

Implementation Of Promethee Ii Method In The Productivity Of Superior Vegetables In Sub-Districts In Northern Aceh


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ABSTRACT

This research aims to determine sub-districts with superior vegetable productivity in North Aceh using the PROMETHEE II Method. This method is used in decision support systems to help analyze various criteria related to vegetable productivity, such as planting area, harvest area, added planting area, and total production. The research data was taken from 23 sub-districts in North Aceh covering various types of vegetables, such as chili, tomato, long bean, and eggplant, for the year 2023. Through analysis using the PROMETHEE Method, this research produced a ranking of sub-districts based on Net Flow values that reflected the level of productivity of each sub-district. The results show that sub-districts Tanah Luas has the highest vegetable productivity with a Net Flow value of 3.0608, while sub-districts Tanah Pasir is at the lowest position with a value of -2.2172. With these results, the research provides recommendations to the local government and farmer groups to focus on improving productivity in the low-ranked sub-districts. In conclusion, the PROMETHEE II Method provides accurate and objective results in analyzing vegetable productivity in various sub-districts and can be used as a decision-making tool related to strategies for improving vegetable agriculture in North Aceh. Therefore, the results of this study are expected to be used as guidelines in planning strategies to increase agricultural productivity in North Aceh .

Keywords: PROMETHEE II, Vegetable Productivity, Decision Support System, Subdistrict, North Aceh, Net Flow.

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1. INTRODUCTION

Most Indonesians depend on agriculture, which is one of the most important sectors in the country. (Ulya et al., 2024).. There are many types of agriculture, including vegetable farming. Demand for vegetables is increasing, with consumers having to spend more money on vegetables each month, which means that the average price per kilogram of vegetables they can afford is getting more expensive. This increases vegetable production in quantity and quality (Mauliddiyah, 2021).

With the existence of farmer groups in each sub-district in North Aceh, it is hoped that they will be able to meet the needs of the local community. Long beans, chili peppers, tomatoes, big tomatoes, and others are among the vegetables that are often grown. Therefore, it is necessary to see which sub-districts have superior vegetable productivity. This is done to meet the increasing consumer demand due to the welfare of life and the increasing population.

Therefore, a decision-making support system using the PROMETREE II method is needed in the productivity of superior vegetables in Districts in North Aceh. Decision Support System , is an extension of a computerized management information system designed to interact with its users. (Kurniawan & Rahmadani, 2020). PROMETHEE is one of many methods for determining ranking or order in multicriteria analysis. this method is widely used because it is efficient and simple, and easier to use than other methods to solve multicriteria problems (Novida & Sunandar, 2018).

The main purpose of conducting this research is to see which districts produce superior vegetables. Vice versa, so that the local government can deal with the problem immediately. For this situation, the PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluation) Method, which relies on preference types in its calculation process, serves to match the needs of decision makers based on predefined criteria.

2. Research Stages

This research uses a quantitative approach, which utilizes data within a certain period of time to solve problems. (Hatta & Nursanty, 2020). This research uses data on the planting area, harvest area, added planting area, and total production of vegetable crops such as large chili peppers, tomatoes, long beans, water spinach and eggplant in each sub-district in North Aceh during 2023. Of all sub-districts, only 23 sub-districts were taken as samples for testing. This sample selection aims to get enough representation to analyze vegetable productivity in each sub-district.

This decision support system research applies the PROMETHEE method as an analytical tool to help the ranking and decision-making process. This method was chosen because of its ability to process various criteria and produce rankings based on alternative comparisons. (Muntiari et al., 2020). By using PROMETHEE, this research can provide more objective and accurate results in determining the sub-districts with the best to lowest vegetable productivity, so that it can be used as a reference in formulating production improvement strategies in areas that need more attention.

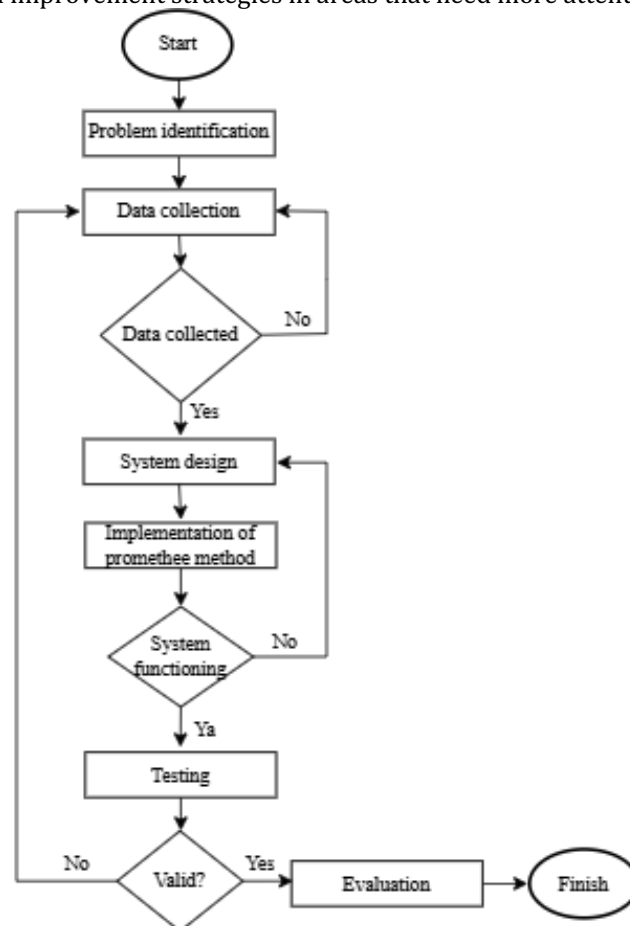


Figure 1. Picture of Research Stages

Figure 2.1 is a picture of the research stages. The following is an explanation:

1. Problem identification.

This research focuses on the uncertainty in determining the sub-districts with the highest and lowest vegetable productivity, resulting in difficulties in maintaining good yields and increasing productivity in sub-optimal areas.

2. Data collection.

Data in this study was obtained from the Meugah Raya Women Farmers Group (KWT) located in Glumpang Sulu Timur, which provided data related to vegetable productivity that supported the implementation of this study.

3. System Design.

Build a system that can process calculation data efficiently using the Python programming language.

4. Implementation of Promethee Method.

At this stage, the calculation of the Promethee method will be implemented using the Python programming language.

5. Testing.

Testing of existing features and the application of the promethee method using data that has been collected previously.

6. Evaluation

This stage involves an evaluation of the trial results, which includes an assessment of the extent to which the research objectives have been achieved.

2.2 PROMETHEE Method

Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE) is one of the methods for ranking in the context of Multi Criteria Decision Making (MCDM). (Siregar et al., 2021). The PROMETHEE method is used to determine the order or priority in multicriteria analysis. The main advantages of this method lie in its simplicity, clarity, and stability. (Geke et al., 2022).. This method is based on the principle of criterion dominance, where the values used to form the outranking relationship become the basis for the analysis. (Suhada et al., 2021).

2.3 Stages of the PROMETHEE Method

To get the selection results with the PROMETHEE method, steps are needed that must be followed by the decision maker.

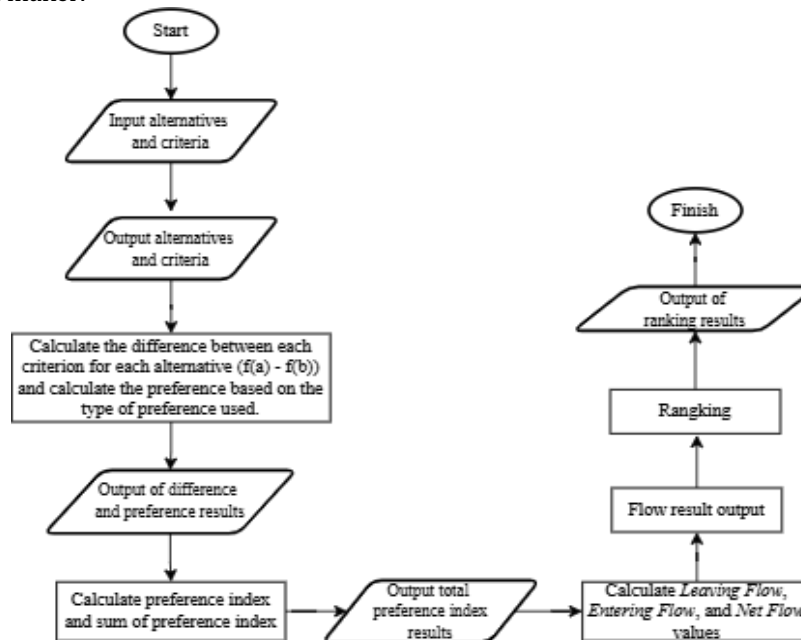


Figure 2.PROMETHEE System Schematic

Figure 2.2 is a system scheme of the PROMETHEE method. The meaning of the picture can be seen in the explanation below:

1. Start

This stage marks the beginning of the calculation process using the PROMETHEE method.

2. Input alternatives and criteria

Alternatives in this context refer to objects to be chosen or selected such as names. In the selection process using the PROMETHEE method, it is necessary to determine several objects to be compared (at least two objects), where each object will be compared with each other (Yasari Br Surbakti et al., 2024). After determining the objects to be selected, the calculation process with the PROMETHEE method also requires the determination of several criteria. These criteria serve as requirements or references in the selection process (Rosmiati, 2023).

3. Output alternatives and criteria

Displaying information about alternatives along with relevant criteria, aims to ensure that the data has been read accurately.

4. Calculate the difference between each criterion for each alternative ($f(a) - f(b)$) and calculate the preference based on the type of preference used.

The calculation process is carried out by comparing the criteria between one alternative and another, and providing an indeference value based on the type that has been determined.

5. Output of difference and preference result
Presents the results of the difference calculation as well as the indifference value.
6. Calculate preference index and sum of preference index
Calculations are carried out by multiplying the indeference results obtained from the previous stage with the weight of each criterion. Then add up the preference index results of all alternatives for each criterion.
7. Output total preference index result
Presents the results of the preference index calculation along with the total of all preference indices.
8. Calculate Leaving Flow, Entering Flow, and Net Flow values
 - a. The Leaving Flow value is the inverse of the Entering Flow value. It includes the total elements that move away from a node. Thus, Leaving Flow can be interpreted as a negative value given to selection objects that have a direction away from the node. (Handayani & Noranita, 2018) . Here is the formula for calculating Leaving Flow:

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

- b. Entering Flow value, also known as Negative Outranking Flow, indicates that the smaller the value, the more dominant an alternative is compared to other alternatives. (Abdulrajak et al., 2020). The following formula calculates Entering Flow:

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

- c. The Net Flow value is a comprehensive assessment. In this case, the assessment is obtained by subtracting the Leaving Flow value from the Entering Flow value. In other words, the higher the Entering Flow value and the lower the Leaving Flow value, the more likely an alternative is to be selected. If the alternative has a greater Net Flow value, it will be ranked higher. (Saifulloh, 2020). The following is the formula for calculating Net Flow:

$$\varphi(a) = \varphi^+(a) - \varphi^-(a) \dots\dots\dots 3$$

9. Flow result output
Present the calculation results of Leaving Flow, Entering Flow, and Net Flow for each alternative.
10. Ranking
Ranking based on the results of the net flow calculation from the highest to the lowest value.
11. Present the ranking results obtained through calculations using the PROMETHEE method.

3. RESULTS AND DISCUSSION

This section contains the calculation and implementation of the PROMETHEE method required for the ranking process in the productivity of superior vegetables in several Districts in North Aceh. In this calculation, the PROMETHEE method is implemented using the Python programming language.

```

Dataset berhasil terbaca. Berikut adalah data awal:
No      Kecamatan      Cabai_Besar_Luas_Tanam_Ha \
0 1      Baktiya          21
1 2      Banda Baro      15
2 3      Cot Girek       23
3 4      Dewantara       12
4 5      Geureungdong Pase 11

Cabai_Besar_Luas_Panen_Ha  Cabai_Besar_Luas_Tambah_Tanam_Ha \
0 5                        8
1 5                        5
2 15                       14
3 7                        7
4 3                        3

Cabai_Besar_Produksi_Kw  Tomat_Buah_Luas_Tanam_Ha \
0 570                     6
1 196                     6
2 996                     4
3 490                     6
4 380                     9

Tomat_Buah_Luas_Panen_Ha  Tomat_Buah_Luas_Tambah_Tanam_Ha \
0 5                        5
1 5                        5
2 3                        3
3 4                        4
4 5                        5
    
```

Figure 3. Initial Data Image

Figure 3. is some of the data displayed from the dataset. The data will later be used to calculate superior vegetables in sub-districts in North Aceh.

```
alternatives = data['Kecamatan'].values

criteria = [
    'Cabai_Besar_Luas_Tanam_Ha', 'Cabai_Besar_Luas_Panen_Ha', 'Cabai_Besar_Luas_Tambah_Tanam_Ha', 'Cabai_Besar_Produksi_Kw',
    'Tomat_Buah_Luas_Tanam_Ha', 'Tomat_Buah_Luas_Panen_Ha', 'Tomat_Buah_Luas_Tambah_Tanam_Ha', 'Tomat_Buah_Produksi_Kw',
    'Kacang_Panjang_Luas_Tanam_Ha', 'Kacang_Panjang_Luas_Panen_Ha', 'Kacang_Panjang_Luas_Tambah_Tanam_Ha', 'Kacang_Panjang_Produksi_Kw',
    'Kangkung_Luas_Tanam_Ha', 'Kangkung_Luas_Panen_Ha', 'Kangkung_Luas_Tambah_Tanam_Ha', 'Kangkung_Produksi_Kw',
    'Terung_Luas_Tanam_Ha', 'Terung_Luas_Panen_Ha', 'Terung_Luas_Tambah_Tanam_Ha', 'Terung_Produksi_Kw'
]
```

Figure 4. Figure Determination of Alternatives and Criteria

Figure 4. is the stage of determining Alternatives and Criteria, where each sub-district in the dataset is designated as an Alternative which will later be ranked. Meanwhile, the calculation criteria are obtained from the planting area, harvest area, added planting area, and production of the 5 vegetables grown in each sub-district.

```
[ ] for crit in criteria:
    min_value = data[crit].min()
    max_value = data[crit].max()
    data[crit] = (data[crit] - min_value) / (max_value - min_value)
```

Figure 5. Data Normalization

In Figure 5, the data normalization process is carried out on the criteria values in the dataset. Data normalization aims to equalize the scale of various criteria so that they can be compared directly so that they can be evaluated fairly during the next calculation process.

```
def preference_function(a, b, p, q):
    diff = a - b
    if diff >= p:
        return 1
    elif q <= diff < p:
        return (diff - q) / (p - q)
    else:
        return 0

p = 0.1 # Threshold p setelah normalisasi
q = 0.05
```

Figure 6. Calculating Preferences

Figure 6. is a step to compare two alternatives, such as sub-districts, based on various predefined criteria. These preferences indicate how superior one alternative is compared to the other on each criterion, such as planting area or production level. The results of these preferences are then used to calculate the "leaving flow" and "entering flow," which will ultimately determine the overall ranking of the alternatives.

```
[ ] leaving_flow = np.sum(preferance_matrix, axis=1) / (n - 1)
    entering_flow = np.sum(preferance_matrix, axis=0) / (n - 1)
```

Figure 7. Calculating *Leaving* and *Entering Flow*

Figure 7. is the calculation of *Leaving flow* and *Entering flow* are two important aspects in the *PROMETHEE* method that serve to determine the order of alternatives. The difference between *leaving flow* and *entering flow* is used to calculate the *net flow* value, which is then used as a reference in determining the final ranking.

```
[ ] net_flow = leaving_flow - entering_flow
```

Figure 8. Calculating *Net flow*

Figure 8. is the most important aspect in the Promethee method, Net flow describes how superior an alternative (sub-district) is overall compared to other alternatives. When the net flow value is positive, the alternative is preferred over others, while a negative value indicates the opposite. This net flow is the basis for determining the final order of all alternatives in the decision-making process.

Below are the results of a partial ranking table organized by Netflow value, which includes 22 rankings from best to worst, based on vegetable productivity in each sub-district.

Table 1. Ranking Results of *NetFlow* Values

Ranking	Subdistrict	<i>Net Flow</i>
1	Tanah Luas	3.0608
2	Lhoksukon	2.3333
3	Banda Baro	1.8429
4	Syamtalira Aron	1.6380
-	-	-
20	Lapangan	-1.6309
21	Muara Batu	-2.1747
22	Tanah Pasir	-2.2172

Based on the table above, the Net Flow value obtained becomes the determining factor in the sub-district ranking process. The results show that the sub-district of Tanah Luas has the highest vegetable productivity, while the sub-district of Tanah Pasir is ranked at the bottom with the lowest productivity. The alternative with the largest Net Flow value is the one with the highest ranking (Batubara et al., 2019).

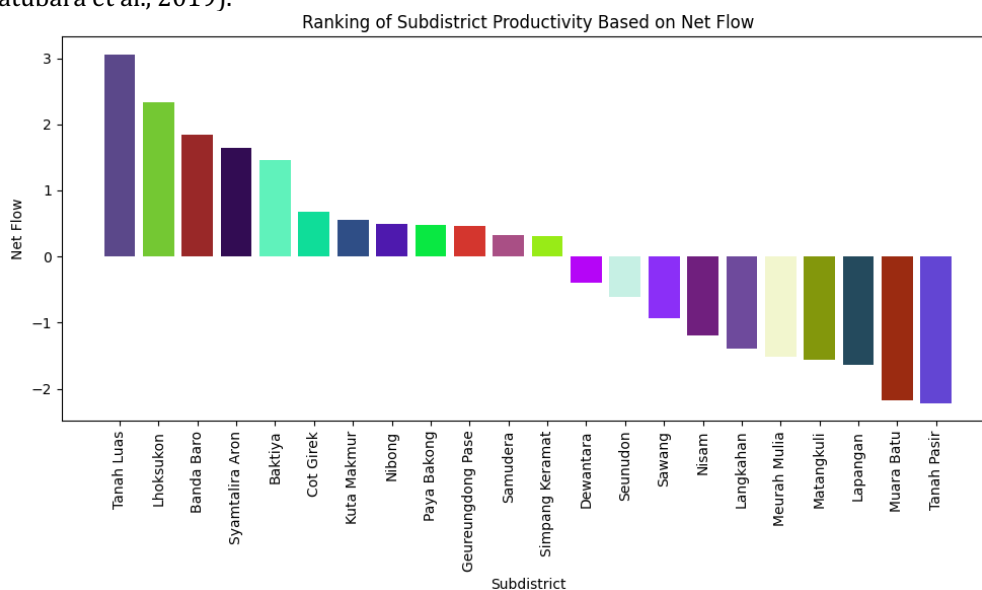


Figure 9. Ranking Graph

Figure 9 shows the entire ranking based on the *Net Flow* value. Categorization can be done as follows: sub- districts with *Net Flow* values above 1 are categorized as very good, while values between 0 and 1 are considered good. Values between -1 to 0 indicate a poor category, while sub-districts with *Net Flow* values below -1 are categorized as very poor. This approach allows for a clearer analysis of the level of vegetable productivity in each sub-district.

4. CONCLUSION

This study concludes that the PROMETHEE method is effective in generating sub-district productivity rankings based on Net Flow values. From the analysis, subdistrict Tanah Luas is in the top position with a Net Flow value of 3.0608, while subdistrict Tanah Pasir is in the bottom position with a value of 2.2172. Sub-districts with good productivity should maintain their performance, while sub-districts with unsatisfactory results need to strive to increase agricultural productivity. By using the PROMETHEE method, farmers and local governments can better understand the level of vegetable productivity, so that they can take the right steps to increase agricultural yields in their area.

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