

# An Implementation of Profile Matching Method to Determine Agricultural Crops that Suit the Land

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## ABSTRACT

The suitability of land conditions and crops is one of the factors that affect agricultural productivity. To get maximum results, agricultural crops must be planted on land that has the right conditions for crops to grow optimally. Lack of knowledge about land characteristics often makes farmers grow crops that are not suitable for their land so that the productivity is not optimal. To make it easier to determine suitable crops, a decision support system is needed to provide plant recommendations based on land conditions by applying the Profile Matching method. This method is broadly a process of comparing the actual data value of a profile to be assessed with the expected profile value, so that differences in competence can be known. There are two aspects used in this research, namely the physical aspect of the soil and the chemical aspect of the soil. There are 13 criteria used for the plant recommendation, namely temperature, rainfall, humidity, drainage, texture, cation exchange capacity, base saturation, pH H<sub>2</sub>O, organic C, alkalinity, slope, erosion, and inundation. The result is an alternative decision support system to provide an alternative ranking of what plants are suitable to be planted on certain land. Data from the evaluation of the Profile Matching method show an accuracy rate of 77.94%, a recall rate of 77.94%, and a precision of 100%.

**Keywords:** Land Suitability, Agricultural Productivity, Decision Support System, Recommendation, Alternative Ranking

## 1. INTRODUCTION

In this era of globalization, human life is required to be more competitive in various fields, one of which is in the field of agriculture. As an agricultural country, many Indonesian are part of the ongoing agriculture, either directly or indirectly. Fortunately, Ministry of Agriculture of our country has also makes use social media to share information about agriculture policies and listen information from community [1].

The productivity of food crops in Bantul Regency from 2013 to 2018 has increased and decreased interchangeably. This shows that the harvest yield is less stable in Bantul Regency. The productivity is influenced by several factors and one of them is the level of suitability of agricultural land in Bantul Regency. To get maximum results, agricultural crops must be planted on land whose conditions are in accordance with what plants

need to grow optimally. Lack of knowledge of land characteristics often makes farmers plant crops that are not suitable for their land so that productivity is not optimal. For this reason, a decision support system is needed to assist the Bantul Regency Agriculture Officer in providing crop recommendations to farmers.

The method used in making decisions on the selection of agricultural crops that are suitable with the land is Profile Matching. This method was chosen because there is an ideal predictor level that must be met, not a minimum level that must be passed [2]. In this case the condition of the land is used as a benchmark for obtaining alternative plants with criteria that are as close as possible to the condition of the land.

In this decision support system we used two aspects that relate to plants [3], namely physical aspects and chemical aspects. From these two aspects, it is divided

into 13 criteria that are used to determine plant recommendations that are suitable for the land. The criteria used can be seen in Table 1 below.

**Table 1.** Criteria

Criteria	
A1	Temperature
A2	Rainfall
A3	Humidity
A4	Drainage
A5	Texture
A6	Cation Exchange Capacity
A7	Base Saturation
A8	pH H <sub>2</sub> O
A9	Organic C
A10	Alkalinity
A11	Slope
A12	Erosion
A13	Inundation

The criteria for the physical aspect consist of temperature, rainfall, humidity, drainage, texture, slope, erosion, and inundation. The criteria for the chemical aspect consist of clay cation exchange capacity, base saturation, pH H<sub>2</sub>O, organic C, and alkalinity [4].

The usage of both aspects and 13 criteria are the differences of our research with others [5], [6]. By using these criteria, hopefully the plant recommendation will be suitable as much to the land. In [5] the researchers used Simple Additive Weighting (SAW) to process recommendation of crops and the number of criteria is six. The criteria are temperature, air pressure, wind velocity, humidity, rainfall, and altitude. Promethee was used instead in [6] to raise the recommendation of crops. In their research, there are 12 criteria. Our criteria that are not used in [6] are erosion, inundation, clay cation exchange capacity, base saturation, and organic

## 2. METHOD

First of all, literature study was conducted to obtain information about the research to be carried out. This study was conducted by reading and studying references in the form of scientific journals, theses, and books. Literature studies are also carried out using internet media to find data and information related to the object of research.

The researcher collected data by interview and literature study. Interviews were conducted in the form of questions and answers with experts from the Department of Agriculture to obtain data and information needed in research. Literature study was carried out to collect secondary data, namely from the Land Evaluation Technical Manual by BBSDLP as well as from the BMKG and BPTP Yogyakarta websites.

From the results of data collection, then the system is developed using the extreme programming method of the

System Development Life Cycle (SDLC) model. The stages of this method are Planning, Design, Coding, and Testing.

Next is the evaluation phase. The evaluation phase is carried out using a confusion matrix validation to calculate the accuracy of the series of activities that have been carried out.

### 2.1. Decision Support System

Decision Support System (DSS) is a system to provide problem solving skills and communication skills for problems with semi-structured and unstructured conditions. This system is used to help make decisions in semi-structured and unstructured situations [7].

DSS is a system to provide data management functions based on a certain model, so that users of the system can choose the best alternative decisions. The thing that needs to be emphasized here is that the decision support system is not a decision-making tool, but to help decision makers about a problem more quickly and accurately [8]

### 2.2. Profile Matching

Profile Matching is a decision-making mechanism by assuming that there is an ideal level of predictor variables that must be met by the subject under study, not a minimum level that must be met or passed [2].

The Profile Matching method is broadly a process of comparing the actual data value of a profile to be assessed with the expected profile value, so that differences in competence (also called gaps) can be known [9]. Here are some steps and formulation of the calculation method of Profile Matching:

#### 2.2.1. Weighting

This phase will be determined the weight value of each aspect of using weights gap. Gap is the difference between the value of the aspect and the target value. It can be obtained by Equation 1:

$$\text{Gap} = \text{Aspect Value} - \text{Target Value} \quad (1)$$

#### 2.2.2. Core and Secondary Factor

This stage determines the weight value gap necessary criteria, each criterion grouped into two groups: core factor and the secondary factor.

##### 2.2.2.1. Core Factor

Core factor is the aspect most needed. The Equation 2 below is to calculate the core factor.

$$NFC = \frac{\sum_{i=1}^n NC}{\sum_{i=1}^n IC} \quad (2)$$

NCF: Core Factor Value

NC: Total Weight Core Factor

IC: Total Item Core Factor

**2.2.2.2. Secondary Factor**

Secondary factors are the items other than that of the core aspects of factors. The formula for calculating the secondary factor is shown on Equation 3 as follows:

$$NSF = \frac{\sum_{i=1}^n NS}{\sum_{i=1}^n IS}$$

$$NCF = \frac{\sum_{i=1}^n NC}{\sum_{i=1}^n IC} \tag{3}$$

NSF: Secondary Factor Value

NS: Total Weight Secondary Factor

IS: Total Item Secondary Factor

**2.2.3. Total Value Calculation**

From the calculation of core factors and secondary factors of every aspect, and then calculated the total value of each aspect of the estimated effect on the performance of each profile. To calculate the total value of each aspect, the following Equation 4 is used.

$$N = (x) \% NCF + (x) \% NSF \tag{4}$$

N: Total value of each aspect

NCF: Average Core Factor

NSF: Average Secondary Factor

X%: Percentage value is entered

**2.2.4. Ranking**

The final result of the profile matching process is a ranking which refers to the calculation results shown by this Equation 5:

$$\text{Ranking} = (x) \% NMA + (x) \% NSA \tag{5}$$

NM: Total value of the Main Aspect criteria

NSA: Total score of the Supporting Aspect criteria

(x) % : Percent value entered

**2.3. Land**

Land is part of a landscape that includes the notion of the physical environment including climate, topography/relief, soil, hydrology, and even natural vegetation, all of which have the potential to affect land use [3].

**2.4. Land characteristics**

Land characteristics are land properties that can be measured or estimated. Land characteristics are: air temperature, rainfall, dry period, humidity, drainage, texture, coarse material, soil depth, peat thickness, peat maturity, clay cation exchange capacity, base saturation, pH H<sub>2</sub>O, organic C, salinity, alkalinity, depth of sulfidic

material, slope, erosion hazard, inundation, rock surface, and rock outcrop [3].

**2.5. Land Suitability**

Land suitability is the suitability of a plot of land for a particular use. The suitability of the land can be assessed for current conditions or after improvements have been made. Specifically, land suitability is the suitability of the physical and chemical properties of a land for farming or certain commodities. Physical properties are climate, soil, topography, hydrology and/or drainage, while chemical properties are pH, base saturation, and micro nutrients [3].

**2.6. Confusion Matrix**

Confusion Matrix is a method used to calculate the accuracy of the concept of data mining or decision support systems. Based on the confusion matrix, the level of precision, recall, and accuracy can be measured. Equation for these three measurements are given on Equation 6-8. Precision is the level of accuracy of information requested by data and system users. Recall is the success of the system in finding back information. While accuracy is the closeness of the measurement of the quantity to the actual value. Table 2 shows the confusion matrix formula.

**Table 2.** Confusion Matrix

		Real Value	
		True	False
Prediction Value	True	TP (True Positive) Correct Result	FP (False Positive) Unexpected Result
	False	FN (False Negative) Missing Result	TN (True Negative) Correct absence of result

$$\text{Precision} = \frac{TP}{TP+fp} * 100\% \tag{6}$$

$$\text{Recall} = \frac{TP}{TP+FN} * 100\% \tag{7}$$

$$\text{Accuracy} = \frac{TP+TN}{TP+TN+FP+FN} * 100\% \tag{8}$$

Measurement of accuracy can be done after matching the data obtained from manual calculations and system calculations. According to [10], the standard accuracy of the measurement results are as follows:

90%-100% accuracy = Excellent Classification

80%-90% accuracy = Best Classification

70%-80% accuracy = Fair Classification

60%-70% accuracy = Poor Classification

50%-60% accuracy = Failure

### 3. RESULTS AND DISCUSSION

#### 3.1. System Description

This system was created with the aim to help determining plants that are suitable for land in Bantul Regency. In determining plants, this system uses the calculation of the Profile Matching method. The system will sort the suitability of plants to the land based on the final value, from the largest to the smallest. This system runs on a web platform, and is built using the PHP programming language, CodeIgniter framework, and MySQL database.

#### 3.2. Calculation of the Profile Matching Method

The following is an example of calculation results of plant and land suitability using the Profile Matching method.

Table 5 shows the calculation results of gap mapping from Table 3 and Table 4. In this paper we simulate for Bambanglipuro area. Moreover, only five criteria are shown for the sake of limited number of pages.

Table 6 shows the weighting results that based on gap mapping results in Table 5. The weight for gap 0 is 5, the weight for gap 1 is 4.5, and so on until gap -4.

Table 7 shows the calculation results of profile matching based on the total value of core factor and secondary factor from both aspects. Equation 2-4 are used to obtain values shown on Table 7. In this research, we defined  $x = 55$  for core factor, and  $x = 45$  for secondary factor. These values for  $x_s$  are used in Equation 4.

Table 8 shows the result of crop ranking based on the final value of profile matching. The greater the final value indicates that the alternative is more suitable for the land. Equation 5 is used here with values for  $x_s$  are 52.5 for core factor, and 47.5 for secondary factor. In other research, 60 is used for core/ main factor, and 40 is used for secondary factor [10].

All of  $x_s$ ' values used here are based on recommendation from the Bantul Regency Agriculture Officer. Values for core factor are bigger than the ones for secondary factor.

**Table 3.** Crop alternative criteria value

Crop Name	A1	A2	A3	A4	...	A13
Peanut	3	2	4	3	...	1
Corn	2	3	5	3	...	1
Cassava	3	3	4	3	...	1
Paddy	3	4	4	2	...	1
Soya Bean	2	2	4	3	...	1
Sweet Potato	2	3	4	3	...	1
Shallot	2	1	5	3	...	1
Red Chili Pepper	2	2	4	3	...	1

**Table 4.** Land criteria value

Land	A1	A2	A3	A4	...	A13
Kec. Bambanglipuro	3	5	4	2	...	2

**Table 5.** Gap mapping results

Crop Name	A1	A2	A3	A4	...	A13
Peanut	0	-3	0	1	...	-1
Corn	-1	-2	1	1	...	-1
Cassava	0	-2	0	1	...	-1
Paddy	0	-1	0	0	...	-1
Soya Bean	-1	-3	0	1	...	-1
Sweet Potato	-1	-2	0	1	...	-1
Shallot	-1	-4	1	1	...	-1
Red Chili Pepper	-1	-3	0	1	...	-1

**Table 6.** Weighting results

Crop Name	A1	A2	A3	A4	...	A13
Peanut	5	2	5	4.5	...	4
Corn	4	3	4.5	4.5	...	4
Cassava	5	3	5	4.5	...	4
Paddy	5	4	5	5	...	4
Soya Bean	4	2	5	4.5	...	4
Sweet Potato	4	3	5	4.5	...	4
Shallot	4	1	4.5	4.5	...	4
Red Chili Pepper	4	2	5	4.5	...	4

**Table 7.** Calculation results

Crop Name	Physical Aspect			...	Profile Matching Final Score
	Core Factor	Secondary Factor	Total Value		
Peanut	4.083	5.000	4.496	...	4.670
Corn	4.000	4.750	4.338	...	4.551
Cassava	4.250	5.000	4.588	...	4.546
Paddy	4.500	5.000	4.725	...	4.719
Soya Bean	3.917	5.000	4.404	...	4.622
Sweet Potato	4.250	5.000	4.588	...	4.683
Shallot	3.667	5.000	4.267	...	4.449
Red Chili Pepper	3.917	5.000	4.404	...	4.622

**Table 8.** Calculation results

Rank	Crop Name	Profile Matching Final Score	Land Suitability
1	Paddy	4.719	Quite Suitable

2	Sweet Potato	4.683	Quite Suitable
3	Peanut	4.670	Quite Suitable
4	Soya Bean	4.622	Quite Suitable
5	Red Chili Pepper	4.622	Quite Suitable
6	Corn	4.551	Quite Suitable
7	Cassava	4.546	Quite Suitable
8	Shallot	4.449	Quite Suitable

**3.3. Evaluation of the Profile Matching Method**

This evaluation is done by comparing the results of the system calculations and the results of manual calculations by officers. System calculations and manual calculations use the same data, which will then get results in the form of rankings. The ranking results are then compared and the data sought are suitable and data that do not match. The results of the process are then analyzed to further calculate the level of accuracy, precision, and recall. Table 9 is the results of the comparison of plant rankings based on the system and manual calculations of each land.

Based on Table 9, 106 data match (TP) and 30 data does not match (FN). Total is 136 data.

Furthermore, the calculation of precision, recall, and accuracy on each land were performed using Equation 6, 7, and 8.

$$\text{Precision} = \frac{TP}{TP+fp} * 100\% = \frac{6}{6+0} * 100\% = 100\%$$

$$\text{Recall} = \frac{TP}{TP+FN} * 100\% = \frac{6}{6+2} * 100\% = 75\%$$

$$\text{Accuracy} = \frac{TP+TN}{TP+TN+FP+FN} * 100\% = \frac{6+0}{6+0+0+2} * 100\% = 75\%$$

The results of the calculation can be seen in Table 10.

Based on calculations that have been done, it can be seen at 100% precision level, the recall level of 77.94%, and an accuracy of 77.94% in a decision support system that has been built. The accuracy of this system is higher than [5] with accuracy of 73.33%. Based on [10], this decision support system is measured as fair classification.

These results indicate that DSS has adaptive and flexible properties which can be applied in all situations, including the process of providing crops recommendations. However, the application of the DSS method not only helps recommendations more quickly, but also accurately.

**Table 9.** Ranking comparison results

Land	Match (TP)	Not Match (FN)	Total Data
Kec. Banganglipuro	6	2	8
Kec. Bantul	8	0	8

Kec. Banguntapan	6	2	8
Kec. Dlingo	6	2	8
Kec. Imogiri	5	3	8
Kec. Jetis	5	3	8
Kec. Kasihan	6	2	8
Kec. Kretek	8	0	8
Kec. Pajangan	8	0	8
Kec. Pandak	6	2	8
Kec. Piyungan	5	3	8
Kec. Pleret	5	3	8
Kec. Pundong	6	2	8
Kec. Sanden	6	2	8
Kec. Sedayu	8	0	8
Kec. Sewon	6	2	8
Kec. Srandakan	6	2	8
<b>Total</b>	<b>106</b>	<b>30</b>	<b>136</b>

**4. CONCLUSION**

Based on the results, it can be concluded that a decision support system for determining plants that are suitable for the land has been successfully built. This system uses the Profile Matching method with two aspects, namely the physical aspect of the soil and the chemical aspect of the soil as well as 13 criteria. The physical aspect of the soil has criteria consisting of temperature, rainfall, humidity, drainage, texture, slope, erosion, and inundation. The chemical aspects of the soil consist of clay cation exchange capacity, base saturation, pH H<sub>2</sub>O, organic C and alkalinity. This system can provide plant recommendations for a land in the form of ranking based on the final value of each alternative plant. The higher the final value of the alternative plant, the more suitable it will be with the land.

**Table 10.** Calculation results of precision, recall, and accuracy

Land	Precision	Recall	Accuracy
Kec. Banganglipuro	100%	75%	75%
Kec. Bantul	100%	100%	100%
Kec. Banguntapan	100%	75%	75%
Kec. Dlingo	100%	75%	75%
Kec. Imogiri	100%	62.5%	62.5%
Kec. Jetis	100%	62.5%	62.5%
Kec. Kasihan	100%	75%	75%
Kec. Kretek	100%	100%	100%
Kec. Pajangan	100%	100%	100%
Kec. Pandak	100%	75%	75%

Kec. Piyungan	100%	62.5%	62.5%
Kec. Pleret	100%	62.5%	62.5%
Kec. Pundong	100%	75%	75%
Kec. Sanden	100%	75%	75%
Kec. Sedayu	100%	100%	100%
Kec. Sewon	100%	75%	75%
Kec. Srandakan	100%	75%	75%
<b>Average</b>	100%	77.94%	77.94%

The results of the Profile matching method evaluation show an accuracy rate of 77.94%, a recall rate of 77.94%, and a precision of 100%. The results of the evaluation of the Profile Matching method show that the system can be used to recommend plants that are suitable for the land.

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