Decision Support System on Potential Land Palm Oil Cultivation using Promethee with Geographical Visualization

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Abstract. Preparation of oil palm cultivation land is the initial physical activity of the planting area. Prior to oil palm cultivation it is advisable to study potential land suitability, to assess the land as appropriate or not to oil palm growth and support crop productivity. Potential land evaluation includes an example of a consideration where it requires the right decision to make a potential land-cultivation way to support crop productivity more effectively. Therefore, system with the PROMETHEE (Preference Ranking Organization for Enrichment Evaluation) method is built because of the ability to handle multiple comparisons, indicating priorities and preferences for each criterion by focusing on values. The criteria needed are: Rainfall, Dry Moon, Topography, Above Sea Level, Soil Acidity, Slope Tilt and Peat Density. The results achieved in this research is decision support system that yields recommendation of potential land of oil palm cultivation, which can be considered by decision maker in determination of potential land of oil palm cultivation.

1. INTRODUCTION

Palm oil (Elaeis Guineensis Jacq) becomes one of the important industrial plants producing cooking oil, industrial oil, and fuel. Indonesia is the largest palm oil producer in the world. The trend of increasing the area of oil palm plantations also occurred in Kutai Kartanegara District. Oil palm plantations with a variety of plantation patterns in Kutai Kartanegara District are spread across 18 districts. In Kutai Kartanegara District with an area of 644,158 hectares, generally using a core plasma partnership pattern with total plantation realization of approximately 175,744.88 (28.18% of IUP) involving participant farmers (plasma) of 15,447 households (KK) incorporated in 44 cooperatives. According to community perceptions based on the percentage and position of the plasma plantation area of 20 percent is built outside the company's IUP or HGU (core), so that the nucleus estate remains 100 percent of its area from the IUP or HGU. This concept is more profitable for the company and narrows APL in an area, even indirectly the productivity of FFB automatically increases by 20%. Including Muara Kaman Subdistrict is one of the areas of oil palm plantation development both by companies in the pattern of nucleus-plasma partnership and independent plantation development by the community. While this sub-district location is in the Mahakam watershed area, the condition of the river and several lakes in the garden or forest area becomes dry. In addition, the condition of the river has also undergone a change with the expansion of the plantation area and the river biota is decreasing [1][2]. Most oil palm farmers do not know and can choose or distinguish potential oil palm cultivation lands, due to lack of education about evaluating oil palm cultivation. This design application makes it
easier for PT. Kawit Kaltim Lestari, Sabintulung village, Muara Kaman sub-district in choosing oil palm cultivation areas that have the potential [3].

2. RESEARCH METHOD

Decision Support System (DSS) is an interactive system that supports decisions in the decision making process through alternatives obtained from the results of data processing [4]. By observing or searching for data information that will be applied to each land with the specified criteria aims to select the potential land for oil palm cultivation. Promethee is a method of determining the order (priority) in multicriteria analysts. The main problem is simplicity, clarity, and stability [5] specifically, six different preference functions are defined in Promethee II, which covers almost all the possible criteria. In this case, the Usual Criterion is used to demonstrate the calculating processes of Promethee II, that is, 1 is used to replace the positive deviation and the rest is replaced with 0 [6][7]. Why is the promethee method used in this study because this method is good enough to take into account the characteristics of the data. The promethee method provides many functions that can accommodate various data characteristics.

In the process of evaluating the land that is released properly and precisely because it can affect the quality of production, the increase and increase in the time that is very effective to produce to produce anywhere is not the same. If one of these factors is felt to be bad by farmers or entrepreneurs, then there is a possibility of increasing the productivity of farmers or entrepreneurs will decrease from the actual results. By using the promethee method of decision-making techniques to provide advice as a material consideration in selecting direct and objective potential oil palm cultivation land.

2.1. Promethee

Promethee has the ability to handle multiple comparisons, to indicate its priorities and preferences for each criterion by focusing on values.

2.1.1. Preferences Structure Built on Criteria.

F value is the real value of a criterion : \( f : K \rightarrow \mathbb{R} \) and the purpose of an optimization procedure. For each "alternative \( a \in K \), \( f(a) \)" is an evaluation of these alternatives for a criterion. The problem induces on the actions of \( K \) a total preorder (complete and transitive relation). Submission of the intensity (P) of alternative \( a \) preferences to alternatives \( b \) such that the preference integrity equation can be seen in equation (1) [7].

\[
P(a,b) = 0
\]

With the following information:

If the value of \( P(a,b) = 0 \) means there is no indifferent between \( a \) and \( b \), or there is no preference from a better than \( b \).
- \( P(a,b) = 0 \), means weak preference from a better than b.
- \( P(a,b) = 1 \), means strong preference from a better than b.
- \( P(a,b) = 1 \), means absolute preference of a is better than b.

2.1.2. Dominance Criteria.

F value is the real value of a criterion, \( f: K \rightarrow \mathbb{R} \) (RealWord) and the goal is an optimization procedure or each alternative that will be selected, \( a \in K \), \( f(a) \) is an evaluation of the alternatives to be selected for each criterion. At the moment two alternatives are compared \( a,b \in K \), should be able to determine the preference ratio.

2.1.3. Data for Promethee Analysis.

Building Outranking relationships from \( K \) (number of alternative sets). The exploitation of this relationship provides an optimization criterion answer in the multi criteria problem paradigm. The
The value of outranking relationships is based on the consideration of the dominance of each criterion. The preference index is determined and the outranking value graphically is presented based on the preferences of the decision maker. Basic data for evaluation with the promethee method are presented as follows:

| C  | f1(.) | f2(.) | ... | fi(.) | ... | Fk(.) |
|----|-------|-------|-----|-------|-----|-------|
| a1 | f1(a1) | f2(a1) | ... | fi(a1) | ... | fk(a1) |
| a2 | f1(a2) | f2(a2) | ... | fi(a2) | ... | fk(a2) |
| ... | ... | ... | ... | ... | ... | ... |
| Ai  | f1(ai) | f2(ai) | ... | fi(ai) | ... | fk(ai) |
| ... | ... | ... | ... | ... | ... | ... |
| An  | f1(an) | f2(an) | ... | fi(an) | ... | fk(an) |

2.1.4. Preference Function.
In Promethee presented six forms of criteria preference function. This is of course not absolute, but this form is quite good in some cases. To give a better picture of the unequal area, the difference between the alternative criteria is used \( H(d) \) this has 11 direct relationships to the preference function “\( P \)”. The criteria preference function equation can be seen in the equation (2).

\[
 f'(a) = f'(b) - \alpha I b (\alpha \text{ indifferent } b) \left\{ \begin{array}{ll}
 f(a) > f(b) & a P b \\
 f(a), f(b) &
\end{array} \right.
\]

Through the analysis of multiple criteria decision making, each preference relationship between alternatives is compared between results, preferably an alternative (\( P = \text{prefer} \)), no different (\( I = \text{indifferent} \)). The preference function itself has 6 functions which can be seen in Table 1. Type of preference criteria.
| No | Criteria Preference Type | Figure | Equation |
|----|--------------------------|--------|----------|
| 1  | Usual Criterion          | ![Figure](image1.png) | \[ H(d) = \begin{cases} 0 & \text{if } d = 0 \\ 1 & \text{if } d > 0 \end{cases} \] |
| 2  | Quasi Criterion          | ![Figure](image2.png) | \[ H(d) = \begin{cases} \frac{q}{q} & \text{if } -q \leq d \leq q \\ 1 & \text{if } d < -q \text{ or } d > q \end{cases} \] |
| 3  | Criteria with Linear Preferences | ![Figure](image3.png) | \[ H(d) = \begin{cases} \frac{d}{p} & \text{if } -p \leq d \leq p \\ 1 & \text{if } d < -p \text{ or } d > p \end{cases} \] |
| 4  | Level Criterion          | ![Figure](image4.png) | \[ H(d) = \begin{cases} \frac{0.5}{q} & \text{if } q < |d| \leq p, \\ 1 & \text{if } p < |d| \end{cases} \] |
| 5  | Criteria with Linear Preferences and Areas that are not Different | ![Figure](image5.png) | \[ H(d) = \begin{cases} 0 & \text{if } |d| \leq q \\ \frac{q}{p} & \text{if } q < |d| \leq p, \\ 1 & \text{if } p < |d| \end{cases} \] |
| 6  | Gaussian Criterion       | ![Figure](image6.png) | \[ H(d) = 1 - \exp \left( -\frac{d^2}{2\sigma^2} \right) \] |

2.2. **Palm Oil**

Palm oil is a plant that almost all of its parts produce use value which consists of several parts, namely fruit flesh, palm seeds, empty bunches, and palm oil. Palm oil is an important industrial plant producing cooking oil, industrial oil, and fuel (biodiesel) and various types of derivatives such as alcohol oil, margarine, wax, soap, steel industry, wire, radio, leather, and pharmaceutical industry. The remaining processing can be used as compost and animal feed mixtures.
2.3. Palm Oil Growth Requirements

Production produced by oil palm plants is the result of the interaction between internal (genetic) factors and environmental factors in which the plant grows and develops. The implementation of high technical culture standards and appropriate technology will optimize efficiency while keeping in mind the factors of sustainability and natural balance, the integration between plant components, technical culture and efficient yield processing will produce high production. The main factors supporting the achievement of high production of palm oil rendemen cultivation are as follows [8]:

1. Plant material used
2. Land suitability, namely soil type, climate, rainfall, and topography.
3. Implementation of good technical culture from the beginning
4. Quality of harvest
5. Human resources
6. Community social
7. Efficiency of the results manager

In oil palm cultivation, land suitability (climatic and soil conditions) is a major factor in addition to other factors, such as genetic treatment given (technical culture) and others. Which will be described as follows [5]:

1. Rainfall and Dry months
   Rainfall is the amount of water that falls on a flat surface during a certain period that can be measured by units of height (mm) above the horizontal surface if there is no evaporation, run off, and infiltration. While dry months are months with total precipitation below 60 mm.
2. Above Sea Level
   Oil palm plants can grow and bear fruit to a height of 1,000 meters above sea level (asl). However, plant growth and optimal productivity will be better if planted in locations with a maximum height of 400 meters above sea level.
3. Topography
   Palm oil should be planted on land that has a slope of 0-12 ° or 21%. Actually the slope area of 13-25 ° can still be planted with oil palm, but the growth is not good.
4. Acidity of Soil
   Soil acidity (pH) is a chemical aspect of soil that is needed in land evaluation. This is due to the influence of very large pH on land suitability and plant growth. The criteria for suitable soil acidity for oil palm are at 5-6.
5. Slope
   The slope in the North Batang Alai District is in accordance with the requirements of growing oil palm. Maximum slope for oil palm plants is not more than 15%.
6. Peat
   Peat is an organic soil with> 20% organic matter or has a thick peat layer> 40 cm. Peat is formed from the accumulation of organic material in large quantities and for a long time, occurs in a place where environmental conditions hinder the weathering process.

Table 3. Land Suitability of SKL Inc.

| Criteria    | Unit     | Class |
|-------------|----------|-------|
3. RESULTS AND DISCUSSION

Based on the results of testing in determining the potential land for oil palm cultivation, the data is sourced from the company's guidebook [4]. The Decision Support System Process for Determining Oil Palm Cultivation Potential Land shows the results that the Promethee Method can assist in determining the potential land for oil palm cultivation based on analytical data. The phases in the Promethee method are as follows:

**Phase 1**: Model Design includes: determining alternatives, criteria, symbol criteria, and system architecture:

The criteria used include:

- K1: Rainfall (mm)
- K2: Dry moon (bln)
- K3: Above the sea level (m)
- K4: Topography
- K5: Soil acidity (pH)
- K6: Slope (°)
- K7: Peat thickness (cm)

Alternative symbols used:

- A1: Alternative 1
- A2: Alternative 2
- A3: Alternative 3
- A4: Alternative 4
- A5: Alternative 5
- A6: Alternative 6
- A7: Alternative 7
- A8: Alternative 8

Symbols calculation results:

- LF: Leaving flow
- EF: Entering flow
- NF: Net flow

**Phase 2**: Design values such as: Outranking based on consideration of the dominance of each criterion. In finding direction values in outranking presentations, using outranking characters from a (Leaving flow) value. Determine the ratio of the best value order or ranking of alternatives (net flow).

**Phase 3**: Outranking is the process of determining the value of each matrix column and process design. Before calculating the value of each column, we must determine which area will be compared:

| Rainfall mm/years | 1 <=60 | 2 601-800 | 3 801-1000 | 4 1001-1201 | 5 1201-1601 | 6 1601-1801 | 7 1801-2000 | 8 >2000 |
|-------------------|------|-----------|-----------|-----------|-----------|-----------|-----------|-------|
| Dry Month >4.5    | 4.1- | 3.6-4    | 3.1-      | 2.6-3     | 2.1-      | 1.6-2     | 1.1-     | <1    |
| Month             | 4.5  | 3.5      | 2.5       | 1.5       |
| Topografi #       |      |          |           |           |           |           |           |       |
| DPL M >160       | 141- | 121-     | 101-      | 81-       | 65-80     | 41-60     | 21-40    | <=20  |
|                   | 160  | 140      | 120       | 100       |
| Acidity pH <1.0   | 1.1- | 2.1-     | 3.1-      | 4.1-      | 5.1-      | 6.1-      | 7.1-     |
|                   | 2.0  | 3.0      | 4.0       | 5.0       | 6.0       | 7.0       | 8.0      |
| Slope O >33       | 29-32| 25-28    | 21-24     | 17-20     | 13-16     | 9-12      | 5-8      | 0-4   |
| Peat Cm >200      | 176- | 151-     | 126-      | 101-      | 76-       | 51-75     | 26-50    | 0-25  |
|                   | 200  | 175      | 150       | 125       | 100       |           |           |       |
Stage 1: Area A1 compared to area A2

Stage 2: For K1

\[ f = A_1 - A_2 \]

Stage 3: Then determine the rules that will be used, namely maximization or minimization

\[ P(A_1, A_2) = a \]
\[ P(A_2, A_1) = b \]

Stage 4: Calculates all values contained in:

\[ \partial \sum(A_1, A_2) = \frac{1}{2} * \sum(A_1, A_2) \]
\[ \partial P(A_1, A_2) = \frac{1}{2} * \sum(A_2, A_1) \]

### Table 4. Promethee Data

| Weight | Criteria | Rule | Alternative | Criteria Type |
|--------|----------|------|-------------|---------------|
| 7      | K1       | Max  | 4 4 4 4 4 4 4 4 | 1             |
| 6      | K2       | Max  | 8 8 8 8 8 8 8 8 | 1             |
| 5      | K3       | Max  | 4 3 4 3 2 4 1 3 | 1             |
| 4      | K4       | Max  | 8 5 7 6 8 9 5 9 | 1             |
| 3      | K5       | Max  | 4 3 1 5 4 3 5 6 | 1             |
| 2      | K6       | Max  | 9 6 7 9 8 7 9 9 | 1             |
| 1      | K7       | Max  | 9 9 9 9 9 9 9 9 | 1             |

Domination criteria or commonly called the highest value weight value is 7 because of the largest number of values, criterion data from a land which is briefly K1, K2 and so on, alternative as a land which is briefly A1, A2 and so on, min and max rules become the value category H(d). Max if the higher the value of d the results are better, while Min is the opposite. While the A1 value and so on have been adjusted to the land class, using type 1 that is usual. Only usual types do not have parameter values [6]. Through the steps of manual calculation promethee with the result value.
Table 5. Finalt Result Calculation

| Ranking | Alternative | EF       | LF       | NF       |
|---------|-------------|----------|----------|----------|
| 1       | A8          | 0.535714286 | 2.25    | 1.714285714 |
| 2       | A1          | 0.607142857 | 2.71428571 | 1.464285714 |
| 3       | A6          | 0.892857143 | 1.928571429 | 1.035714286 |
| 4       | A4          | 1.357142857 | 1.464285714 | 1.035714286 |
| 5       | A3          | 1.678571429 | 1.392857143 | -0.28571429 |
| 6       | A5          | 1.964285714 | 1.285714286 | -0.67857143 |
| 7       | A7          | 2.214285714 | 0.841428571 | -1.39285714 |
| 8       | A2          | 2.428571429 | 0.464285714 | -1.96428571 |

From the results of calculations in Figure 4, the results of the recommendations are obtained with the ranking sequence:

Rangking 1 = Area 8 with net flow 1.714285714
Rangking 2 = Area 1 with net flow 1.464285714
Rangking 3 = Area 6 with net flow 1.035714286
Rangking 4 = Area 4 with net flow 1.035714286
Rangking 5 = Area 3 with net flow -0.28571429
Rangking 6 = Area 5 with net flow -0.67857143
Rangking 7 = Area 7 with net flow -1.39285714
Rangking 8 = Area 2 with net flow -1.96428571

It is known from the outranking results that land 8 is the most potential area for oil palm cultivation with category S1 in the land suitability table and is included in grade 8 in the evaluation table of potential land for oil palm cultivation.

4. CONCLUSION

Decision support system with promethee method helps companies in determining potential land for oil palm cultivation can obtain alternative information on oil palm planting areas that have the potential and produce productivity for companies in the PLASMA program quickly with a percentage of accuracy 100% of the 8 data that has been processed.

With a decision support system an objective decision can be determined. Decisions resulting from the decision support system for selecting oil palm plantations using the promethee method are not an absolute decision or ranking where the final decision is still determined by the user. With the promethee method can be determined the order (priority) in multicriteria analysis with the main problem is simplicity, clarity and stability.

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