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BIG DATA CONCEPT ANALYSIS FOR AGRICULTURAL SUITABLE LAND GEOGRAPHIC INFORMATION SYSTEM APPROACH

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Abstract

Big data analysis for agriculture provides farmers with a comprehensive view of the concept of increasing agricultural productivity using the effectiveness of irrigation canals, predicting rainfall to determine outcrop patterns, and identifying the adequacy of agricultural land. It also allows farmers to optimize irrigation, increasing yields while reducing costs and environmental impact. It also will enable farmers to optimize irrigation; Rainfall predictions are used to determine cropping patterns and identify suitability for permits. It can also be used to deal with weather patterns and climate change, allowing farmers to adapt their practices to reduce the impact of climate change, ultimately protecting their crops and currency. This research aims to develop plant productivity through several stages of research and the use of methods. The methods used in this study are 1)Prediction of water discharge using the linear regression method; 2)Prediction of Rainfall for Planting Pattern Training using the SARIMA method, and 3)Suitability of Agricultural Land using the Cluster Area Analysis Approach. The results of this study are that in the Sleman region, the adequacy of water for agricultural areas is in the excellent category (fulfilled), cropping pattern spending is divided into 2, namely dry and wet months. In the wet months (high rainfall), rice is suitable for planting from January to May; for the dry months between June and October, tobacco, soybeans, corn, peanuts, green beans, cassava, and sweet potatoes. As for land suitability, it consisted of 46025.36 Ha (81%) suitable and 10811.48 Ha not suitable for use.

Keywords: *Irrigation Channels, Land Suitability, Rainfall Prediction.*

1. INTRODUCTION

Big data analysis for agriculture emerged due to the rapid development of information technology, making geospatial information and sensor data more accessible and easy to use in various applications, including agriculture. Big data analysis for agriculture offers solutions to increasingly complex agricultural problems, such as climate change, rapid population growth, and limited natural resources, by combining geospatial data and sensor technology to help farmers make better decisions. Big data analysis for agriculture provides detailed maps of land, soil, and water conditions and information on weather, rainfall, and soil quality. Farmers can use this information to make more efficient farming plans, determine suitable crop varieties, and monitor crop conditions throughout the season. [1]

Utilizing Internet of Things (IoT) technology, Big data analysis for agriculture also allows farmers to monitor crop conditions in real time, monitor water and nutrient consumption, and predict crop yields. This helps farmers take preventive measures to address problems such as water or nutrient deficiencies, thereby ensuring optimal crop productivity and quality [2], [3]. Big data analysis for agriculture also assists in managing natural resources, such as water and soil, by monitoring and predicting [4] the impact of agricultural activities on the environment. This ensures that farming practices are sustainable and maintain environmental quality for future generations. Overall, big data analysis for agriculture helps farmers overcome increasingly complex agricultural challenges [1] and ensures more efficient, productive, and sustainable agriculture in the era of Agriculture 4.0.

Some of the problems that need to be resolved in the concept of Big data analysis for agriculture in the era of Agriculture 4.0 include several factors [5], including 1) Limited data collection: Spatial data in agriculture is still limited and incomplete, making it difficult development of effective and efficient Big data analysis for agriculture applications. 2) Infrastructure limitations: Infrastructure limitations such as internet networks and connectivity in agricultural areas can hinder the implementation of Big data analysis for agriculture. 3) Limited technological skills: Farmers may not be familiar with the technology and find it challenging to benefit from Big data analysis for agriculture applications if they need help understanding how to use them. 4) Data security issues: Important data generated from the Big data analysis for agriculture applications in agriculture needs to be kept confidential and stored securely to prevent data leakage and misuse. 5) Financial barriers: Implementation of Big data analysis for agriculture technology can require significant financial investment, making it difficult for small and medium farmers to access this technology.

In facing these challenges, a holistic and integrated strategy is needed to maximize the benefits of big data analysis for agriculture in Agriculture 4.0 [6], [7], such as increasing the availability of spatial data, training, and technology education for farmers, as well as investment in infrastructure and data security. This research has an output of an intelligent geographic information system model that benefits the agricultural sector to obtain a class of agricultural land use in the Sleman Regency area. The interim research results are investigations of irrigation networks [8], then predictions of rainfall [9] [10]to find outcropping patterns [11] [12] [13]. In addition, it is also necessary to look at the suitability of the land that has been used so far [14].

2. RESEARCH METHOD

There are three stages of developing the concept of this research can be see in Figure 1, namely:

1. Identification of irrigation canals for prediction [15]–[17]of agricultural land water discharge. [8]
2. Prediction of rainfall to determine cropping patterns to obtain the effectiveness of land management [18]
3. Identification of land suitability for agricultural land to increase the productivity of farm products[19] [14]
4. The concept of big data analysis to increase agricultural yields.

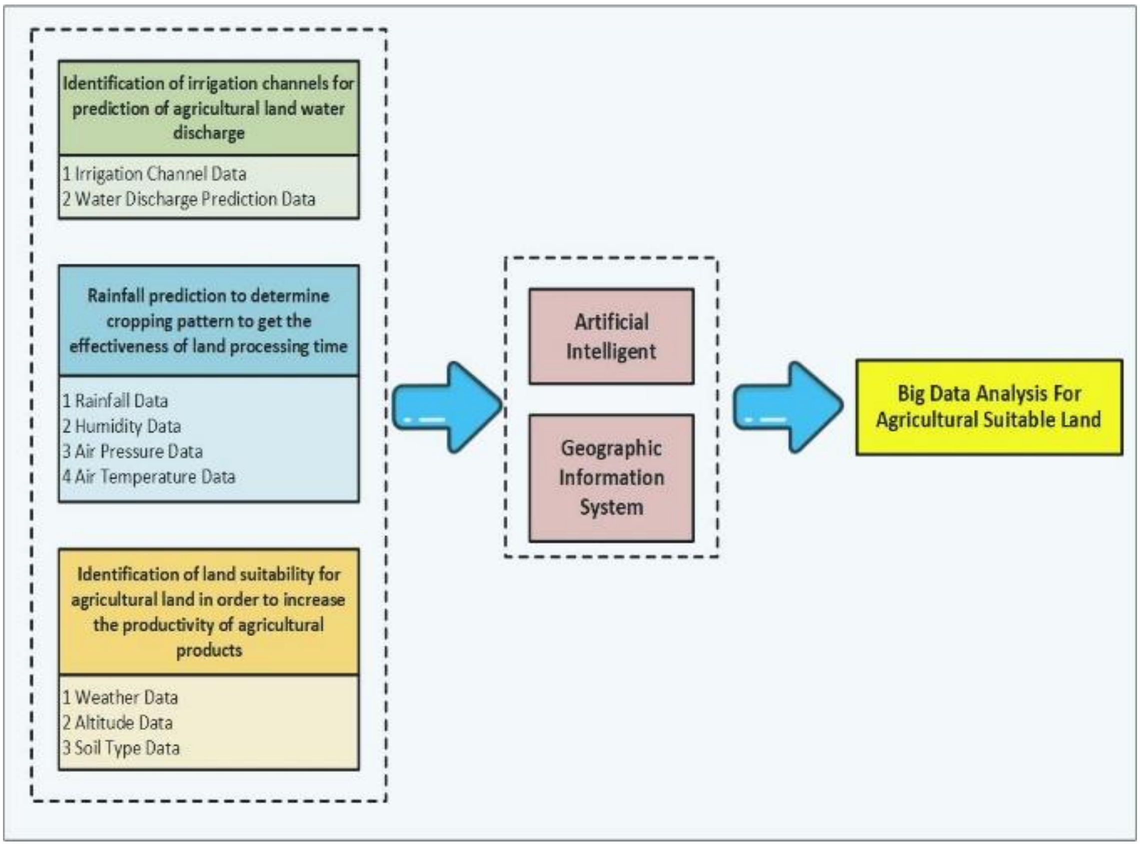

Figure 1 Framework Big Data Analysis for Agricultural Suitable Land

In Figure 2, an inventory of irrigation network identification data is carried out by dividing it into two stages, namely:

1. Initialization stage of spatial data for Sleman regency and non-spatial data in dam, irrigation canal, and location data.
2. Spatial and non-spatial data integration stage. Visualization of irrigation mapping data for the Sleman district.

Analysis of functional requirements in this system are:

1. The system can facilitate data collection of irrigation canals and dams in the Sleman Regency area.
2. The system can display a map of the location of irrigation canals and dams.
3. The system can provide information on estimated water discharge in irrigation canals and dams

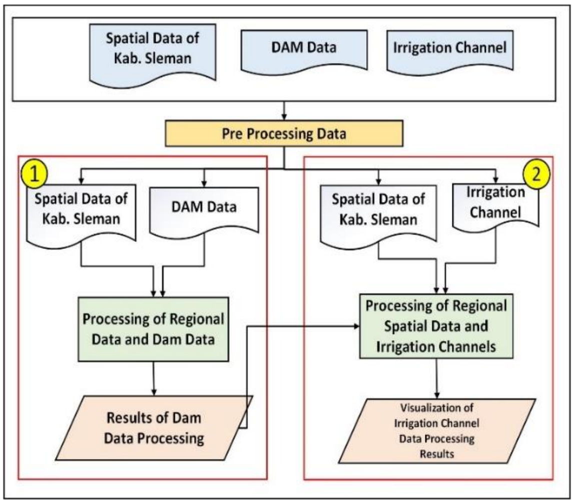

Figure 2 Identification of Irrigation Network Mapping

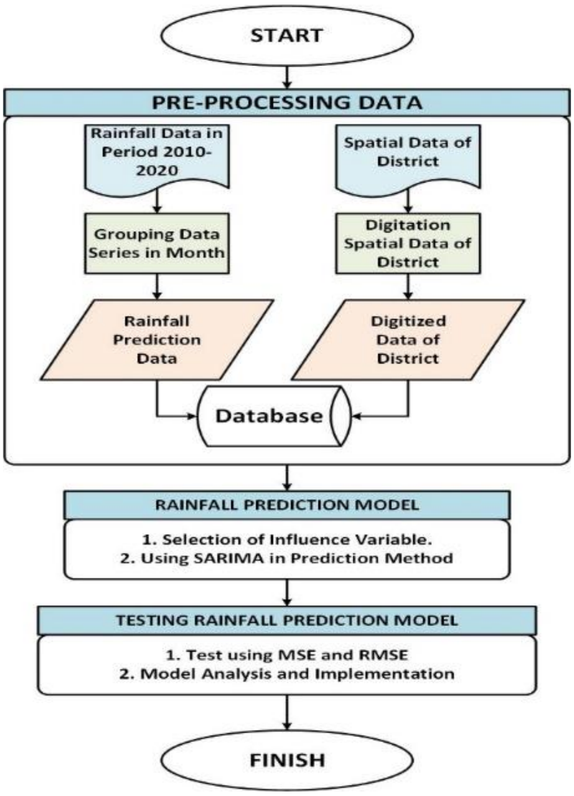

Figure 3 Prediction of Rainfall Step by Step

In Figure 3, step by step of rainfall prediction:

1. The initial stage is to collect references for enriching the material according to the reference in the research. The references consist of all literature studies on rainfall prediction methods and their relation to cropping patterns on agricultural land. Data needs include rainfall data with monthly series starting from 2010 to 2020, while for sub-district spatial data in the form of administrative data for 17 sub-districts in Sleman district.
2. Phase II is carried out by modelling rainfall predictions involving several variables, namely rainfall, humidity, temperature, and regional spatiality. The investigation of influential variables used statistical methods, namely the test of determination (R2), to see how much influence each variable used in the study had. Then the prediction process is carried out using the Seasonal Autoregressive Integrated Moving Average (SARIMA) method. Furthermore, at this stage, algorithms are also arranged and implemented in a rainfall prediction model using the Seasonal Autoregressive Integrated Moving Average method.
3. Phase – III, namely, testing the rainfall prediction model using the Seasonal Autoregressive Integrated Moving method Average with test size RMSE (Root Mean Squared Error) and MSE (Mean Squared Error). Tests are carried out to see the error value prediction, and a suitable error value is close to 0.

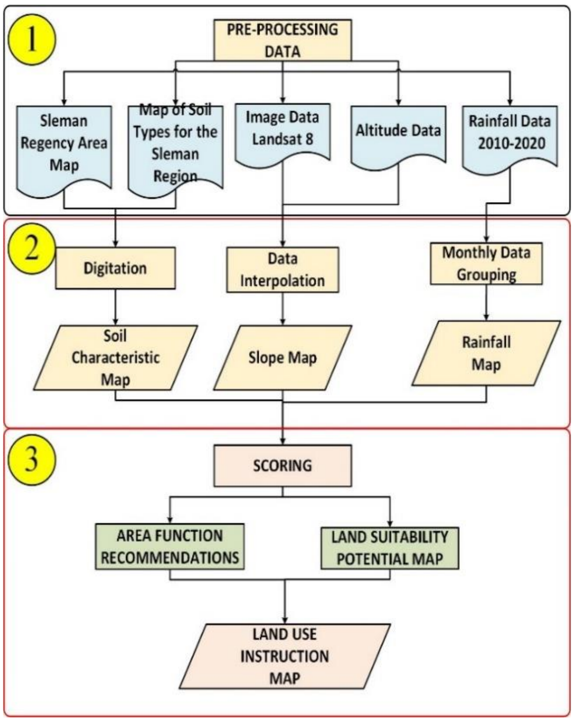

Figure 4 Identification of Land Suitability for Agricultural Land

1. Phase – I, in this section, collects references to enrich the material according to the concerns in the research. The reference consists of all literature related to geographic information systems on land use and its relation to agricultural products. Data requirements include map data for the Sleman Regency area, Landsat imagery (land use), elevation maps, and rainfall data with monthly series from 2010 to 2020.
2. Phase – II, at this stage, a geographic information system modeling design involves several variables, namely soil characteristic maps and rainfall maps. At this stage, digitization is carried out for each type of map needed, data interpolation, and grouping of rainfall data into monthly series.

3. Phase – III, namely the scoring stage, by giving weight to the map variables and supporting variables (rainfall) to get the recommended area function and land suitability values. Furthermore, from calculating the score, an algorithm is used to map land use directions.

3. RESULT

3.1. Identification of Irrigation Channels

In the Sleman Regency area, the standard procedure for managing irrigation networks has generally been carried out at the Public Works and Public Housing Office. However, there are areas for improvement, namely, filling out operational forms. The blanks still being filled in routinely are 05-0 to 09-0. In this irrigation area, water distribution rotation is applied when there is a water shortage (K factor is less than 0.7). The shift period used is based on market days in the Javanese calendar with shifts per village. To be able to calculate the estimated required water discharge, the following parameters are needed:

1. Physical condition of irrigation networks
2. Water discharge is available

$$Q = 1{,}70\ BH^{3/2} \tag{1}$$

Where:
Q = Water discharge (m3/dt)
B = Gauge width (m)
H = Water height upstream (m)

3. Demand Water Debit

$$Q = NFR * A \tag{2}$$

Where:
NFR = Plant water requirement unit (lt/dt/ha)
A = Land area (ha)

4. Loss water

$$Q_{loss} = Q_{input}(m^3/dt) - Q_{output}(m^3/dt) \tag{3}$$

5. Factor K

$$K = \frac{Q_{available} - Q_{loss}}{Q_{needed}} \tag{4}$$

The Sleman regency area has types of irrigation networks in the form of 1) Primary Irrigation Channels, 2) Secondary Irrigation Channels, 3) Primary Carrier Irrigation Channels, and 4) Tertiary Irrigation Channels. There are 12 ponds, 346.8 km of primary irrigation canals, 421.4 km of secondary irrigation canals, 1,960.9 km tertiary canals, and 1,579 sluice gates.

3.2. Rainfall Prediction Knowing Planting Patterns

Determining the characteristic of rain is based on rainfall data used the Oldeman method to determine the natural characteristic of rain by month. The grouping of rainfall prediction results is divided into three: Rainfall less than 100 mm is dry, average rainfall between 100-200 mm in the valley, and rain has an average of over 200 mm is wet. Furthermore, the determination of the cropping pattern based on the suitability of the cropping pattern can be seen in table 1.

The cropping pattern was based on conditions of adequate rainfall that occurred during the planting to harvest period, ranging from 1 mm/day to 72.7 mm/day. Rainfall patterns in Indonesia generally have three main characteristics, namely high rainfall (around January – to April), low Rainfall (around May-August), and moderate Rainfall (around September – to December). Even though there has been a change in peak rainfall in the last 12 years, the cropping pattern in Indonesia follows the three types of rainfall characteristics. The rice cropping pattern is carried out if, on three consecutive bases, the rainfall value is more than 50 mm or the average monthly rainfall is at least 200 mm in one planting period. The cropping pattern of Malawi is carried out if the average monthly rainfall is between 100 mm to 200 mm, and tillage or fallow is carried out if the average monthly rainfall is less than 100 mm.

Table 1. Determination of Crops Pattern

Month	Rainfall Data Prediction	Planting Time	Cropping Pattern
Jan	390,8	1	Rice Plant
Feb	380,1		
March	352,8		
April	353,4		
May	138,4	2	
June	50,7		Palawija
July	8,84		
August	15,6		
Sept	9,71	3	
Oct	10,64		
Nov	171,2		Rice Plant
Dec	369,3		

3.3. Identification of Suitability of Agricultural Land

Research [14] shows that there are 5 class areas of Sleman Regency consisting of

1. Protection Forest;
2. City Center;
3. High-Density Urban Residential Areas;
4. Medium Density Urban Residential Areas;
5. Settlement Development Areas Rural and Agriculture.

The land suitability group for the Sleman district area has the most significant percentage in the agricultural development sector, reaching 64.7%; land as an urban center and protected forest has a ratio of 5.9%, dense residential land is 11.8%, and medium residential land is 17. 6%. Figure 3 is a map visualization of the land suitability area of Sleman Regency, Special Region of Yogyakarta.

Figure 5 is a land suitability map for the Sleman Regency area.

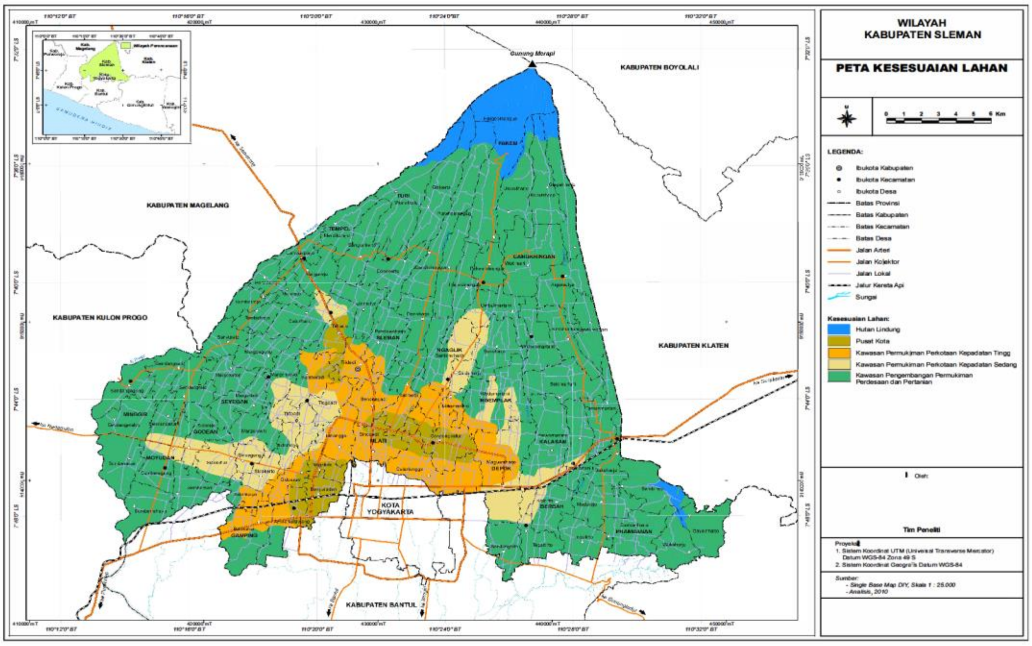

Figure 5 Map of Land Suitability for Sleman Regency

Table 2 shows the name of the area, type of land use and percentage of area use.

The function map of the Sleman district area 2022 was obtained from the overlay results and scoring of the parameters following the Regulation of the Minister of Public Works Number 41 of 2007. The parameters used were rainfall intensity, slope, and soil type—the conditions of the three-parameter factors used in making the area recommendation function. The function recommendation map in.

Table 2. Percentage of Land Suitability

No	Region	Name Region	Percentage
1	Protection Forest	Pakem	5,9%
2	City Center	Depok	5,9%
3	Dense Settlements	Mlati, Sleman	11,8%
4	Medium Settlements	Moyudan, Godean, Ngaglik	17,6%
5	Agricultural Development	Tempel, Cangkringan, Sleman, Ngemplak, Kalasan, Prambanan, Berbah, Gamping, Moyudan, Minggir, Godean.	64,7%

4. DISCUSSION

This section discusses the discussion of research consisting of:

1. Prediction of the amount of water discharge for adequacy of agricultural land.
2. Rainfall prediction to determine cropping pattern
3. Identification of suitability of agricultural land.

4.1. Prediction of The Amount of Water Discharge for Adequacy of Agricultural Land

Prediction calculations were made using trends in water availability and demand in previous years, namely from 2010 to 2021. Predictions were made in this study until 2025. Predictions were made using linear regression. Based on the last data, the forecast of the average water discharge in Sleman Regency is relatively stable. This is due to adequate management of water and dams in the area of agricultural land in Sleman Regency.

4.2. Rainfall Prediction to Determine Cropping Pattern

Based on research, the results of rainfall forecasts obtained in January, February, March, April, and May have relatively high rainfall, with relatively high rainfall conditions, which greatly determine the suitability and optimization of the cultivation of crops, such as rice. Furthermore, June, July, August, September, and October tend to have dry months or very little rainfall, so it can be optimized for cultivating tobacco, soybeans, corn, peanuts, green beans, cassava, and sweet potatoes.

4.3. Identification of Agricultural Land Suitability

The Sleman district has an area of land use that follows the site's function, namely 46025.36 Ha or 81% of the total area, while land use that is not suitable is 10811.48 Ha or 19% of the entire region. This condition indicates that the scope of Sleman Regency in using land types is almost the following all area functions. Land use that is not following the area's role can impact ecological imbalances and have the potential for disasters. This will undoubtedly be homework for the Regional Government in adjusting its land use.

5. CONCLUSSION

Irrigation networks are needed to support the productivity of crops. This is used to be able to display complete irrigation management in Sleman Regency, including being able to display maps of administrative areas, maps of irrigation canals, maps of primary floodgates, maps of secondary floodgates, maps of flood barrier embankments, and road maps. In addition, the reports generated by the irrigation flow data inventory system through attribute data for each map are following existing data in the field and are dynamic, can be changed according to updating of map data, and can provide information on the amount of available water as a form of water adequacy in irrigating agricultural areas.

The rainfall prediction model using the SARIMA method is proven to predict 12 months with an accuracy rate of 98.54% of the predicted rainfall data. Precipitation forecasts can be classified a year into two categories: dry months and wet months. In the wet months (high rainfall), rice is suitable for planting from January to May. For the dry months between June and October, tobacco, soybeans, corn, peanuts, green beans, cassava and sweet potatoes. In addition, there are similarities in the determination of planting period-I (January- April), planting season II (May-August), and planting season III (September-December) between the research model and the cropping pattern guidelines issued by Sleman Regency.

In the area of Sleman Regency, after identifying the suitability of the land, recommendations for the function of the area were made the area is divided into three groups, namely, the recommendation for the part of the area nationally (**N1**-Mount Merapi National Park Area and **N2**-Prambanan Ratu Boko Temple), advice for the function of the provincial area (**P1**-Urban Area, **P2**- Jogja Corridor – Wonosari – Rongkop - Sadeng, **P3**-Temon-Wates-Yogyakarta-Prambanan Corridor, **P4**-Parangtritis Area, **P5**-Temple Area, **P6**-High Technology Area), and recommendations for the function of the district area (**K1**-Water Catchment Area and **K2**-Area Food security).

In future research, it is necessary to implement all data to be processed using a machine learning or artificial intelligence approach to implement the concept of Agriculture 4.0.

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