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Research article

# Land-use suitability evaluation for organic rice cultivation using fuzzy-AHP ELECTRE method

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**ABSTRACT**

Land conversion to organic agriculture is the answer to land degradation problems that interfere with land resources sustainability. An evaluation of land-use suitability is crucial to measure the appropriateness of land for agricultural cultivation. Specifically, organic rice cultivation has some particular standard criteria such as temperature, rainfall, soil depth, pH, c-organic, slope, erosion level, a transition period that influence ranking results, and land suitability classes. Eight organic farmlands were used as alternatives, namely Sawangan, Mangunsari, Tirtosari, Podosoko, Butuh, Krogowanan, Kapuhan, and Jati. Fuzzy Analytic Hierarchy process is used to determine the level of importance of the criteria based on weight assessments by three agricultural experts. The ELECTRE method is applied to rank the most suitable land from several alternatives for organic rice cultivation. The combination of these two multi-criteria decision-making methods complements each other to solve problems in land suitability evaluation. A web-based decision support system (DSS) was created to accelerate data processing integration and present factual information from the land suitability selection process. The implementation of DSS with fuzzy-AHP ELECTRE for evaluating land-use suitability in organic rice cultivation provided the best score for Tirtosari with *Ekl*=4 and spearman rank correlation the system comparison results with actual data *rs*=0.95. This study's results indicate that integrating the web with fuzzy-AHP ELECTRE is quite effectively applied for decision-making in organic farming.



## 1. Introduction

Sustainable organic agriculture is crucial to improve the quality of land and the supply of healthy food [1]. The suitability of land determines organic agriculture's success, especially for organic rice cultivation that relies on natural materials to improve the land quality and restore soil fertility [2]. Meanwhile, conventional agriculture still uses synthetic materials that decrease soil productivity and increases the potential of erosion and environmental pollution [3, 4].

Considering the land suitability decreases negative impacts of non-environmental agriculture, a reliable decision supporting system is needed to determine land suitability for organic rice cultivation [5]. Several decision-making methods have been used for measuring land suitability. One of them is MCDM (Multi-Criteria Decision Making). This method is divided into two categories, namely MADM (Multi-Attribute Decision Making) and MODM (Multi-Objective Decision Making). The MADM method has more advantages compared to MODM to find the most suitable alternative in ranking

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attributes, weights, and measure the comparisons between alternatives [6]. These advantages make this method the right choice to overcome problems in land suitability evaluation.

Evaluation of land suitability in agriculture is still carried out conventionally [7], using parameters without weighting considerations from agricultural experts [8], yet only for food crop cultivation [9], and relying on software without any system development planning [10]. The accuracy in data management and the evaluation results' accuracy will undoubtedly impact organic rice cultivation's growth and productivity [5, 11]. This impact is a fundamental reason that the land-use suitability evaluation for organic rice needs to be developed with an information system that applies a multicriteria decision-making method.

Several evaluations have been carried out for measuring land suitability using MCDM, such as the application of the PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluation) to select optimal locations for wind power electricity [12]. TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) method was used to determine location ratings for installing wind turbines [13]. The VIKOR (*VIsekriterijumsko KOmpromisno Rangiranje*) method was used to determine the renewable technology [14], while the ELECTRE method was implemented to measure land-use suitability [15]. The PROMETHEE, TOPSIS, VIKOR, and ELECTRE methods only focus on alternative rankings, so that one of these methods needs to be combined with other methods that are reliable in weighting criteria. The MCDM methods that are often used for weighting criteria are AHP (Analytic Hierarchy Process), BWM (Best–Worst Method), and BCM (Base-Criterion Method) [16]. BCM is a new method in MCDM which has been developed into fuzzy BCM [17]. Likewise, AHP has been developed into fuzzy AHP, so the Triangular Fuzzy Numbers (TFNs) concept can cover the lack of consistency in AHP and represent the preferences of decision-makers [18]. Therefore, this study chose fuzzy-AHP to weigh the criteria and ELECTRE for ranking the best land alternatives.

The ELECTRE method is one of the MCDM methods with a MADM type using a paired comparison of alternatives based on ranking concepts [19]. This method can be applied with more alternatives. The concept of outranking relations can identify the relationship between the two alternatives. An alternative can be more dominant than other alternatives if a sufficient condition occurs. It makes the selection and evaluation process faster [20]. The ELECTRE method is appropriate to be used in the selection and elimination procedures. However, the weakness of this method is in weighting the criteria. Therefore, this study used fuzzy-AHP to determine the normalized criterion weight by converting linguistic values to the TFNs scale to represent decision-makers [21]. The ELECTRE method, as well as the fuzzy-AHP method in previous research, has been combined with other methods for evaluating land suitability for sustainable agriculture [9, 22, 23], renewable technologies [24, 25], waste disposal [26], and tourism areas [15].

After reviewing the previous studies, this study proposed the fuzzy-AHP and ELECTRE method to evaluate the land use's suitability in organic rice cultivation [27]. This research aimed to provide a decision-supporting system that helps rank the best land for organic rice cultivation. This study's steps include proposing problem statements and solutions in the background, reviewing related research in the related work, designing calculations based on research methods, showing the results of the scientific method calculations, then discussing them, and making conclusions and suggestions. This study involved nine land suitability criteria: 1) Temperature: annual average temperature, 2) Rainfall or the number of wet months, 3) Drainage, 4) Soil depth, 5) pH, 6) C-organic, 7) Slope, 8) Erosion level, 9) Transition period to organic. In general, these criteria are used in rice farming, except for the transition period to organic. Organic rice cultivation has uniqueness in the land use's suitability, especially for converting from inorganic to organic. This case study was located in 8 alternatives in Magelang regency, Indonesia, known as an organic rice-producing center. The alternatives were Sawangan (*L1*), Mangunsari (*L2*), Tirtosari (*L3*), Podosoko (*L4*), Butuh (*L5*), Krogowanan (*L6*), Kapuhan (*L7*), and Jati (*L8*). The benefits of this research are as a consideration to improve land quality and productivity of organic rice agricultural products. The results obtained can be used as an evaluation material for stakeholders and farmers in managing agricultural land organically and sustainably.

## 2. Related Work

Proper land-use planning and land suitability evaluation will be essential decisions in sustainable agricultural management. Tercan et al. [23], in their research, evaluated the suitability of land for citrus

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cultivation in Turkey by combining DSS with GIS (Geographic Information System). AHP is applied for the weighting of criteria, IDW (Inverse Distance Weighting) is used to estimate the value of meteorological parameters, and GIS is used in mapping suitable zones. Criteria such as topographic conditions, meteorology, infrastructure and hydrology, and land use capability are considered for decision making. The weakness of this study is the implementation of AHP in weighting the criteria. Fuzzy logic is used to fix this weakness, such as research [22] in evaluating rice cultivation land in Turkey. The fuzzy-AHP approach is applied to determine the preference weights of 9 physiochemical criteria of cropland. Choosing the best location using the ranking concept in agricultural cultivation can be done by combining fuzzy-AHP with one of the MCDM methods.

Environmental problems are global problems that have a negative impact on the balance of nature and human activities. Especially in the renewable technology sector, Garcia et al. [24] try to evaluate location selection for renewable power plants using ELECTRE. The ELECTRE method is applied to calculate the outranking relationship between numeric and semantic data. The 5 criteria used are 3 numerical criteria (energy source, cost, and water usage) and 2 semantic criteria (waste by-product and environmental pollution damage). The decision-making procedure is carried out by creating a subjective semantic user profile based on ontology, creating a matrix with objective information, the parameters (discrimination threshold and criterion weight) determined by the decision-maker, and calculating the concordance and discordance indexes. The paper stated that the proposed semantic criteria must be following the ontology concept made. This shows that the subjectivity of the decision-maker is still very influential in the system.

Renewable energy is an energy offer that is environmentally friendly and appears to be a global energy supplier. In the development of Pumped Hydro-Energy Storage (PHES), Nzotcha et al. [25] proposed selecting the best location using ELECTRE based on a sustainable development perspective. This research is based on three factors, namely techno-economic factors, social factors, and environmental factors. The integration of the three methods is applied in decision making with weighting stages using AHP, conducting criteria assessments based on Fuzzy membership values. The ELECTRE method is applied in calculating aggregation scores. The combination of methods has been run and tested practically and efficiently. However, this study is still using the J-Electre-v1.0 software platform for data processing.

**Table 1**
Summarize of the related works

| Research | Strength | Weakness |
|---|---|---|
| Tercan et al. [23] | The combination of MCDM methods in a GIS environment for land evaluation has resulted in an organized instrument for the best land selection and land mapping. | Criteria weighting using AHP still has shortcomings in the subjectivity of decision making. |
| Garcia et al. [24] | Developed the application of the ELECTRE method with the semantic concept to analyze two environmental criteria. | The decision support system results still depend on the subjectivity of the semantic value of the decision-maker. |
| Nzotcha et al. [25] | A fuzzy AHP ELECTRE combination is applied for selecting the best location for PHES. | Implementation of the method still uses a platform system, practical research but lacking in developing a data security-based system. |
| Ayhan et al. [15] | Used the integration of mapping and decision-making systems as a tool to analyze the potential for rural tourism. | The system only focuses on processing data for analysis and method stages without using a normalized weighting process. |
| Biluca et al. [26] | Decision making considers the concept of compensatory and non-compensatory approaches to solving construction waste problems. | Data analysis requires a variety of relevant criteria for the selection of the best waste disposal site. |

The selection of the right location is a recommendation in developing a more planned and strategic area. In rural tourism, Ayhan et al. [15] analyzed the land use's suitability for rural tourism activities. Decision-makers can analyze land suitability based on three factors: place/location, environmental elements, and development activities. The ELECTRE method is applied with some basic


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steps 1) comparing pairwise alternatives with concordance and discordance matrices 2) comparing alternatives based on a matrix that has been formed and 3) determining the most suitable alternative based on threshold values based on the concordance and discordance matrices. Following the stages that have been carried out, that research relies on numerical values for mathematical operations. Data processing still uses software such as Fortran and ArcGIS.

Decision making that is oriented towards environmental sustainability is a priority in urban planning development. Biluca et al. [26], in his research, integrated GIS and ELECTRE for evaluation of suitable areas for construction waste disposal. The 9 criteria used are distance to population centers, distance to roads and highways, distance to educational institutions, distance to health institutions, distance to water bodies, slope, types of soils, use and occupation of the soil, and required area size. The method's working mechanism involves sorting the areas using WLC (weighted linear combination) with AHP normalization calculations, determining relevant criteria, calculating the normalized AHP vector weight, identifying suitable and unsuitable areas, and conducting alternatives pairwise comparison using the ELECTRE method. Compensation and non-compensation approaches are novelty that needs to be integrated with various criteria. This approach shows that various relevant criteria can affect the performance of choices according to the ELECTRE method. A summary of the related work is presented in Table 1.

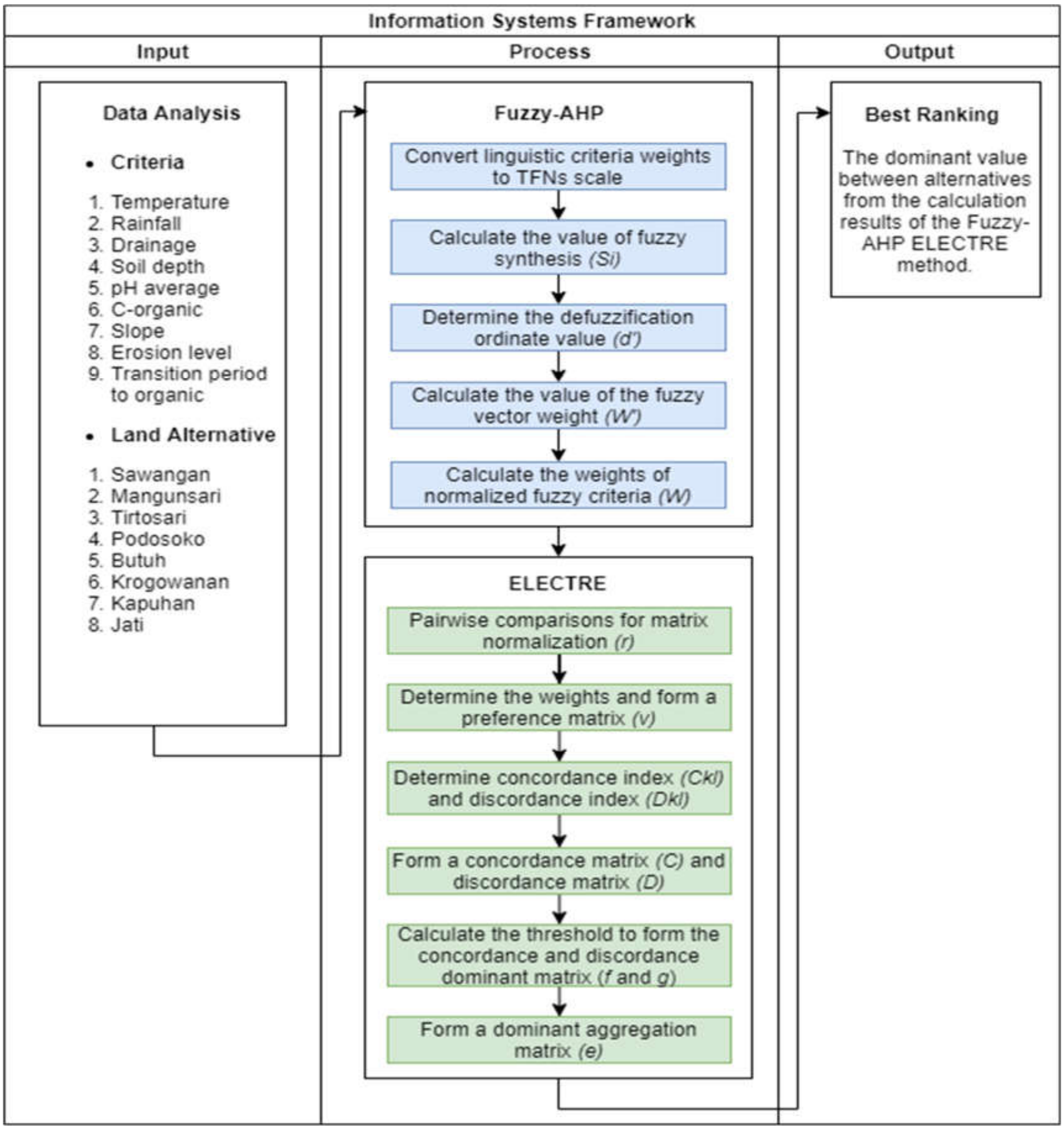


**Fig. 1.** Information systems framework

## 3. Method

### *3.1. Information systems framework*

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The Information Systems Framework (IS Framework) in this study is divided into three stages: input, process, and output. First, the input stage is the pre-processing of data analysis in the form of criteria and alternatives. The criteria are land use requirements or environmental characteristics used as a reference to determine values and decision making. Based on the Ministry of Agriculture and FAO's land assessment guidelines, 9 (nine) criteria of land suitability for organic rice cultivation were obtained. Meanwhile, alternatives are strategic choices for locations or research areas that have implemented organic rice cultivation. The alternatives that exist in the study are eight organic lands (*L*) in the Sawangan sub-district, Magelang regency, Indonesia.

Criteria and alternatives are compared in pairs or managed according to the fuzzy-AHP approach and the ELECTRE method. To process the data, it used the fuzzy-AHP approach for criteria weighting. The steps are converting the linguistic criteria to the TFNS scale, calculating the fuzzy synthesis value, determining the defuzzification ordinate value, and calculating the fuzzy vector weight and the normalization weights. Then, the outranking relationships were obtained in the ELECTRE method. Six stages of ELECTRE method is 1) determine *r*-value, 2) determine *v* value in preference matrix, 3) determine set index of $C_{kl}$ and $D_{kl}$ value, 4) Form a *C* matrix and *D* matrix, 5) determine *f* matrix and *g* matrix, and 6) calculate $E_{kl}$ from $F_{kl}$ multiplication by $G_{kl}$ for form an *e* matrix.

Finally, the output obtained is land-suitability based on the dominant value between alternatives from the calculation results using the fuzzy-AHP ELECTRE method. This information system framework serves as the basis for developing a land evaluation information system in a web-based decision support system. The ranking results of the system will be compared with three agricultural experts and also related research. The complete IS framework is shown in Fig. 1.

### 3.2. *Fuzzy-AHP*

**Table 2**
TFNs scale of fuzzy AHP pairwise comparison

| Linguistic scale | TFNs | TFNs reciprocal | Crisp |
|---|---|---|---|
| | (*l*, *m*, *u*) | ($u^{-1}$, $m^{-1}$, $l^{-1}$) | |
| Equally importance | (1, 1, 1) | (1, 1, 1) | 1 |
| Intermediate | (1, 2, 3) | (1/3, 1/2, 1) | 2 |
| Moderate importance | (2, 3, 4) | (1/4, 1/3, 1/2) | 3 |
| Intermediate | (3, 4, 5) | (1/5, 1/4, 1/3) | 4 |
| Strong importance | (4, 5, 6) | (1/6, 1/5, 1/4) | 5 |
| Intermediate | (5, 6, 7) | (1/7, 1/6, 1/5) | 6 |
| Very strong importance | (6, 7, 8) | (1/8, 1/7, 1/6) | 7 |
| Intermediate | (7, 8, 9) | (1/9, 1/8, 1/7) | 8 |
| Extreme importance | (8, 9, 9) | (1/9, 1/9, 1/8) | 9 |

Fuzzy Analytic Hierarchy Process is a combination of the AHP method with a fuzzy logic approach. Fuzzy AHP solves the problem of AHP in determining subjective priority criteria. Uncertainty is represented by order of the non-single fuzzy scale using the function of the Triangular Fuzzy Numbers (TFNs). The TFNs function models of fuzzy logic can analyze uncertainties and ambiguities comparable to human language [21, 28]. The fuzzy triangle value scale is represented (*l*, *m*, *u*), where *l* is the smallest value possible, *m* is the most expected value, and *u* is the largest value possible. TFNs use the membership function represented in $\widetilde{M}(x)$ to describe the fuzzy subset *A* in discourse *X* in Eq. 1:

$$\mu(x|\widetilde{M}) = \begin{cases} 0, & x < l, \\ (x-l)/(m-l), & l \le x \le m, \\ (u-x)/(u-m), & m \le x \le u, \\ 0, & x > u, \end{cases} \tag{1}$$

Basic arithmetic is used in AHP fuzzy calculations, for $\widetilde{M}_1 = (l_1, m_1, u_1)$ and $\widetilde{M}_2 = (l_1, m_1, u_1)$ the TFN is operated as in Eq. 2-5:

- Fuzzy summation

  $$\widetilde{M}_1 \oplus \widetilde{M}_2 = (l_1 + l_2,\ m_1 + m_2,\ u_1 + u_2)$$
  (2)

- Fuzzy subtraction


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$$\tilde{M}_1 \ominus \tilde{M}_2 = (l_1 - l_2,\ m_1 + m_2,\ u_1 + u_2)$$
(3)

- Fuzzy multiplication

$$K \otimes \tilde{M}_1 = (k \times l_1,\ k \times m_1,\ k \times u_1), k \in R, \text{k>0}, l_1 \geq 0 \quad (4)$$

- Fuzzy division

$$K \oslash \tilde{M}_2 = (k/u_2,\ k/m_2,\ k/l_2), k \in R, \text{k>0}, l_2 \geq 0 \quad (5)$$

After knowing the basic logic of fuzzy arithmetic, the next step is evaluating the criteria that have been determined according to the FAHP stage [29]. The decision-maker determines the level of importance of the criteria based on the linguistic terms converted to the TFNs scale weights.

The conversion results in Table 2 are used as a reference to calculate the pairwise comparison between criteria by the decision-maker. After obtaining the pairwise comparison matrix between the criteria, the next stage determines the value of the fuzzy synthesis using Eq. 6.

$$S_i = \sum_{j=1}^{m} M_{g_i}^{j} \otimes \frac{1}{\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_i^j\right]} \quad (6)$$

Si is the value of fuzzy synthesis, calculated by adding up the column's cell values starting from column 1 in each row of the matrix. After calculating the fuzzy synthesis assessment, the third stage will obtain the defuzzification ordinate value ($d'$), which is used as the value of d' minimum. Based on the equation for $x$, the values of d' and $v$ can be calculated. To calculate the value of $V'$ using Eq. 7,

$$V(M_2 \geq M_1) = \begin{cases} 1, & \text{if } m_2 \geq m_1, \\ 0, & \text{if } l_1 \geq u_2, \\ \frac{l_1 - u_2}{(m_2 - u_2)(m_1 - l_1)}, & \text{other than above} \end{cases} \quad (7)$$

In determining the vector, it can be understood that if the value of m synthesis in criterion 2 is more significant than m in criterion 1, then the result is 1. After getting the value $V'$, then determine the defuzzification ordinate value ($d'$) with Eq. 8,

$$d'(VM_1) = min(VM_1 \geq VM_2, \ldots., VM_1 \geq VM_n) \quad (8)$$

$d'(VM_1)$ is the ordinate value of the criterion vector 1 to determine the ordinate criterion $n$ ($VM_n$). The fourth stage is calculating the value of the fuzzy vector weight ($W'$). Determining the weight vector using $d'(A_i) = min\, V\,(S_i \geq S_k)$ where $i$ = (1,2…$k$); $k \neq i$, $W'$ is obtained as in Eq. 9

$$W' = \left(d'(A_1), d'(A_2), \ldots \ldots, d'(A_n)\right)^T \quad (9)$$

The fifth stage is normalizing the value of the fuzzy vector weight ($W$) as in Eq. 10.

$$W = \left(d(A_1), d(A_2), \ldots \ldots, d(A_n)\right)^T \quad 10)$$

Each vector weight element is divided by the vector itself's total weight, and the number of normalized weights will be = 1. In Equation 10, $W$ is not a fuzzy number. Normalization of the value of the fuzzy vector's weight aims to be a global priority weight value in decision-making. The results of weighting the criteria using fuzzy-AHP will be used to calculate the preference matrix at the ranking stage. After obtaining normalized weight values for each new criterion, the calculations are ranked using the ELECTRE method.

### 3.3. *ELECTRE method*

ELECTRE is used in the ranking process using the concordance and discordance index to choose the dominant alternative [30]. This method measures the extent to which choices or alternatives can outperform others. An alternative can be more dominant if some facts support it. When the alternatives are equally good, the preference of all criteria that are mutually convincing and not contradictory is needed [31]. Six stages in the ELECTRE method are as follows:

**Step I**: Make a paired comparison for matrix normalization ($r$)

The ELECTRE method begins by forming a paired comparison of each alternative in each criterion ($x_{ij}$). To determine the rating value on each comparison is based on a scale of 1-4 following the land evaluation framework rules with the $S$ and $N$ order categories, which are divided into land suitability

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classes *S* (Suitable: *S1, S2, S3*) and *N* (Not Suitable). This step causes the assessment *S1= 4, S2= 3, S3= 2*, and *N= 1* as a reference is matched with the available data (objective). Normalization of the $R_{ij}$ matrix can be done with Eq. 11 and Eq. 12,

$$\boldsymbol{r_{ij}} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \quad \text{where } i = 1,2,3,4,5 \ldots m \text{ and } j = 1,2,3,4,5 \ldots n. \tag{11}$$

$$\boldsymbol{r\ matrix} = \begin{bmatrix} r_{11} & \cdots & r_{1n} \\ r_{21} & \cdots & r_{2n} \\ r_{m1} & \cdots & r_{mn} \end{bmatrix} \tag{12}$$

*r* is a normalized matrix or called a normalized decision matrix. *m* states the number of alternatives. *n* states the number of criteria, and $r_{ij}$ is the measurement of the *i*-alternative related to the *j*-criterion.

Step II: Determine the preference matrix (*v*)

After being normalized, each matrix *r* column is multiplied by *w*, which is expressed as a normalized criterion weight based on the result of fuzzy-AHP, with Eq. 13,

$$\boldsymbol{v = r.w} \tag{13}$$

So that it forms a preference matrix (*v*) with Eq. 14,

$$v = \begin{bmatrix} v_{11} & v_{12} & \cdots & v_{1n} \\ v_{21} & v_{22} & \cdots & v_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ v_{m1} & v_{m2} & \cdots & v_{mn} \end{bmatrix} \tag{14}$$

**Step III**: Decide a set index of concordance ($C_{kl}$) and discordance ($D_{kl}$)

When a criterion in an alternative includes concordance, it will be (Eq. 15)

$$C_{kl} = \{j, v_{kj} \geq v_{lj}\}, \text{ for } (j=1,2,3,4,5\ldots n) \tag{15}$$

Contrarily, the complementary of the subsets for discordance is (Eq.16)

$$D_{kl} = \{j, v_{kj} < v_{lj}\}, \text{ for } (j=1,2,3,4,5\ldots n). \tag{16}$$

**Step IV**: Compute the matrix of concordance (*C*) and discordance (*D*)

Concordance matrix element values are formed by adding the weights included in the concordance subset. Compute by Eq. 17,

$$C_{kl} = \sum_{j \in C_{kl}} W_j \tag{17}$$

So, the result of Concordance matrix is (Eq.18)

$$C = \begin{bmatrix} - & c_{12} & c_{13} & \cdots & c_{1n} \\ c_{21} & - & c_{23} & \cdots & c_{2n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ c_{m1} & c_{m2} & c_{m3} & \cdots & - \end{bmatrix} \tag{18}$$

Meanwhile, the discordance matrix is obtained by dividing the maximum difference between the discordance sub-section criteria by the maximum difference of all elements' value. It can be calculated mathematically in Eq. 19:

$$\boldsymbol{D_{kl}} = \frac{\boldsymbol{max}\,\{|v_{kj} - v_{lj}|\} j \in D_k}{\boldsymbol{max}\,\{|v_{kj} - v_{lj}|\} \forall j} \tag{19}$$

So, the result of discordance matrix is (Eq. 20)

$$\boldsymbol{D} = \begin{bmatrix} - & \cdots & d_{1n} \\ d_{21} & \cdots & d_{2n} \\ \vdots & \vdots & \vdots \\ d_{m1} & \cdots & - \end{bmatrix} \tag{20}$$

**Step V**: Calculate the threshold to form the dominant concordance (*f*) and discordance matrix (*g*)

Matrix of Concordance's dominant can be formed with the help of threshold $\underline{c}$, which compares any value of the matrix element of concordance with $\underline{c}$ value. $Ckl \geq \underline{c}$ where the threshold concordance value ($\underline{c}$) is (Eq. 21)


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$$\underline{c} = \frac{\sum_{k=1}^{n} \sum^{nl=1} c_{kl}}{m*(m-1)} \tag{21}$$

The value of each element in f matrix is determined in Eq. 22

$$f_{kl} = 1,\ jika\ c_{kl} \geq\ c\ dan\ f_{kl} = 0, jika\ c_{kl} < c \tag{22}$$

To construct the matrix of dominant discordance using the assist of the threshold value on discordance ($\underline{d}$) is by Eq. 23

$$\underline{d} = \frac{\sum_{k=1}^{n} \sum^{nl=1} d_{kl}}{m*(m-1)} \tag{23}$$

The value of each element for the $g$ matrix is determined dy Eq. 24

$$g_{kl} = 0,\ jika\ c_{kl} \geq\ d\ dan\ g_{kl} = 1, jika\ c_{kl} < d \tag{24}$$

**Step VI**: Form the dominant aggregation matrix ($e$)

The final step is to determine the matrix $e$ (aggregate dominance matrix). Any element in matrix $e$ is a multiplication of the matrix element $f$ with the matrix element $g$, with Eq. 25,

$$E_{kl} = f_{kl}\ x\ g_{kl} \tag{25}$$

The equation produces matrix $e$, which serve the ordered choice of the largest to small values. If $e_{kl} = 1$, the alternative $A_k$ is a better choice than $A_r$. So, the row in matrix $e$, that has the number of $e_{kl} = 0$ can be eliminated first. The superior alternative is an alternative that can dominate other alternatives.

### 3.4. *Distribute the questionnaire*

This study used attribute data that has been adapted to standards and provisions regarding land suitability criteria to analyze the data. The research data criteria were determined based on the technical guidelines for the land suitability assessment for strategic agricultural commodities [7] and the stages of conversion to organic agriculture [2]. The literature study results obtained 9 (nine) criteria for land suitability of organic rice cultivation. The criteria for organic rice cultivation are shown in Table 3.

**Table 3**

Criteria of land-use suitability for organic rice cultivation [2, 7, 22]

| **TR: Temperature** (°C) | | **RF: Rainfall** (mm/month) | | **DN: Drainage** | | **Ordo** |
|---|---|---|---|---|---|---|
| Class | Value | Class | Value | Class | Value | S/N |
| 25-28 | 4 | 6-8 | 4 | inhibited, rather inhibited | 4 | S1 |
| >28-30 | 3 | 4-<6 | 3 | rather good | 3 | S2 |
| >30-33 | 2 | 2-<4 or >8-10 | 2 | very inhibited, good, rather quick | 2 | S3 |
| >33 | 1 | <2 or >10 | 1 | quick | 1 | N |
| **SD: Soil depth** (cm) | | **PH: pH average** | | **CO: C-organic** (%) | | |
| Class | Value | Class | Value | Class | Value | S/N |
| >50 | 4 | 5,5-7,0 | 4 | >1,5 | 4 | S1 |
| 40-50 | 3 | 4,5-5,5 or 7,0-8,0 | 3 | 0,8-1,5 | 3 | S2 |
| 25-40 | 2 | <4,5 or >0,8 | 2 | <0,8 | 2 | S3 |
| <25 | 1 | - | 1 | - | 1 | N |
| **SL: Slope** (%) | | **EL: Erosion level** | | **TP: Transition period** | | |
| Class | Value | Class | Value | Class | Value | S/N |
| <3 | 4 | - | 4 | >5 | 4 | S1 |
| 3-5 | 3 | very mild | 3 | 4-5 | 3 | S2 |
| 5-8 | 2 | mild | 2 | 3 | 2 | S3 |
| >8 | 1 | moderate-danger | 1 | - | 1 | N |

The nine criteria were then codified into *TR, RF, DN …, TP*, as well as alternatives (land for organic rice cultivation), were codified into *L1, L2, L3…, L8*. Alternatives can be compared in pairs on each criterion by classifying them based on land suitability classes, namely *S* (suitable) and *N* (not

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suitable) [32, 33]. When an alternative has a criterion value in class *N*, it has a low match value. Conversely, when it has a criterion value in class *S*, it has a high match value. The suitability class is then converted to a positive value with a scale of 1-4, namely *S1* = 4, *S2* = 3, *S1* = 2, and *N* = 1. The interval scale determination is based on references from research [22] to facilitate the calculation. For example, when *L1* has *TP* criteria with 28°C data, the decision-maker will give the value $x = 4$.

Decision-makers can make assessments by making pairwise comparisons between alternatives and criteria that produce an $x$. As a reference in appraisal $x$, the criteria data such as temperature (TR), rainfall (RF), soil depth (SD), pH average (PH), slope (SL) were obtained from government agencies. Meanwhile, drainage (DN), erosion level (EL), and transition period data were obtained from interviews with 3 (three) agricultural experts; GATOS, LeSOS, and BPPK Sawangan. Furthermore, c-organic (CO) criteria data were obtained from laboratory tests at BPTP Central Java. The results of the $x$ assessment were shown in Table 4.

**Table 4**
Pairwise comparison with decision matrix ($x$)

| Code | TR | RF | DN | SD | PH | CO | SL | EL | TP |
|---|---|---|---|---|---|---|---|---|---|
| L1 | 4 | 3 | 2 | 2 | 4 | 4 | 4 | 3 | 2 |
| L2 | 4 | 3 | 2 | 2 | 4 | 3 | 4 | 3 | 3 |
| L3 | 4 | 3 | 2 | 3 | 4 | 4 | 4 | 2 | 2 |
| L4 | 4 | 3 | 2 | 2 | 4 | 4 | 4 | 2 | 3 |
| L5 | 4 | 3 | 3 | 2 | 4 | 4 | 4 | 2 | 2 |
| L6 | 4 | 3 | 3 | 2 | 4 | 4 | 3 | 2 | 3 |
| L7 | 4 | 3 | 2 | 3 | 4 | 3 | 3 | 3 | 2 |
| L8 | 4 | 3 | 3 | 3 | 4 | 3 | 3 | 2 | 2 |

## 4. Results and Discussion

This section will explain the results of the formulation of methods for ELR measurement, the results of ELR measurement trials at tertiary institutions and analyze the results of these trials.

### 4.1. *Determination of the criteria weights using fuzzy-AHP*

The first step of the fuzzy-AHP method is to determine each criterion's importance using a pairwise comparison matrix, the pairwise comparison matrix created by executives or stakeholders. The way to read the matrix is to determine the criteria row's importance with the criteria column. If the criteria row is more important than the column criteria, then it has a TFNs value. If the criteria row is less critical than the criteria column, then the reciprocal value is given as in Table 2. The determination of the intensity of interest is very influential in the weight output of the resulting criteria. The results are in Table 5.

**Table 5**
Pairwise comparison matrix of criteria with TFNs scale

| Code | TR | RF | DN | SD | PH | CO | SL | EL | TP |
|---|---|---|---|---|---|---|---|---|---|
| **TR** | (1,1,1) | (1,1,1) | (1/3,1/2,1) | (1,1,1) | (1/3,1/2,1) | (1/4,1/3,1/2) | (1,1,1) | (1/3,1/2,1) | (1/4,1/3,1/2) |
| **RF** | (1,1,1) | (1,1,1) | (1/3,1/2,1) | (1,1,1) | (1/3,1/2,1) | (1/4,1/3,1/2) | (1,1,1) | (1/3,1/2,1) | (1/4,1/3,1/2) |
| **DN** | (1,2,3) | (1,2,3) | (1,1,1) | (1,2,3) | (1,1,1) | (1/3,1/2,1) | (1,2,3) | (1,1,1) | (1/3,1/2,1) |
| **SD** | (1,1,1) | (1,1,1) | (1/3,1/2,1) | (1,1,1) | (1/3,1/2,1) | (1/4,1/3,1/2) | (1,1,1) | (1/3,1/2,1) | (1/4,1/3,1/2) |
| **PH** | (1,2,3) | (1,2,3) | (1,1,1) | (1,2,3) | (1,1,1) | (1/3,1/2,1) | (1,2,3) | (1,1,1) | (1/3,1/2,1) |
| **CO** | (2,3,4) | (2,3,4) | (1,2,3) | (2,3,4) | (1,2,3) | (1,1,1) | (2,3,4) | (1,2,3) | (1,1,1) |
| **SL** | (1,1,1) | (1,1,1) | (1/3,1/2,1) | (1,1,1) | (1/3,1/2,1) | (1/4,1/3,1/2) | (1,1,1) | (1/3,1/2,1) | (1/4,1/3,1/2) |
| **EL** | (1,2,3) | (1,2,3) | (1,1,1) | (1,2,3) | (1,1,1) | (1/3,1/2,1) | (1,2,3) | (1,1,1) | (1/3,1/2,1) |
| **TP** | (2,3,4) | (2,3,4) | (1,2,3) | (2,3,4) | (1,2,3) | (1,1,1) | (2,3,4) | (1,2,3) | (1,1,1) |

Based on Table 5, several fuzzy weight values are obtained, namely, the triplet numbers ($l$, $m$, $u$), which are lower ($l$), medium ($m$), and upper ($u$). The next step is to calculate the fuzzy vector's normalized weight of the fuzzy vector with several calculation steps from equations (6)-(10). It can be analyzed that the results of each criterion weight if added together, will produce a value of 1. The results can be seen in Table 6 below.

Based on the evaluation of the decision-maker on the criteria comparison matrix and the results of the normalized fuzzy criteria weighting. It is known that the criteria that have the highest level of

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preference are c-organic and the transition period, with the result $w$ = 0.23. For criteria with moderate preference, there are drainage, pH, and erosion levels with the result $w$ = 0.15. Meanwhile, the criteria with low preference are temperature, rainfall, soil depth, and slope, with the result $w$ = 0.03. These results indicate that the organic rice cultivation criteria must pay attention to land fertility by improving the level of c-organic in soil and land management according to the transition period from non-organic to organic farming systems.

**Table 6**

The normalized criteria weight

| Code | Criteria | Weight | Weight |
|---|---|---|---|
| | | *W* | *W* |
| *TR* | Temperature | 0.025897591 | 0.03 |
| *RF* | Rainfall | 0.025897591 | 0.03 |
| *DN* | Drainage | 0.146902343 | 0.15 |
| *SD* | Soil depth | 0.025897591 | 0.03 |
| *PH* | pH average | 0.146902343 | 0.15 |
| *CO* | C-organic | 0.227851304 | 0.23 |
| *SL* | Slope | 0.025897591 | 0.03 |
| *EL* | Erosion level | 0.146902343 | 0.15 |
| *TP* | Transition Period | 0.227851304 | 0.23 |
| | Sum | 1 | 1 |

### 4.2. *Conduct ranking the land alternative with ELECTRE method*

Calculations using the ELECTRE method are applied to rank the most suitable land from several alternative lands for organic rice cultivation. Based on the $x$ value that has been determined by the decision-maker in Table 5, the first step is to calculate the $r$ with Eq. 11. The normalized pairwise comparison results are presented in Table 7.

**Table 7**

Pairwise comparison on a normalized matrix ($r$)

| Code | TR | RF | DN | SD | PH | CO | SL | EL | TP |
|---|---|---|---|---|---|---|---|---|---|
| *L1* | 0.35 | 0.35 | 0.29 | 0.29 | 0.35 | 0.39 | 0.39 | 0.44 | 0.29 |
| *L2* | 0.35 | 0.35 | 0.29 | 0.29 | 0.35 | 0.29 | 0.39 | 0.44 | 0.44 |
| *L3* | 0.35 | 0.35 | 0.29 | 0.44 | 0.35 | 0.39 | 0.39 | 0.29 | 0.29 |
| *L4* | 0.35 | 0.35 | 0.29 | 0.29 | 0.35 | 0.39 | 0.39 | 0.29 | 0.44 |
| *L5* | 0.35 | 0.35 | 0.44 | 0.29 | 0.35 | 0.39 | 0.39 | 0.29 | 0.29 |
| *L6* | 0.35 | 0.35 | 0.44 | 0.29 | 0.35 | 0.39 | 0.29 | 0.29 | 0.44 |
| *L7* | 0.35 | 0.35 | 0.29 | 0.44 | 0.35 | 0.29 | 0.29 | 0.44 | 0.29 |
| *L8* | 0.35 | 0.35 | 0.44 | 0.44 | 0.35 | 0.29 | 0.29 | 0.29 | 0.29 |

After obtaining the $r$ value in Table 7, perform the calculation on the preference decision matrix ($v$) by multiplying $w$ by $r$. Here, w is the normalized fuzzy weight calculated using fuzzy-AHP, according to Table 6. The results of the preference decision matrix are as in Table 8.

**Table 8**

Pairwise comparison matrix preference (v)

| Code | TR | RF | DN | SD | PH | CO | SL | EL | TP |
|---|---|---|---|---|---|---|---|---|---|
| *L1* | 0.01 | 0.01 | 0.04 | 0.01 | 0.05 | 0.09 | 0.01 | 0.07 | 0.07 |
| *L2* | 0.01 | 0.01 | 0.04 | 0.01 | 0.05 | 0.07 | 0.01 | 0.07 | 0.1 |
| *L3* | 0.01 | 0.01 | 0.04 | 0.01 | 0.05 | 0.09 | 0.01 | 0.04 | 0.07 |
| *L4* | 0.01 | 0.01 | 0.04 | 0.01 | 0.05 | 0.09 | 0.01 | 0.04 | 0.1 |
| *L5* | 0.01 | 0.01 | 0.07 | 0.01 | 0.05 | 0.09 | 0.01 | 0.04 | 0.07 |
| *L6* | 0.01 | 0.01 | 0.07 | 0.01 | 0.05 | 0.09 | 0.01 | 0.04 | 0.1 |
| *L7* | 0.01 | 0.01 | 0.04 | 0.01 | 0.05 | 0.07 | 0.01 | 0.07 | 0.07 |
| *L8* | 0.01 | 0.01 | 0.07 | 0.01 | 0.05 | 0.07 | 0.01 | 0.04 | 0.07 |

After obtaining the $v$ value, the next step is to determine the concordance and discordance index set. $C_{kl}$ values are calculated by Eq. 15, with results in Table 9. Whereas, the set index of discordance ($D_{kl}$) is calculated by Eq.16 with the results in Table 10. After $C_{kl}$ is obtained, the next step is forming the

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concordance matrix by append the weights included in the concordance subset. The matrix is according to Eq. 18, which results in Table 11.

**Table 9**

The index of concordance ($C_{kl}$)

| Code | *L1* | *L2* | *L3* | *L4* | *L5* | *L6* | *L7* | *L8* |
|---|---|---|---|---|---|---|---|---|
| *L1* | - | 1-8 | 1-3,5-9 | 1-8 | 1,2,4-8 | 1-2,4-8 | 1-3,5-9 | 1,2,5-9 |
| *L2* | 1-5,7-9 | - | 1-3,5,7-9 | 1-5,7-9 | 1,2,4-5,7-9 | 1,2,4,5,7-9 | 1-3,5-9 | 1,2,5-9 |
| *L3* | 1-7,9 | 1-7 | - | 1-8 | 1,2,4-9 | 1,2,4-9 | 1-3,5-7,9 | 1,2,4-9 |
| *L4* | 1-7,9 | 1-7,9 | 1-3,5-9 | - | 1,2,4-9 | 1,2,4-9 | 1-3,5-7,9 | 1,2,5-9 |
| *L5* | 1-7,9 | 1-7 | 1-3,5-9 | 1-8 | - | 1-8 | 1-3,5-7,9 | 1-3,5-9 |
| *L6* | 1-6,9 | 1-6,9 | 1-3,5,6,8,9 | 1-6,8,9 | 1-6,8,9 | - | 1-3,5-7,9 | 1-3,5-9 |
| *L7* | 1-5,8,9 | 1-6,8 | 1-5,8,9 | 1-5,8 | 1,2,4,5,8,9 | 1,2,4,5,7,8 | - | 1,2,4-9 |
| *L8* | 1-5,9 | 1-6 | 1-5,8,9 | 1-5,8 | 1-5,8,9 | 1-5,7,8 | 1-7,9 | - |

**Table 10**

The index of discordance ($D_{kl}$)

| Code | *L1* | *L2* | *L3* | *L4* | *L5* | *L6* | *L7* | *L8* |
|---|---|---|---|---|---|---|---|---|
| *L1* | - | 9 | 4 | 9 | 3 | 3,9 | 4 | 3,4 |
| *L2* | 6 | - | 4,6 | 6 | 3,6 | 3,6 | 4 | 3,4 |
| *L3* | 8 | 8,9 | - | 9 | 3 | 3,9 | 8 | 3 |
| *L4* | 8 | 8 | 4 | - | 3 | 3 | 4,8 | 3,4 |
| *L5* | 8 | 8,9 | 4 | 9 | - | 9 | 4,8 | 4 |
| *L6* | 7,8 | 7,8 | 4,7 | 7 | 7 | - | 4,8 | 4 |
| *L7* | 6,7 | 7,9 | 6,7 | 6,7,9 | 3,6,7 | 3,6,9 | - | 3 |
| *L8* | 6,7,8 | 7,8,9 | 6,7 | 6,7,9 | 6,7 | 6,9 | 8 | - |

**Table 11**

Concordance matrix (*C*)

| Code | *L1* | *L2* | *L3* | *L4* | *L5* | *L6* | *L7* | *L8* |
|---|---|---|---|---|---|---|---|---|
| *L1* | - | 0.8 | 1 | 0.8 | 0.88 | 0.65 | 1 | 0.85 |
| *L2* | 0.8 | - | 0.77 | 0.8 | 0.65 | 0.65 | 1 | 0.85 |
| *L3* | 0.88 | 0.65 | - | 0.8 | 0.88 | 0.65 | 0.88 | 0.88 |
| *L4* | 0.88 | 0.88 | 1 | - | 0.88 | 0.88 | 0.85 | 0.85 |
| *L5* | 0.88 | 0.65 | 1 | 0.8 | - | 0.8 | 0.85 | 1 |
| *L6* | 0.85 | 0.85 | 0.97 | 1 | 1 | - | 0.85 | 1 |
| *L7* | 0.77 | 0.77 | 0.77 | 0.54 | 0.62 | 0.42 | - | 0.88 |
| *L8* | 0.62 | 0.62 | 0.77 | 0.54 | 0.77 | 0.57 | 0.88 | - |

After $D_{kl}$ is obtained, the next step is to form a discordance matrix by calculating the maximum difference between discordance subsection criteria divided by the maximum value difference of all discordance elements. The results of calculate using Eq. 20 in Table 12.

**Table 12**

Discordance matrix (*D*)

| Code | *L1* | *L2* | *L3* | *L4* | *L5* | *L6* | *L7* | *L8* |
|---|---|---|---|---|---|---|---|---|
| *L1* | - | 1 | 0.2 | 1 | 1 | 1 | 0.2 | 0.98 |
| *L2* | 0.66 | - | 0.66 | 1 | 0.66 | 1 | 0.13 | 0.65 |
| *L3* | 1 | 1 | - | 1 | 1 | 1 | 0.98 | 0.98 |
| *L4* | 0.65 | 0.98 | 0.13 | - | 0.65 | 1 | 0.65 | 0.65 |
| *L5* | 1 | 1 | 0.2 | 1 | - | 1 | 0.98 | 0.2 |
| *L6* | 0.65 | 0.98 | 0.13 | 0.13 | 0.09 | - | 0.65 | 0.13 |
| *L7* | 1 | 1 | 1 | 1 | 1 | 1 | - | 1 |
| *L8* | 1 | 1 | 1 | 1 | 1 | 1 | 1 | - |

After obtaining the Discordance matrix's value, the threshold concordance ($\underline{c}$) = 0.81 is generated. Based on $F_{kl}$ Eq. 22, a concordance (*c*) dominant matrix is formed with Table 13.

Conversely, after obtaining the threshold discordance value ($\underline{d}$) = 0.79, based on $G_{kl}$ Eq. 24, a dominant discordance (*d*) matrix can be formed. The results are shown in Table 14. The next step is determining the aggregate of the dominant matrix by multiplying $F_{kl}$ with $G_{kl}$. The results are in Table 15.

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**Table 13**
Dominant concordance matrix (*f*)

| Code | *L1* | *L2* | *L3* | *L4* | *L5* | *L6* | *L7* | *L8* |
|---|---|---|---|---|---|---|---|---|
| *L1* | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 |
| *L2* | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *L3* | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1 |
| *L4* | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| *L5* | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 |
| *L6* | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 |
| *L7* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *L8* | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |

**Table 14**
Dominant discordance matrix (*g*)

| Code | *L1* | *L2* | *L3* | *L4* | *L5* | *L6* | *L7* | *L8* |
|---|---|---|---|---|---|---|---|---|
| *L1* | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1 |
| *L2* | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| *L3* | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 |
| *L4* | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| *L5* | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 |
| *L6* | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *L7* | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| *L8* | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |

**Table 15**
The dominant matrix aggregate (*e*)

| Code | *L1* | *L2* | *L3* | *L4* | *L5* | *L6* | *L7* | *L8* | *e* |
|---|---|---|---|---|---|---|---|---|---|
| *L1* | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 2 |
| *L2* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *L3* | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 4 |
| *L4* | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 2 |
| *L5* | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 |
| *L6* | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *L7* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *L8* | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |


**Fig. 2.** A Bar chart of alternatives ranking result

Based on Table 15, the results show that all alternatives have an $E_{kl}$ value ≥ 1, except *L2*. After being compared, the largest value is in *L3*: Alternative "Tirtosari" with an $E_{kl}$ value = 4. The land

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suitability level can be sorted on each alternative based on the ranking of the evaluation results, namely Tirtosari, Sawangan, Podosoko, Butuh, Krogowanan, Kapuhan, Jati, and Mangunsari. The ranking of systems results in the form of a bar chart graph is shown in Fig. 2.

Based on the results obtained, 8 alternatives are classified based on the land suitability class for organic rice cultivation. *S1* Class (very suitable) is for $Ekl > 3$, *S2* class (moderately suitable) includes $Ekl$ >1 and <3, and *S3* class (marginally suitable) with $Ekl \leq 1$. The results show that 12.5% is very suitable ("*L3*"), 37.5% is quite suitable ("*L1*", "*L4*", "*L5*"), and 50% is marginally appropriate ("*L6*", "*L7*", "*L8*","*L2*"). Each criterion data for each alternative influence these results. For example, in this study, the difference in ***c***-organic laboratory test data between Tirtosari (*L3*) and Mangunsari (*L2*) alternative lands. *L3* with c-organic 2.20%, while *L2* with c-organic 1.44% of course, this striking difference considers that the criteria with the most priority weight will determine a land's ranking results. Likewise, pH and drainage criteria have similarities with research [22] regarding land evaluation effects on rice cultivation.

Valid land suitability ranking results were obtained based on the research objectives and the information system development output. Then the system ranking validity test was carried out by analyzing land fertility data from the Department of Agriculture. Data collected from BPPK Sawangan in a 2019 monograph contains a summary of each alternative land-based fertility on 5 (five) criteria. These criteria are derived from land characteristics, namely elevation, slope, soil depth, average pH, and drainage. Then, the actual ranking results are compared with the system results. The ranking comparison results are then used as a material to test the system's accuracy and ranking correlation. The accuracy is calculated by dividing the data according to (true) with the number of land data, then multiplied by 100%. Based on 8 land data, there are 6 consistent (valid) and 2 inconsistent (invalid) data. From the test results calculated based on the accuracy calculation, the system accuracy results are 75%. To test the level of ranking correlation using the rank spearman [34]. From the difference in rank $d = 2$ from the amount of data $n = 8$ results in $rs = 0.95$. The two tests' results show that the system's accuracy is running well, and the spearman rank test shows that the correlation between the research rankings and the actual data results in a near-perfect relationship.

Final of the discussion, the research results obtained will be compared with related research. One similar study using the ELECTRE method for land suitability is research by Rahayu et al. [9]. The study used 28 data and 12 criteria for sorting food plants. The results of the system accuracy of this study were 85,71% of the 26 correct and 2 incorrect data. Meanwhile, in this study, the accuracy of 75% of 6 data is correct, and 2 data is incorrect. A striking difference is in the number of alternative data and criteria used and the more general research objectives on food crops. Meanwhile, this research is more specific and focuses on land suitability data for organic rice cultivation. So from this comparison, it can be concluded that this study has a novelty side in land suitability evaluation for the organic rice agricultural sector using the fuzzy-AHP ELECTRE method with a web-based decision support system.

## 5. Conclusion

Decision Support Systems using the fuzzy-AHP ELECTRE method has been applied to evaluate and-use suitability for organic rice cultivation. Nine criteria were used, namely, temperature, rainfall, drainage, soil depth, pH, c-organic, slope, erosion level, and transition period. The integration of the ELECTRE method for ranking and fuzzy-AHP for criteria weighting has been successfully applied in developing web-based information systems with perfect results.

The ranking succeeded in eliminating several alternatives to get the best. The alternative on L2 was removed first because it had the lowest value: $E_{kl} = 0$. Another alternative was compared to find the best alternative. The same value was obtained for alternatives *L6*, *L7*, *L8* with 1 point. *L1*, *L4*, *L5* obtained $E_{kl}$=2, while the greatest value was at *L3* with $E_{kl} = 4$. The ranking order from the highest to the lowest was the organic land in Tirtosari, Sawangan, Podosoko, Butuh, Krogowanan, Kapuhan, Jati, and Mangunsari. While the land suitability criteria that most determine the ranking results were CO (c-organic) and TP (transition period to organic) with a fuzzy criterion weight of 0.23.

Suggestions for further research development is adding some land suitability criteria based on relevant land assessment guidelines for organic rice cultivation. Lack of data on organic farming than conventional farming due to the lack of inventory data can be bridged by system integration in several


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strategic locations for cultivation. Future systems can be developed decision support systems in zone species and geographic mapping.

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