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Implementation of PROMETHEE Method for Potential Suitability of Land Oil Palm Plant

Implementation of PROMETHEE Method for Potential Suitability of Land Oil Palm Plant

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Abstract. Palm oil has become the most widely used vegetable oil in the world. The first physical task of the planting area is the preparation of the oil palm plantation field. Oil palm plantations necessitate land suitability research to assess if the land is appropriate and profitable. Crop production more competitive when a future land potential is assessed. Farmers' lack of understanding of the nature of the field and the varieties of fruit to be planted renders determining their land's suitability difficult. This study aims to develop a decision-support system for oil palm land suitability based on multicriteria analysis using the Preference Rating Organization Method for Enrichment Assessment (PROMETHEE) method. This method works by performing calculations based on the properties of each criterion. Based on seven metrics, alternative eight was determined to be the best location, with a net flow of 0.2143, accompanied by alternatives 1 and 6. Alternative seven, with a net flow of -0.1786, was the least suggested.

1. Introduction

Palm oil is produced from the palm tree's fruit (*Elaeis guineensis*) and provides a good mixture of unsaturated and saturated fatty acids. Margarine, frying fats, and confectionery fats are all made from palm oil. The palm tree fruit is the smallest of the main oilseed crops, accounting for just 5.5 percent of all planted land for oils and fats worldwide, thus providing the most (32 percent) overall production [1]. Palm oil has become the most commonly used vegetable oil in the world due to these benefits [2]. Vegetable oils are a better alternative to animal fats when eaten as a food commodity because they produce more unsaturated fatty acids. Canola oil, also known as rapeseed oil, is one of the most frequently used cooking oils. It has made from rapeseed that's been slightly heated and crushed before being harvested [2].

This plant was first imported to Indonesia in 1911, and it has quickly developed to become one of the most valuable commodities since 1970. The total area of oil palm plantations in 1970 was just 133,298 hectares, but by 2019 it had risen to 14.60 million hectares [3]. Oil palm plantations can be found in 26 of Indonesia's provinces. With 2.82 million ha of oil palm plantations in 2019, Riau Province has the highest area of oil palm plantations, contributing to 19.31% of the overall oil palm plantations in Indonesia [4].

While corporations operate most oil palm plantations, some areas in Indonesia are still run by individuals. The issue is that most oil palm farmers lack awareness regarding selecting prospective land. Farmers' lack of knowledge of the field's characteristics and the varieties of fruit to be cultivated allows assessing the suitability of their land challenging. This research aims to establish a decision support system for oil palm land suitability based on multicriteria analysis using the Preference Rating

Organization Method for Enrichment Assessment (PROMETHEE) method. This approach operates by conducting measurements dependent on the properties of each criterion. This strategy would allow choices dependent on several standard and alternative parameters, producing the highest benefit, which would then be preferred as the best alternative in selecting oil palm ground.

2. Methodology

The variation of land characteristics leads to oil palm productivity diversity. As a consequence, knowledge of land characteristics is needed to achieve an optimal output. For the management of a particular plantation field, this knowledge is critical. Oil palm production is affected by the physical characteristics of the land. However, since oil palm land is still determined historically or by looking only at previous experience parameters rather than computerized criteria, there is a risk of making a mistake in deciding the land to be selected, resulting in losses in both time and money [5].

Figure 1. Oil palm plantation [6]

2.1 Oil palm plantation

Oil palm plants produce the relationship between the internal (genetic) factors and environmental factors under which they grow and evolve. In palm oil production, soil adequacy (climate and soil conditions) is an essential factor, for example [7][8]:

a) Rainfall and dry months. The volume of rain that falls on a flat surface over a horizontal surface with a height unit of millimeters is referred to as rainfall. The average rainfall during the dry months is less than 60 millimeters.
b) Above sea level. At a height of 1,000 meters above sea level (asl), oil palm trees grow and produce fruit. Planting in a location with a maximum elevation of 400 asl, on the other hand, will maximize plant growth and productivity.
c) Topography. Palm oil should be cultivated on land, which is 0-12° or 21% sloping. The pitch area of 13-25 degrees is still possible with oil palms, but the development is not strong.
d) Acidity of Soil. The acidity of the soil (pH) is a chemical component of soil assessment—this attribute to the tremendous effect of pH on land suitability and plant development. The required soil acidity criteria are 5-6 for palm oil.
e) Slope. The overall slope for oil palm plants is not greater than 15%.
f) Peat. Peat is organic soil with a content of more than 20 percent of organic matter or a thickness of more than 40 cm in the peat sheet. Peat is produced by the deposition of organic matter in vast numbers and for an extended period in the areas where environmental factors hinder the weather.

Table 1. Land Suitability Criteria for Oil Palm

No.	Land Characteristics	Symbol	Separation energies		
			Light	medium	Heavy Weight
1	Rainfall (mm)	H	1.750-1.500>3.000	1.500-1.250	< 1.250
2	Dry month (<60	K	1-2	2-3	>3
3	mm)	L	200-300	300-400	>400
4	Elevation (asl m)	B	3-15	15-40	>40
5	Crude ingredients	S	60-150	150-300	>300

No.	Land Characteristics	Symbol	Separation energies		
			Light	medium	Heavy Weight
6	(%v)	T	Hemosaprik,	Hemik, Fibrohemik,	Fibrik
	Peat thickness (cm)		Saprohemik	Hemofibrik	
	Peat Weathering			Hampered	
7	Rate	D	-		very Hampered, flooded
				3,5-4,0	<3,5
8	Drainage class	a	4,0-5,0		
	Soil acidity (pH)				

2.2 PROMETHEE II

The Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE) is the analysis method used for determining the order or priorities in the MCDM (Multi-Criterion Decision Making)[9][10]. The PROMETHEE I method can generate a limited order of judgment alternatives, while the PROMETHEE II method can generate a complete ranking of alternatives[11][12]. PROMETHEE II is one of the approaches for determining the order of priority in a multi-criteria analysis that provides consumers (decision-makers) with a versatile and easy way to evaluate multi-criteria issues. This approach can handle both quantitative and qualitative selection parameters. The key benefits of these methods are ease, transparency, and stability. The use of value in the relationship is an assumption of the superiority of the parameters used in Promethee. The outranking relationship value is calculated in the first stage based on the advantages of each parameter. The preference index is determined, and the scores over competitors are displayed graphically based on preference and decision support[13]. The approximate direction of preference depends on the index value. The Promethee system consists of three methods[14][15]:

a) Leaving Flow. Each anode a in the Outranking value chart is assigned a value dependent on the outflow using the equation:

$$\varphi^{+}(a) = \frac{1}{n-1} + \sum_{x \in A} \delta(a, x) \quad (1)$$

Where $\varphi^{+}(a)$indicates that alternative an is preferable to alternative x. Leaving Flow is a quantity that flows away from the anode a which is a characteristic of outrigging calculation.

b) Enter Flow. A value of entry Flow with the equation can be described while the symmetrical:

$$\varphi^{-}(a) = \frac{1}{n-1} + \sum_{x \in A} \delta(a, x) \quad (2)$$

Where $\varphi^{+}(a)$prefers alternatives x rather than alternative a. The flow entry is determined by the outranking of a character.

c) Net Flow. The calculation takes into consideration the determination of net flow:

$$\varphi(a) = \varphi^{+}(a) - \varphi^{-}(a) \quad (3)$$

The higher the value of leaving flow and the smaller the entry flow, the higher the chosen choice. Partially, Promethee I's rating is based on the importance of leaving flow and joining the flow. Although Promethee II contains the ranking complex since it is centered on each alternative's net flow worth, it occupies one better level.

3. Result and Discussion

The tests' results in evaluating the land potential for oil palm cultivation indicate that the Promethee Approach will help determine land potential based on analytical evidence. The first stage is to define the alternatives and the parameters that would be used.

Table 2. Alternatives

Alternatives	Code
Alternatives 1	A1

Alternatives	Code
Alternatives 2	A2
Alternatives 3	A3
Alternatives 4	A4
Alternatives 5	A5
Alternatives 6	A6
Alternatives 7	A7
Alternatives 8	A8

Table 2 presents the eight alternatives that were decided when choosing prospective land. The Promethee approach will be used to list these alternatives. Table 3 identifies the major criterion for choosing oil palm land for processing with alternatives.

Table 3. Criteria

Criterion	Code	Information
Criterion 1	C1	Rainfall (mm)
Criterion 2	C2	Dry Month (month)
Criterion 3	C3	Above the sea level (m)
Criterion 4	C4	Topography
Criterion 5	C5	Soil acidity (Ph)
Criterion 6	C6	Slope (o)
Criterion 7	C7	Peat thickness (cm)

Once alternate principles and parameters have been defined, the next step is to classify them based on each criterion's dominance. The meaning of the current path is then calculated using the outflow value outline to achieve a better or alternate rating.

Table 4. Data

Weight	Criterion	Rule	Alternatives							
			A1	A2	A3	A4	A5	A6	A7	A8
7	C1	Max	5	5	5	5	5	5	5	5
6	C2	Max	9	9	9	9	9	9	9	9
5	C3	Max	5	4	5	4	3	5	2	4
4	C4	Max	9	6	8	7	9	10	6	10
3	C5	Max	5	4	2	6	5	4	6	7
2	C6	Max	10	7	8	10	9	8	10	10
1	C7	Max	10	9	10	10	10	10	10	10

The alternate rating was calculated using the PROMETHEE II system after the parameters and weighting were determined. As seen in Table 5, the results are dependent on net Phi flow, with the green half of the scale representing a positive Phi score and the red half representing a negative score. Alternatively, higher on the graph would be equivalent to those, and vice versa[16].

Table 5. PROMETHEE Flow Table

Rank	Alternative	Phi	Phi+	Phi-
1	Alternative 8	0,2143	0,2143	0,0000
2	Alternative 1	0,1429	0,1582	0,0153
3	Alternative 6	0,0612	0,1480	0,0867
4	Alternative 4	0,0204	0,1020	0,0816
5	Alternative 5	-0,0051	0,0867	0,0918
6	Alternative 3	-0,0969	0,0918	0,1888
7	Alternative 2	-0,1582	0,0408	0,1990

Rank	Alternative	Phi	Phi+	Phi-
8	Alternative 7	-0,1786	0,0765	0,2551

Alternative 8 is the alternative with the highest rating in the assessment table of the potential for oil palm production with the Promethee method, suggesting that the measure is the most substantial alternative in evaluating the suitability of oil palm land, as seen in table 5.

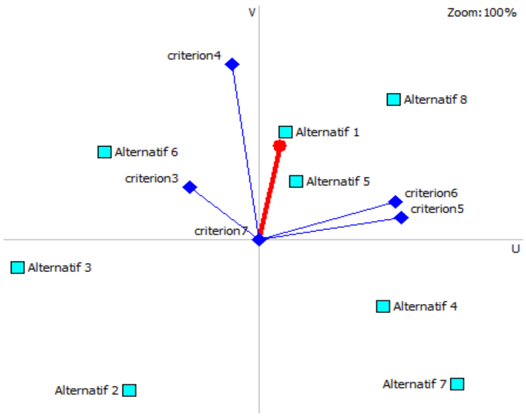

Figure 2. Alternative ranking

4. Conclusion

The decision support system using the Promethee method helps companies determine potential land for oil palm cultivation by obtaining alternative information on potential and productive oil palm planted areas. This study resulted in alternative eight as the best location with a net flow of 0.2143, followed by alternatives 1 and 6 on seven criteria. While alternative seven was the least recommended with a net flow of -0.1786.

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