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Classification System for Soil Types Suitable for Food Crops using Naïve Bayes Method

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Abstract

Agriculture in Indonesia, especially in Aceh, plays a central role in supporting the economy and food security. The success of agriculture is greatly influenced by the selection of appropriate soil types. This research aims to develop a classification system for soil types suitable for food crops by applying the Naive Bayes algorithm to help farmers choose the right type of soil. The steps taken in this research are literature study, observation, interviews, data collection, system design and system implementation. In this study, the variables / criteria used include pH, humidity, drainage, soil texture, and nutrients, as input to provide recommendations for the most suitable soil type. By dividing the data into 70% training data and 30% testing data, the system achieved an accuracy rate of 83.3%. The results of the testing data used in this study were obtained in areas suitable for planting all three types of food, namely kong, tetinggi, Blangbengkik, Gantung Geluni, Porang Ayu, Anak Reje and Bener Baru. While the area that is only suitable for planting one type of food crop is Cinta Maju.

Keywords: Agriculture, Crops, Type of soil, Naïve Bayes, Confusion Matrix.

1 Introduction

Agriculture is an important sector in the Indonesian economy, so Indonesia continues to be committed to maintaining Indonesia's food security. In Aceh, agriculture is the most labor-intensive sector. In Aceh's Gross Regional Domestic Product (GRDP) in the fourth quarter of 2011, the agricultural sector contributed 27.70 percent. This sector is dominated by food crops, such as rice, corn, tubers, and beans [1]. One important factor in the success of agriculture is the selection of suitable soil types for food crops to be planted. However, selecting the right soil type for food crops is not an easy task. Farmers or agricultural experts need to identify various soil characteristics such as acidity, nutrient content, texture and drainage to select the most suitable soil type. Soil type classification is an alternative for farmers and experts in land management. Classification is a part of data mining that involves two main phases, namely the learning phase and the classification phase [2]. Data mining was recognized in the 1990s when data utilization became important in various fields [3]. Data mining is the process of extracting information or something important or interesting from the data in a database to obtain very valuable information [4].

Food crops refer to various types of plants that are capable of producing carbohydrates and proteins. Therefore, food crops have an important role as the main source of food for most of Indonesia's population [5]. Food crop cultivation involves various stages starting from land preparation, planting, maintenance, pest and disease control, to harvesting.

The use of artificial intelligence can make it easier and faster to determine suitable food crops through the classification process. Classification Refers to the process of grouping, meaning combining similar objects and separating those that are not similar [6]. Classification has a target category variable. In variable classification, the goal is categorical [7]. Furthermore, to find out how

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well the results can make predictions, it is necessary to carry out an evaluation process by measuring accuracy, precision, sensitivity, and other metrics [8].

This researchers the Naïve Bayes method. The Naive Bayes method is a simple probability classification method by calculating a set of possibilities calculated by summing the frequencies and values of training data that guide information [9]. This algorithm shows competitive classification performance, even though it operates ignoring the relationship between attributes [10]. The Naive Bayes method was chosen because it has the advantage of dealing with complex data and a large number of features. It also performs well in data classification with independent features. By implementing the Naive Bayes method in the soil type classification system for food crops, it is expected to provide accurate and effective results [11].

This research aims to develop a classification system that uses the naive bayes method to identify suitable soil types for food crops. The system will take data on soil characteristics as input, such as soil pH, nutrients, moisture level, drainage and texture of the soil. Then, the system will apply the Naive Bayes method to classify soil types based on the input data.

2 Literature Review

Previous related research is one of the authors' references in conducting this research to get an overview or comparison that has been done by previous researchers, so that differences with this research will be seen. There are several studies that become literal studies, including related research conducted by [12], In this study using 7 criteria namely soil fertility, soil nutrients, soil moisture, soil texture, soil thickness, soil reaction (pH) and soil drainage. The results of the research application of the Smarter and SAW methods gave the highest value of 0.824286 for the Andosol soil type for rice plants.

Most recent research was conducted by [13], In this study, there were 7 criteria, namely rainfall, drainage, soil texture, soil depth, C- organic hazards and land slope. The highest accuracy result of 92.2% was obtained from 110 chili field cases, and the average accuracy result of the entire fold was 89.1%/. by [14], Soil is good in certain soils because there are things that affect including pH and soil moisture levels. The result of this research is a tool that can be used to identify the level of soil fertility and the type of plants suitable for the soil based on the level of humidity and acidity, classifying objects accordingly based on characteristics and test data. for my research that gives 90 percent accuracy.

Most recent research was conducted by [15], The analysis criteria used in this study are temperature, sunlight, soil type and water availability. The result of this research is a decision support system to select land suitability for corn crops. There are five options for corn fields, and it appears that the Sungai Kerbau land is the most suitable corn land option with a probability of yes of 0.810 for the given criteria. recent research was conducted by [16], In this research, the problem raised is how to maintain and increase the production of a plant. The results of the study show that the Naïve Bayes method is suitable for the classification of soil types against plants whose probability is quite high up to 88%.

In addition to some researches, the author took references to other researches that are related to the researcher's research with the aim of providing more references of the researches that the author has used references include implementation of data mining using naïve bayes classifier in Food Crop prediction [17], implementation of the naïve bayes method in recommendations for planting food crops [18], classification of soil and crop suggestions using machine learning techniques [19], machine learning based soil classification for crop suggestion [20].

In of the previous related research, there are differences with this research. This research focuses on food crops such as rice, corn and tubers and there are also differences from the attributes or variables used in the calculation or classification process. In addition to this research, there are several studies that have been conducted by researchers related to the application of data mining methods and the creation of application systems, including research on the classification of student scientific papers using the naive bayes classifier method.[21], The implementation of fuzzy c-means to determine the level of student satisfaction in online learning [22], application of data mining to determine recipients of non-cash food assistance using the k-nearest neighbor method [23], decision support system for

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determining PKH acceptance using the naïve bayes method [24], application of the profile matching analysis method to the decision support system for study program recommendations [25] and implementation of data mining to analyze student competition categories using the apriori algorithm [26]

3 Research method

The method or stages carried out in this study are shown in Figure 1.

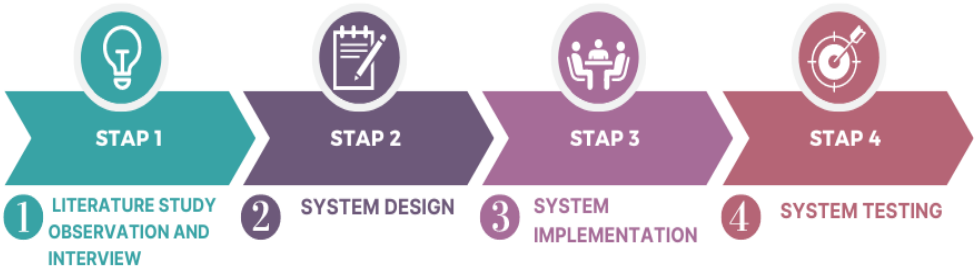

Figure 1. Research Methods or Stages

The following is an explanation of figure1. The methods or stages carried out in the research of the classification system for soil types suitable for food crops using the naïve bayes method are as follows:

a. Data Retrieval
In this study authors collected from the Agricultural Extension Agency (BPP) and made observations to several fields for sampling, then the researchers also conducted interviews with several agricultural extension workers related to the selection of suitable soil types.

b. System Design
System design involves creating the plan and architecture of the system to be built based on the findings from the literature study, observations, and interviews. Researchers identify system requirements and plan the data flow, process flow, and database structure required. This system design stage aims to describe recognizing the overall system design process from the initial stage of data input to completion by displaying the classification results in the form of the type of plant.

c. System Implementation.
At this stage, the author implements the system design into real form through development or programming using the PHP (Hypertext Preprocessor) programming language. System components are integrated and tested to ensure their interconnectedness. At this stage the author also applies the naïve bayes algorithm to the program.

d. System testing
System testing is conducted to verify the functionality and performance of the implemented system. Researchers prepare test scenarios that cover various situations and conditions that may occur. Functionality testing is done to ensure that the system works according to the design and requirements. Performance testing is performed to ensure that the system can handle the expected workload. Test results are analyzed and detected problems are fixed to ensure the system functions properly.

4 Results and Discussion

The results and discussion consist of the results of data collection, the results of system flowchart design, the application of the Naive Bayes method, the results of confusion matrix calculations and the results of system implementation.

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4.1 Data Collection Results

The dataset in this research consists of alternative datasets and criteria datasets. Alternative data is a set of data deliberately placed by researchers to group areas in the Blangpegayon sub-district which consists of 12 villages in Table 1.

Table 1. Village Data in Blangpegayon Sub-district

Villages in Blangpegayon Sub-district	
1	Kong
2	Tetinggi
3	Cinta Maju
4	Gantung Geluni
5	Porang Ayu
6	Umelah
7	Kutebukit
8	Anak Reje
9	Bener Baru
10	Akang Siwah
11	Blang Bengkik
12	Bemem Buntul Pegayon

Criterion data is a variable used to determine the classification process using the naïve bayes method. There are 200 data which are then numerical data grouped to make it easier to find the chances of the criteria. The data used is divided into 70% training data in Table 2 and 30% testing data in Table 3.

Tabel 2. Data Training

No.	pH	Humidity	Drainage	Soil texture	Nutrients	Plants
1	Slightly Acidic	wet	both	sandy loam	Simply	corn
2	Neutral	Nice	both	sandy clay loam	Nice	Root vegetables
3	Neutral	wet	both	sandy loam	Nice	rice
4	Acid	wet	not good	sandy loam	Simply	corn
5	Neutral	Nice	both	dusty	bad	rice
6	Slightly Acidic	Nice	not good	sandy clay	bad	Root vegetables
7	Neutral	dry	very good	dusty	Nice	corn
8	Acid	dry	bad	sandy clay	bad	Root vegetables
...	...	...	...	...	...	...
67	Acid	dry	very good	dusty	Nice	rice
68	Acid	dry	very good	sandy loam	bad	corn
69	Neutral	wet	bad	dusty	bad	rice
70	Acid	wet	bad	silty clay	bad	rice
...	...	...	....	...	...	...
135	Slightly Acidic	wet	bad	sandy loam	Simply	rice
136	Slightly Acidic	Nice	bad	sandy clay	Simply	Root vegetables
137	Slightly Acidic	Nice	not good	dusty	Simply	rice

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138	Slightly Acidic	wet	not good	silty clay	Simply	rice
139	Acid	dry	bad	sandy loam	Simply	rice
140	Slightly Acidic	Nice	bad	sandy clay loam	Simply	Root vegetables

Tabel 3. Data Testing

No.	pH	Humidity	Drainage	Soil texture	Nutrients	Location
1	Neutral	wet	both	sandy loam	Nice	
2	Neutral	dry	not good	dusty	Simply	
3	Neutral	Nice	both	dusty	Nice	Kong
4	Slightly Acidic	wet	bad	sandy clay	Nice	
5	Acid	wet	bad	sandy clay	bad	
...	....	...	...	...	...	...
56	Acid	Nice	bad	dusty	bad	
57	Neutral	Nice	both	sandy clay	Nice	Bemem
58	Neutral	dry	both	dusty	Nice	Buntul
59	Acid	Nice	bad	silty clay	bad	Pegayon
60	Neutral	dry	very good	sandy loam	Nice	

4.2 System Flowchart Design Results

The following is the system scheme of the classification of suitable soil types for palm trees using the naïve bayes method as shown in Figure 2.

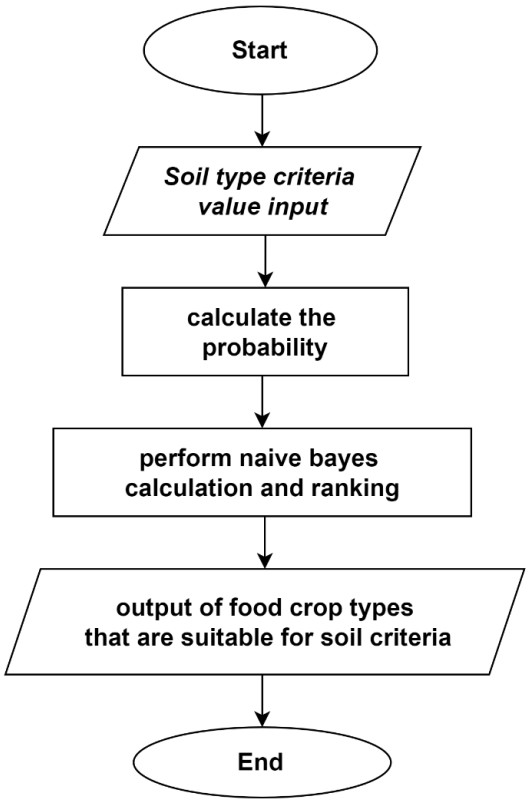

Figure 2. System scheme

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4.3 Application of the Naïve Bayes Method

Manual classification calculation using Naïve Bayes using Training data. Based on the datset / training data, the classification process is carried out on one of the testing data as follows in Table 4.

Table 4. Manual Calculation of Testing Data

pH	Humidity	Drainage	Soil Texture	Nutrients	Plants
Neutral	wet	both	Sandy loam	Nice	?

1. Class probability
   P(Y=corn) = 42/140 = 0,3
   P(Y= rice) = 54/140 = 0,3857
   P(Y= root vegetables) = 44/140 = 0,3143
2. Calculating the probability of each criterion/variable
   Calculating the probability of including corn plants
   P(pH = neutral |Y = corn=28/42 = 0.6667
   P(Humidity = wet |Y = corn=15/42 = 0.3571
   P(Drainage = good |Y = corn=20/42 = 0.4762
   P(Soil Texture = sandy loam |Y = corn = 19/42 = 0.4524)
   P(Nutrient = good |Y = corn=25/42 = 0.5952
   Then the possibilities including corn plants are
   Maize Class= 0.6667*0.3571*0.4762*0.4524*0.5952*0.3
   Maize *Class* = 0,009159

   Calculating the probability of including rice plants
   P(pH = neutral |Y = rice=15/54 = 0.2778
   P(Humidity = wet |Y = rice=27/54 = 0.5
   P(Drainage = good |Y = rice=10/54= 0.1852
   P(Soil Texture = sandy loam |Y = rice = 9/54 = 0.1667
   P(Nutrient = good |Y = rice=12/54 = 0.2222
   Maize *Class* = 0,2778*0,5*0,1852*0,1667*0,2222*0,3857143
   Corn *Class* = 0,0003674

   Calculate the probability of including tuberous plants
   P(pH = neutral |Y = root vegetables=12/44 = 0.2727
   P(Humidity = wet |Y = root vegetables= 14/44 = 0.3182
   P(Drainage = good |Y = root vegetables =9/44 = 0.2045
   P(Soil Texture = sandy loam |Y = root vegetables = 3/44 = 0.0682
   P(Nutrient = good |Y = root vegetables=3/44 = 0.0682
   Corn *Class* = 0,2727*0,3182*0,2045*0,0682*0,0682*0,3142857
   Corn *Class* = 0,0000259

   From each of the above calculations, the largest value of the three classes is sought to determine the predicted crop. In the case above, the largest value is in the corn class so that the test data criteria above can be classified as **Corn.**
3. Testing data results

   The results of the process using the calculation of nalïve bayes on the testing data totaling 60 data resulted in the classification prosels in Table 5.

Table 5. Data Testing Calcification Scale

No.	Corn	Rice	Root vegetables	Highest score	Plants

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1	0,0091590	0,0003674	0,0000259	0,0091590	corn
2	0,0002507	0,0014861	0,0001921	0,0014861	rice
3	0,0022496	0,0004445	0,0000284	0,0022496	corn
4	0,0000775	0,0007447	0,0006083	0,0007447	rice
5	0,0000124	0,0009929	0,0032443	0,0032443	Root vegetables
6	0,0091590	0,0003674	0,0000259	0,0091590	corn
7	0,0000403	0,0016134	0,0050692	0,0050692	Root vegetables
8	0,0000403	0,0016134	0,0050692	0,0050692	Root vegetables
9	0,0000806	0,0018823	0,0003042	0,0018823	rice
10	0,0001053	0,0005229	0,0042473	0,0042473	Root vegetables
11	0,0004499	0,0005335	0,0000379	0,0005335	rice
12	0,0004499	0,0002286	0,0003787	0,0004499	corn
...	...	...	...	...	...
53	0,0008890	0,0007430	0,0004734	0,0008890	corn
54	0,0022496	0,0001905	0,0002840	0,0022496	corn
55	0,0024103	0,0005716	0,0000173	0,0024103	corn
56	0,0000116	0,0018019	0,0005330	0,0018019	rice
57	0,0022496	0,0001905	0,0002840	0,0022496	corn
58	0,0024103	0,0005716	0,0000173	0,0024103	corn
59	0,0000116	0,0018019	0,0005330	0,0018019	rice
60	0,0073272	0,0002939	0,0000086	0,0073272	corn

Based on the calculation of the testing data above based on the Naïve Bayes algorithm. The results for the recommended plant types can be seen in Table 6.

Table 6. Food Crop Recommendations by Location

No.	Village	Crop recommendations
1	Kong	Corn, rice, tubers
2	Tetinggi	Tubers, corn, rice
3	Love Forward	Rice, tubers, corn
4	Hang the Geluni	Tubers, rice, corn
5	Porang Ayu	Corn, rice, tubers
6	Umelah	Rice, Tubers
7	Kutebukit	Root vegetables, rice
8	Son of Reje	Tubers, rice, corn
9	Bener Baru	Tubers, corn, rice
10	Akang Siwah	Corn, rice
11	Blang Bengkik	Corn
12	Bemem Buntul Pegayon	Corn, rice

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4.4 *Confusion matrix* calculation

Based on the results of the Naïve Bayes calculation above and the results obtained, the confusion matrix can be formulated in Table 7.

Table 7. Confusion Matrix Calculation

Original/predicted	Corn	Rice	Root vegetables
Corn	17	4	2
Rice	0	18	1
Root vegetables	3	0	15

Accuracy $= \frac{TP+TN}{TP+TN+FP+FN}\ x\ 100\%$

$= \frac{50}{60}\ x\ 100\%$

= 0,8333 x 100%

= 83,3%

Precision $= \frac{TP}{TP+FP}\ x\ 100\%$

$= \frac{0,73913+0,947368+0.833333}{3}\ x\ 100\%$

$= \frac{2,519832}{3}\ x\ 100\%$

= 0,8399 x100%

= 84,0%

Recall $= \frac{TP}{TN+FN}\ x\ 100\%$

$= \frac{0,85+0,818182+0,833333}{3}\ x\ 100\%$

$= \frac{2,5015151}{3}\ x\ 100\%$

= 0,8338 x100%

= 83,4%

The following is a graph of the results of the confusion matrix calculation in Figure 3 below.

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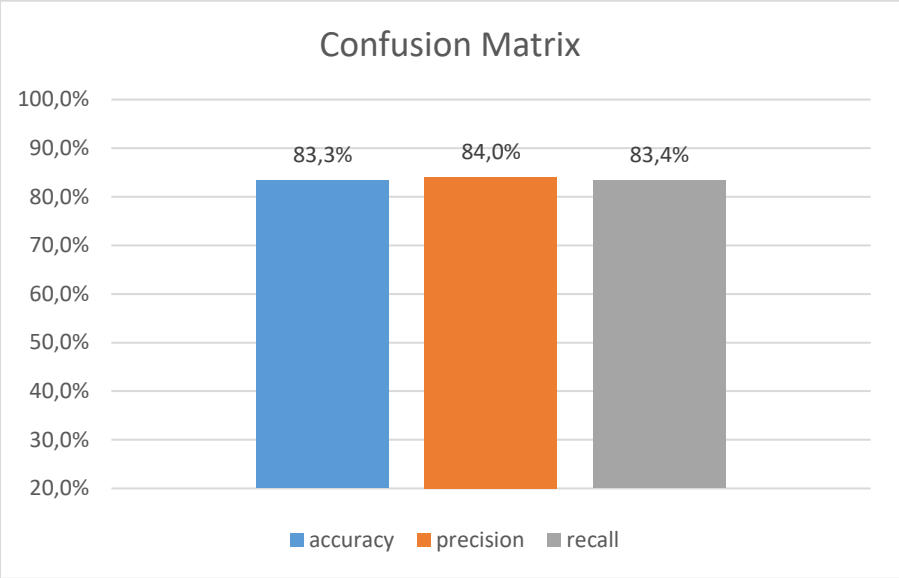

Figure 3. Confusion Matrix Calculation Calculation Error Graph

4.5 System Implementation Calculation (System Output)

From the system implementation that the author has created, the output results from the classification system of types of land that are suitable for palm plants use the following naïve nayes method.

1. Dashboard page

After entering the username and password and logging in, the system will display the dashboard page. On the dashboard page the admin can see related training, testing and account data information. On this page the admin can also see accuracy, precision and recall. The following is a view of the main page shown in Figure 4.

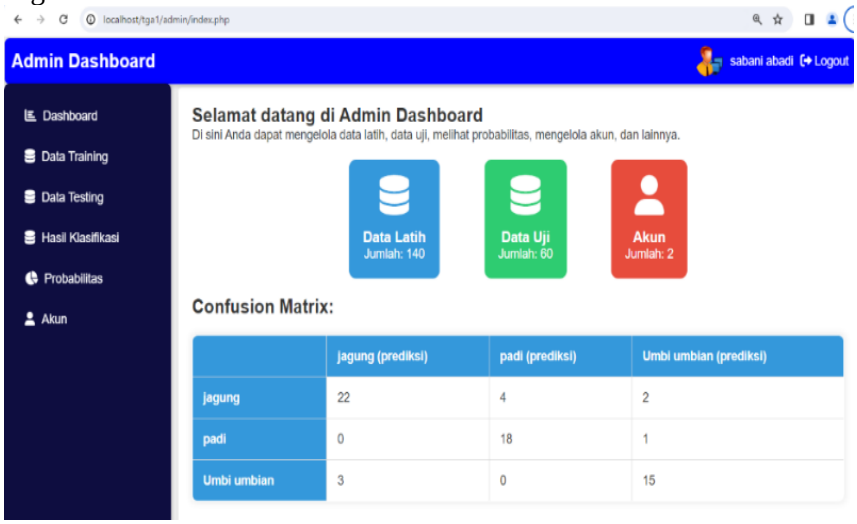

Figure 4. Dashboard Page

2. Training data page

On the training data page, admin can calculate probabilities, and admin can add, edit and delete training data. The following is a view of the training data page shown in Figure 5.

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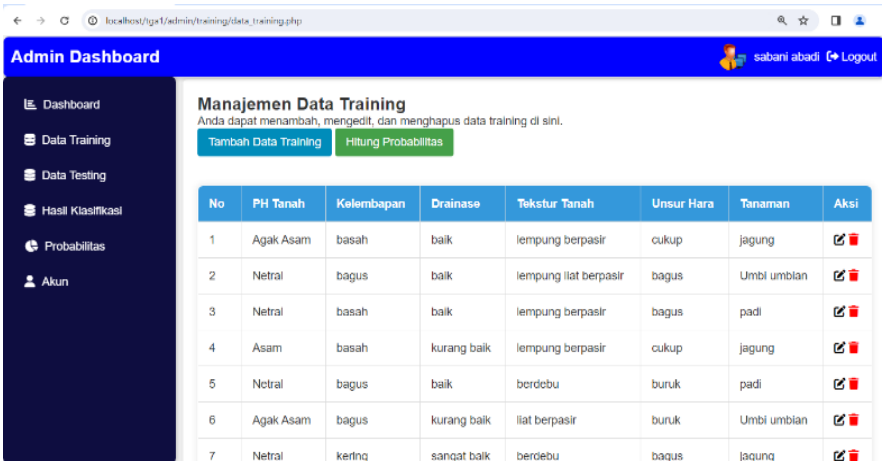

Figure 5. Data Training Page

3. Data testing page

On the testing data page after the admin processes one of the testing data, the system will display the calculation results as shown in Figure 6.

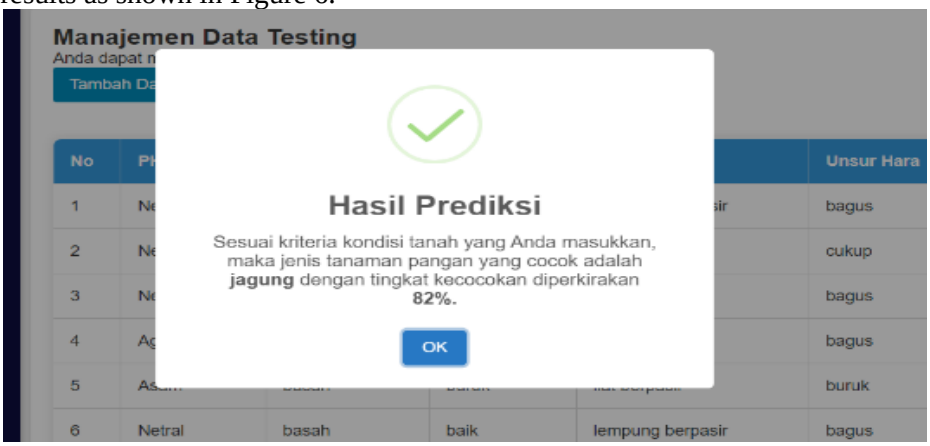

Figure 6. Display of Testing Data Calculation Results

4. Classification result page

On this page will display all the calculation history that has been done by the admin or also the *user* on this page displays the criteria and also the results obtained and the admin can download the data as Figure 7.

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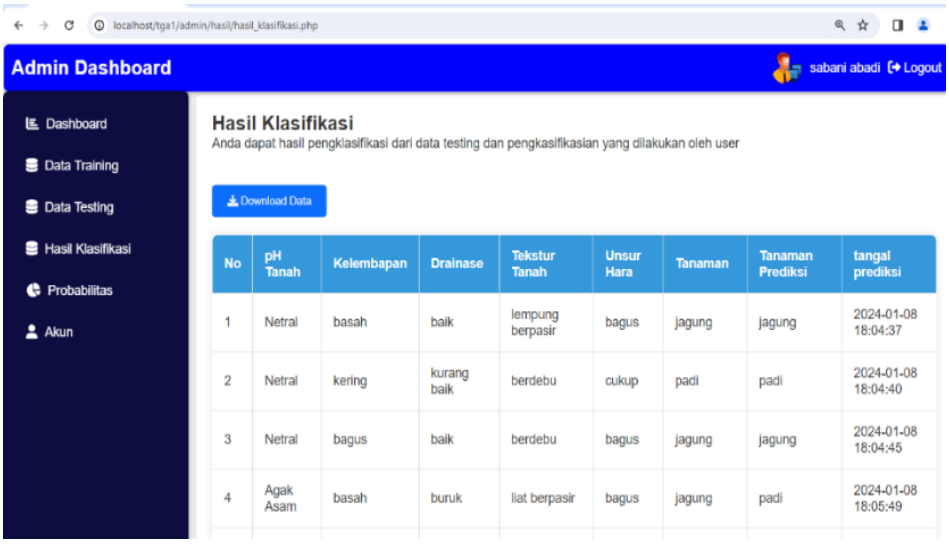

Figure 7. Classification Result Page

5 Conclusion

From the results of research and development of a classification system of for food crops using the Naive Bayes method, it can be concluded that the Naive Bayes Method can be implemented the of suitable soil for food crops based on five criteria, namely pH, moisture, drainage, soil texture, and nutrients. This proves the effectiveness of the method in the context of agricultural management The results obtained from testing data using Naive Bayes calculations are in the form of crop recommendations as follows: Kong village with recommended results for corn, rice, and tubers, Tetinggi village with recommended results for tubers, corn, and rice, Blang Bengkik village with recommended results for rice, tubers, and corn, Gantung Geluni village tubers, rice and corn, Porang Ayu village corn, rice, and tubers, Umelah village with recommended results for rice and tubers, Kutebukit Village with recommended tubers and rice, Anak Reje Village with recommended tubers, rice, and corn, Bener Baru Village with recommended tubers, corn and rice, Akang Siwah Village with recommended corn and rice, Cinta Maju Village with recommended corn, and for Bemem Buntul Pegayon Village with recommended corn and rice. As well as from calculations using the Naive Bayes method, an accuracy rate of 83.3% was obtained. In addition, precision and recall reached 84.0% and 83.4% respectively. These results show that the Naive Bayes algorithm works well in classifying soil types for food crops. The high level of accuracy indicates that the model is able to provide consistent and reliable results.

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