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Fuzzy type-2 trapezoid methods for decision making salt farmer mapping

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Abstract

The need for domestic salt every year has increased, both for consumption and industrial salt. Some of the fisheries service programs include providing assistance to people's businesses, providing geomembrane, and online marketing training. A large number of salt farmers and official work programs have caused the implementation of the program to be less than optimal, resulting in low salt production. This study uses a type-2 fuzzy method by integrating two methods, namely type-2 Fuzzy Analytical Hierarchy Process AHP (FAHP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). Fuzzy type-2 has higher accuracy than fuzzy type-1 and is more efficient and more flexible in determining the linguistic scale for criteria. The Fuzzy Analytical Hierarchy Process AHP (FAHP) interval is used to determine the weight of the salt farmer mapping criteria. Technique for Order Preference by Similarity to Ideal Solution (FTOPSIS), used to determine. The findings of this study are that the indicators that most influence the mapping of salt farmers are land area, marketing, and market. The results of the mapping of salt farmers are the classification of salt farmer class groups and recommendations for improvement for each salt farmer. Hybrid type-2 Fuzzy Analytical Hierarchy Process AHP (FAHP) method and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), can be used for mapping salt farmers based on the consistency ratio value below 10 percent, 37 percent enter high class, 28 percent enter the middle class and 35 percent enter low class.

1. Introduction

Indonesia is a country with a sea area potential of 70 percent, 17,508 islands, and a coastline of 81,000 km. One area that has the potential to develop marine resources is Madura Island. Most of the residents of Polagan Village, Sampang District work as salt farmers. The process of making salt in Polagan Village is carried out during the dry season, where the evaporation area is drained by seawater using a pump. There are about 211 salt farmers in the village with 20 farmer groups. Salt is a very important commodity for economic development in Indonesia. A large number of salt needs makes the country have to produce salt to meet the national salt demand [1][2]. The Covid-19 pandemic has caused all sectors to be paralyzed [3], salt farmers in Sampang Madura are no exception. The number of restaurants, factories, food shops, beauty salons, and hotels that are closed causes the demand for salt to decline [4]. Various government program efforts (Marine and Fisheries Service) in helping salt farmers face acceleration of handling Covid-19, namely through technology training programs, providing People's Business Credit assistance, providing appropriate technical assistance such as geomembranes to increase the amount of production and online marketing training [2][5].

The provision of this assistance is also uneven due to the lack of accurate information from each fishpond farmer. The problems in this research are that many salt farmers experience a decrease in salt production, government assistance that is not well-targeted, and difficulties selling salt products due to the impact of the Covid-19 pandemic. So far, the agency does not have a recommendation system for mapping salt farmers, so it is difficult to identify problems for each salt farmer. Based on these problems, a mapping model for salt farmers is needed based on several indicators, namely salt productivity, land area, ownership, operating profit, marketing system, aid classification, and market. Many farmer mapping indicators contain elements of uncertainty, inaccuracy, unclear information, and several qualitative value indicators, so a fuzzy method is needed. This research uses fuzzy type-2, this method provides more accurate modeling, better rating value performance, and high flexibility[6][7][8][9]. The comparison with fuzzy type-1, interval fuzzy type-2 has a clearer model and linguistic representation and better accuracy [10][11][12]. The Analytical Hierarchy Process (AHP) method produces a model that is more flexible and easier to do because it can solve multi-criteria problems in a hierarchical structure. In determining optimal weight, Analytical Hierarchy Process (AHP) considers the value of the Consistency Ratio (CR) in determining a consistent decision [13] [14].

Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method for recommendations in determining multi-criteria decisions, using Euclidian distance to determine positive and negative ideals. TOPSIS has a calculation concept that is simple, easy to understand, and computationally efficient [15][16]. The Analytical Hierarchy Process (AHP) and The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) methods have been widely used in solving decision-making problems [7]. Several studies have used a hybrid method of Analytical Hierarchy Process (AHP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) to evaluate and select software quality [17][18][19][20]. Several journals use the fuzzy method to handle data that contains uncertainty and inaccuracies, fuzzy method is also hybridized with Analytical Hierarchy Process (AHP), Analytical Network Process (ANP), and TOPSIS for weighting and data selection [21][22][23]. The Analytical Hierarchy Process (AHP)-Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) and Multi-Objective Programming (MOP) hybrid method approaches are used to determine the allocation of air resources. the first stage is the AHP method which is used to calculate the weight of the criteria, while the second stage uses the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) and Multi-Objective Programming (MOP) methods to complete the allocation alternatives. [24][25]. Many studies have also used the fuzzy AHP method, hybrid Fuzzy AHP-TOPSIS, Fuzzy type-2 interval for the implementation of computer repair priorities, forecasting, SME management, and GIS mapping for groundwater potential zones [26][27][28][29]. Based on previous research, there has been no research on salt mapping using the fuzzy interval type-2 method, The indicators used are also different because they are adjusted to conditions and needs of the Sampang Madura area. The contribution of this research is the mapping of salt farmers using a group-based decision-making model by optimizing decisions based on the modification of the Fuzzy Number (Tra-FN) trapezoid interval point. Decisions based on group decision-making have higher consensus than individual decisions[16][30][31]. The purpose of this study was to construct a multi-criteria decision-making model by hybrid type-2 Fuzzy Analytical Hierarchy Process (FAHP) method, and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) for mapping salt farmers. With the salt mapping system above, salt farmers can increase production and sales during new normal conditions after the Covid-19 pandemic and the 4.0 industrial revolution.

2. Research Method

2.1 Interval type-2 Fuzzy Sets [24]

Interval type-2 Fuzzy Sets $\tilde{\tilde{A}}$ in the universe of discourse X can be defined as follows Equation 1.

$$\tilde{\tilde{A}} = \{((x,u), \mu_{\tilde{\tilde{A}}}(x,u)) \mid \forall x \in X, \forall u \in J_X \subseteq [0,1], 0 \leq \mu_{\tilde{\tilde{A}}}(x,\mu) \leq 1\} \tag{1}$$

With $\mu_{\tilde{\tilde{A}}}$ = membership function

J_X = interval in [0,1]

Interval type-2 Fuzzy Sets $\tilde{\tilde{A}}$ can also be represented as follows Equation 2.

$$\tilde{\tilde{A}} = \int_{x \in X} \int_{u \in J_X} \mu_{\tilde{\tilde{A}}}(x,u)/(x,u) \tag{2}$$

With $J_X \subseteq [0,1]$, and $\iint$ state union overall acceptable *x* and *u*

Interval type-2 Fuzzy Sets $\tilde{\tilde{A}}$ can be regarded as a special case of a type-2 fuzzy set as follows Equation 3.

$$\tilde{\tilde{A}} = \int_{x \in X} \int_{u \in J_X} 1/(x,u) \tag{3}$$

With $J_X \subseteq [0,1]$,

2.2 Membership Function

The membership function is a curve that maps the input to the degree of membership with a value between 0 and 1. This study uses a trapezoidal membership function. The type-1 fuzzy membership function curve is shown in

Figure 1, while Figure 2 is a trapezoidal type-2 fuzzy interval. Membership function according to trapezoid fuzzy number [32].

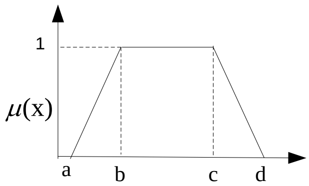

Figure 1. Fuzzy Number Trapezoidal Curve [10][32]

$$\mu(x) = \begin{cases} 0; & x \le a \text{ or } x \ge d \\ (x-a)/(b-a); & a \le x \le b \\ 1; & b \le x \le c \\ (d-x)/(d-c); & c \le x \le d, \end{cases} \tag{4}$$

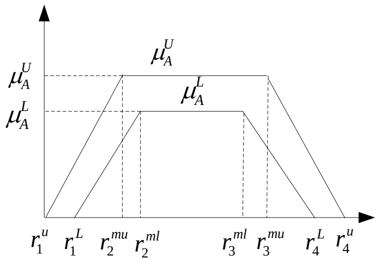

Figure 2. Interval Value Trapezoidal Fuzzy Number [12] [24]

TraFN membership function is defined as follows Equation 5 and Equation 6.

$$\mu_A^L(x) = \begin{cases} (x-r_1^l)/(r_2^{ml}-r_1^l) \ ; r_1^l \le x \le r_2^{ml} \\ (r_4^{ml}-x)/(r_4^l-r_3^{ml}); b \le x \le c \\ 0; \quad x \le r_1^l \text{ or } x \ge r_4^l \\ 1; \quad r_2^{ml} \le x \le r_3^{ml} \end{cases} \tag{5}$$

$$\mu_A^U(x) = \begin{cases} (x-r_1^u)/(r_2^{mu}-r_1^u) \ ; r_1^u \le x \le r_2^{mu} \\ (r_4^{mu}-x)/(r_4^u-r_3^{mu}); b \le x \le c \\ 0; \quad x \le r_1^u \text{ or } x \ge r_4^u \\ 1; \quad r_2^{mu} \le x \le r_3^{mu} \end{cases} \tag{6}$$

Arithmetic operations for Interval type-2 Trapezoid Fuzzy numbers can be seen from the following Equation 7 [33][34].

$$\begin{aligned} P &= [P^L, P^U] = [(p_1^l, p_2^{ml}, p_3^{ml}, p_4^l), (p_1^u, p_2^{mu}, p_3^{mu}, p_4^u)] \\ S &= [S^L, S^U] = [(s_1^l, s_2^{ml}, s_3^{ml}, s_4^l), (s_1^u, s_2^{mu}, s_3^{mu}, s_4^u)] \end{aligned} \tag{7}$$

with $p_1^u \le p_2^{mu} \le p_3^{mu} \le p_4^u, s_1^u \le s_2^{mu} \le s_3^{mu} \le s_4^u$

2.3 Flowchart hybrid method Interval type-2 FAHP dan FTOPSIS

The flowchart of the method can be seen in Figure 3. Hybrid interval type-2 FAHP and FTOPSIS. This flowchart begins by determining the salt mapping indicator. Salt mapping indicators are determined based on several criteria, namely salt productivity, land area, ownership, operating profit, marketing system, aid classification, and marketplace.

The next step is to determine the scale of interval fuzzy type-2 and determine a pairwise comparison matrix, calculate the value of CR, if CR is less than 10 percent, calculation of geometric means, and produce the weight of each criterion. the weights of the interval type-2 fuzzy AHP method are entered in the type-2 FTOPSIS method, in the weighted normalization step, then the positive and negative ideals are determined for each criterion, and the final result is ranking.

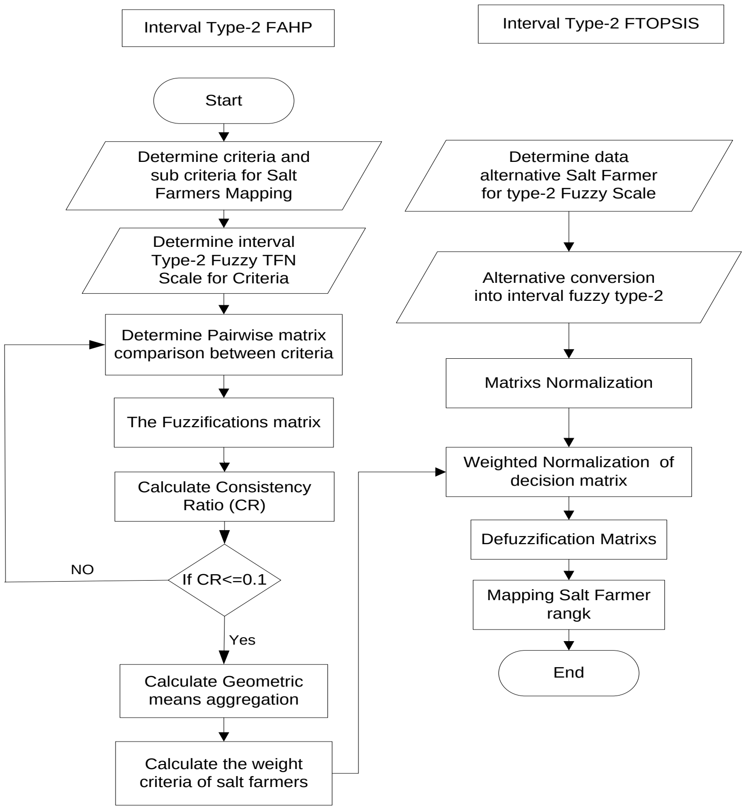

Figure 3. Hybrid interval type-2 Trapezoid Fuzzy AHP and TOPSIS

3. Results and Discussion

3.1 Hybrid Interval Type-2 MCGDM with Trapezium Model.

Hybrid Interval type-2 Fuzzy AHP and Fuzzy TOPSIS based on Trapezoidal Fuzzy Number function in Figure 2. The steps for hybrid Interval type-2 Fuzzy AHP and Fuzzy TOPSIS method are:

1. Construct the M matrix as a pairwise comparison matrix. Calculate the Consistency Ratio value based on the assessment of respondents, and normalizatithe on of matrix

$$M = \begin{bmatrix} 1 & m_{12} & m_{13} \dots & m_{1n} \\ m_{21} & 1 & m_{23} \dots & m_{2n} \\ m_{31} & m_{32} & 1 \quad \dots & m_{3n} \\ \vdots & \vdots & \vdots \;\; \ddots & \vdots \\ m_{n1} & m_{n2} & m_{n3} \;\dots & 1 \end{bmatrix} \tag{8}$$

With i, j = 1, 2, … , n.

M = Pairwise comparison matrix, m_{ij} = Matrix elements m row to i column to j

2. Convert the matrix into an interval matrix of type-2 interval Trapezoid Fuzzy number according to Figure 2.

$$R = \begin{bmatrix} 1 & r_{12} & r_{13} \dots & r_{1n} \\ r_{21} & 1 & r_{23} \dots & r_{2n} \\ r_{31} & r_{32} & 1 \quad \dots & r_{3n} \\ \vdots & \vdots & \vdots \quad \ddots & \vdots \\ r_{n1} & r_{n2} & r_{n3} \dots & 1 \end{bmatrix} \tag{9}$$

With

$$r_{ij} = [(r^{l}_{ij1}\, r^{ml}_{ij2}, r^{ml}_{ij3}, r^{l}_{ij4}, \mu^{l}_{ij}), (r^{u}_{ij1}, r^{mu}_{ij2}, r^{mu}_{ij3}, r^{u}_{ij4}, \mu^{u}_{ij})]$$

R = Pairwise comparison Criteria interval matrix of type-2, r_{ij} = Matrix elements r row to i column to j

Based on matrix R, then the matrix is converted into intervals. To calculate results assessment of several respondents, a group decision-making system was used using the Geometric Means Aggregation method. Fuzzy type-2 interval geometric means aggregation can be represented in matrix V below Equation 10.

$$\mathrm{V} = \begin{bmatrix} v_{11} & v_{12} & v_{13} \dots v_{1n} \\ v_{21} & v_{22} & v_{23} \dots v_{2n} \\ v_{31} & v_{32} & v_{33} \dots v_{3n} \\ \vdots & \vdots & \vdots \; \ddots \; \vdots \\ v_{n1} & v_{n2} & v_{n3} \dots v_{nn} \end{bmatrix} \tag{10}$$

With

$$v_{ij} = \left(\left(\prod_{k=1}^{n} r^{u}_{1ijk}\right)^{1/n}, \left(\prod_{k=1}^{n} r^{mu}_{2ijk}\right)^{1/n}, \left(\prod_{k=1}^{n} r^{mu}_{3ijk}\right)^{1/n}, \left(\prod_{k=1}^{n} r^{u}_{4ijk}\right)^{1/n}, \left(\prod_{k=1}^{n} r^{l}_{1ijk}\right)^{1/n}, \left(\prod_{k=1}^{n} r^{ml}_{2ijk}\right)^{1/n}, \left(\prod_{k=1}^{n} r^{ml}_{3ijk}\right)^{1/n}, \left(\prod_{k=1}^{n} r^{l}_{4ijk}\right)^{1/n} \right)$$

i, j = 1,2,...,n.

V = Geometric Mean interval matrix of type-2, v_{nn} = Matrix elements v row to n column to n

3. Determine the weight of criteria for matrix S denoted by the K^{*} matrix below Equation 11 and Equation 12.

$$\mathrm{K}^{*} = \begin{bmatrix} k_1 \\ k_2 \\ k_3 \\ \vdots \\ k_n \end{bmatrix}, \tag{11}$$

$$k_i = \left(\frac{\prod_{j=1}^{n} (v^{u}_{1ij})^{1/n}}{\sum_{i=1}^{n} v^{u}_{4ij}}, \frac{\prod_{j=1}^{n} (v^{l}_{1ij})^{1/n}}{\sum_{i=1}^{n} v^{l}_{4ij}}, \frac{\prod_{j=1}^{n} (v^{mu}_{2ij})^{1/n}}{\sum_{i=1}^{n} v^{mu}_{3ij}}, \frac{\prod_{j=1}^{n} (v^{ml}_{2ij})^{1/n}}{\sum_{i=1}^{n} v^{ml}_{3ij}}, \frac{\prod_{j=1}^{n} (v^{mu}_{3ij})^{1/n}}{\sum_{i=1}^{n} v^{mu}_{2ij}} \frac{\prod_{j=1}^{n} (v^{ml}_{3ij})^{1/n}}{\sum_{i=1}^{n} v^{ml}_{2ij}} . \frac{\prod_{j=1}^{n} (v^{l}_{4ij})^{1/n}}{\sum_{i=1}^{n} v^{l}_{1ij}}, \frac{\prod_{j=1}^{n} (v^{u}_{4ij})^{1/n}}{\sum_{i=1}^{n} v^{u}_{1ij}} \right) \tag{12}$$

with *i,j = 1,2,...,n.*

K = The Weight interval matrix of type-2, k_i = Matrix elements k

4. The next step is defuzzification, which Equation 13 is changing interval value to a single value.

$$BNIP_i = \frac{\left[\frac{(\mathrm{p}^{u}_{4i} - p^{u}_{1i}) + (\mu^{mu}_{A} . \mathrm{p}^{mu}_{2i} - p^{u}_{1i}) + (\mu^{mu}_{A} . \mathrm{p}^{mu}_{3i} - p^{u}_{1i})}{4} + p^{u}_{1i} \right] + \left[\frac{(\mathrm{p}^{l}_{4i} - p^{l}_{1i}) + (\mu^{ml}_{A} . \mathrm{p}^{ml}_{2i} - p^{l}_{1i}) + (\mu^{ml}_{A} . \mathrm{p}^{ml}_{3i} - p^{l}_{1i})}{4} + p^{l}_{1i} \right]}{2}, \tag{13}$$

With i = 1,2,...,n.
BNIP = Best No Interval Fuzzy Performance

5. In this step, the TOPSIS fuzzy type-2 method is used. Matrix Z below Equation 14 is an alternative matrix for decision support.

$$Z = \begin{bmatrix} z_{11} & z_{12} & \cdots & z_{1n} \\ z_{21} & z_{22} & \cdots & z_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ z_{n1} & z_{n2} & \cdots & z_{nn} \end{bmatrix} \quad (14)$$

With,

$$z_{ij} = [(z^{l}_{ij1}\, z^{ml}_{ij2}, z^{ml}_{ij3}, z^{l}_{ij4}, \mu^{l}_{ij}), (z^{u}_{ij1}, z^{mu}_{ij2}, z^{mu}_{ij3}, z^{u}_{ij4}, \mu^{u}_{ij})]$$

i,j = 1,2,..,n. Z = Alternative matrix , z_{ij} = Matrix elements z row to i column to j

6. The construction of a normalized decision matrix based on Z matrix, which is denoted by D can be expressed as follows Equation 15,

$$D = \begin{bmatrix} d_{11} & d_{12} & d_{13} \cdots & d_{1n} \\ d_{21} & d_{22} & d_{23} \cdots & d_{2n} \\ d_{31} & d_{32} & d_{33} \cdots & d_{3n} \\ \vdots & \vdots & \vdots \ \ddots & \vdots \\ d_{n1} & d_{n2} & d_{n3} \cdots & d_{nn} \end{bmatrix} \quad (15)$$

$$d_{ij} = \left[\frac{z^{u}_{1ij}}{c^{+}_{j}}, \frac{z^{l}_{1ij}}{c^{+}_{j}}, \frac{z^{mu}_{2ij}}{c^{+}_{j}}, \frac{z^{ml}_{2ij}}{c^{+}_{j}}, \frac{z^{mu}_{3ij}}{c^{+}_{j}}, \frac{z^{ml}_{3ij}}{c^{+}_{j}}, \frac{z^{l}_{4ij}}{c^{+}_{j}}, \frac{z^{u}_{4ij}}{c^{+}_{j}} \right], \text{ j = 1,2… , n.}$$

Or

$$d_{ij} = \left[\frac{a^{-}_{j}}{z^{u}_{4ij}}, \frac{a^{-}_{j}}{z^{l}_{4ij}}, \frac{a^{-}_{j}}{z^{ml}_{3ij}}, \frac{a^{-}_{j}}{z^{mu}_{3ij}}, \frac{a^{-}_{j}}{z^{ml}_{2ij}}, \frac{a^{-}_{j}}{z^{mu}_{2ij}}, \frac{a^{-}_{j}}{z^{l}_{1ij}}, \frac{a^{-}_{j}}{z^{u}_{1ij}} \right], \text{ j = 1,2…,n}$$

With *i,j = 1,2,...,n.*

D = Normalized matrix, d_{ij} = Matrix elements d row to i column to j

7. Normalization of weights is notated by matrix Y and can be expressed as follows Equation 16.

$$Y = \begin{bmatrix} y_{11} & y_{12} & \cdots & y_{1n} \\ y_{21} & y_{22} & \cdots & y_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ y_{n1} & y_{n2} & \cdots & y_{nn} \end{bmatrix} \quad (16)$$

$$y_{ij} = w_j \,.\, d_{ij}$$

$$y_{ij} = (d^{u}_{1ij}.w_j, d^{l}_{1ij}.w_j, d^{mu}_{2ij}.w_j, d^{ml}_{2ij}.w_j, d^{mu}_{3ij}.w_j, d^{ml}_{3ij}.w_j, d^{l}_{4ij}.w_j, d^{u}_{4ij}.w_j)$$

With *i,j = 1,2,...,n.*

y = Weight matrix, y_{ij} = Matrix elements y row to i column to j.

8. Determine positive and negative ideal solutions, then determine shortened distance using the Euclidian distance as Follows Equation 17, Equation 18, Equation 19, and Equation 20.

$$g^{+}_{i1} = \sum_{j=1}^{n} \sqrt{\frac{1}{4}\left[\left(y^{u}_{1ij} - \tilde{v}^{+}_{j}\right)^2 + \left(y^{mu}_{2ij} - \tilde{v}^{+}_{j}\right)^2 + \left(y^{mu}_{3ij} - \tilde{v}^{+}_{j}\right)^2 + \left(y^{u}_{4ij} - \tilde{v}^{+}_{j}\right)^2 \right]} \quad (17)$$

$$g_{i2}^{+}=\sum_{j=1}^{n}\sqrt{\frac{1}{4}\left[\left(y_{1ij}^{l}-\tilde{v}_{j}^{+}\right)^{2}+\left(y_{2ij}^{ml}-\tilde{v}_{j}^{+}\right)^{2}+\left(y_{3ij}^{ml}-\tilde{v}_{j}^{+}\right)^{2}+\left(y_{4ij}^{l}-\tilde{v}_{j}^{+}\right)^{2}\right]} \quad (18)$$

$$g_{i1}^{-}=\sum_{j=1}^{n}\sqrt{\frac{1}{4}\left[\left(y_{1ij}^{u}-\tilde{v}_{j}^{-}\right)^{2}+\left(y_{2ij}^{mu}-\tilde{v}_{j}^{-}\right)^{2}+\left(y_{3ij}^{mu}-\tilde{v}_{j}^{-}\right)^{2}+\left(y_{4ij}^{u}-\tilde{v}_{j}^{-}\right)^{2}\right]} \quad (19)$$

$$g_{i2}^{-}=\sum_{j=1}^{n}\sqrt{\frac{1}{4}\left[\left(y_{1ij}^{l}-\tilde{v}_{j}^{-}\right)^{2}+\left(y_{2ij}^{ml}-\tilde{v}_{j}^{-}\right)^{2}+\left(y_{3ij}^{ml}-\tilde{v}_{j}^{-}\right)^{2}+\left(y_{ij4}^{l}-\tilde{v}_{j}^{-}\right)^{2}\right]} \quad (20)$$

With *i,j = 1,2,...,n.*

g_{ij}^{+} = Determine the positive ideal solutions

g_{ij}^{-} = Determine the negative ideal solutions

10. Calculate relative proximity and Alternative Rank

3.2 Implementation and Analysis of Results

Implementation model hybrid interval type-2 FAHP and TOPSIS for mapping salt farmers. The data used in this study is data of salt farmers in 2020 as many as 100 salt farmers. Questionnaires were conducted at Sampang Madura Fisheries Service to determine the importance of the criteria. The aim is to find out the indicators that have the most influence on the mapping of salt farmers. The next questionnaire was conducted on salt farmers, to fill in data used in ranking and mapping salt farmers. The criteria used are land area (A1), a number of workers (A2), capital (A3), production yield (A4), Market place (A5), and marketing system (A6). Determining the linguistic scale of interval fuzzy type-2 using a numerical scale can be seen in Table 1. using the same middle point on Trapezoid Fuzzy Number (TFN). The user interface for login admin mapping salt farmer can be seen in Figure 4. The main interfaces consist of a home page, user data, AHP menu there are input criteria, criteria data, and values, in the fuzzy type-2 interval there is an interval scale, linguistic scale, and geometric mean to calculate group assessments, then after that, they are ranked using TOSPSIS.

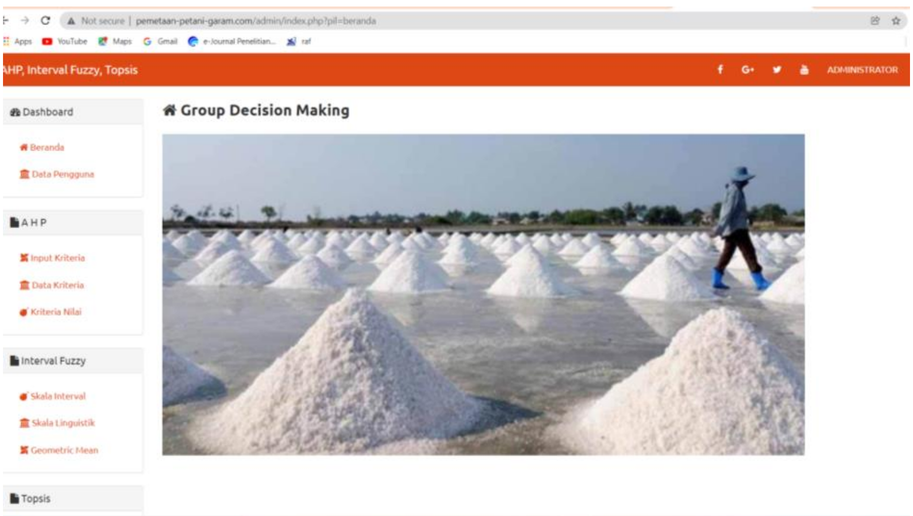

Figure 4. The User Interface for Login Admin Mapping Salt Farmer

Table 1. Linguistic Scale interval Type-2 Fuzzy

Numeric	Fuzzy Type-2 Scale	Linguistic Definition
	[(1,1,1,1) (1,1,1,1)]	Comparison of 2 Same Criteria
1	[(0.1, 0.5, 1.3, 7) (0.3, 0.7, 1, 1.5)]	Equally Important
3	[(1.5, 2, 2.7, 3.2) (1.7, 2.2, 2.5, 3)]	A Little More Important
5	[(3, 3.5, 4.2, 4.7) (3.2, 3.7, 4, 4.5)]	More important
7	[(4.5, 5, 6, 6.5) (4.7, 5.2, 5.6, 6.3)]	Very More Important
9	[(6.3, 6.7, 7.5, 8)(6.5, 7, 7.3, 7.7)]	The most important

This system group assessment consists of 3 assessors, namely Sampang Fisheries Service, agricultural researchers, and the head of the salt farmer group. The results of the three assessors can be seen in decision maker 1 until decision maker 3 in Table 2. Decision Maker 1., Table 3. Decision Maker 2., Table 4. Decision Maker 3. The three tables have been converted into fuzzy type-2 geometric mean aggregation values. The value of geometric mean aggregation results based on intervals can be seen in Table 5. The results of weights in intervals are used as weighted normalization inputs in the TOPSIS method. The results of interval weights can be seen in Table 6.

Table 2. Decision Maker 1

	A1								…	A6							
	U1	**MU**	**MU1**	**U2**	**L1**	**ML**	**ML1**	**L2**	**…**	**U1**	**MU**	**MU1**	**U2**	**L1**	**ML**	**ML1**	**L2**
A1	1	1	1	1	1	1	1	1	…	0.15	0.17	0.20	0.22	0.16	0.18	0.19	0.21
A2	1.5	2	2.7	3.2	1.7	2.2	2.5	3	…	0.16	0.18	0.19	0.21	0.22	0.25	0.27	0.31
A3	1.5	2	2.7	3.2	1.7	2.2	2.5	3	…	0.21	0.24	0.29	0.33	0.22	0.25	0.27	0.31
A4	3	3.5	4.2	4.7	3.2	3.7	4	4.5	…	0.31	0.37	0.50	0.67	0.33	0.40	0.45	0.59
A5	1.5	2	2.7	3.2	1.7	2.2	2.5	3	…	0.31	0.37	0.50	0.67	0.33	0.40	0.45	0.59
A6	4.5	5	6	6.5	4.7	5.2	5.6	6.3	…	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 3. Decision Maker 2

	A1								…	A6							
	U1	**MU**	**MU1**	**U2**	**L1**	**ML**	**ML1**	**L2**	**…**	**U1**	**MU**	**MU1**	**U2**	**L1**	**ML**	**ML1**	**L2**
A1	1	1	1	1	1	1	1	1	…	0.21	0.24	0.29	0.33	0.22	0.25	0.27	0.31
A2	1.5	2	2.7	3.2	1.7	2.2	2.5	3	…	0.31	0.37	0.50	0.67	0.33	0.40	0.45	0.59
A3	1.5	2	2.7	3.2	1.7	2.2	2.5	3	…	0.21	0.24	0.29	0.33	0.22	0.25	0.27	0.31
A4	1.5	2	2.7	3.2	1.7	2.2	2.5	3	…	0.31	0.37	0.50	0.67	0.33	0.40	0.45	0.59
A5	1.5	2	2.7	3.2	1.7	2.2	2.5	3	…	0.31	0.37	0.50	0.67	0.33	0.40	0.45	0.59
A6	3	3.5	4.2	4.7	3.2	3.7	4	4.5	…	1	1	1	1	1	1	1	1

Table 4. Decision Maker 3

	A1								…	A6							
	U1	**MU**	**MU1**	**U2**	**L1**	**ML**	**ML1**	**L2**	**…**	**U1**	**MU**	**MU1**	**U2**	**L1**	**ML**	**ML1**	**L2**
A1	1	1	1	1	1	1	1	1	…	0.31	0.37	0.50	0.67	0.33	0.40	0.45	0.59
A2	1.5	2	2.7	3.2	1.7	2.2	2.5	3	…	0.31	0.37	0.50	0.67	0.33	0.40	0.45	0.59
A3	1.5	2	2.7	3.2	1.7	2.2	2.5	3	…	0.21	0.24	0.29	0.33	0.22	0.25	0.27	0.31
A4	3	3.5	4.2	4.7	3.2	3.7	4	4.5	…	0.31	0.37	0.50	0.67	0.33	0.40	0.45	0.59
A5	1.5	2	2.7	3.2	1.7	2.2	2.5	3	…	0.31	0.37	0.50	0.67	0.33	0.40	0.45	0.59
A6	1.5	2	2.7	3.2	1.7	2.2	2.5	3	…	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 5. Geometric Mean Aggregation

	A1								…	A6							
	U1	**MU**	**MU1**	**U2**	**L1**	**ML**	**ML1**	**L2**	**…**	**U1**	**MU**	**MU1**	**U2**	**L1**	**ML**	**ML1**	**L2**
A1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	…	0.46	0.49	0.55	0.60	0.47	0.50	0.53	0.58
A2	1.23	1.42	1.66	1.81	1.31	1.49	1.60	1.75	…	0.49	0.53	0.60	0.67	0.53	0.58	0.61	0.69
A3	1.23	1.42	1.66	1.81	1.31	1.49	1.60	1.75	…	0.45	0.48	0.53	0.57	0.46	0.49	0.51	0.55
A4	1.56	1.72	1.93	2.06	1.63	1.78	1.87	2.01	…	0.55	0.60	0.70	0.81	0.57	0.63	0.67	0.76
A5	1.23	1.42	1.66	1.81	1.31	1.49	1.60	1.75	…	0.55	0.60	0.70	0.81	0.57	0.63	0.67	0.76
A6	1.67	1.83	2.05	2.18	1.74	1.89	1.98	2.13	…	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Tabel 6. The Weight Interval for TOPSIS Process

	U1	MU	MU1	U2	L1	ML	ML1	L2
A1	0.06	0.08	0.11	0.14	0.07	0.09	0.10	0.13
A2	0.07	0.08	0.11	0.14	0.08	0.10	0.11	0.14
A3	0.08	0.11	0.15	0.19	0.09	0.12	0.14	0.17
A4	0.11	0.15	0.23	0.35	0.13	0.17	0.20	0.28
A5	0.13	0.17	0.24	0.32	0.15	0.19	0.22	0.28
A6	0.19	0.25	0.34	0.41	0.21	0.27	0.31	0.38

The result of defuzzification table 6 is a single-valued weight, namely land area (A1) = 0.0434, number of workers (A2) = 0.045129, capital (A3) =0.05916, production yield (A4) = 0.101981, Market place (A5) =0.097789, marketing system (A6) = 0.129194. The next step is to determine indicator mapping for salt farmers. The value of each criterion is shown in Table 7. This table describes the value of each criterion, and description criteria, and then serves as input for the assessment of each alternative or farmer data.

Table 7. Mapping Indicators for Salt Farmers

Code	Criteria	Value of Criteria	Description
A1	land area	<=0.1 ha	Bad
		0.2 - 0.75 ha	Moderate
		0.76 - 1.2 ha	Good
		>1.2 ha	Very Good
A2	Number of workers	1 People	Bad
		2-4 People	Moderate
		5-10 People	Good
		>10 People	Very Good
A3	Capital	1- 2 million	Bad
		3 - 4 million	Moderate
		5 - 6 million	Good
		> 6 million	Very Good
A4	Production yield	1-5 tons	Bad
		6-10 tons	Moderate
		11-18 tons	Good
		>18 tons	Very Good
A5	Market Place	Not Applied	Bad
		Have 1 marketplace	Moderate
		Have 2 marketplaces	Good
		Have 3 marketplaces	Very Good
A6	Marketing	Merchants, collectors	Bad
		Farmer, collector	Moderate
		Factory intermediary	Good
		Salt factory	Very Good

Results Recommendations for salt farmers can be seen in Table 8. The results of the recommendations stated that 37 percent enter the high level, 28 percent enter the moderate level and 35 percent enter the low level. Based on interval points Triangular Fuzzy Number (TFN) and Trapezoidal Fuzzy Number (Tra-FN) functions, the Tra-FN function has a very small range or distance of points, so the resulting accuracy is better than TFN.

Table 8. Recommendation Salt Farmer

No	Salt Farmer	Recommendation
1	Mudoffar	Moderate level
2	Adnan	Low level
3	H Aunur Rofiq	High level
4	Nur Hidayat	High level
5	Siti Hitijah	High level
7	Bahtiar Arifin	High level
8	Moh Adi	High level
9	Saniri	Moderate level
10	Abdul Wasik	Moderate level
11	Abdul Rohman	Moderate level
…	….	....
98	Yahya	Low level
99	Afsa	Low level
100	Rahman	Low level

4. Conclusion

The recommendation system for mapping salt farmers using fuzzy type-2 with a group-based method is suitable for use as a decision support system. The result is a ranking and recommendation of salt farmers. Trapezoidal fuzzy numbers have point intervals with a very small range, so they have better accuracy than triangular fuzzy numbers. The indicators that most influence mapping of salt farmers are land area, marketing, and market. The results of the recommendations stated that 37 percent enter the high level, 28 percent enter the moderate level and 35 percent enter the low level. This method can be further developed using a fuzzy trapezoid with different fuzzy interval points. trapezoidal fuzzy type-2 can also be hybridized with other methods, namely data mining and the other multicriteria decision-making.

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