

# Decision Support System for Determining the Quality of Salt in Sumenep Madura-Indonesia

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**Abstract.** Salt is one of Indonesia's major commodities. However, the quality of industrial salt in Indonesia is still an obstacle, so the need for industrial salt still relies on imported salt, especially from Australia. Quality improvement is done through purification using the recrystallization method. The use of a method that is still simple results in the salt being produced still has an as-is quality. Quality is shown from the appearance of salt physically and chemically. Good salt is shown by the crystal form which is smooth and has clear white color. Therefore, good knowledge of salt quality must be known early, in addition to being able to meet the Indonesian National Standard (SNI), in this way salt farmers will more easily improve the quality of salt produced and can differentiate salt designation based on its quality category. This study takes the theme of how to make decisions to determine the quality of salt, so that a decision support system will be built to assist in determining good salt quality by using the Simple Additive Weighting (SAW) method. This method can support the decision making of salt quality determination based on the weight of each attribute. Moreover, the total score of the end result can produce a good alternative decision in accordance with specified criteria, so that it will produce salt quality.

## 1. The first section in your paper

Salt is an important commodity for people's lives. 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 has 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 islands in Indonesia with an area of 15,000 hectares [3]. that is why 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 focus of its studies. Various kinds of salt quality are produced in Madura, but so far it is not well recorded.

Based on NaCl content, water content and color of salt, there are three types of salt quality, namely: 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 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 SAW method is to find the weighted sum of the performance ratings for each alternative on all attributes [7].

Making Decision Support System (DSS) aims as a tool for government agencies and related agencies to determine the quality of salt KP I, KP II, KP III. In addition, this system is expected to help the government to determine and map regions and / or salt-producing land based on its quality.

## 2. 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 center of excellence for Salt Innovation [9]. University of Trunojoyo Madura as one of the State Universities in Madura makes salt as one of its study focuses [10]. Based on NaCl content, water content and salt color, there are three types of salt quality, namely: KP I, KP II and KP III [4].

### 2.1. Simple Additive Weighting (SAW)

Simple Additive Weighting 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 scale that can be compared with all available 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 use self-methods to solve various types of problems, such as determining employee salaries with achievement criteria, discipline, attitude, and length of work can be completed using the SAW method [12]. The SAW method is also used to determine egg quality with criteria for 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 following are the completion steps using the SAW method:

- 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.  $W = [W^1 W^2 W^3 \dots W_j]$

**Table 1.** Comparison of Pairwise Matrix

	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) The matching rating table of each alternative in each criteria will be the basis for making a decision matrix X. The value of X every alternative in each criterion ( $C_j$ ) 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.

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

- $r_{ij}$  = Normalized performance rating value.
- $x_{ij}$  = Attribute value owned by each criterion.
- $\text{Max}_i x_{ij}$  = The biggest value of each criterion.
- $\text{Min}_i x_{ij}$  = The smallest value of each criterion.
- 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.
- 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, while 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  
 $r_{ij}$  = Matrix normalization

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 because it is based on criteria and weighting of the required level of importance. 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].

## 2.2 Salt quality criteria and weighting

The salt quality criteria are as follows:

1. C1: NaCL
2. C2: Water content
3. C3: Salt Color

Here are the total weights for each criterion:

1. Rating of NaCl criteria weights

**Table 2.** Rating of NaCl criteria weights

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

2. Water Content Assessment

**Table 3.** Water Content Assessment

Kandungan Air	Weight
Water content 0 – 04	90
Water content 05 - 06	60
Water content 06 - 10	30

3. Assessment of salt color weight

**Table 4.** Assessment of salt color weight

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

## 3. Result and discussion

Implementation of the decision support system program for determining the quality of salt using SAW is based on a design that has been made previously. The several interfaces of the system that have been built, consist of the following. Figure 1 is the main menu page.



**Figure 1.** Main page

Figures 2 and 3 are the Criteria and Parameter Weight List page. The criteria weight list page is a form that is used to view the weight value of each criterion as well as the value of each parameter.

**Bobot Kriteria**

No.	Nama Kriteria	Bobot Kriteria	Aksi
1	Warna Garam	0.3	<a href="#">Edit</a>   <a href="#">Hapus</a>
2	kandungan Air	0.3	<a href="#">Edit</a>   <a href="#">Hapus</a>
3	NaCl	0.4	<a href="#">Edit</a>   <a href="#">Hapus</a>

**Figure 2** Page list weight criteria criteria

**Daftar Parameter**

No.	Nama Parameter	Nilai Parameter	Nama Kriteria	Aksi
1	warna coklat Bercampur lumpur	40	Warna Garam	<a href="#">Edit</a>   <a href="#">Hapus</a>
2	Warna coklat	60	Warna Garam	<a href="#">Edit</a>   <a href="#">Hapus</a>
3	Warna kristal	90	Warna Garam	<a href="#">Edit</a>   <a href="#">Hapus</a>
4	Kandungan Air 04% - 10 %	40	kandungan Air	<a href="#">Edit</a>   <a href="#">Hapus</a>
5	Kandungan Air 05% - 06 %	60	kandungan Air	<a href="#">Edit</a>   <a href="#">Hapus</a>
6	Kandungan Air 0 % - 04%	90	kandungan Air	<a href="#">Edit</a>   <a href="#">Hapus</a>
7	NaCl 90 % - 94 %	90	NaCl	<a href="#">Edit</a>   <a href="#">Hapus</a>

**Figure 3** Page list parameters

Whereas figure 4 is the Normalization Results page. Normalized results page is a form that is used to see the value of data normalization data that has been inputted.

**Daftar Hasil Normalisasi**

No	Kriteria	NaCl	kandungan Air	Warna Garam
1	PT. Garam Persero	0.959	1	0.667
2	PT. Garam Persero	1	0.667	1
3	PT. Garam Persero	0.518	1	0.667
4	PT. Gerindro	0	0	0

**Figure 4** Normalization result page

**Daftar Hasil Normalisasi Matrik**

No	Kriteria	NaCl	kandungan Air	Warna Garam
1	PT. Garam Persero	0.384	0.3	0.2
2	PT. Garam Persero	0.4	0.2	0.3
3	PT. Garam Persero	0.367	0.3	0.2
4	PT. Gerindro	0	0	0

**Figure 5** Matrix result page

Figure 5 is the Martrik Results page. Matrix result page is a form that is used to see the value of the data matrix results that have been normalized for each weight. While Figure 6 is a form of determining the quality of salt.

**Daftar Keputusan Desa Kalianget**

Periode :

No.	NIK	Perusahaan	Desa	Bulan	Tahun	Nilai Akhir	Status
1	123456789012	PT. Garam Persero	Kalianget	Januari	2017	0.9	Memerine
2	123456789012	PT. Garam Persero	Kalianget	Februari	2017	0.85	Memerine
3	069106190	PT. Gerindro	Kalianget	Januari	2017	0	Tidak Memerine

**Figure 6** Page List of lists determining salt quality

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 of the analyzes produced include:

1. Can display detailed information about salt
2. Can input the value of criteria and parameter weights.
3. Can process using SAW about salt quality.
4. Can show the results of the decision which quality of salt is the best.

#### 4. Conclusion

The initial process that can be done by the system is data input. The data input process can only be done by the admin. The data entered into the system is salt data along with complete information about the criteria and parameters. Next is the calculation process using the SAW method. The conclusions which were obtained from this decision support system include:

1. Providing the criteria and parameters about salt can provide the best quality salt.
2. Functionality tests which can make all system functions work well.

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