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Mapping The Distribution Of Soil pH, Pyrite (FeS2) Content, Soil Texture, And Waterlogging In Rice Field Areas In Jejangkit District, Barito Kuala Regency

Akhmad Maki[1)], Muhammad Efendi[2)]
[1,2)] Geography Study Program, Lambung Mangkurat University

*Corresponding Author
E-mail: akhmadmaki20@gmial.com

Abstract

This study aims to identify the characteristics of soil pH, pyrite (FeS_2) content, soil texture, and waterlogging in rice fields in Jejangkit District, Barito Kuala Regency, map their spatial distribution using the Inverse Distance Weighting (IDW) method based on Geographic Information Systems (GIS), evaluate the accuracy of the interpolation results, and develop land management guidelines based on the physical conditions of the land. The study uses a quantitative approach with field survey methods and GIS-based spatial analysis. A total of 64 sample points are used as the main data for interpolation. The results show that the soil pH value ranges from 3.5–5.5, pyrite content is 0.3–4.4%, soil texture is dominated by clay fractions, while the height of waterlogging ranges from 14–64 cm. The IDW interpolation results are able to describe the spatial distribution pattern of all research parameters continuously. Validation testing shows that the interpolation results have a good level of accuracy so that they can be used to describe the condition of the research land.

Keywords: Soil pH, pyrite, soil texture, waterlogging, Geographic Information System, Inverse Distance Weighting

INTRODUCTION

Jejangkit District, as one of the main agricultural development areas in this district, has complex land characteristics with potential physical and chemical constraints that limit crop productivity.(Suratman, 2025)The main obstacles often encountered are the presence of pyrite (FeS_2) content and extreme soil acidity levels.(Maulidi, 2023)Pyrite is a stable compound in flooded conditions, but if the groundwater level drops below a critical level due to excessive drainage or prolonged drought, pyrite will oxidize to produce sulfuric acid which is toxic to plants.(Noor, 2019)The dynamics of oxidation are greatly influenced by the characteristics of the soil texture which determines porosity, as well as the pattern of waterlogging in the agricultural area.(Ir Anthon Monde, 2025).

The fundamental problem in the field is that the variation and spatial distribution of these four parameters—pH, pyrite, texture, and waterlogging—are often not uniform within a single area. Cultivation treatments that are applied uniformly without considering the variability of these land parameters often lead to crop failure.(Maulianawati & Lembang, 2022)Therefore, it is necessary to map the distribution of these parameters using a Geographic Information System technology approach with the Inverse Distance Weighting interpolation method. (Makawimbang & Langi, 2022)The IDW method works on the assumption that soil parameter values at unsampled locations have a greater similarity to the nearest sample points, so that it is able to produce accurate and refined estimates of land parameter distribution mapping results.(Yudanegara, 2021)The application of this method in Jejangkit is crucial for visualizing the gradation of pH changes, pyrite content, distribution of soil texture fractions, and waterlogging conditions in digital map format.(Marlinae, 2021). The use of IDW allows the identification of vulnerable zones that have previously not been detected by visual observation alone.(Prianata, 2023).

RESEARCH METHODS

The data processing method used in this study was the Inverse Distance Weighting (IDW) interpolation method. This method works by estimating parameter values at unsampled locations based on values from the nearest sample points. Theoretically, this method refers to the two-dimensional interpolation function developed by(Shepard, 1968), with the basic principle that closer sample points have a more significant influence on the predicted value than points that are further away. Mathematically, the determination of the predicted value of land characteristics (soil pH, pyrite depth, and groundwater level) is calculated using the Shepard equation as follows:

$$Z_p = \frac{\sum_{i=1}^{n}\left(\frac{Z_i}{d_i^p}\right)}{\sum_{i=1}^{n}\left(\frac{1}{d_i^p}\right)}$$

Where: ( ) is the predicted value of the parameter at the target location. () The actual value of the field measurement results at the sample point to . () The Euclidean distance between the predicted point and the sample point. The application of the IDW-Shepard method was chosen because of its effectiveness in modeling the spatial variability of environmental parameters that have a strong distance correlation, without requiring complex statistical assumptions (such as data stationarity). The analysis process is carried out by inputting coordinate point data and attribute values into a Geographic Information System (GIS). The interpolation results will produce a continuous distribution map which is then classified based on land suitability criteria to produce a distribution map of soil pH, pyrite (FeS2) content, soil texture and waterlogging at the research location.$Z_p Z_i i d_i$

The classification method was applied to group the field measurement data into several categories based on the characteristics of the swamp land in Jejangkit District. The purpose of this classification is to simplify quantitative data for analysis and to show differences in land characteristics between regions. The parameters classified include soil pH, pyrite (FeS_2) content, soil texture, and waterlogging, which were obtained through sampling and direct measurements in the field at sample points for each farmer group in Jejangkit District. Laboratory tests were also conducted to ensure the data was accurate. Each parameter was grouped into three categories: low, medium, and high, based on the criteria of the Minister of Public Works and Housing Regulation No. 05/PRT/M/2010. The classification results were then processed using a Geographic Information System (GIS) to produce thematic maps as a basis for further analysis.

Table 1. Parameters and Classification

Parameter	Lower Class	Medium Class	High grade
Soil pH	>5.5	4.0-5.5	<4.0
Pyrite Content (FeS2)	<1%	1-3%	>3%
Soil Texture	Sand (>50% sand)	Clay (20-40% clay)	Look (>40% clay)
Puddle	<30 cm	30-60 cm	>60 cm

Source :(Ministry of Public Works and Public Housing Regulation No. 05/PRT/M/2010 of 2010.)

RESULTS AND DISCUSSION

Soil pH Distribution Map

The interpolation results show that soil pH values in agricultural areas in Jejangkit District have quite diverse spatial variations. These differences in pH values reflect variations in soil acidity levels between regions, influenced by the characteristics of tidal swamps, hydrological conditions, water management systems, and the presence of sulfidic minerals such as pyrite. These variations in conditions cause soil acidity levels to be unevenly distributed across the study area. To facilitate interpretation of the mapping results, soil pH values are classified into several constraint classes based on soil acidity levels, as presented in the following table.

Table 2. Soil pH Classification

Constraint Class	pH Value Range	Information
High grade	< 4.0	Very Sour
Medium Class	4.0 – 5.5	Sour
Lower Class	> 5.5	Normal

Source :(Ministry of Public Works and Public Housing Regulation No. 05/PRT/M/2010 of 2010,.)

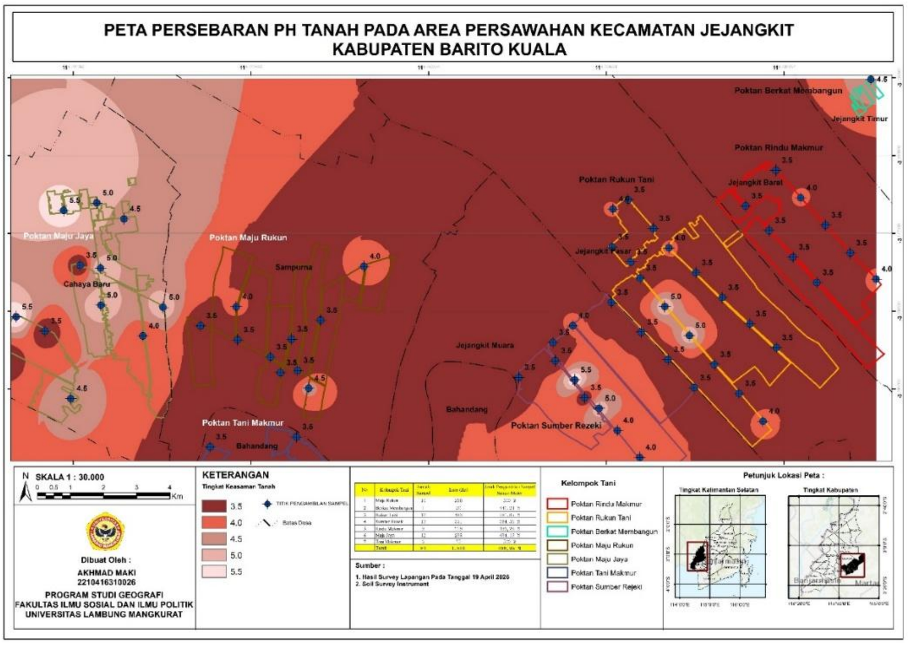
Prior to the interpolation process, soil pH data was obtained through field measurements at 64 sample points spread across the study area. The distribution of these sample points served as the basis for describing the soil acidity conditions in each farmer group. The distribution of soil pH values based on the 64 field sample points is presented in the table below.

Table 3. Use of 64 pH Sample Points

No	Farmers Group	pH value	Number of Samples	Percentage
1	Progressing in Harmony	3.5-4.5	10	15.63
2	Blessings of Building	3.5	1	1.56
3	Farmer's Pillars	3.5-5.0	16	25
4	Source of Sustenance	3.5-5.5	13	20.31
5	Longing for Prosperity	3.5-4.0	9	14.06
6	Go Forth	3.5-5.5	12	18.75
7	Prosperous Farmers	3.5	3	4.69
Total		64		100%

Source: Fieldwork Results April 19, 2026

Next, spatial interpolation was performed using the Inverse Distance Weighting (IDW) method to generate a continuous map of soil pH distribution. This study used two interpolation scenarios: one with 64 primary sample points and one with 106 sample points. The comparison of the two interpolation results was used to assess the effect of the number of observation points on the detail and accuracy of the resulting spatial pattern.



Based on the interpolation results using 64 sample points, the soil pH distribution pattern is generally able to describe the acidity conditions of swamp agricultural land in Jejangkit District. The visualization results show that most of the study area is dominated by zones with high acidity levels, indicated by a color gradation of dark red to dark red. These zones are spread across East Jejangkit, West Jejangkit, Bahandang, most of Jejangkit Pasar, and several areas in Sampurna and Jejangkit Muara Villages. This color dominance indicates that the soil pH value in these areas is in the very acidic range with an average value approaching pH 3.5.

Pyrite (FeS2) Content Distribution Map

Based on the interpolation results using the Inverse Distance Weighting (IDW) method, the pyrite (FeS_2) content in the rice fields of Jejangkit District shows quite different spatial variations between regions. The interpolation results describe the continuous distribution of pyrite content so that the distribution pattern of sulfidic material in tidal swamps can be observed in more detail. Pyrite content is an important parameter in swamps because it plays a role in the formation of acid sulfate soils. The higher the oxidized pyrite content due to unflooded land conditions, the greater the potential for sulfuric acid formation which can increase soil acidity. To facilitate the interpretation of the spatial interpolation results, pyrite (FeS_2) content is classified into three classes as shown in the following table.

Table 4. Classification of Pyrite Content (FeS2)

Parameter	Lower Class	Medium Class	High grade
Pyrite Content (FeS2)	<1%	1-3%	>3%

Source :(Ministry of Public Works and Public Housing Regulation No. 05/PRT/M/2010 of 2010.)

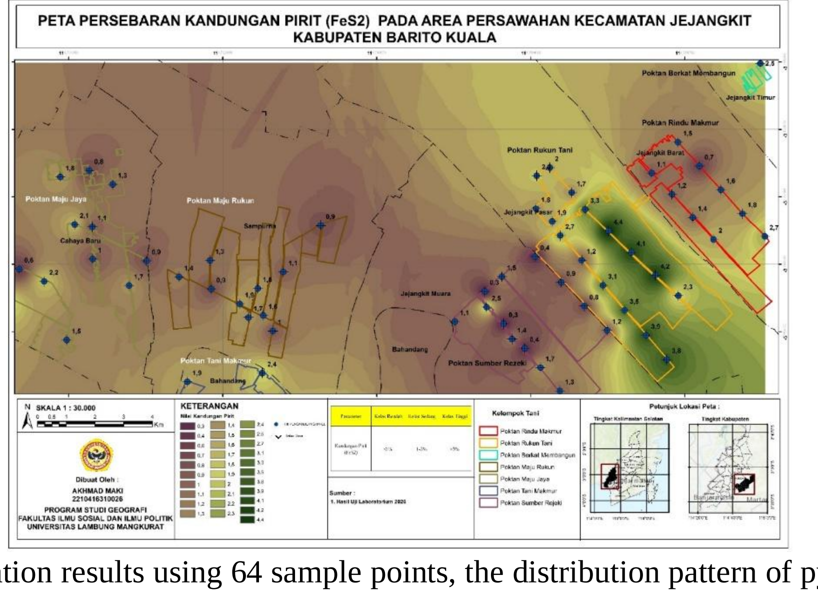
Based on the measurement results at 64 main sample points, the distribution of pyrite content in each farmer group can be seen in the following table.

Table 5. Use of 64 Sample Points for Pyrite Content (FeS2)

No	Farmers Group	Pyrite Value	Number of Samples	Percentage (%)
1	Progressing in Harmony	0.9–1.9	10	15.63
2	Blessings of Building	2.5	1	1.56
3	Farmer's Pillars	1.2–4.4	16	25
4	Source of Sustenance	0.3–2.5	13	20.31
5	Longing for Prosperity	0.7–2.7	9	14.06
6	Go Forth	0.6–2.4	12	18.75
7	Prosperous Farmers	1.9–2.4	3	4.69
Total		64		100%

Source: Fieldwork Results April 19, 2026

Based on the table, the pyrite content in the study area shows quite large variations, ranging from 0.3% to 4.4%. The Rukun Tani Farmers Group has the highest pyrite content range compared to other areas, namely between 1.2% and 4.4%. This value indicates that in some locations there is a pyrite content that is included in the high category (>3%). Meanwhile, the Sumber Rezeki and Maju Jaya Farmers Groups show a relatively lower pyrite content range with minimum values of 0.3% and 0.6%, respectively. The variation in pyrite content indicates that sulfidic material in the tidal swamp land of Jejangkit District is not evenly distributed and tends to be influenced by land formation processes, sedimentation conditions, and local hydrological characteristics. Furthermore, the measurement data is used as a basis for the spatial interpolation process using the IDW method to produce a continuous pyrite content distribution map.



Based on the interpolation results using 64 sample points, the distribution pattern of pyrite content is generally able to indicate the distribution of sulfidic material in the rice fields of Jejangkit District. The visualization results show that most of the study area is dominated by moderate to high pyrite content. Zones with relatively high pyrite content are seen in the Jejangkit Pasar area, parts of West Jejangkit, and several areas around the Rukun Tani area, indicated by a dark green color gradation. In contrast, the Maju Jaya, Maju Rukun, and parts of Sumber Rezeki areas tend to show lower to moderate pyrite content.

Soil Texture Map

Laboratory analysis results showed that the soil texture composition in the study area was dominated by clay fractions, while sand and silt fractions had lower proportions. The average value of each soil texture fraction in each farmer group was used as the basis for spatial interpolation to produce a continuous soil texture distribution map.

Sand Texture

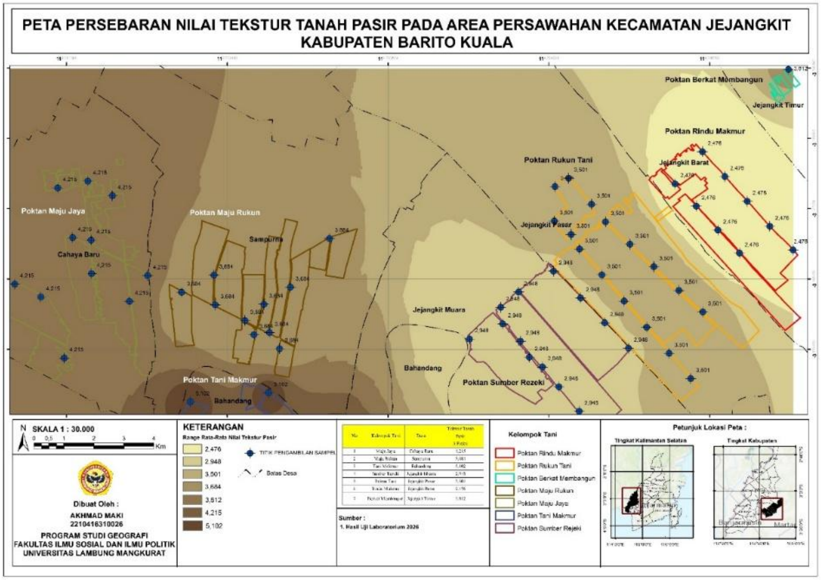
Based on the IDW interpolation results, the distribution of sand fractions in the rice fields of Jejangkit District shows relatively low spatial variation. Sand fraction values in the study area ranged from 2.476% to 5.102%. This distribution indicates that the entire study area has a relatively low sand content, resulting in soil characteristics dominated by fine fractions.

Table 6. Sandy Soil Texture

o	Farmers Group	Village	Soil Texture
			3 Factions
			Sand
	Go Forth	New Light	4,215
	Progressing in Harmony	Perfect	3,684
	Prosperous Farmers	Bahandan g	5,102
	Source of Sustenance	Jejangkit Muara	2,948
	Farmer's Pillars	Market Jejangkit	3,501
	Longing for Prosperity	West Jejangkit	2,476
	Blessings of Building	East Jejangkit	3,812

Source: Laboratory Test Results 2026

Based on the interpolated map, the highest sand content was identified in the Tani Makmur Farmers Group in Bahandang Village with an average value of 5.102%. This zone is indicated by a darker color gradation compared to other areas. Meanwhile, the lowest sand content was found in the Rindu Makmur Farmers Group in West Jejangkit Village with an average value of 2.476%. Spatially, it can be seen that the western to southern areas of the study, particularly Cahaya Baru, Sampurna, and Bahandang, have a relatively higher sand content than the Jejangkit Muara and West Jejangkit areas. However, the differences in values between the regions are not too striking because the entire study area still shows a dominance of fine fractions. The low sand content indicates that the soil's ability to retain water is relatively high, so this condition supports the characteristics of tidal swamps that tend to be saturated with water.



Dust Texture

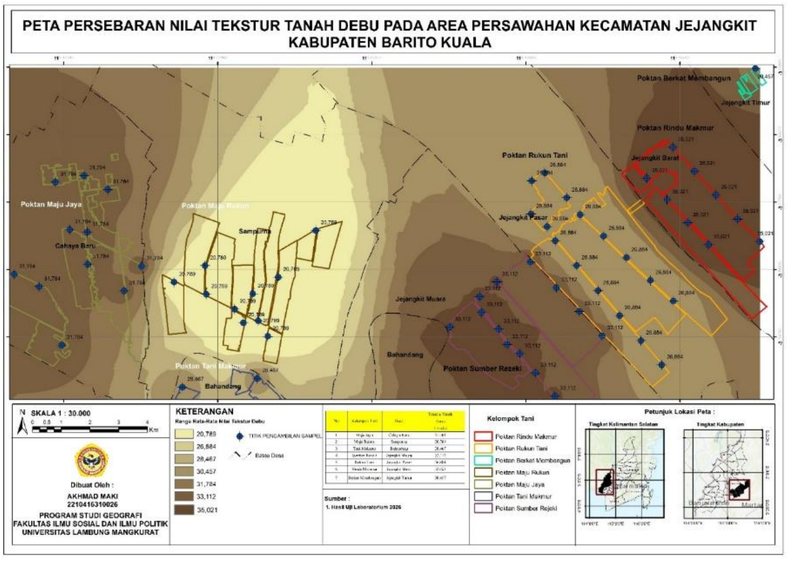
The dust fraction is a component of soil texture that plays a role in determining water and nutrient storage capacity. Spatial interpolation results indicate that the dust content in Jejangkit District ranges from 20.789% to 35.021%.

Table 7. Dust Textures

o	Farmers Group	Village	Soil Texture 3 Factions Dust
	Go Forth	New Light	31,784
	Progressing in Harmony	Perfect	20,789
	Prosperous Farmers	Bahandang	28,467
	Source of Sustenance	Jejangkit Muara	33,112
	Farmer's Pillars	Market Jejangkit	26,884
	Longing for Prosperity	West Jejangkit	35,021
	Blessings of Building	East Jejangkit	30,457

Source: Laboratory Test Results 2026

Based on the interpolation results, the highest dust content was found in the Rindu Makmur Farmers Group in Jejangkit Barat Village with an average value of 35.021%, followed by Sumber Rezeki in Jejangkit Muara at 33.112%. Conversely, the lowest dust content was found in the Maju Rukun Farmers Group in Sampurna Village with a value of 20.789%. The spatial pattern of the interpolation results shows that the eastern and southeastern regions of the study tend to have higher dust content than the western region. This distribution indicates variations in sedimentary material that form swamp land in each region. Relatively high dust content is generally associated with the soil's ability to retain water and nutrients better than soil dominated by sand fractions.



Clay Texture

Clay fraction interpolation results indicate that the entire study area is dominated by very high clay content. Clay fraction values ranged from 62.504% to 75.526%, indicating fine-textured soil characteristics.

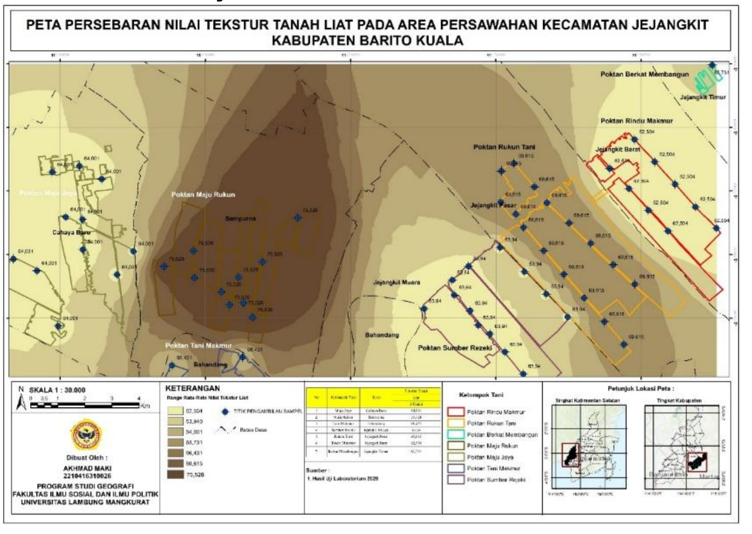
Table 8. Clay Texture

o	Farmers Group	Village	Soil Texture
			3 Factions
			Dust
	Go Forth	New Light	64,001
	Progressing in Harmony	Perfect	75,526
	Prosperous Farmers	Bahandang	66,431
	Source of Sustenance	Jejangkit Muara	63,940
	Farmer's Pillars	Market Jejangkit	69,615
	Longing for Prosperity	West Jejangkit	62,504
	Blessings of Building	East Jejangkit	65,731

Source: Laboratory Test Results 2026

Based on the interpolation results, the highest clay content was found in the Maju Rukun Farmers Group in Sampurna Village with an average value of 75.526%, while the lowest clay content was found in the Rindu Makmur Farmers Group in West Jejangkit Village at 62.504%. Nevertheless, all study areas still showed a very high dominance of the clay fraction. Spatially, the dominance of the clay fraction was distributed almost evenly across the rice fields in Jejangkit District. This condition indicates that the soil in the study area has a high water retention capacity and relatively low permeability. These characteristics significantly influence the hydrological conditions of tidal swamps because they are able to maintain standing water for a longer period. The ability of clay to retain water also plays a role in maintaining the pyrite layer in a saturated condition so that the potential for pyrite oxidation can be minimized.

Overall, the results of spatial interpolation of soil texture indicate that the rice fields in Jejangkit District are dominated by clayey soils with low sand content and moderate silt content. This distribution pattern indicates that most areas have a high water retention capacity, thus supporting the characteristics of tidal swamps. The results of this spatial mapping of soil texture provide important information in understanding the relationship between soil physical conditions, water level, pyrite content, and soil acidity levels in the study area.



Waterlogging Distribution Map

Based on the interpolation results using the Inverse Distance Weighting (IDW) method, the spatial distribution of water levels in the rice fields of Jejangkit District shows a distribution pattern that varies between regions. This variation is continuously visualized on the interpolated map so that differences in hydrological conditions between agricultural areas can be seen more clearly. In this study, the water level parameter is used to describe the condition of the tidal swamp water system that affects soil moisture stability and the oxidation process of pyrite minerals in agricultural land. To facilitate the interpretation of the spatial interpolation results, water levels are classified into three classes as shown in the following table.

Table 9. Classification of Waterlogging

Flood Class	Flood Height	Information
Lower Class	< 30 cm	Shallow
Medium Class	30 – 60 cm	Optimal
High grade	> 60 cm	In

Source:(Ministry of Public Works and Public Housing Regulation No. 05/PRT/M/2010 of 2010, nd)

Based on the measurement results of 64 main sample points, the distribution of water level in each farmer group can be seen in the following table.

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Table 9. Use of 64 Water Pool Sample Points

No	Farmers Group	Flood Height	Number of Samples	Percentage
1.	Progressing in Harmony	27–34 cm	10	15.63%
2.	Blessings of Building	16 cm	1	1.56%
3.	Farmer's Pillars	15–30 cm	16	25.00%
4.	Source of Sustenance	14–25 cm	13	20.31%
5.	Longing for Prosperity	15–25 cm	9	14.06%
6.	Go Forth	28–64 cm	12	18.75%
7.	Prosperous Farmers	20–29 cm	3	4.69%
Total			64	100%

Source: Fieldwork results on April 19, 2026

Based on the table, the distribution of observation points has been adjusted to the area of each farmer group. The Rukun Tani Farmer Group has the largest number of sample points, namely 27 points, because it has the largest area of 403 hectares. In contrast, the Berkat Membangun Farmer Group only has one sample point because its area is relatively small, namely 20 hectares. The distance between observation points ranges from 382–447 meters so that the sample distribution is relatively even across the study area. In addition, the average highest water level was found in the Maju Jaya Farmer Group at 45 cm, while the lowest average was found in the Berkat Membangun Farmer Group at 16 cm.

The interpolation results show that shallow inundation patterns dominate most areas of Jejangkit District, especially in the areas of East Jejangkit, West Jejangkit, Bahandang, Jejangkit Muara, and most of Jejangkit Pasar. On the interpolated map, these zones are represented by a gradation of light green to whitish green, indicating relatively low inundation levels. Conversely, zones with higher inundation levels are concentrated in the western part of the study area, particularly in the area of the Maju Jaya Farmers Group in Cahaya Baru Village, which is represented by dark green to deep green.

CONCLUSIONS

Based on the research results, the characteristics of rice fields in Jejangkit District show spatial variations in soil pH, pyrite (FeS_2) content, soil texture, and waterlogging. Soil pH values range from 3.5–5.5 with conditions dominated by acidic to very acidic soils, pyrite content ranging from 0.3–4.4%, soil texture dominated by clay fractions, and waterlogging heights ranging from 14–64 cm. These variations reflect differences in the physical and chemical conditions of the land in each study area.

The Inverse Distance Weighting (IDW) method based on Geographic Information Systems (GIS) can continuously depict the spatial distribution of each parameter, facilitating the identification of agricultural land characteristics. Validation results indicate that the interpolation has a good level of accuracy, so the resulting map can be used as supporting information in tidal swamp agricultural land management, particularly in water management and soil fertility management in Jejangkit District.

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