Decision Making of Banana Varieties Based on Land in Samarinda Using ELECTRE Method

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Abstract—**Indonesia is an agrarian country, a country with fertile soil and rich in nutrients so that a lot of land that can be used as agricultural land for a variety of plants one of which is a banana plant. Banana is a plant that has a good adaptability to the condition of water shortage, so that many planted bananas in dry land in East Kalimantan. Despite having good adaptability but some varieties of bananas cannot grow on certain lands. Utilization of Decision Support Systems (DSS) as one of the computerized intelligent systems can be used to help make decisions quickly, accurately and consistently. The system was developed by applying the ELECTRE method where the criteria used were soil type, rainfall, soil fertility level, and soil pH. Alternative bananas used there were 10 types of *Ambon* Banana, *Kepok* Banana, Mas Banana, *Nangka* Banana, Lampung Banana, *Raja* Banana, *Tanduk* Banana, *Awak* Banana, *Merah* Banana, and *Barangan* Banana. The system successfully selected banana varieties to the land in Samarinda, where the best variety of selected varieties was *Raja* Banana.**

Keywords—bananas; DSS; ELECTRE; land; criteria

I. INTRODUCTION

Land is an area on the surface of the earth, covering all components of the biosphere that could be considered permanent or cyclical located above and below the region, including the atmosphere, soil, parent rock, relief, hydrology, plants and animals, as well as all activity of past and present human activity. All of which affect the use of land by humans today and in the future. Land have many kinds of lands including plantation land, mining land, and agricultural land [1, 2]. The use of the land itself must be in accordance with the results to be obtained from the land use and the suitability of the land. Indonesia is a country with many clusters of islands surrounded by vast waters, of course, land use needs to be through the analysis of conformity in advance so that its use can be more optimum.

Indonesia is an agrarian country, a country with fertile soil and rich in nutrients so many land that can be used as agricultural land. Indonesia has many types of land that has earned an honor as a host and earth and soil research site in 1982 along with FAO [3]. Agricultural land in Indonesia is very diverse with the characteristics of the soil of each region scattered throughout the archipelago in Indonesia, so the variety of its use, especially for the activities of food crops also has a variety of variations. Many food crops that can grow in Indonesia in accordance with the land or land that is the rooting medium [4], one of which is a banana plant. In Indonesia Banana Plants are an important horticultural commodity that has a variety or type, there are many types of bananas in Indonesia, such as plantains, *ambon* banana, *kepok* banana, and others.

Banana is a plant that has a good adaptability to the condition of water shortage, so that many bananas planted farmers in dry land in East Kalimantan. Despite having good adaptability but some varieties of bananas cannot grow on certain lands [5]. Selection of banana varieties in accordance with the criteria of land can be assisted with decision support systems. Decision support systems can provide the best recommendations based on data from criteria and alternatives [6, 7]. Decision support systems have several methods i.e., AHP [8], TOPSIS [9], K-Means [10] then one of which is the method of ELECTRE, which can provide recommendations as a consideration for decision-making appropriately.

II. METHODOLOGY

Decision support system of selection of banana varieties on land in Samarinda using this method of ELECTRE can be used by modern farmers or researchers who want to find alternative bananas in accordance with the criteria of land. The system of selection of banana varieties to the land using the ELECTRE method has eight stages of the process to get the recommendation of banana varieties, Fig. 1.

III. RESULT AND DISCUSSION

The testing phase of the application of ELECTRE is required to evaluate alternative results provided by the system with manually done results in order to minimize errors in the system. For example user enter the weight as in Table I.

TABLE I.   WEIGHT (W)

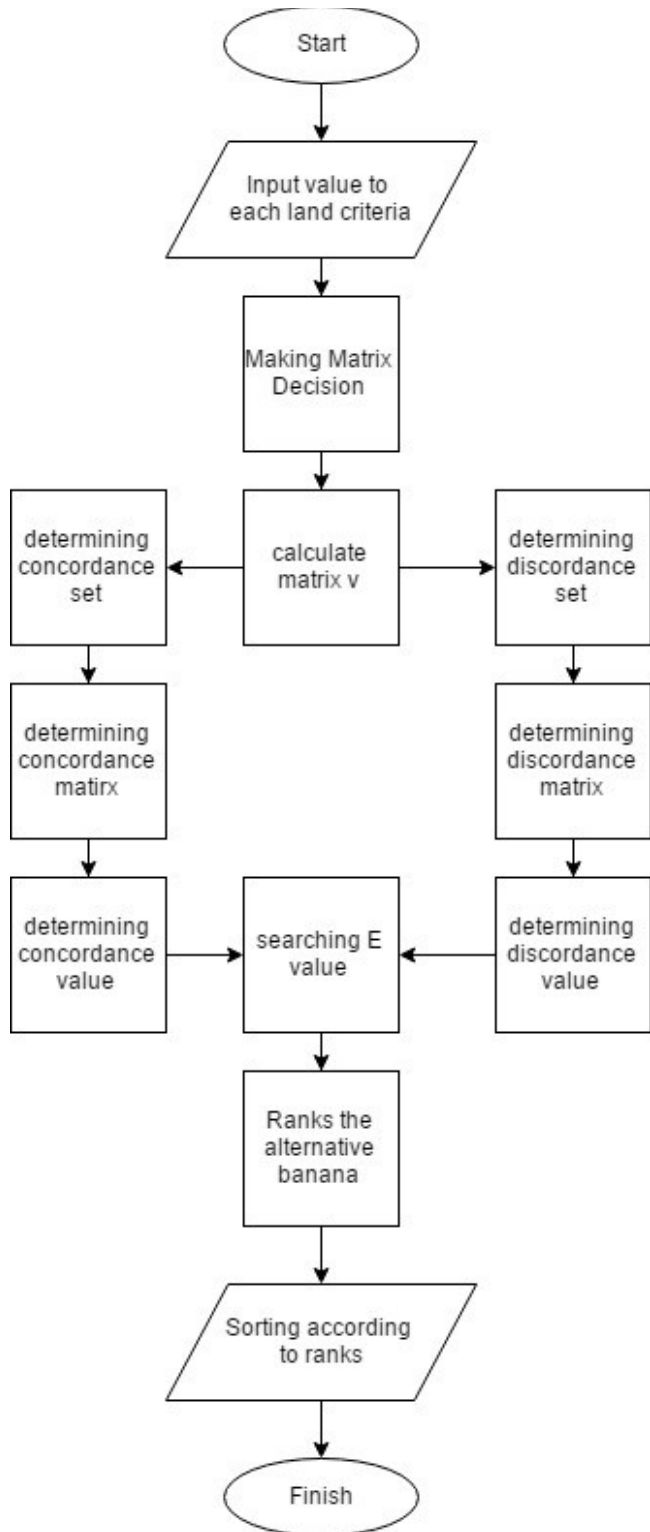| Weights	Criteria Values
Soil Type (W1)	Peat (1)
Rainfall (W2)	Enough (4)
Fertility Level (W3)	Medium (3)
Soil pH (W4)	Neutral (2)

Fig. 1. Stages of Selection of Banana Varieties

TABLE II.   RESULT OF NORMALIZATION OF DECISION MATRIX

No	Alternative	Criteria			
		Soil Type	Rainfall	Fertility Level	Soil pH
1	Ambon Banana	0.472	0.286	0.286	0.248
2	Kepok Banana	0.472	0.381	0.381	0.372
3	Mas Banana	0.189	0.381	0.381	0.372
4	Lampung Banana	0.189	0.286	0.286	0.372
5	Nangka Banana	0.094	0.191	0.191	0.372
6	Raja Banana	0.378	0.286	0.286	0.248
7	Awak Banana	0.189	0.286	0.191	0.248
8	Tanduk Banana	0.189	0.191	0.286	0.248
9	Merah Banana	0.189	0.286	0.477	0.248
10	Barangan Banana	0.472	0.477	0.286	0.372

TABLE III.   WEIGHTING ON A NORMALIZED MATRIX

No	Alternative	Criteria			
		Soil Type	Rainfall	Fertility Level	Soil pH
1	Ambon Banana	0.472	1.144	0.858	0.496
2	Kepok Banana	0.472	1.526	1.144	0.744
3	Mas Banana	0.189	1.526	1.144	0.744
4	Lampung Banana	0.189	1.144	0.858	0.744
5	Nangka Banana	0.094	0.763	0.572	0.744
6	Raja Banana	0.378	1.144	0.858	0.496
7	Awak Banana	0.189	1.144	0.572	0.496
8	Tanduk Banana	0.189	0.763	0.858	0.496
9	Merah Banana	0.189	1.144	1.43	0.496
10	Barangan Banana	0.472	1.907	0.858	0.744

TABLE IV.   CONCORDANCE MATRIX

	1	2	3	4	5	6	7	8	9	10
1	-	1	1	8	8	10	10	10	7	4
2	10	-	10	10	10	10	10	10	7	6
3	9	9	-	10	10	9	10	10	7	5
4	9	2	3	-	10	9	10	10	7	5
5	2	2	2	2	-	2	5	6	2	2
6	9	0	1	8	8	-	10	10	7	3
7	6	0	1	5	8	6	-	7	7	0
8	5	0	1	4	8	5	6	-	3	3
9	9	3	4	8	8	9	10	10	-	3
10	10	7	7	10	10	10	10	10	7	-

So that from Table I we get the weight value W = (1, 4, 3, 2) against a land in Samarinda as a trial. The next steps to be done based on Fig. 1.

1) Normalization of Decision Matrix. General matrix decision formula:

TABLE V.   DISCORDANCE MATRIX

	1	2	3	4	5	6	7	8	9	10
1	-	1	1	0.875	0.65	0	0	0	1	1
2	0	-	0	0	0	0	0	0	0.75	1
3	0.743	1	-	0	0	0.496	0	0	0.75	1
4	1	1	1	-	0	0.762	0	0	1	1
5	1	1	1	1	-	1	1	1	1	1
6	1	1	1	1	0.65	-	0	0	1	1
7	1	1	1	1	0.65	1	-	0.75	1	1
8	1	1	1	1	0.867	1	1	-	1	1
9	0.496	1	1	0.434	0.289	0.33	0	0	-	1
10	0	0.75	0.75	0	0	0	0	0	0.75	-

TABLE VI. CONCORDANCE DOMINANT MATRIX

	1	2	3	4	5	6	7	8	9	10
1	-	0	0	1	1	1	1	1	1	0
2	1	-	1	1	1	1	1	1	1	0
3	1	1	-	1	1	1	1	1	1	0
4	1	0	0	-	1	1	1	1	1	0
5	0	0	0	0	-	0	0	0	0	0
6	1	0	0	1	1	-	1	1	1	0
7	0	0	0	0	1	0	-	1	1	0
8	0	0	0	0	1	0	0	-	0	0
9	1	0	0	1	1	1	1	1	-	0
10	1	1	1	1	1	1	1	1	1	-

TABLE VII. DISORDANCE DOMINANT MATRIX

	1	2	3	4	5	6	7	8	9	10
1	-	1	1	1	1	0	0	0	1	1
2	0	-	0	0	0	0	0	0	1	1
3	1	1	-	0	0	0	0	0	1	1
4	1	1	1	-	0	1	0	0	1	1
5	1	1	1	1	-	1	1	1	1	1
6	1	1	1	1	1	-	0	0	1	1
7	1	1	1	1	1	1	-	1	1	1
8	1	1	1	1	1	1	1	-	1	1
9	0	1	1	0	0	0	0	0	-	1
10	0	1	1	0	0	0	0	0	1	-

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \quad for \ i = 1,2,3,\dots,m \ and \ j = 1,2,3,\dots,n. \quad (1)$$

The result of calculation based on Eq. 1 can be seen in Table II.

2) Weighting on a normalized matrix. The result of multiplying the preference of each criterion with a normalized decision matrix can be seen in Table III.

3) Determining the Set of Concordance and Discordance Index.

a) Concordance. A criteria in an alternative includes concordance if:

$$C_{kl} = \{j, v_{kj} \geq v_{lj}\}, for \ j = 1,2,3,\dots,n.$$
$$C_{12} = \{j, v_{1j} \geq v_{2j}\}, for \ j = 1,2,3,\dots1 = \{1,2,3,4\}$$
$$C_{13} = \{j, v_{1j} \geq v_{3j}\}, for \ j = 1,2,3 = \{2,3,4\}$$

And so on up to

$$C_{110} = \{j, v_{15j} \geq v_{14j}\}, for \ j = 1,2,3,\dots10$$
$$= \{1,2,3,4\}$$

b) Discordance. A criteria in an alternative includes discordance if:

$$D_{kl} = \{j, v_{kj} < v_{lj}\}, for \ j = 1,2,3,\dots,n.$$
$$D_{12} = \{j, v_{1j} < v_{2j}\}, for \ j = 1,2,3,\dots10 = \{0\}$$
$$D_{13} = \{j, v_{1j} < v_{3j}\}, for \ j = 1,2,3,\dots10 = \{1\}$$

And so on up to

$$D_{110} = \{j, v_{15j} < v_{14j}\}, for \ j = 1,2,3 = \{0\}$$

4) Calculating Concordance and Disorder Matrices.

a) Calculate concordance matrix. So from Eq. 2 the obtained sconcordance matrix which can be seen in Table IV.

$$C_{kl} = \sum_{j \in C_{kl}} w_j \quad (2)$$

b) Calculate discordance matrix. For j where $max\{|v_{kj} - v_{lj}|\}_{\forall j} = 0$, then the value d_{kl} is considered equal to 0. So from Eq. 3 the obtained disordance matrix as in Table V.

$$d_{kl} = \frac{max\{|v_{kj} - v_{lj}|\}_{j \in D_{kl}}}{max\{|v_{kj} - v_{lj}|\}_{\forall j}} \quad (3)$$

5) Determine the dominant matrix of concordance and discordance.

a) Calculates the dominant matrix of concordance. The threshold value ($\underline{c}$) is Eq. 4.

$$\underline{c} = \frac{\sum_{k=1}^{m} \sum_{l=1}^{m} c_{kl}}{m(m-1)} \quad (4)$$

$$= \frac{\sum_{k=1}^{10} \sum_{l=1}^{10} c_{kl}}{10(10-1)} = 6.522$$

The matrix element f_{kl} is determined by Eq. 5. So the concordance dominant matrix can be seen in Table VI.

$$f_{kl} = \begin{cases} 1, jika \ c_{kl} \geq \underline{c} \\ 0, jika \ c_{kl} < \underline{c} \end{cases} \quad (5)$$

b) Calculates the dominant matrix of discordance. The threshold value ($\underline{d}$) is Eq. 6.

$$\underline{d} = \frac{\sum_{k=1}^{m} \sum_{l=1}^{m} d_{kl}}{m(m-1)} \quad (6)$$

$$= \frac{\sum_{k=1}^{10} \sum_{l=1}^{10} d_{kl}}{10(10-1)} = 0{,}63$$

The matrix element g_{kl} is determined by Eq. 7. So the dominant matrix of discordance can be seen in Table VII.

$$g_{kl} = \begin{cases} 1, jika \ d_{kl} \geq \underline{d} \\ 0, jika \ d_{kl} < \underline{d} \end{cases} \quad (7)$$

6) Determine the dominant matrix of aggregate. The general formula for calculating the dominant matrix of aggregates using Eq. 8. So the result of dominant aggregate matrix can be seen in Table VIII.

$$e_{kl} = f_{kl} \ x \ g_{kl} \quad (8)$$

7) Alternative elimination. Matrix E gives the order of choice of each alternative, the best alternative is Raja Banana with a value of 4. This result is the same as the result shown by the application system that has been created. Thus based on the results of manual and program calculations, it can be

concluded that theoretically the best alternative bananas that can be planted on trial land in the Samarinda is a plantain. The best alternative selection result made by the system can be seen in Fig. 2.

TABLE VIII.   AGGREGATE DOMINANT MATRIX

	1	2	3	4	5	6	7	8	9	10
1	-	0	0	1	1	0	0	0	1	0
2	0	-	0	0	0	0	0	0	1	0
3	1	1	-	0	0	0	0	0	1	0
4	1	0	0	-	0	1	0	0	1	0
5	0	0	0	0	-	0	0	0	0	0
6	1	0	0	1	1	-	0	0	1	0
7	0	0	0	0	1	0	-	1	1	0
8	0	0	0	0	1	0	0	-	0	0
9	0	0	0	0	0	0	0	0	-	0
10	0	1	1	0	0	0	0	0	1	-

Pengurutan Alternatif (ELECTRE)	
Nama Pisang	**Urutan Bobot**
Pisang Raja	4
Pisang Ambon	3
Pisang Mas	3
Pisang Lampung	3
Pisang Tanduk	3
Pisang Barangan	3
Pisang Kepok	1
Pisang Awak	1
Pisang Nangka	0
Pisang Merah	0

Fig. 2.   The Best Alternative Selection with the ELECTRE Method

IV.   CONCLUSIONS

The ELECTRE method has been successfully applied in the selection of decision support systems of banana varieties in Samarinda area. The criteria chosen in this research were soil type, rainfall, soil fertility, and soil pH can be processed and then produce recommendation through stages that have been specified in ELECTRE method. The best result of banana varieties of the system is Raja Banana with a value of 4, followed by Ambon Banana, Mas Banana, Lampung Banana, Tanduk Banana, and Barangan Banana with a value of 3.

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