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# Modeling Productive Land Determination Using Entropy-Mabac Method Based on Multicriteria Data in Central Java Province

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**ABSTRACT**

Central Java Province has a diversity of land use characteristics that reflect the potential as well as challenges in regional development, so that optimization of productive land is important to support economic growth, community welfare, and environmental sustainability. For this reason, this research was conducted with an objective approach using the Entropy method in determining the weight of each criterion based on actual data variations, as well as the Multi-Attributive Border Approximation Area Comparison (MABAC) method to systematically evaluate and rank the level of land productivity in 35 districts/cities. The results of the analysis show that Demak, Brebes, and Rembang districts ranked the highest in land productivity with the highest score of 0.249, while Wonogiri and Banjarnegara districts ranked the lowest with scores of -0.392 and -0.234. Validation using the Spearman Rank test resulted in a correlation coefficient of 0.82, indicating strong agreement between the method results and historical data. The findings show that the combination of Entropy and MABAC methods is effective in determining productive land, and the results are relevant as a basis for formulating sustainable land use policies, including recommendations for irrigation development, farmland protection, and strengthening spatial policies for low productivity areas.



## I. INTRODUCTION

Central Java Province is one of the agricultural provinces in Indonesia, where land use has a very important role in supporting various economic sectors, especially in agriculture, plantations, and forestry [1]. Each regency/city in Central Java has different land use characteristics, reflecting the potential and development priorities of each region [2]. These diverse land use patterns affect how land resources are utilized to support community needs and drive regional economic growth. Land use optimization is a strategic step to ensure that the management of these resources can provide long-term benefits [3]. Therefore, it is very important to conduct an in-depth analysis of land use in each region to determine which land can be categorized as productive land.

Productive land is land that has the ability to provide optimal results when used in accordance with its function, be it for agriculture, plantations, forestry, or other sectors [4]. With the increasingly limited amount of land and the rapid changes in land functions due to urbanization and land conversion for non-agricultural purposes, the determination of productive land becomes very crucial [5]. Improper land management can lead to a decline in environmental quality and an imbalance in land resource utilization [6]. One of the challenges faced is how to evaluate and identify land that has high productivity potential using objective and systematic methods. Therefore, data-based policies and thorough analysis are needed to optimize the use of existing land.

In the context of land utilization, the application of decision support systems becomes very important to assist complex and data-driven decision-making processes [7]. A decision support system is a computer-based system designed to assist the process of evaluating and solving complex and unstructured problems, by involving input from decision makers or experts, based on a number of relevant criteria [8]. This system enables structured and efficient analysis in determining land use priorities according to certain criteria. For this reason, this research used the Entropy method approach for weighting and the Multi-Attributibutive Border Aproximation area Comparason (MABAC) method to determine ranking as a tool to identify and determine productive land in the Regency / City of Central Java Province. The criteria weighting method using the entropy approach utilizes the concept of entropy to assess the level of uncertainty in data, especially in the context of decision making with various criteria that must be considered [9]. The entropy method was chosen mainly because this approach uses objective statistical analysis, so as to minimize the influence of subjectivity in the process of determining criteria weights [10].

The Multi-Atributive Broder Approximation Area Comparison (MABAC) method is an approach in multi-criteria decision making used to assess alternatives based on a number of relevant and significant attributes [11]. The MABAC method was chosen because compared to other multi-criteria decision making methods such as SAW, COPRAS, MOORA, TOPSIS, and VIKOR, it produces more consistent ranking of solutions and is considered more reliable for rational decision making [12]. The basis of the MABAC method lies in determining the distance of the criterion function from each alternative under consideration, with reference to the approximate boundaries of the relevant area [13].

The Entropy method is used in this research because it is able to produce criteria weights objectively based on actual data distribution, without requiring subjective intervention from decision makers. Meanwhile, the Multi-Attributive Border Approximation Area Comparison (MABAC) method was chosen because it has the advantage of calculating the closeness of each alternative to the ideal solution directly, and does not require a complex normalization process. The combination of these two methods is considered effective in reducing potential bias in the multicriteria decision-making process and improving the consistency and reliability of the results obtained.

The data used in the study was taken from the Environment and Forestry Service of the Central Java Provincial Government regarding the area according to the main land use of districts / cities in Central Java Province 2023, which includes information on the area of non-agricultural land, rice fields, dry land, plantation land, forest land, and land area of water bodies in districts / cities in Central Java Province. This research has novelty value because there have not been many similar studies that specifically integrate the Entropy method approach and the Multi-Attributibutive Border Aproximation area Comparison (MABAC) method to determine productive land in Central Java. So the results are expected to make a significant contribution in formulating more appropriate land use policies, by prioritizing economic aspects, sustainability, and community welfare, through an objective approach in determining productive land using the Entropy method and the Multi-Attributibutive Border Aproximation area Comparason (MABAC) method.

## II. METHOD

Research methods are procedures or stages that are systematically designed to solve a problem, carried out sequentially in order to obtain an effective solution to the problem [14]. The stages can be seen in Figure 1:

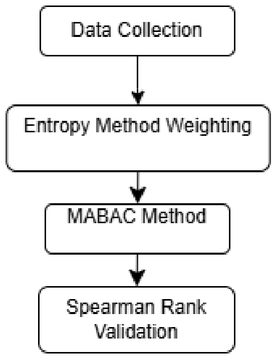


Figure 1. Research Stages

### *A. Data Collection*

The data taken is secondary data from the Department of Environment and Forestry of the Central Java Provincial Government in 2023. The dataset covers the area of land use for 35 districts/cities based on the main land categories, and is administrative aggregate data.

TABLE I
DATASET OF DISTRICT/CITY AREA OF CENTRAL JAVA PROVINCE 2023 (HA)

| N0 | District | Non-Agriculture | Rice Field | Dry | Plantation | Forest | Water Body |
|---|---|---|---|---|---|---|---|
| 1 | Banjarnegara | 12.467,17 | 12.209,04 | 69.303,93 | 0 | 19.604,75 | 253,04 |
| 2 | Banyumas | 23.653,72 | 36.321,43 | 45.150,82 | 1.284,55 | 32.110,99 | 622,71 |
| 3 | Batang | 12.127,95 | 14.386,96 | 34.416,71 | 6.519,62 | 17.612,77 | 590,98 |
| 4 | Blora | 21.950,33 | 72.082,69 | 17.029,94 | 171,82 | 83.338,25 | 687,07 |
| 5 | Boyolali | 34.748,61 | 21.349,41 | 33.747,61 | 0 | 17.633,36 | 744,53 |
| 6 | Brebes | 15.635,49 | 75.632,60 | 24.076,31 | 607,2 | 46.171,65 | 10.893,87 |
| 7 | Cilacap | 38.215,40 | 77.135,13 | 51.549,33 | 10.583,27 | 50.722,05 | 4.053,94 |
| 8 | Demak | 17.830,62 | 62.394,38 | 1.406,51 | 0 | 3.812,09 | 11.870,06 |
| 9 | Grobogan | 32.234,78 | 81.191,77 | 17.663,57 | 0 | 70.494,17 | 496,73 |
| 10 | Jepara | 21.428,01 | 16.521,05 | 38.963,87 | 4.129,09 | 18.714,67 | 1.745,19 |
| 11 | Karanganyar | 17.893,30 | 24.013,07 | 27.479,22 | 3.826,73 | 6.599,05 | 201,05 |
| 12 | Kebumen | 24.530,48 | 47.200,97 | 39.858,28 | 118,82 | 20.312,59 | 945,59 |
| 13 | Kendal | 15.780,97 | 22.088,23 | 34.744,44 | 8.225,10 | 14.736,20 | 4.823,18 |
| 14 | Klaten | 26.215,40 | 33.848,89 | 8.093,19 | 0 | 1.212,24 | 189,93 |
| 15 | Kudus | 10.520,96 | 21.041,57 | 10.420,97 | 63,86 | 2.559,55 | 102,06 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 16 | Magelang | 17.036,49 | 29.451,58 | 57.243,06 | 0 | 8.554,77 | 304,14 |
| 17 | Pati | 25.303,57 | 64.692,86 | 32.719,48 | 2.126,42 | 20.513,86 | 11.607,68 |
| 18 | Pekalongan | 10.161,26 | 25.361,55 | 17.918,87 | 3.037,42 | 30.638,88 | 2.145,14 |
| 19 | Pemalang | 13.986,96 | 39.816,70 | 24.673,04 | 1.033,05 | 30.791,16 | 3.269,74 |
| 20 | Purbalingga | 11.403,20 | 23.672,82 | 31.801,93 | 0 | 13.281,85 | 413,2 |
| 21 | Purworejo | 19.356,51 | 33.538,56 | 37.880,61 | 0 | 16.106,97 | 1.068,17 |
| 22 | Rembang | 12.259,07 | 52.725,31 | 9.838,89 | 0 | 25.767,62 | 2.427,30 |
| 23 | Semarang | 23.205,40 | 17.243,18 | 42.648,27 | 6.824,87 | 9.995,60 | 420,38 |
| 24 | Sragen | 25.881,02 | 37.295,19 | 25.555,67 | 1.879,82 | 5.835,71 | 1.083,44 |
| 25 | Sukoharjo | 19.144,23 | 20.938,25 | 7.477,78 | 951,13 | 419,78 | 264,39 |
| 26 | Tegal | 14.126,66 | 45.807,14 | 19.437,55 | 0 | 17.705,34 | 769,23 |
| 27 | Temanggung | 9.953,15 | 17.927,91 | 44.513,90 | 764,19 | 13.177,52 | 97,23 |
| 28 | Wonogiri | 21.628,98 | 34.213,81 | 100.772,84 | 0 | 25.619,32 | 483,35 |
| 29 | Wonosobo | 7.130,80 | 6.617,11 | 66.875,38 | 748,48 | 18.159,64 | 107,3 |
| 30 | Kota Magelang | 1.429,65 | 268,84 | 77,88 | 0 | 77,53 | 0,78 |
| 31 | Pekalongan City | 2.752,99 | 1.189,55 | 0,001 | 0 | 0 | 673,05 |
| 32 | Salatiga City | 3.589,71 | 873,27 | 743,01 | 288,34 | 0 | 0 |
| 33 | Semarang City | 21.628,29 | 1.948,69 | 9.766,94 | 483,16 | 2.172,93 | 708,48 |
| 34 | Surakarta City | 4.598,69 | 21,86 | 0,001 | 0 | 0 | 47,59 |
| 35 | Tegal City | 2.344,02 | 607,45 | 13,52 | 0 | 0 | 929,28 |

Source: Environment and Forestry Service of Central Java Provincial Goverment, 2023

The data above is from the data of the Department of Environment and Forestry of the Central Java Provincial Government, 2023 the value of 0.001 in criteria 3 of Pekalongan city and Surakarta city, the actual value is 0. Written 0.001 because to facilitate the calculation without changing the value of the 0 value.

In this study, the alternatives used consist of 35 administrative regions covering all districts and cities in Central Java Province, each of which is analyzed as a decision-making unit. Meanwhile, the criteria used to assess land productivity include six main aspects, namely non-agricultural land area, paddy land area, dry land area, plantation land area, forest land area, and water body land area. These criteria were taken from secondary data from the Central Java Provincial Environment and Forestry Office (2023), with the data unit being the land area in hectares for each category per district/city. These criteria were chosen because they represent the main dimensions of agricultural and ecological productivity.

TABLE II
CRITERIA

| Code | Criteria (Ha) | Type | Brief Explanation | Data Source |
|---|---|---|---|---|
| C1 | Non-agricultural Land Area | Cost | Representing productive land conversion | Environment and Forestry Service of Central Java Provincial Government, 2023 |
| C2 | Rice Field Area | Benefit | Direct representation of productive agricultural land | Environment and Forestry Service of Central Java Provincial Government, 2023 |
| C3 | Dry Land Area | Cost | Area with limited potential without irrigation | Environment and Forestry Service of Central Java Provincial Government, 2023 |
| C4 | Plantation Land Area | Benefit | Supporting high-value agricultural products | Environment and Forestry Service of Central Java Provincial Government, 2023 |
| C5 | Forest Land Area | Benefit | Supporting ecological sustainability and economic resources | Environment and Forestry Service of Central Java Provincial Government, 2023 |
| C6 | Land Area of Water Bodies | Benefit | Supports irrigation and environmental resilience | Environment and Forestry Service of Central Java Provincial Government, 2023 |

In the context of this study, productive land is defined as land that has a high potential to support the agricultural sector, including agriculture, plantations, forestry and surface water systems, quantitatively measured by the area of these lands. Non-agricultural lands and drylands are considered less productive if they are not under special management.

## *B. Entropy Weighting*

The Entropy method is one of the weighting techniques in decision support systems that serves to determine the weight of each criterion based on a predetermined level of relevance [15] [16]. The Entropy method determines criteria weights objectively based on the degree of spread or dispersion of numerical data values, without involving the subjective judgment of the decision maker [17]. The stages of the Entropy method are as follows:

1. *Create a decision matrix (Decision Matrix)*

$$X = \begin{bmatrix} x_{11} & x_{12} & x_{1n} \\ x_{21} & x_{22} & x_{2n} \\ x_{m1} & x_{m2} & x_{mn} \end{bmatrix} \quad (1)$$

Where m is the number of alternatives, n is the number of criteria, and $x_{ij}$ states the assessment of alternative Ai on criteria Cj.

2. *Normalization of the decision matrix*

$$r_{ij} = \frac{x_{ij}}{max(x_{ij})} \quad \text{Benefit Criteria} \qquad (2)$$

$$r_{ij} = \frac{\min(x_{ij})}{x_{ij}} \quad \text{Cost Criteria} \qquad (3)$$

Where rij is the normalized value of element xij in alternative i and criterion j, xij is the assessment of alternative Ai on criterion Cj, Max(xij) is the maximum value of criterion j in all alternatives and Min(xij) states the minimum value of criterion j in all alternatives.

3. *Calculating the proportion value*

$$P_{ij} = \frac{r_{ij}}{\sum_{i=1}^{m} r_{ij}} \qquad (4)$$

$p_{ij}$ is the proportion of element $r_{ij}$, $r_{ij}$ states the value of the element in the normalized decision matrix and m is the number of alternatives.

4. *Menghitung nilai entropy*

$$E_j = \left[\frac{-1}{\ln m}\right] \sum_{i=1}^{n} \left[p_{ij} * ln(p_{ij})\right] \qquad (5)$$

Symbol $E_j$ is the entropy value for criterion j, m is the number of alternatives, n states the number of criteria, $p_{ij}$ is the value of alternative i on criterion j, which has been normalized into a proportion and ln is the natural logarithm function.

5. *Calculating the dispersion value*

$$d_j = 1 - E_j \qquad (6)$$

Where $d_j$ is the dispersion value for criterion j and $E_j$ is the entropy value for criterion j.

6. *Calculating criteria weights*

$$\mathcal{W}_j = \frac{d_j}{\sum_{j=1}^{n} d_j} \qquad (7)$$

Where $w_j$ is the weight for criterion j, dj is the dospersion value for criterion j and n is the number of criteria.

## C. MABAC Method

The Multi-Atributive Border Appoximation Area Comparison (MABAC) method, developed by Pamucar and Cirovic, bases its approach on measuring the distance of the criteria of each alternative to an area that represents the approximate boundary [18] [19] [20]. The following are the stages of the MABAC method:

1. *Create an Initial Decision Matrix (X)*

$$X = \begin{matrix} A_1 \\ A_2 \\ A_3 \\ \cdots\cdots \\ A_n \end{matrix} \begin{pmatrix} X_{11} & \cdots\cdots & X_{mn} \\ X_{21} & \cdots\cdots & X_{mn} \\ X_{1m} & \cdots\cdots & X_{mn} \end{pmatrix} \qquad (8)$$

Where m is the number of alternatives, n is the total number of criteria.

2. *Normalization of initial matrix elements (N)*

Benefit Criteria Type:

$$t_{ij} = \frac{X_{ij} - X_i^-}{X_i^+ - X_i^-} \qquad (9)$$

Cost Criteria Type:

$$t_{ij} = \frac{X_{ij} - X_i^+}{X_i^- - X_i^+} \qquad (10)$$

$X_i^+$ is max (x1, x2, x3, ..., xm) representing the maximum value of the criteria observed by the alternative and $X_i^-$ is min (x1, x2, x3, ..., xm) representing the minimum value of the criteria observed by the alternative.

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

$$V_{ij} = (\mathcal{W}_i \, x \, t_{ij}) + \mathcal{W}_i \qquad (11)$$

Where $w_i$ is presenting the criteria weight coefficient and $t_{ij}$ is presenting the normalized matrix element (N).

4. *Determination of the border forecast area matrix (G)*

$$g_i = \left[\prod_{j=1}^{m} v_{ij}\right]^{\frac{1}{m}} \qquad (12)$$

$V_{ij}$ is displaying the weighted matrix elements (V) and m is presenting the total number of alternatives.

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

$$Q = V - G \qquad (13)$$

The symbol V denotes the weighted matrix element and G is the border forecast area matrix.

6. *Ranking of alternatives (S)*

$$S_i = \sum_{j=1}^{n} Q_{ij}, \; j = 1,2 \ldots n, \; i = 1,2 \ldots m \qquad (14)$$

Where n is criteria and m is alternatives.

## D. Spearman Rank Validation

The validation process is a stage to compare the results of a method with factual data or real events known as historical data [21].

# III. Results and Discussion

This research uses the Entropy method for weighting criteria and the MABAC method for ranking alternatives in determining productive land in Central Java Province. This analysis aims to identify lands that have high productivity potential based on several main criteria, such as non-agricultural land area, paddy fields, dry land, plantation land, forests, and water bodies. This assessment not only identifies lands with the best potential but also emphasizes the importance of sustainable management, so that land use can provide optimal results in the long term. With this approach, it is expected that the research results can provide more accurate and data-based recommendations in determining which lands are suitable for development, in accordance with development goals and environmental sustainability.

### A. Alternatives

These alternatives are several options that have been determined and then assessed and selected the best one. In this study there are 35 alternatives, namely the Regency / City in Central Java Province, which can be seen in Table 3.

TABLE III
ALTERNATIVE DATA

| Code | Alternative | Code | Alternative |
|---|---|---|---|
| A1 | Banjarnegara | A19 | Pemalang |
| A2 | Banyumas | A20 | Purbalingga |
| A3 | Batang | A21 | Purworejo |
| A4 | Blora | A22 | Rembang |
| A5 | Boyolali | A23 | Semarang |
| A6 | Brebes | A24 | Sragen |
| A7 | Cilacap | A25 | Sukoharjo |
| A8 | Demak | A26 | Tegal |
| A9 | Grobogan | A27 | Temanggung |
| A10 | Jepara | A28 | Wonogiri |
| A11 | Karanganyar | A29 | Wonosobo |
| A12 | Kebumen | A30 | Magelang City |
| A13 | Kendal | A31 | Pekalongan City |
| A14 | Klaten | A32 | Salatiga City |
| A15 | Kudus | A33 | Semarang City |
| A16 | Magelang | A34 | Surakarta City |
| A17 | Pati | A35 | Tegal City |
| A18 | Pekalongan | | |

### B. Criteria

Criteria in a decision support system is a consideration used in the decision-making process. The criteria data taken in this study regarding land area are listed in Table 4.

TABLE IV
CRITERIA DATA

| Code | Criteria (Ha) | Type |
|---|---|---|
| C1 | Non-agricultural Land Area | Cost |
| C2 | Rice Field Area | Benefit |
| C3 | Dry Land Area | Cost |
| C4 | Plantation Land Area | Benefit |
| C5 | Forest Land Area | Benefit |
| C6 | Land Area of Water Bodies | Benefit |

The data contains two types of criteria, namely benefit criteria and cost criteria. The benefit criterion is the area of land that is profitable, which includes the area of rice fields, the area of plantations, the area of forest land and the area of water bodies. Conversely, the cost criterion covers the area of non-agricultural land which is considered less productive land because it tends to reduce agricultural potential and the area of dry land is less productive if there is no adequate management or irrigation effort.

### C. Application of Entropy Method

The entire application of the Entropy method is to provide accurate criteria weight values with the calculations in the Entropy method.

1. *Creating a decision matrix*

The initial step in applying the Entropy method is to compile a decision matrix that contains the performance value of each alternative against each criterion. This matrix is then normalized to eliminate differences in scale between criteria, so that data can be compared equally in the next weighting process. The results can be seen in Table 5 as follows.

TABLE V
DECISION MATRIX

| C1 | C2 | C3 | C4 | C5 | C6 |
|---|---|---|---|---|---|
| 12.467,17 | 12.209,04 | 69.303,93 | 0 | 19.604,75 | 253,04 |
| 23.653,72 | 36.321,43 | 45.150,82 | 1.284,55 | 32.110,99 | 622,71 |
| 12.127,95 | 14.386,96 | 34.416,71 | 6.519,62 | 17.612,77 | 590,98 |
| 21.950,33 | 72.082,69 | 17.029,94 | 171,82 | 83.338,25 | 687,07 |
| 34.748,61 | 21.349,41 | 33.747,61 | 0 | 17.633,36 | 744,53 |
| - | - | - | - | - | - |
| 2.752,99 | 1.189,55 | 0,001 | 0 | 0 | 673,05 |
| 3.589,71 | 873,27 | 743,01 | 288,34 | 0 | 0 |
| 21.628,29 | 1.948,69 | 9.766,94 | 483,16 | 2.172,93 | 708,48 |
| 4.598,69 | 21,86 | 0,001 | 0 | 0 | 47,59 |
| 2.344,02 | 607,45 | 13,52 | 0 | 0 | 929,28 |

2. *Normalization of the decision matrix*

Normalization of the decision matrix is an important step in the Entropy method that aims to equalize the values between criteria. With normalization, each element in the matrix is converted into a proportion relative to the total value of the criteria, thus enabling an objective comparison. The results can be seen in Table 6 as follows.

TABLE VI
MATRIX NORMALIZATION

| C1 | C2 | C3 | C4 | C5 | C6 |
|---|---|---|---|---|---|
| 0,115 | 0,150 | 0,000 | 0,000 | 0,235 | 0,021 |
| 0,060 | 0,447 | 0,000 | 0,121 | 0,385 | 0,052 |
| 0,118 | 0,177 | 0,000 | 0,616 | 0,211 | 0,050 |
| 0,065 | 0,888 | 0,000 | 0,016 | 1,000 | 0,058 |
| 0,041 | 0,263 | 0,000 | 0,000 | 0,212 | 0,063 |
| - | - | - | - | - | - |
| 0,519 | 0,015 | 0,000 | 0,000 | 0,000 | 0,057 |
| 0,398 | 0,011 | 0,000 | 0,027 | 0,000 | 0,000 |
| 0,066 | 0,024 | 0,000 | 0,046 | 0,026 | 0,060 |
| 0,311 | 0,000 | 0,000 | 0,000 | 0,000 | 0,004 |
| 0,610 | 0,007 | 0,000 | 0,000 | 0,000 | 0,078 |
| ∑5,445 | ∑13,119 | ∑0,447 | ∑5,071 | ∑7,733 | ∑5,579 |

3. *Calculating the proportion value*

The next step is to calculate the proportion value, which is the ratio between the normalized value of each alternative to the total value of the criteria concerned. This value is the basis for measuring the relative contribution of each element to the overall criteria information. The results of the proportion value can be seen in Table 7.

TABLE VII
PROPORTION VALUE

| C1 | C2 | C3 | C4 | C5 | C6 |
|---|---|---|---|---|---|
| 0,021 | 0,011 | 0,000 | 0,000 | 0,030 | 0,004 |
| 0,011 | 0,034 | 0,000 | 0,024 | 0,050 | 0,010 |
| 0,022 | 0,013 | 0,000 | 0,121 | 0,027 | 0,009 |
| 0,012 | 0,067 | 0,000 | 0,003 | 0,129 | 0,011 |
| 0,008 | 0,020 | 0,000 | 0,000 | 0,027 | 0,011 |
| - | - | - | - | - | - |
| 0,095 | 0,001 | 0,000 | 0,000 | 0,000 | 0,010 |
| 0,073 | 0,001 | 0,000 | 0,005 | 0,000 | 0,000 |
| 0,012 | 0,002 | 0,000 | 0,009 | 0,003 | 0,011 |
| 0,057 | 0,000 | 0,000 | 0,000 | 0,000 | 0,001 |
| 0,112 | 0,001 | 0,000 | 0,000 | 0,000 | 0,014 |

4. *Calculating the entropy value*

The calculation of the entropy value is done to measure the level of uncertainty or diversity of information on each criterion. The greater the entropy value, the smaller the contribution of the criteria information in distinguishing alternatives.

$$E_1 = -0,281 * -3,077 = 0,866$$
$$E_2 = -0,281 * -3,230 = 0,909$$
$$E_3 = -0,281 * -0,002 = 0,001$$
$$E_4 = -0,281 * -2,438 = 0,686$$
$$E_5 = -0,281 * -3,055 = 0,859$$
$$E_6 = -0,281 * -2,637 = 0,742$$

5. *Calculating the dispersion value*

The calculation of the dispersion value in the entropy method is used to measure the extent of data variation in each criterion. This stage is important to ensure fair weight distribution before normalization. The results will be used to determine the final weight of each criterion objectively. The calculation results are as follows.

$$d_1 = 1 - 0,866 = 0,134$$
$$d_2 = 1 - 0,909 = 0,091$$
$$d_3 = 1 - 0,001 = 0,999$$
$$d_4 = 1 - 0,686 = 0,314$$
$$d_5 = 1 - 0,859 = 0,141$$
$$d_6 = 1 - 0,742 = 0,258$$

$$\sum_{j=1}^{n} d_j = 1,939$$

6. *Calculating criteria weights*

Calculating criteria weights is an important step in the entropy method to determine the relative importance of each criterion.

TABLE VIII
WEIGHT OBTAINED

| Code | Criteria (Ha) | Type | Weight |
|---|---|---|---|
| C1 | Non-agricultural Land Area | Cost | 0,069 |
| C2 | Rice Field Area | Benefit | 0,047 |
| C3 | Dry Land Area | Cost | 0,516 |
| C4 | Plantation Land Area | Benefit | 0,162 |
| C5 | Forest Land Area | Benefit | 0,073 |
| C6 | Land Area of Water Bodies | Benefit | 0,133 |

The weight values are calculated based on the dispersion results, thus reflecting the contribution of each criterion's goal in decision-making. This stage ensures that the evaluation process is fair and proportional.

*D. Application of the MABAC Method*

In the application of this MABAC method to produce alternative rankings, where later the alternative with the highest value is the selected alternative [22].

1. *Calculation of weighted matrix elements (V)*

This calculation in the MABAC method is carried out to combine the normalized value with the previously obtained criteria weights. This stage is important to produce a decision matrix that reflects the relative influence of each alternative in terms of objectives. Furthermore, this matrix is used as the basis in the calculation stage of the distance to the border area boundary.

TABLE IX
WEIGHTED MATRIX

| C1 | C2 | C3 | C4 | C5 | C6 |
|---|---|---|---|---|---|
| 0,118 | 0,054 | 0,676 | 0,162 | 0,090 | 0,136 |
| 0,097 | 0,068 | 0,800 | 0,182 | 0,101 | 0,140 |
| 0,119 | 0,056 | 0,855 | 0,262 | 0,088 | 0,140 |
| 0,100 | 0,089 | 0,944 | 0,165 | 0,145 | 0,141 |
| 0,076 | 0,060 | 0,858 | 0,162 | 0,088 | 0,142 |
| - | - | - | - | - | - |
| 0,136 | 0,048 | 1,031 | 0,162 | 0,073 | 0,141 |
| 0,135 | 0,048 | 1,027 | 0,167 | 0,073 | 0,133 |
| 0,101 | 0,048 | 0,981 | 0,170 | 0,075 | 0,141 |
| 0,133 | 0,047 | 1,031 | 0,162 | 0,073 | 0,134 |
| 0,137 | 0,048 | 1,031 | 0,162 | 0,073 | 0,144 |

2. *Determination of the approximate border area matrix (G)*

The determination of the border estimation area matrix (G) aims to calculate the average value of the weighted matrix elements on each criterion. This matrix acts as a reference in measuring the distance that refers to the difference in values between alternatives and the border estimation area matrix, which is used to assess how far the alternative performance is from the average reference value.

$$m = \frac{1}{35} = 0,029$$

$$G_{C1} = (0,118\ x\ 0,097\ x\ 0,119\ x\ 0,100\ x\ 0,076\ x \ldots x\ 0,137)^{0,029} = 0,108$$

$$G_{C2} = (0,054\ x\ 0,068\ x\ 0,056\ x\ 0,089\ x\ 0,060\ x \ldots x\ 0,048)^{0,029} = 0,064$$

$$G_{C3} = (0,676\ x\ 0,800\ x\ 0,855\ x\ 0,944\ x\ 0,858\ x \ldots x\ 1,031)^{0,029} = 0,879$$

$$G_{C4} = (0,162\ x\ 0,182\ x\ 0,262\ x\ 0,165\ x\ 0,162\ x \ldots x\ 0,162)^{0,029} = 0,182$$

$$G_{C5} = (0,090\ x\ 0,101\ x\ 0,088\ x\ 0,145\ x\ 0,088\ x \ldots x\ 0,073)^{0,029} = 0,087$$

$$G_{C6} = (0{,}136\ x\ 0{,}140\ x\ 0{,}140\ x\ 0{,}141\ x\ 0{,}142\ x \ldots.x\ 0{,}144)^{0{,}029} = 0{,}151$$

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

Calculation of alternative distance matrix elements (Q) is carried out to measure the deviation of each alternative against the estimated border area matrix (G).

TABLE X
BORDER FORECAST AREA MATRIX

| C1 | C2 | C3 | C4 | C5 | C6 |
|---|---|---|---|---|---|
| 0,010 | -0,009 | -0,202 | -0,020 | 0,002 | -0,015 |
| -0,011 | 0,005 | -0,079 | 0,000 | 0,013 | -0,011 |
| 0,010 | -0,008 | -0,024 | 0,080 | 0,001 | -0,011 |
| -0,008 | 0,025 | 0,065 | -0,017 | 0,058 | -0,010 |
| -0,032 | -0,004 | -0,020 | -0,020 | 0,001 | -0,009 |
| - | - | - | - | - | - |
| 0,028 | -0,016 | 0,152 | -0,020 | -0,015 | -0,010 |
| 0,027 | -0,016 | 0,149 | -0,016 | -0,015 | -0,018 |
| -0,007 | -0,015 | 0,102 | -0,013 | -0,013 | -0,010 |
| 0,025 | -0,016 | 0,152 | -0,020 | -0,015 | -0,017 |
| 0,029 | -0,016 | 0,152 | -0,020 | -0,015 | -0,007 |

This stage serves to assess the relative alternative position in relation to the reference value. The results of this calculation are the basis for determining the final score of each alternative.

4. *Ranking alternatives (S)*

Ranking of alternatives (S) is done by summing the distance values in the Q matrix for each alternative. This process produces a ranking that reflects the relative performance between alternatives. Thus, the order of alternatives from the most superior to the less optimal is obtained. The results of this ranking are shown in Figure 2.

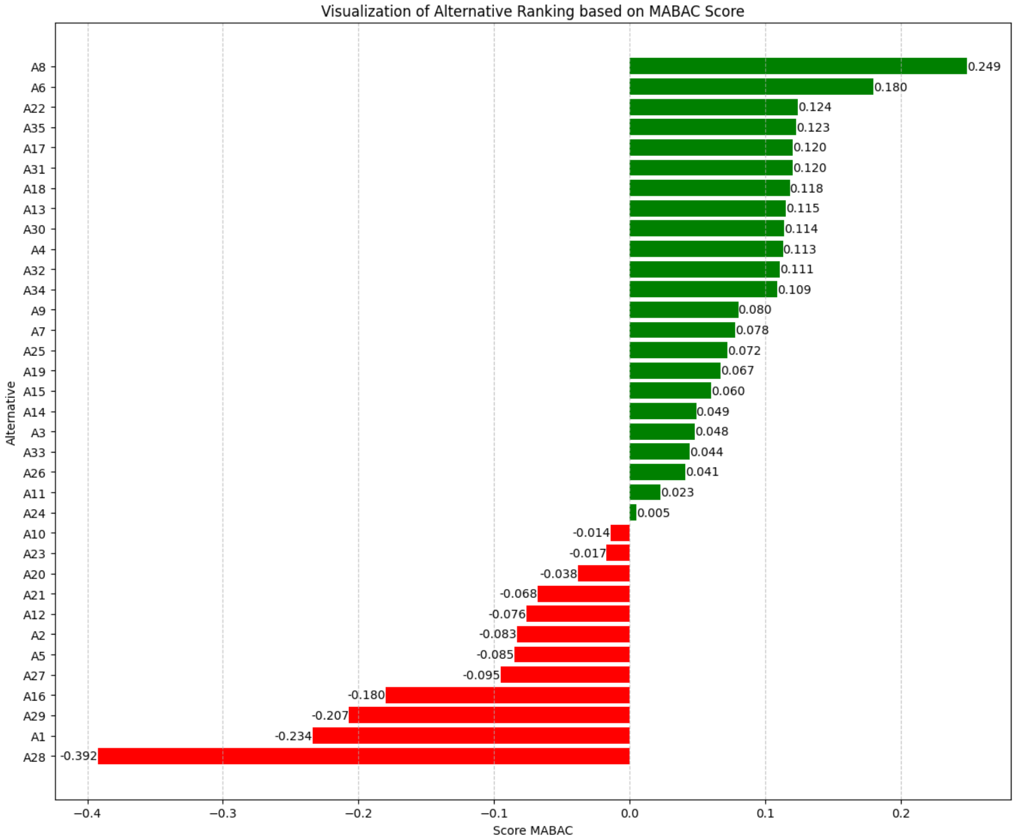


Figure 2. Visualization of Ranking Results

In this ranking, alternatives that have positive values indicate alternatives that have good performance and are closer to the ideal solution, so they are considered to fulfill the criteria optimally. Conversely, alternatives with negative values indicate that the alternative has inadequate performance and is far from the ideal solution. For the ranking results, A8, A6, and A22 are ranked 1, 2, and 3, which means they have the highest land productivity with S = 0.249, S = 0.180, and S = 0.124, respectively.

## E. *Analysis of Regional Performance Differences*

Demak, Brebes and Rembang are at the top of the rankings because they have a high dominance of paddy fields and water bodies and minimal dry land. In contrast, Wonogiri and Banjarnegara are at the bottom of the ranking due to their high dominance of dry land and lack of paddy fields. For example, Wonogiri has >100,000 ha of dry land and almost no significant plantation land or water bodies. The region is divided into three zones based on the quartile values of the

MABAC score, below is a visualization of the land productivity zones based on the MABAC score:

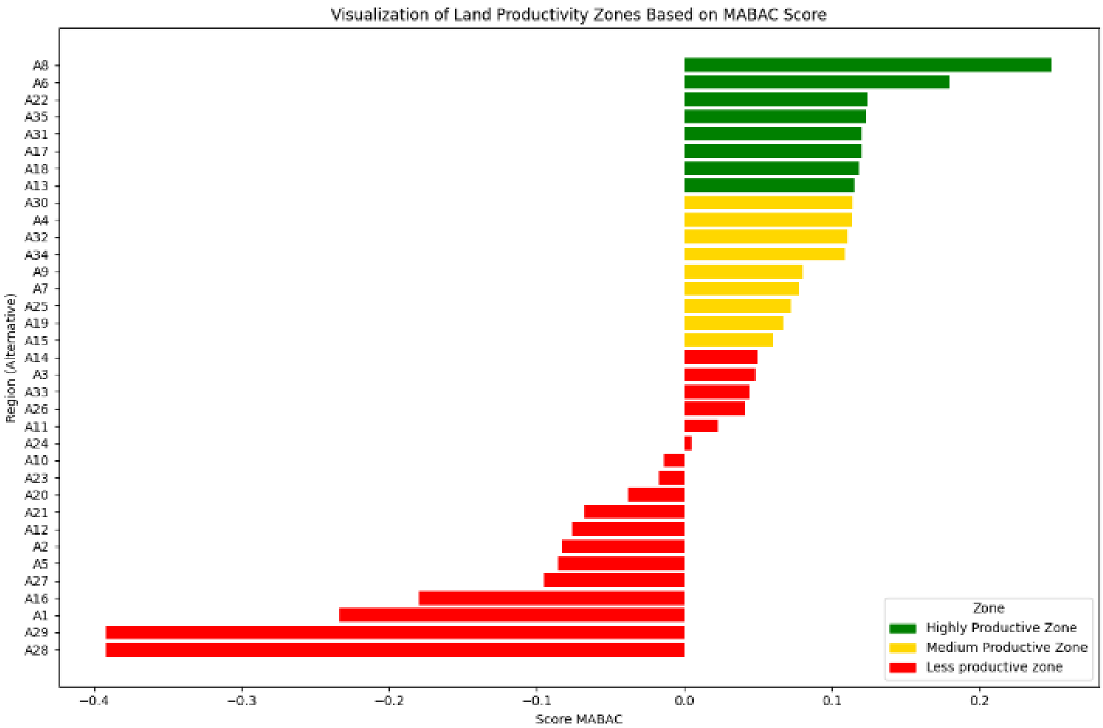


Figure 3. Zone Visualization

### *F. Rank Spearman Validation*

Validation is carried out by calculating the Rank Spearman correlation coefficient between the ranking results of the MABAC method and the ranking results of the AHP method calculation which are prepared based on procedures and adjusted from the journal references used as references[23]. The AHP calculation results are then used as historical data.

TABLE XI
RANK SPEARMAN

| Alternative | Ranki | Histori | Alternative | Rank | Histori |
|---|---|---|---|---|---|
| **A1** | 34 | 34 | **A19** | 16 | 17 |
| **A2** | 29 | 30 | **A20** | 26 | 23 |
| **A3** | 19 | 22 | **A21** | 27 | 27 |
| **A4** | 10 | 13 | **A22** | 3 | 8 |
| **A5** | 30 | 24 | **A23** | 25 | 26 |
| **A6** | 2 | 14 | **A24** | 23 | 18 |
| **A7** | 14 | 28 | **A25** | 15 | 7 |
| **A8** | 1 | 1 | **A26** | 21 | 16 |
| **A9** | 13 | 15 | **A27** | 31 | 31 |
| **A10** | 24 | 25 | **A28** | 35 | 35 |
| **A11** | 22 | 20 | **A29** | 33 | 33 |
| **A12** | 28 | 29 | **A30** | 9 | 4 |
| **A13** | 8 | 21 | **A31** | 6 | 3 |
| **A14** | 18 | 9 | **A32** | 11 | 6 |
| **A15** | 17 | 111 | **A33** | 20 | 10 |
| **A16** | 32 | 32 | **A34** | 12 | 5 |
| **A17** | 5 | 19 | **A35** | 4 | 2 |
| **A18** | 7 | 12 | | | |
| **Spearman Correlation Coefficient** | | | | **0,82** | |

The Rank Spearman correlation coefficient value of 0.82 shown in Table 11 indicates that the rankings generated by the Entropy and MABAC methods have a very strong agreement with historical data, which means that the method can be used for determining productive land.

## IV. CONCLUSION

This study successfully determined productive land in the regencies/cities of Central Java Province by combining the Entropy method and the MABAC method, which showed that Demak, Brebes, and Rembang regencies have the highest land productivity with S = 0.249, S = 0.180, and S = 0.124, respectively. Meanwhile, Banjarnegara and Wonogiri districts are in the lowest position with S = -0.234, and S = -0.392, respectively. The Spearman Rank validation is 0.82, which means that the method has a very strong fit with the historical data, which means that the method can be used to determine productive land. This research provides objective and relevant results in land use planning, with potential for further development through integration of spatial data and economic aspects to support sustainable development policies. To maximize productivity, especially in the high zone, and improve conditions in the low zone, land management incentives such as irrigation development, protection of sustainable paddy fields (PL2B), and appropriate spatial policy support are needed.

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