

Selection of the Best Village Crop Potential Using the Multi-Attribute Border Approximation Area Comparison (MABAC) Method

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Abstract

The difference in the location of each geographical condition of each village resulted in many different types of superior agricultural products in each village, this resulted in not all villages in Langkat Regency being able to utilize the crops in their village. This has caused the Community and Village Empowerment Service of Langkat Regency to work very hard in providing support for the progress of each village in developing existing agricultural products. The support provided by the government through the Langkat Regency DPMD is subsidized fertilizer, subsidized seeds and so on. Based on the results of research that has been conducted at the DPMD of Langkat Regency, the selection process to determine the village with the best agricultural products which is done manually can slow down the results of the decisions given and the results obtained are ineffective and inefficient. In overcoming this, it is necessary to build a system to streamline the process of selecting villages with the best agricultural products that have been properly computerized by utilizing the process of the Decision Support System (DSS). In this study a Decision Support System (DSS) will be built using the Multi-Attribute Border Approximation Area Comparison (MABAC) method which in this method is known as a method that can provide solutions in making a decision compared to other methods. The system was successfully built using the PHP programming language with a MySQL database. In the system built, the appropriate criteria to be used in supporting the final results of decisions that have been successfully analyzed and applied to the system are land area, income per harvest, number of workers and number of harvests each year. Based on the results of the research that has been done, the MABAC method is able to determine the ranking of the processed data based on the results of the total value of the criterion function.

Keywords: Decision Support Systems, Potential Agricultural Products, MABAC Method, PHP Programming, MySQL Database

1. Introduction

The rapid development of technology in the current era of globalization has provided many benefits in progress in various social aspects. The use of technology by humans to help complete work is a must in life. This technological development must also be followed by developments in Human Resources (HR). Making decisions quickly and accurately is the key to facing global competition. The amount of information possessed coupled with the ability to process this information quickly becomes an alternative in decision making is the key to success in competition. Before making a decision from various available information, criteria are also needed, where these criteria are able to answer an important question about how well an alternative can solve the problem at hand.

The difference in the location of each geographical condition of each village resulted in many different types of superior agricultural products in each village, this resulted in not all villages in Langkat Regency being able to utilize the crops in their village. This has caused the Langkat Regency Community and Village Empowerment Service to work very hard in providing support for the progress of each village in developing existing agricultural products. The support provided by the government through the Langkat Regency DPMD is subsidized fertilizers, subsidized seeds and so on. Based on the results of research that has been conducted at the DPMD of Langkat Regency, the selection process to determine the village with the best agricultural products which is done manually can slow down the results of the decisions given and the results obtained are ineffective and inefficient. The selection process that has been carried out so far is to make an assessment in each village, then the results of the assessment are added up one by one using Ms. Office Excel, so this method is considered very ineffective. To overcome this, it is necessary to build a system to streamline the village selection process with the best agricultural products which has been properly computerized by utilizing the process of the Decision Support System (SPK). In this study a Decision Support System (DSS) will be built using the Multi-Attribute Border Approximation Area Comparison (MABAC) method which is a method developed by Pamucar and Cirovic in 2015 which in this method is known as a method that can provide solutions in making a decision compared to other methods.

The purpose of this study is to apply the Multi-Attribute Border Approximation Area Comparison (MABAC) method in a decision support system to determine the best village agricultural products and to obtain the results of implementing the Multi-Attribute Border Approximation Area Comparison (MABAC) method in a decision support system. in determining the best village produce. The benefits

to be obtained from this research are to facilitate the Community and Village Empowerment Service of Langkat Regency in making decisions to determine the best village produce and utilizing the MABAC method, the resulting decisions are more effective than the previous method.

2. Research Methodology

In conducting research on this research, the authors followed the methodological stages in this study, namely as follows:

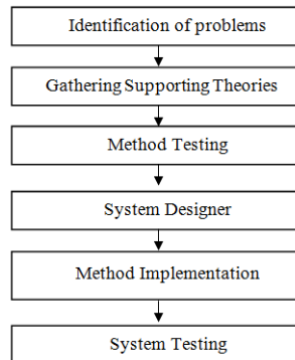


Fig. 2: The structure of the research methodology

To clarify the structure of the research methodology above, the author makes the following statement:

1. **Identify the Problem**
This stage is the initial stage used to identify problems with the aim of observing and looking for problems being faced at the research object, namely the Langkat Regency Community and Village Empowerment Service (DPMD).
2. **Gathering Supporting Theory**
Collection of theories related to the main problem such as theories about Decision Support Systems (DSS), research supporting theories, methods used and design applications of the required systems. In this stage, theory is collected from several sources such as books, journals, articles and other references.
3. **Method Testing**
At this stage the researcher will test the Multi-Attribute Border Approximation Area Comparison (MABAC) method used in the decision support process in determining appropriate differentiation learning, with existing guidance on supporting theories from books and journals related to the main problem. . As well as data sources for Village Partners obtained from the Langkat Regency Office of Community and Village Empowerment (DPMD).
4. **System Designer**
At this stage, a system design is carried out for the problem being researched, in the form of a stage for designing the workflow of the system and also designing the design of the face-to-face display (interface) of the system to be created. The system will be designed using the PHP programming language which is based on a website with a MySQL database.
5. **Method Implementation**
Implementing the Multi-Attribute Border Approximation Area Comparison (MABAC) method which has been tested previously with the system design that has been created and coding according to the PHP programming language and MySQL database used to create the system.
6. **System Testing**
In the final stage, a series of tests are carried out on the system that has been created. The tests are carried out in order to find errors in the system and make the necessary improvements.

2.1. Decision support systems

According to [1], Decision Support Systems (DSS) are part of a computer-based information system including a pGrain base system or pGrain management that is used to make decisions within an organization or company. It can also be said to be a computer system that processes data into information to make decisions on specific semi-structured problems .

Decision Support Systems are interactive information systems that provide information, modeling and data manipulation. The system is used to assist decision making in semi-structured and unstructured situations.

According to [2], The Decision Support System, which we will briefly refer to in this study as DSS, is generally defined as a system capable of providing the ability to support decisions in problem solving.

2.2. Crops

According to [3], crops are anything that comes from nature that can be used to meet the needs of human life. This includes not only biotic components, such as animals, plants and microorganisms, but also abiotic components, such as petroleum, natural gas, various types of metals, water and soil.

Technological innovation, advances in civilization and human population, as well as the industrial revolution have brought humans into an era of exploitation of natural resources so that their supplies continue to decrease significantly, especially in the last century. Agricultural products are needed to support human needs, but unfortunately their presence is not evenly distributed and several countries such as Indonesia, Brazil, Congo, Morocco and various countries in the Middle East have very abundant biological or non-biological natural resources.

2.3. MABAC method

According to [4], The MABAC method was developed by Pamucar and Cirovic. The MABAC method provides stable (consistent) solutions and this method is considered a reliable method for rational decision making. In this paper the MABAC method is used for ranking alternatives. The basic assumptions of the MABAC method are reflected in the definition of the distance criterion function of each observed alternative from the estimated frontier area. In the following section, the procedure for applying the MABAC (Multi-Attributive Border Approximation area Comparison) method is presented, namely a mathematical formulation.

According to [5], MABAC is a method developed by Pamucar and Cirovic in 2015 which in this method is known as a method that can provide solutions in making a decision compared to other methods. In the MABAC method, the best alternative can be based on the distance between the Border Approximation Area (BAA) and the alternative.

The basic assumptions of the MABAC method are reflected in the definition of the distance of the criterion function of each alternative that is observed from the estimated boundary area. The following section presents the procedure for applying the MABAC method, that is, its mathematical formulation, which consists of 6 steps:

1. *Forming initial decision matrix (X)*

In the first step, "m" alternatives are evaluated with "n" criteria. Alternatives are presented with vectors $A_i = (x_{i1}, x_{i2}, x_{i3}, \dots, x_{in})$, Where x_{ij} is the value of alternative "i" with criteria "j", ($i = 1, 2, 3, \dots, m$; $j = 1, 2, 3, \dots, n$).

$$X = \begin{matrix} A_1 \\ A_2 \\ \dots \\ A_n \end{matrix} \begin{bmatrix} C_1 & C_2 & \dots & C_n \\ X_{11} & X_{12} & \dots & X_{1n} \\ X_{21} & X_{22} & \dots & X_{2n} \\ \dots & \dots & \dots & \dots \\ X_{m1} & X_{m2} & \dots & X_{mn} \end{bmatrix} \quad (1)$$

Where "m" is the alternative number, n is the total number of criteria.

2. *Normalization of initial matrix (X) elements:*

$$X = \begin{matrix} A_1 \\ A_2 \\ \dots \\ A_n \end{matrix} \begin{bmatrix} C_1 & C_2 & \dots & C_n \\ T_{11} & T_{12} & \dots & T_{1n} \\ T_{21} & T_{22} & \dots & T_{2n} \\ \dots & \dots & \dots & \dots \\ T_{m1} & T_{m2} & \dots & T_{mn} \end{bmatrix} \quad (2)$$

The normalized matrix elements (N) are obtained by applying the formula:

a. *For benefit-type criteria*

$$T_{ij} = \frac{x_{ij} - x_1^-}{x_1^+ - x_1^-} \quad (3)$$

b. *For cost-type criteria*

$$T_{ij} = \frac{x_1^+ - x_{ij}}{x_1^+ - x_1^-} \quad (4)$$

Where x_{ij} , x_i^+ dan x_i^- presents the elements of the initial decision matrix (X), where, x_i^+ dan x_i^- defined as follows:

$x_i^+ = \max(x_1, x_2, x_3, \dots, x_m)$ represents the maximum value of the criterion observed by the alternative.

$x_i^- = \min(x_1, x_2, x_3, \dots, x_m)$ represents the minimum value of the criterion observed by the alternative.

3. *Calculation of weighted matrix (V) elements:*

$$X = \begin{matrix} A_1 \\ A_2 \\ \dots \\ A_n \end{matrix} \begin{bmatrix} C_1 & C_2 & \dots & C_n \\ V_{11} & V_{12} & \dots & V_{1n} \\ V_{21} & V_{22} & \dots & V_{2n} \\ \dots & \dots & \dots & \dots \\ V_{m1} & V_{m2} & \dots & V_{mn} \end{bmatrix} \quad (5)$$

The weighted matrix elements (V) are calculated based on the formula:

$$vij = (wi * tij) + wi \quad (6)$$

By applying formula (6) a weighted matrix (V) is obtained, which can also be written as follows:

$$X = \begin{bmatrix} W_1 * T_{11} * W_1 & W_2 * T_{12} * W_2 & \dots & W_n * T_{1n} * W_n \\ W_1 * T_{21} * W_1 & W_2 * T_{22} * W_2 & \dots & W_n * T_{2n} * W_n \\ \dots & \dots & \dots & \dots \\ W_1 * T_{m1} * W_1 & W_2 * T_{m2} * W_2 & \dots & W_n * T_{mn} * W_n \end{bmatrix} \quad (7)$$

where "n" represents the total number of criteria, "m" represents the total number of alternatives.

4. *Determination of border approximate area matrix (G):*

The estimated boundary area for each criterion is determined according to the formula:

$$X = (\prod_{j=1}^m V_{ij})^{1/m} \quad (8)$$

where v_{ij} displays the weighted matrix elements (V), "m" presents the total number of alternatives.

After calculating the g_i values based on the criteria, it forms a matrix of approximate border areas G of the form $n \times 1$ ("n" represents the total number of criteria by which the offered alternatives are selected):

$$G = \begin{bmatrix} C_1 & C_2 & \dots & C_n \\ g_1 & g_2 & \dots & g_n \end{bmatrix} \tag{9}$$

5. Calculation of matrix elements of alternative distance from the border approximate area (Q):

$$Q = \begin{bmatrix} q_{11} & q_{12} & \dots & q_{1n} \\ q_{21} & q_{22} & \dots & q_{2n} \\ \dots & \dots & \dots & \dots \\ q_{m1} & q_{m2} & \dots & q_{mn} \end{bmatrix} \tag{10}$$

The alternative distance from the approximate boundary area (q_{ij}) is determined as the difference of the weighted matrix elements (V) and the approximate border area value (G), which can be written in another way:

$$V = \begin{bmatrix} v_{11}-g_1 & v_{12}-g_2 & \dots & v_{1n}-g_n \\ v_{21}-g_1 & v_{22}-g_2 & \dots & v_{2n}-g_n \\ \dots & \dots & \dots & \dots \\ v_{m1}-g_1 & v_{m2}-g_2 & \dots & v_{mn}-g_n \end{bmatrix} \tag{11}$$

where g_i presents the approximate border area for criterion C_i, v_{ij} presents the weighted matrix elements (V), “n” presents the number of criteria, “m” presents the number of alternatives. Alternative A_i can belong to the border estimate area (G), upper estimate area (G+) or lower estimate area (G-), namely: A_i ∈ {GvG+ vG-}. The upper forecast area (G+) presents the area where the ideal alternative lies (A+), while the lower forecast area (G-) presents the area where the anti-ideal alternative lies (A-). or G- is determined based on formula (13):

$$A_{ie} = \begin{cases} G^+ifg_{ij} > 0 \\ G \quad fg_{ij} = 0 \\ G^-ifg_{ij} > 0 \end{cases} \tag{12}$$

To be selected as the best of the set, alternative A_i must belong to the upper estimate area (G+) by as many criteria as possible. For example, if the alternative A_i belongs to the upper estimate area by 5 criteria (out of a total of 6 criteria), and by one criterion it belongs to the lower estimate area (G-), this means that According to the 5 criteria it is close to or equal to the ideal alternative, but by one criterion it is close to or equal to the anti-ideal alternative. A higher value *gieG+* indicates that alternative A_i is closer to the ideal alternative, while a smaller value *gieG-* indicates that alternative A_i is closer to the anti-ideal alternative.

6. Ranking alternatives:

Calculation of the criteria function values with alternatives is obtained as the sum of the alternative distances from the estimated border area (q_i). Adding the elements of the matrix Q with a line obtains the final value of the alternative criterion function:

$$S_i = \sum_{j=1}^n q_{ij}, j=1,2,\dots,n; i=1,2,\dots,m \tag{13}$$

3. Analysis and Design

In this research, the Decision Support System (DSS) will be built using the Multi-Attribute Border Approximation Area Comparison (MABAC) method, which is a method developed by Pamucar and Cirovic in 2015, which is known as a method that can provide solutions in making decisions. decisions compared to other methods.

3.1. Analysis of the MABAC method process

In the analysis of testing the decision support system method used in determining the best village produce is the Multi-Attribute Border Approximation Area Comparison method, the following data is used as an analysis of testing this method:

Table 1: Research data

No	Crops (Village)	Alternative	Land area	Income from Each Harvest	The number of workers	Many Harvests Every Year
1	Palm oil (Dendang)	A1	> 100 Ha	> 500.000.000	>100 People	> 5.000 Tons
2	Palm oil (Perdamaian)	A2	> 50 – 100 Ha	> 250.000.000 - 500.000.000	50 - 100 People	> 5.000 Tons
3	Grain (Banyumas)	A3	25 – 50 Ha	100.000.000 - 250.000.000	50 - 100 People	1000 - 2.500 Tons
4	Chilli (Banyumas)	A4	< 25 Ha	< 100.000.000	>100 People	<1000 Tons
5	Grain (Karang Rejo)	A5	25 – 50 Ha	100.000.000 - 250.000.000	50 - 100 People	>2.500 – 5.000 Tons
6	Palm oil (Kwala Begumit)	A6	> 50 – 100 Ha	> 500.000.000	>100 People	> 5.000 Tons
7	Palm oil (Ara Condong)	A7	25 – 50 Ha	< 100.000.000	>100 People	< 1.000 Tons
8	Sugarcane (Ara Condong)	A8	> 100 Ha	> 250.000.000 - 500.000.000	50 - 100 People	1000 - 2.500 Tons
9	Chocolate (Dendang)	A9	< 25 Ha	< 100.000.000	<50 People	< 1.000 Tons
10	Palm oil (Pantai Gemi)	A10	25 – 50 Ha	100.000.000 - 250.000.000	50 - 100 People	> 2.500 - 5.000 Tons
11	Grain (Sido Mulyo)	A11	< 25 Ha	< 100.000.000	<50 People	< 1.000 Tons
12	Corn (Sido Mulyo)	A12	> 50 – 100 Ha	> 500.000.000	50 - 100 People	1000 - 2.500 Tons
13	Sugarcane (Stabat Baru)	A13	25 – 50 Ha	100.000.000 - 250.000.000	>100 People	> 2.500 - 5.000 Tons
14	Chilli (Paya Mabar)	A14	< 25 Ha	100.000.000 - 250.000.000	<50 People	< 1.000 Tons
15	Chilli (Sido Mulyo)	A15	< 25 Ha	> 250.000.000 - 500.000.000	50 - 100 People	1000 - 2.500 Tons

Based on the research supporting data above, in order to further analyze the Multi-Attribute Border Approximation Area Comparison (MABAC) method, follow the following steps:

1. Define criteria

The following criteria are used as decision support in this research, namely:

Table 2: Decision support criteria

No	Criteria	Criteria Code	Criteria Description
1	Land area	K1	Criteria that assess the area of land from which agricultural products are planted will be assessed, because area area is an important factor in assessment, area is the main criterion
2	Income from Each Harvest	K2	Criteria that assess the income generated from agricultural products with estimates for each harvest
3	The number of workers	K3	Criteria that assess the number of workers who can work in a village using agricultural products
4	Many Harvests Every Year	K4	The criterion that assesses the number of harvests of these crops produced each year

2. Determining criteria weight

Next is to determine the weight of each criterion, which is as follows:

Table 3: Criteria weight

No	Criteria	Weight
1	Land area	40
2	Income from Each Harvest	30
3	The number of workers	20
4	Many Harvests Every Year	10

3. Criteria Weight Normalization

Normalization of criteria weights can be seen in the following table:

Table 4: Normalization of criteria weights

No	Criteria Code	Weight	Bobot	Proses	Hasil Normalisasi
1	K1	Land area	40	$\frac{40}{100}$	0,40
2	K2	Income from Each Harvest	30	$\frac{30}{100}$	0,30
3	K3	The number of workers	20	$\frac{20}{100}$	0,20
4	K4	Many Harvests Every Year	10	$\frac{10}{100}$	0,10
Total			100	$\frac{100}{100}$	1,00

4. Provide a match value for each criterion

The suitability parameter values are given at intervals of 1-100 for each criterion. The suitability values for each criterion in this study can be seen in the following tables:

Table 5: Land area criteria compatibility value (K1)

No	Match Parameters	Match Value Weight
1	>100 Ha	35
2	> 50 – 100 Ha	30
3	25 – 50 Ha	20
4	< 25 Ha	15

Table 6: Value of suitability of income criteria for each harvest (K2)

No	Match Parameters	Match Value Weight
1	> Rp. 500.000.000	35
2	> Rp. 250.000.000 – Rp. Rp. 500.000.000	30
3	Rp. 100.000.000 – Rp. Rp. 250.000.000	20
4	< Rp. 100.000.000	15

Table 7: Value of compatibility criteria number of workers (K3)

No	Match Parameters	Match Value Weight
1	>100 People	40
2	50 - 100 People	35
3	<50 People	25

Table 8: Value of suitability criteria for many harvests each year (K4)

No	Match Parameters	Match Value Weight
1	> 5.000 Tons	35

2	> 2.500 - 5.000 Tons	30
3	1.000 - 2.500 Tons	20
4	< 1.000 Tons	15

5. Transform alternative data with weighted suitability values from criteria
 The alternative data transformation above can be seen in the following table:

Table 9: Data alternative transformation

No	Alternative	Criteria			
		K1	K2	K3	K4
1	A1	35	35	40	35
2	A2	30	30	35	35
3	A3	20	20	35	20
4	A4	15	15	40	15
5	A5	20	20	35	30
6	A6	30	35	40	35
7	A7	20	15	40	15
8	A8	35	30	35	20
9	A9	15	15	25	15
10	A10	20	20	35	30
11	A11	15	15	25	15
12	A12	30	35	35	20
13	A13	20	20	40	30
14	A14	15	20	25	15
15	A15	15	30	35	20
	X⁺	35	35	40	35
	X⁻	15	15	25	15

6. Form the initial decision matrix (X)
 The decision matrix is symbolized by X, the matrix can be seen as follows:

$$X = [X_{ij}] = \begin{matrix} \begin{matrix} 35 & 35 & 40 & 35 \\ 30 & 30 & 35 & 35 \\ 20 & 20 & 35 & 20 \\ 15 & 15 & 40 & 15 \\ 20 & 20 & 35 & 30 \\ 30 & 35 & 40 & 35 \\ 20 & 15 & 40 & 15 \\ 35 & 30 & 35 & 20 \\ 15 & 15 & 25 & 15 \\ 20 & 20 & 35 & 30 \\ 15 & 15 & 25 & 15 \\ 30 & 35 & 35 & 20 \\ 20 & 20 & 40 & 30 \\ 15 & 20 & 25 & 15 \\ 15 & 30 & 35 & 20 \end{matrix} \end{matrix}$$

7. Normalization of initial matrix elements (T)

The next step, according to the equation $T_{ij} = \frac{X_{ij}-X_1^-}{X_1^+-X_1^-}$ is to determine the normalization value for each criterion for each alternative, and make it into a normalization matrix. The detailed calculations for each criterion and alternative are as follows:

- Column 1 Normalization (Land Area) :

$$\text{Max}\{X_{i1}\} = 35$$

$$\text{Min}\{X_{i1}\} = 15$$

$$T_{11} = \frac{X_{11}-X_1^-}{X_1^+-X_1^-} = \frac{35-15}{35-15} = 1,000$$

$$T_{21} = \frac{X_{21}-X_1^-}{X_1^+-X_1^-} = \frac{30-15}{35-15} = 0,750$$

$$T_{31} = \frac{X_{31}-X_1^-}{X_1^+-X_1^-} = \frac{20-15}{35-15} = 0,250$$

$$T_{41} = \frac{X_{41}-X_1^-}{X_1^+-X_1^-} = \frac{15-15}{35-15} = 0,000$$

$$T_{51} = \frac{X_{51}-X_1^-}{X_1^+-X_1^-} = \frac{20-15}{35-15} = 0,250$$

$$T_{61} = \frac{X_{61}-X_1^-}{X_1^+-X_1^-} = \frac{30-15}{35-15} = 0,750$$

$$T_{71} = \frac{X_{71}-X_1^-}{X_1^+-X_1^-} = \frac{20-15}{35-15} = 0,250$$

$$T_{81} = \frac{X_{81}-X_1^-}{X_1^+-X_1^-} = \frac{35-15}{35-15} = 1,000$$

$$T_{91} = \frac{X_{91}-X_1^-}{X_1^+-X_1^-} = \frac{15-15}{35-15} = 0,000$$

$$T_{10-1} = \frac{X_{10-1}-X_1^-}{X_1^+-X_1^-} = \frac{20-15}{35-15} = 0,250$$

$$T_{11-1} = \frac{X_{11-1} - X_1^-}{X_1^+ - X_1^-} = \frac{15-15}{35-15} = 0,000$$

$$T_{12-1} = \frac{X_{12-1} - X_1^-}{X_1^+ - X_1^-} = \frac{30-15}{35-15} = 0,750$$

$$T_{13-1} = \frac{X_{13-1} - X_1^-}{X_1^+ - X_1^-} = \frac{20-15}{35-15} = 0,250$$

$$T_{14-1} = \frac{X_{14-1} - X_1^-}{X_1^+ - X_1^-} = \frac{15-15}{35-15} = 0,000$$

$$T_{15-1} = \frac{X_{15-1} - X_1^-}{X_1^+ - X_1^-} = \frac{15-15}{35-15} = 0,000$$

- Column 2 Normalization (Income from Each Harvest) :

$$\text{Max}\{X_{i2}\} = 35$$

$$\text{Min}\{X_{i2}\} = 15$$

$$T_{12} = \frac{X_{12} - X_2^-}{X_2^+ - X_2^-} = \frac{35-15}{35-15} = 1,000$$

$$T_{22} = \frac{X_{22} - X_2^-}{X_2^+ - X_2^-} = \frac{30-15}{35-15} = 0,750$$

$$T_{32} = \frac{X_{32} - X_2^-}{X_2^+ - X_2^-} = \frac{20-15}{35-15} = 0,250$$

$$T_{42} = \frac{X_{42} - X_2^-}{X_2^+ - X_2^-} = \frac{15-15}{35-15} = 0,000$$

$$T_{52} = \frac{X_{52} - X_2^-}{X_2^+ - X_2^-} = \frac{20-15}{35-15} = 0,250$$

$$T_{62} = \frac{X_{62} - X_2^-}{X_2^+ - X_2^-} = \frac{35-15}{35-15} = 1,000$$

$$T_{72} = \frac{X_{72} - X_2^-}{X_2^+ - X_2^-} = \frac{15-15}{35-15} = 0,000$$

$$T_{82} = \frac{X_{82} - X_2^-}{X_2^+ - X_2^-} = \frac{30-15}{35-15} = 0,750$$

$$T_{92} = \frac{X_{92} - X_2^-}{X_2^+ - X_2^-} = \frac{15-15}{35-15} = 0,000$$

$$T_{10-2} = \frac{X_{10-2} - X_2^-}{X_2^+ - X_2^-} = \frac{20-15}{35-15} = 0,250$$

$$T_{11-2} = \frac{X_{11-2} - X_2^-}{X_2^+ - X_2^-} = \frac{15-15}{35-15} = 0,000$$

$$T_{12-2} = \frac{X_{12-2} - X_2^-}{X_2^+ - X_2^-} = \frac{35-15}{35-15} = 1,000$$

$$T_{13-2} = \frac{X_{13-2} - X_2^-}{X_2^+ - X_2^-} = \frac{20-15}{35-15} = 0,250$$

$$T_{14-2} = \frac{X_{14-2} - X_2^-}{X_2^+ - X_2^-} = \frac{20-15}{35-15} = 0,250$$

$$T_{15-2} = \frac{X_{15-2} - X_2^-}{X_2^+ - X_2^-} = \frac{30-15}{35-15} = 0,750$$

- Normalization of Column 3 (Number of Workers):

$$\text{Max}\{X_{i3}\} = 40$$

$$\text{Min}\{X_{i3}\} = 25$$

$$T_{13} = \frac{X_{13} - X_3^-}{X_3^+ - X_3^-} = \frac{40-25}{40-25} = 1,000$$

$$T_{23} = \frac{X_{23} - X_3^-}{X_3^+ - X_3^-} = \frac{35-25}{40-25} = 0,667$$

$$T_{33} = \frac{X_{33} - X_3^-}{X_3^+ - X_3^-} = \frac{35-25}{40-25} = 0,667$$

$$T_{43} = \frac{X_{43} - X_3^-}{X_3^+ - X_3^-} = \frac{40-25}{40-25} = 1,000$$

$$T_{53} = \frac{X_{53} - X_3^-}{X_3^+ - X_3^-} = \frac{35-25}{40-25} = 0,667$$

$$T_{63} = \frac{X_{63} - X_3^-}{X_3^+ - X_3^-} = \frac{40-25}{40-25} = 1,000$$

$$T_{73} = \frac{X_{73} - X_3^-}{X_3^+ - X_3^-} = \frac{40-25}{40-25} = 1,000$$

$$T_{83} = \frac{X_{83} - X_3^-}{X_3^+ - X_3^-} = \frac{35-25}{40-25} = 0,667$$

$$T_{93} = \frac{X_{93} - X_3^-}{X_3^+ - X_3^-} = \frac{25-25}{40-25} = 0,000$$

$$T_{10-3} = \frac{X_{10-3} - X_3^-}{X_3^+ - X_3^-} = \frac{35-25}{40-25} = 0,667$$

$$T_{11-3} = \frac{X_{11-3} - X_3^-}{X_3^+ - X_3^-} = \frac{25-25}{40-25} = 0,000$$

$$T_{12-3} = \frac{X_{12-3} - X_3^-}{X_3^+ - X_3^-} = \frac{35-25}{40-25} = 0,667$$

$$T_{13-3} = \frac{X_{13-3} - X_3^-}{X_3^+ - X_3^-} = \frac{40-25}{40-25} = 1,000$$

$$T_{14-3} = \frac{X_{14-3} - X_3^-}{X_3^+ - X_3^-} = \frac{25-25}{40-25} = 0,000$$

$$T_{15-3} = \frac{X_{15-3} - X_3^-}{X_3^+ - X_3^-} = \frac{35-25}{40-25} = 0,667$$

- Column 4 Normalization (Many Harvests Each Year):

$$\text{Max}\{X_{i4}\} = 35$$

$$\text{Min}\{X_{i4}\} = 15$$

$$T_{14} = \frac{X_{14} - X_4^-}{X_4^+ - X_4^-} = \frac{35-15}{35-15} = 1,000$$

$$\begin{aligned}
 T_{24} &= \frac{X_{24} - X_4^-}{X_4^+ - X_4^-} = \frac{35-15}{35-15} = 1,000 \\
 T_{34} &= \frac{X_{34} - X_4^-}{X_4^+ - X_4^-} = \frac{20-15}{35-15} = 0,250 \\
 T_{54} &= \frac{X_{54} - X_4^-}{X_4^+ - X_4^-} = \frac{35-15}{35-15} = 0,750 \\
 T_{64} &= \frac{X_{64} - X_4^-}{X_4^+ - X_4^-} = \frac{35-15}{35-15} = 1,000 \\
 T_{74} &= \frac{X_{74} - X_4^-}{X_4^+ - X_4^-} = \frac{15-15}{35-15} = 0,000 \\
 T_{84} &= \frac{X_{84} - X_4^-}{X_4^+ - X_4^-} = \frac{20-15}{35-15} = 0,250 \\
 T_{94} &= \frac{X_{94} - X_4^-}{X_4^+ - X_4^-} = \frac{15-15}{35-15} = 0,000 \\
 T_{10-4} &= \frac{X_{10-4} - X_4^-}{X_4^+ - X_4^-} = \frac{35-15}{35-15} = 0,750 \\
 T_{11-4} &= \frac{X_{11-4} - X_4^-}{X_4^+ - X_4^-} = \frac{15-15}{35-15} = 0,000 \\
 T_{12-4} &= \frac{X_{12-4} - X_4^-}{X_4^+ - X_4^-} = \frac{20-15}{35-15} = 0,250 \\
 T_{13-4} &= \frac{X_{13-4} - X_4^-}{X_4^+ - X_4^-} = \frac{35-15}{35-15} = 0,750 \\
 T_{14-4} &= \frac{X_{14-4} - X_4^-}{X_4^+ - X_4^-} = \frac{15-15}{35-15} = 0,000 \\
 T_{15-4} &= \frac{X_{15-4} - X_4^-}{X_4^+ - X_4^-} = \frac{20-15}{35-15} = 0,250
 \end{aligned}$$

The results of the Xij matrix normalization process above are as follows:

X (ij) =

1,000	1,000	1,000	1,000
0,750	0,750	0,667	1,000
0,250	0,250	0,667	0,250
0,000	0,000	1,000	0,000
0,250	0,250	0,667	0,750
0,750	1,000	1,000	1,000
0,250	0,000	1,000	0,000
1,000	0,750	0,667	0,250
0,000	0,000	0,000	0,000
0,250	0,250	0,667	0,750
0,000	0,000	0,000	0,000
0,750	1,000	0,667	0,250
0,250	0,250	1,000	0,750
0,000	0,250	0,000	0,000
0,000	0,750	0,667	0,250

8. Calculation of Weighted Matrix Elements (V)

Calculation of the weighted normalized value using the equation $v_{ij} = w_i \cdot (t_{ij} + 1)$, the calculation is as follows:

Wi:

- W1 = 0,40
 - W2 = 0,30
 - W3 = 0,20
 - W4 = 0,10
- Column 1:
- V11 = 0,40 * (1,000 + 1) = 0,800
 - V21 = 0,40 * (0,750 + 1) = 0,700
 - V31 = 0,40 * (0,250 + 1) = 0,500
 - V41 = 0,40 * (0,000 + 1) = 0,400
 - V51 = 0,40 * (0,250 + 1) = 0,500
 - V61 = 0,40 * (0,750 + 1) = 0,700
 - V71 = 0,40 * (0,250 + 1) = 0,500
 - V81 = 0,40 * (1,000 + 1) = 0,800
 - V91 = 0,40 * (0,000 + 1) = 0,400
 - V10-1 = 0,40 * (0,250 + 1) = 0,500
 - V11-1 = 0,40 * (0,000 + 1) = 0,400
 - V12-1 = 0,40 * (0,750 + 1) = 0,700
 - V13-1 = 0,40 * (0,250 + 1) = 0,500
 - V14-1 = 0,40 * (0,000 + 1) = 0,400
 - V15-1 = 0,40 * (0,000 + 1) = 0,400
- Column 2:
- V12 = 0,30 * (1,000 + 1) = 0,600
 - V22 = 0,30 * (0,750 + 1) = 0,525
 - V32 = 0,30 * (0,250 + 1) = 0,375
 - V42 = 0,30 * (0,000 + 1) = 0,300
 - V52 = 0,30 * (0,250 + 1) = 0,375
 - V62 = 0,30 * (0,750 + 1) = 0,600
 - V72 = 0,30 * (0,000 + 1) = 0,300

$$\begin{aligned}
 V_{82} &= 0,30 * (0,750 + 1) = 0,525 \\
 V_{92} &= 0,30 * (0,000 + 1) = 0,300 \\
 V_{10-2} &= 0,30 * (0,250 + 1) = 0,375 \\
 V_{11-2} &= 0,30 * (0,000 + 1) = 0,300 \\
 V_{12-2} &= 0,30 * (1,000 + 1) = 0,600 \\
 V_{13-2} &= 0,30 * (0,250 + 1) = 0,375 \\
 V_{14-5} &= 0,30 * (0,250 + 1) = 0,375 \\
 V_{15-5} &= 0,30 * (0,750 + 1) = 0,525 \\
 \text{- Column 3:} \\
 V_{13} &= 0,20 * (1,000 + 1) = 0,400 \\
 V_{23} &= 0,20 * (0,667 + 1) = 0,333 \\
 V_{33} &= 0,20 * (0,667 + 1) = 0,333 \\
 V_{43} &= 0,20 * (1,000 + 1) = 0,400 \\
 V_{53} &= 0,20 * (0,667 + 1) = 0,333 \\
 V_{63} &= 0,20 * (1,000 + 1) = 0,400 \\
 V_{73} &= 0,20 * (1,000 + 1) = 0,400 \\
 V_{83} &= 0,20 * (0,667 + 1) = 0,333 \\
 V_{93} &= 0,20 * (0,000 + 1) = 0,200 \\
 V_{10-3} &= 0,20 * (0,667 + 1) = 0,333 \\
 V_{11-3} &= 0,20 * (0,000 + 1) = 0,200 \\
 V_{12-3} &= 0,20 * (0,667 + 1) = 0,333 \\
 V_{13-3} &= 0,20 * (1,000 + 1) = 0,400 \\
 V_{14-3} &= 0,20 * (0,000 + 1) = 0,200 \\
 V_{15-3} &= 0,20 * (0,667 + 1) = 0,333 \\
 \text{- Column 4:} \\
 V_{14} &= 0,10 * (1,000 + 1) = 0,200 \\
 V_{24} &= 0,10 * (1,000 + 1) = 0,200 \\
 V_{34} &= 0,10 * (0,250 + 1) = 0,125 \\
 V_{44} &= 0,10 * (0,000 + 1) = 0,100 \\
 V_{54} &= 0,10 * (0,750 + 1) = 0,175 \\
 V_{64} &= 0,10 * (1,000 + 1) = 0,200 \\
 V_{74} &= 0,10 * (0,000 + 1) = 0,100 \\
 V_{84} &= 0,10 * (0,250 + 1) = 0,125 \\
 V_{94} &= 0,10 * (0,000 + 1) = 0,100 \\
 V_{10-4} &= 0,10 * (0,750 + 1) = 0,175 \\
 V_{11-4} &= 0,10 * (0,000 + 1) = 0,100 \\
 V_{12-4} &= 0,10 * (0,250 + 1) = 0,125 \\
 V_{13-4} &= 0,10 * (0,750 + 1) = 0,175 \\
 V_{14-4} &= 0,10 * (0,000 + 1) = 0,100 \\
 V_{15-4} &= 0,10 * (0,250 + 1) = 0,125
 \end{aligned}$$

The results of the calculation of the weighted normalized matrix above can be seen in the following table:

Table 10: Weighted retention value

No	Alternative	Criteria			
		K1	K2	K3	K4
1	A1	0,800	0,600	0,400	0,200
2	A2	0,700	0,525	0,333	0,200
3	A3	0,500	0,375	0,333	0,125
4	A4	0,400	0,300	0,400	0,100
5	A5	0,500	0,375	0,333	0,175
6	A6	0,700	0,600	0,400	0,200
7	A7	0,500	0,300	0,400	0,100
8	A8	0,800	0,525	0,333	0,125
9	A9	0,400	0,300	0,200	0,100
10	A10	0,500	0,375	0,333	0,175
11	A11	0,400	0,300	0,200	0,100
12	A12	0,700	0,600	0,333	0,125
13	A13	0,500	0,375	0,400	0,175
14	A14	0,400	0,375	0,200	0,100
15	A15	0,400	0,525	0,333	0,125

9. Determination of the approximate boundary area matrix (G)

The approximate boundary area for each criterion is determined according to the formula $X = (\prod_{j=1}^m V_{ij})^{1/m}$, the calculation is as follows:

$$G1 = (0,800 * 0,700 * 0,500 * 0,400 * 0,500 * 0,700 * 0,500 * 0,800 * 0,400 * 0,500 * 0,400 * 0,700 * 0,500 * 0,400 * 0,400)^{1/15} = 0,556$$

$$G2 = (0,600 * 0,525 * 0,375 * 0,300 * 0,375 * 0,600 * 0,300 * 0,525 * 0,300 * 0,375 * 0,300 * 0,600 * 0,375 * 0,375 * 0,525)^{1/15} = 0,414$$

$$G3 = (0,400 * 0,333 * 0,333 * 0,400 * 0,333 * 0,400 * 0,400 * 0,333 * 0,200 * 0,333 * 0,200 * 0,333 * 0,400 * 0,200 * 0,333)^{1/15} = 0,325$$

$$G4 = (0,200 * 0,200 * 0,125 * 0,100 * 0,175 * 0,200 * 0,100 * 0,125 * 0,100 * 0,175 * 0,100 * 0,125 * 0,175 * 0,100 * 0,125)^{1/15} = 0,138$$

10. Calculation of alternative distance matrix elements from the estimated border area (Q)

The process is as follows:

-
- Column 1:
 - Q11 = 0,800 - 0,556 = 0,244
 - Q21 = 0,700 - 0,556 = 0,144
 - Q31 = 0,500 - 0,556 = -0,056
 - Q41 = 0,400 - 0,556 = -0,156
 - Q51 = 0,500 - 0,556 = -0,056
 - Q61 = 0,700 - 0,556 = 0,144
 - Q71 = 0,500 - 0,556 = -0,056
 - Q81 = 0,800 - 0,556 = 0,244
 - Q91 = 0,400 - 0,556 = -0,156
 - Q10-1 = 0,500 - 0,556 = -0,056
 - Q11-1 = 0,400 - 0,556 = -0,156
 - Q12-1 = 0,700 - 0,556 = 0,144
 - Q13-1 = 0,500 - 0,556 = -0,056
 - Q14-1 = 0,400 - 0,556 = -0,156
 - Q15-1 = 0,400 - 0,556 = -0,156
- Column 2:
 - Q12 = 0,600 - 0,414 = 0,186
 - Q22 = 0,525 - 0,414 = 0,111
 - Q32 = 0,375 - 0,414 = -0,039
 - Q42 = 0,300 - 0,414 = -0,114
 - Q52 = 0,375 - 0,414 = -0,039
 - Q62 = 0,600 - 0,414 = 0,186
 - Q72 = 0,300 - 0,414 = -0,114
 - Q82 = 0,525 - 0,414 = 0,111
 - Q92 = 0,300 - 0,414 = -0,114
 - Q10-2 = 0,375 - 0,414 = -0,039
 - Q11-2 = 0,300 - 0,414 = -0,114
 - Q12-2 = 0,600 - 0,414 = 0,186
 - Q13-2 = 0,375 - 0,414 = -0,039
 - Q14-2 = 0,375 - 0,414 = -0,039
 - Q15-2 = 0,525 - 0,414 = 0,111
- Column 3:
 - Q13 = 0,400 - 0,325 = 0,075
 - Q23 = 0,333 - 0,325 = 0,008
 - Q33 = 0,333 - 0,325 = 0,008
 - Q43 = 0,400 - 0,325 = 0,075
 - Q53 = 0,333 - 0,325 = 0,008
 - Q63 = 0,400 - 0,325 = 0,075
 - Q73 = 0,400 - 0,325 = 0,075
 - Q83 = 0,333 - 0,325 = 0,008
 - Q93 = 0,200 - 0,325 = -0,125
 - Q10-3 = 0,333 - 0,325 = 0,008
 - Q11-3 = 0,200 - 0,325 = -0,125
 - Q12-3 = 0,333 - 0,325 = 0,008
 - Q13-3 = 0,400 - 0,325 = 0,075
 - Q14-3 = 0,200 - 0,325 = -0,125
 - Q15-3 = 0,333 - 0,325 = 0,008
- Column 4:
 - Q14 = 0,200 - 0,138 = 0,062
 - Q24 = 0,200 - 0,138 = 0,062
 - Q34 = 0,125 - 0,138 = -0,013
 - Q44 = 0,100 - 0,138 = -0,038
 - Q54 = 0,175 - 0,138 = 0,037
 - Q64 = 0,200 - 0,138 = 0,062
 - Q74 = 0,100 - 0,138 = -0,038
 - Q84 = 0,125 - 0,138 = -0,013
 - Q94 = 0,100 - 0,138 = -0,038
 - Q10-4 = 0,175 - 0,138 = 0,037
 - Q11-4 = 0,100 - 0,138 = -0,038
 - Q12-4 = 0,125 - 0,138 = -0,013
 - Q13-4 = 0,175 - 0,138 = 0,037

$$Q_{14-4} = 0,100 - 0,138 = -0,038$$

$$Q_{15-4} = 0,125 - 0,138 = -0,013$$

11. 11. Calculation of criteria function values with alternatives obtained as the sum of alternative distances from the estimated border area (Q_i).

Adding the elements of the matrix Q with the line, the final value of the alternative criterion function is obtained using the formula $S_i = \sum_{j=1}^n q_{ij}$. The calculation is as follows:

$$A1 = 0,244 + 0,186 + 0,075 + 0,062 = 0,566$$

$$A2 = 0,144 + 0,111 + 0,008 + 0,062 = 0,325$$

$$A3 = -0,056 + -0,039 + 0,008 + -0,013 = -0,100$$

$$A4 = -0,156 + -0,114 + 0,075 + -0,038 = -0,234$$

$$A5 = -0,056 + -0,039 + 0,008 + 0,037 = -0,050$$

$$A6 = 0,144 + 0,186 + 0,075 + 0,062 = 0,466$$

$$A7 = -0,056 + -0,114 + 0,075 + -0,038 = -0,134$$

$$A8 = 0,244 + 0,111 + 0,008 + -0,013 = 0,350$$

$$A9 = -0,156 + -0,114 + -0,125 + -0,038 = -0,434$$

$$A10 = -0,056 + -0,039 + 0,008 + 0,037 = -0,050$$

$$A11 = -0,156 + -0,114 + -0,125 + -0,038 = -0,434$$

$$A12 = 0,144 + 0,186 + 0,008 + -0,013 = 0,325$$

$$A13 = -0,056 + -0,039 + 0,075 + 0,037 = 0,016$$

$$A14 = -0,156 + -0,039 + -0,125 + -0,038 = -0,359$$

$$A15 = -0,156 + 0,111 + 0,008 + -0,013 = -0,050$$

From the results of calculating the ranking values above, the results of the ranking values can be seen in the following table:

Table 11: Ranking Results

No	Alternative	Rating Value	Rank
1	A1	0,566	1
2	A6	0,466	2
3	A8	0,350	3
4	A2	0,325	4
5	A12	0,325	5
6	A13	0,016	6
7	A15	-0,050	7
8	A5	-0,050	8
9	A10	-0,050	8
10	A3	-0,100	10
11	A7	-0,134	11
12	A4	-0,234	12
13	A14	-0,359	13
14	A9	-0,434	14
15	A11	-0,434	15

From the ranking results above, it was found that A1 was ranked first based on the results of the analysis of the Multi-Attribute Border Approximation Area Comparison (MABAC) method test, so it can be concluded that alternative 1 (A1) is the potential for agricultural products from the village.

3.2. System flow design

1. Flowchart

The flowchart created is to find out how the system carries out the process of determining the best village produce. The flowchart design is as follows:

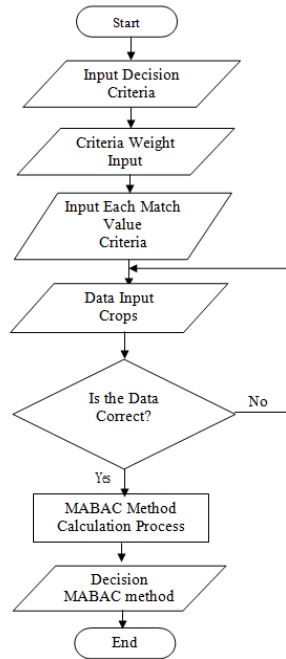


Fig. 2: Flowchart

2. Use Case Diagram

The use case diagram design is to show how the interaction between actors (users) and other users, the use case diagram design in the system to be built is as follows:

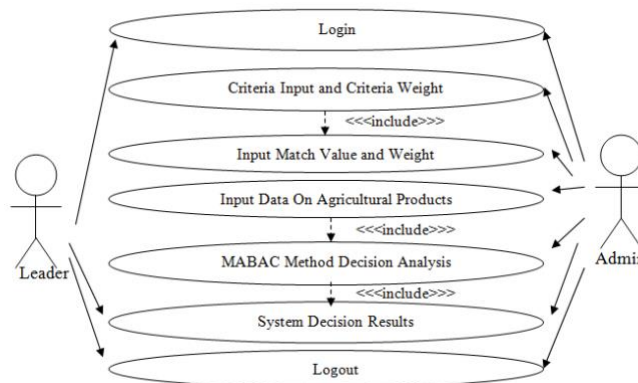


Fig. 3: Use case diagram

4. Results and Discussion

Implementation is a continuation process of applying the Multi-Attribute Border Approximation Area Comparison (MABAC) method to the system. The application of the MABAC method and the design of a decision support system that has been discussed in the previous chapter will be implemented in the best crop determination system that has been built. At this stage the Multi-Attribute Border Approximation Area Comparison (MABAC) method used in the decision process will be applied to the system program according to the system design that was previously designed. This implementation is carried out in the PHP programming language with a MySQL database.

After implementing the Multi-Attribute Border Approximation Area Comparison (MABAC) method and system design for the decision support system, to find out the results of implementing the system, it is necessary to test the system that has been built. The system test process is as follows:

1. System login



Fig. 4: System login page

2. Decision criteria data



Fig. 5: Decision criteria data page

3. Data on agricultural products



Fig. 6: Crop data page

4. MABAC method decision results

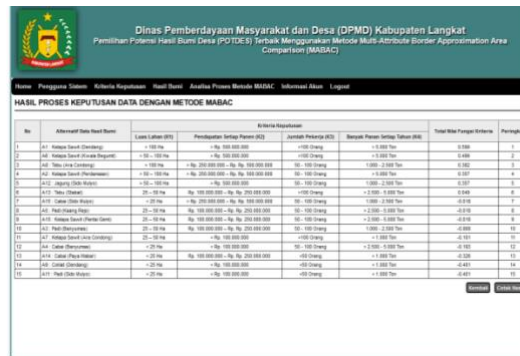


Fig. 7: MABAC method decision results page

5. Conclusion

The following are the conclusions that the authors wrote in this study related to the decision support system for selecting the best village agricultural potential using the Multi-Attribute Border Approximation Area Comparison (MABAC) method at the Community and Village Empowerment Service Langkat Regency, namely:

1. The system design was successfully built using the PHP programming language with a MySQL database. It has succeeded in determining the best produce from villages in Langkat Regency by implementing the MABAC method in decision support on the system.
2. In the system, the appropriate criteria to be used in supporting the final results of decisions that have been successfully analyzed and applied to the system are land area, income per harvest, number of workers and number of harvests each year.
3. The application of the Multi-Attribute Border Approximation Area Comparison (MABAC) method for a decision support system for selecting the best village agricultural potential has succeeded in determining the best agricultural produce from villages in Langkat Regency by utilizing the research data provided. So it is stated that the MABAC method is able to determine a decision from the results of ranking the criteria function values.

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