighting (SAW) is known as the weighted sum method. The basic idea of the SAW method is to find a weighted sum of the performance ratings for each alternative on all criteria. There are two attributes in the SAW method, namely the benefit criterion attribute and the cost criterion attribute [11]. The SAW method requires the decision matrix normalization process (X) to a level that can be compared with all existing alternative ratings. This SAW method requires decision making to find weight for each attribute. The total score for the alternative is obtained by adding up all the multiplication results between the rating (which can be compared across attributes) and the weight of each attribute. The rating of each attribute must be dimension free in the sense that it has passed the previous matrix normalization process.

Many studies using self-methods to solve various types of problems, such as determining employee salaries with achievement criteria, discipline, attitude, and length of work that can be completed using the SAW method [12]. The SAW method is also used to determine egg quality by the criteria of Size of Eggs, Styling or Color Eggshells, Eggshell Thickness, Extensive Shells, Shape Eggs and Eggshell Cleanliness [13]. The same method is also used in research to determine the recipient of the achievement scholarship with the criteria for the average value of the last report card, Attendance, Good Behavior, Good Character and Active in Organizations (Extracurricular) [14]. SAW method has a shorter execution time compared to the Weighted Product (WP) method [5].

The completion steps using the SAW method can be seen below::

1. Determine alternatives, namely  $A_i$ ;

2. Determine the criteria as a reference in decision making, namely  $C_j$ .
3. Faithful criteria are given a matching rating value for each alternative.
4. Determine the weight of preference or level of importance ( $W$ ) for each criterion.  $W = [W^1 \ W^2 \ W^3 \dots\dots\dots W_j]$

Table 1. Pairwise matrix comparison

	C1	C2	.....	Cn
A1	x11	x21	.....	a1n
A2	x12	x22	.....	a2n
.....	.....	.....	.....	.....
An	xn1	xn2	.....	xnn

5. Make a match rating table of each alternative on each criterion.
6. From the matching rating table of each alternative in each keriteria will be the basis for making a decision matrix  $X$ . The value of  $X$  every alternative in each criterion ( $C_j$ ) that has been determined, where,  $i = 1,2, \dots m$  and  $j = 1,2, \dots n$ .

$$X = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1j} \\ x_{i1} & x_{i2} & \dots & x_{ij} \end{bmatrix} \quad (1)$$

7. Normalize the decision matrix  $X$  by calculating the value of the nominalized performance rating ( $R_{ij}$ ) from alternative  $A_i$  on the  $C_j$  criterion.

$$r_{ij} = \begin{cases} \frac{x_{ij}}{\text{Max}_i(x_{ij})} \\ \frac{\text{Min}_i(x_{ij})}{x_{ij}} \end{cases} \quad (2)$$

- a.  $r_{ij}$  = Normalized performance rating value.
- b.  $x_{ij}$  = Attribute value owned by each criterion.
- c.  $\text{Max}_i x_{ij}$  = The biggest value of each criterion.
- d.  $\text{Mini } x_{ij}$  = The smallest value of each criterion.
- e. It is said that the profit criteria if the value of  $X_{ij}$  provides benefits for decision makers, on the contrary the cost criteria if  $X_{ij}$  incurs costs for decision makers.
- f. If it is in the form of profit criteria, the value of  $X_{ij}$  is divided by  $\text{Max}_i (X_{ij})$

from each column, whereas for the cost criteria, the value of  $\text{Min}_i (X_{ij})$ .

8. The results of the normalized performance rating ( $R_{ij}$ ) form a normalized matrix ( $R$ )

$$r_{ij} = \begin{bmatrix} r_{11} & r_{12} & \dots & r_{1j} \\ r_{i1} & r_{i2} & \dots & r_{ij} \end{bmatrix} \quad (3)$$

$r_{ij}$  = Normalized performance rating  
 $r$  = Rating

9. The final preference value ( $V_i$ ) is obtained from the sum of the multiplications of normalized matrix row elements ( $R$ ) with preference weights ( $W$ ) corresponding to the matrix column elements ( $W$ ).

$$v_i = \sum_{j=1}^n w_j r_{ij} \quad (4)$$

$v_i$  = Alternative Final Value  
 $w_j$  = Weight that has been determined  
 $r_{ij}$  = Normalisasi matri Weight that has been determined..

The advantage of the Simple Additive Weighting (SAW) method compared to other decision support system methods lies in its ability to conduct assessments more precisely which is based on the criteria of value and weighting the level of importance required. In the SAW method, it can also select the best alternative from a number of alternatives then a ranking process is carried out in which the total weighted values of all criteria are added after determining the weight value of each criteria [15].

### ANALYTICAL HIRARKI PROCESS (AHP)

Analytical Hierarchy Process (AHP) AHP is a practical approach to solving complex decision problems that include alternative comparisons [16]. AHP also allows decision making that presents a hierarchical relationship between factors, attributes, characteristics or alternatives in the decision making environment. AHP is a process of identifying to understand and provide estimates of overall system interaction. The procedure in using the AHP method consists of several stages, namely:

1. Arrange the hierarchy of the problems. The preparation of the hierarchy is to determine

the goals which are the overall system goals at the top level. The next level consists of criteria for assessing and determining alternatives. Each criterion can have sub-criteria below and have an intensity value.

2. Determine the priority of elements by making a pairwise comparison to start the pairwise comparison process, starting from the top level of the hierarchy to choose criteria. Fill in the pairwise comparison matrix, synthesis.
3. AHP measures the consistency of consideration with a consistency ratio.

### Criteria and Weighting of salt quality

The criteria for salt quality are as follows:

- a. C1: NaCL
- b. C2: Water content
- c. C3: Salt Color

Here are the total weights for each criterion:

#### 1. Assessment of NaCl criterion weights

NaCL	Weight
NaCL 98 – 99	90
NaCL 94 – 98	60
NaCL 90 – 94	30

#### 2. Water Content Assessment

Water Content	Weight
Water Content 0 - 04	90
Water Content 05 - 06	60
Water Content 06 - 10	30

#### 3. Assessment of salt color weight

Salt Color	Weight
Crystal color	90
Brown color	60
Brown color mixed with mud	30

## RESULT AND DISCUSSION

### a. SAW

- The first stage is determining the criteria, the criteria in question are the criteria for salt content to be used as input for input, the criteria are NaCl, H<sub>2</sub>O, and color

Table 2. Comparisons between criteria

Criteria	C1	C2	C3
C1	1.00	3.00	3.00
C2	0.33	1.00	5.00
C3	0.33	0.20	1.00

Total number	1.67	4.20	9.00
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- The second stage determines the weighting of each criterion.
- The third step is to input salt data, namely the type / brand / salt product and its contents according to the criteria requirements.
- The final stage is the system to process data to produce ranking; the data process includes normalization of salt content data and weighting preferences for decision making

0,866754	V1	A3
0,877827	V2	A2
0,866822	V3	A5
0,867997	V4	A4
0,96	V5	A1
0,866622	V6	A6

### b. AHP

- Enter the Pairwise Weight among the criteria. The following table presents a pairwise comparison table between criteria or levels of interest between criteria.

Criteria	C1	C2	C3
C1	1.00	3.00	3.00
C2	0.33	1.00	5.00
C3	0.33	0.20	1.00
Total	1.67	4.20	9.00

- Matrix Normalization. The following table shows the normalization of the matrix obtained from the data to i which is divided by the amount of data in the row to i

Criteria	C1	C2	C3	Average
C1	0.60	0.71	0.33	0.55
C2	0.20	0.24	0.56	0.33
C3	0.20	0.05	0.11	0.12
Total	1.00	1.00	1.00	1.00

- The product of the initial matrix with weights. The following table is the product of the paired tables between the criteria and the average in the matrix normalization table.

1.901587302

1.112169312

0.368888889

- Eigen value

The result of 1 was divided by a lot of data; times X is divided by the criteria weights.

3.301736991

- Consistency Index dan Consistency Ratio

The following table is to find the CI by means of eigen value minus a lot of data which was divided by a lot of data minus 1. While to determine the CR, CI is divided by the number of criteria or Random Index.

Consistency Index	Consistency Ratio
0.15	0.26

- Alternative Value

Alternative	C1	C2	C3
A1	98	90	90
A2	94	60	60
A3	90	40	40
A4	98	90	90
A5	90	40	40
A6	94	60	60
Minimum criteria	90	40	40

Each column is divided by a minimum value of these criteria

d. Ranking: Suppose there are n objectives and m alternatives to the AHP, then the alternative ranking process can be carried out through the following steps:

- For each objective i, assign a pairwise comparison matrix A, for alternative m.
- Determine the weight vector for each Ai that represents the relative weight of each to J-alternative in the i-th destination (s<sub>ij</sub>).
- Calculate the total score:

$$s_j = \sum (s_{ij})(w_i)$$

d. Choose the alternative with the highest score.

1. A1	2. 0.125873
3. A2	4. 0.148695
5. A3	6. 0.181395
7. A4	8. 0.125873
9. A5	10. 0.181395
11. A6	12. 0.148695

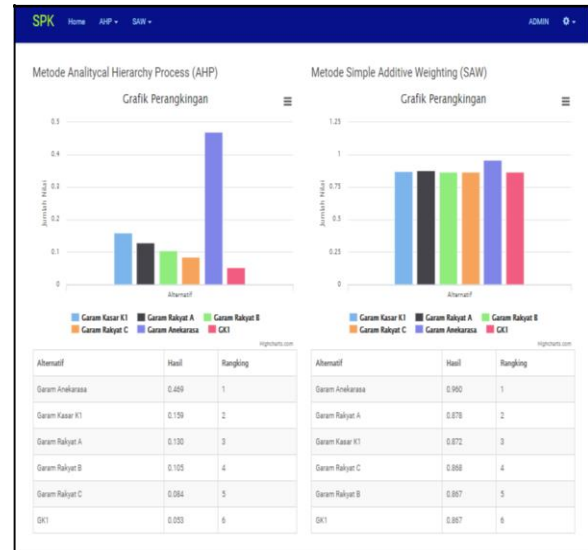


Fig 1. Comparison chart of SAW and AHP

The system built in this study is a decision support system for determining salt quality which is a web-based system and uses the SAW method.

Based on the development of a system test, some results of the analysis are:

- Can display detailed information about salt.
- Can input the value of criteria and parameter weights.
- Can process using SAW and AHP about salt quality.
- Can display the results of which salt quality decisions are best.

### CONCLUSION

- Based on the results obtained in this study it can be concluded that:
- Decision support system for determining the best salt using AHP and SAW methods can help companies in making decisions.
- The SAW method can produce recommendations for determining the best salt according to needs and based on predetermined criteria because it produces the greatest accuracy value. The accuracy of the test results obtained by the SAW method is 80% and the results of the SAW method is 76.67%.

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