Land Suitability for Cornbased on Land Characteristics in Block A5 Right of Dadahup Swamp Irrigation Area Kapuas Regency

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Abstract. The development of the Dadahup Swamp irrigation area, as one of the food estate program locations, focuses on agriculture for rice cultivation. Besides rice, corn is also included as a food staple. Corn can be used as an alternative crop for farmers in case of rice crop failure during the dry season. Therefore, it is necessary to identify land characteristics for corn cultivation. In this study, land suitability analysis for corn used the FAO method based on eleven characteristic land parameters, including temperature, water availability, oxygen availability, root media, peat thickness, cation-exchange capacity, base saturation, pH H_2O, soil organic carbon, toxicity and sulfidic hazard displayed on a map using QGIS. The results showed that seven parameters were very suitable for land use for corn, including water availability, oxygen availability, root media, peat thickness, cation-exchange capacity, pH H_2O, soil organic carbon, and toxicity. Besides that, two parameters were marginally suitable for corn cultivation:temperature and base saturation. However, two parameters wereunsuitable for corn cultivation: water availability and sulfidic hazard. It was caused by rainfall with an average rainfall of 2245 mm/year and the depth of pyrite was found lower than 75 cm from the topsoil.The recommendations to make the land suitable for corn cultivation are good drainage system planning, leaching acid sulphate soil, liming and organic fertilizer application. The impact of this study is that it can be useful in designing corn cultivation so that it contributes to the food estate program.
Keywords: agriculture, food estate, soil, pyrite, crop

1 Introduction

Indonesia's populationis estimated to increment 238.5 million in 2010 to 305.6 million in 2035 [1]. As the population continues to grow, food needs are also increasing. The Government of Indonesia designed a food estate program in 2020 to prevent food scarcity. One of the program locations is the Dadahup swamp irrigation area. The Dadahup Swamp Irrigation Area is in Bangun Jaya Village, Dadahup District, Kapuas Regency, Central

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Kalimantan Province. The Dadahup swamp irrigation area is 21,226 ha [2].The location of the pilot project for the Dadahupswamp irrigation area is Block A5. Block A5 is divided into two areas namely Block A5 Right and Block A5 Left. The Indonesian government focuses on developing rice cultivation in this area, planning to build a 358-ha rice demonstration plot in Block A5 right.[3].

The food estate program should not focus only on the development of rice cultivation, but other food staples that can be alternative crops. Corn is another food staple often planted in swamps [4]. Corn has great potential for agribusiness, such as the price is lower than rice, it can be sold as feed for poultry, and the corn harvest duration is fast,around 3 to 4 months. [5].Farmers usually plant corn when the rice harvest is finished or during the dry season [6].Corn requires a little water for its growth, so it can be an alternative food crop during the dry season[7]. Therefore, it can create food diversification, increase agricultural productivity in the dry season and increase farmers' income in support of sustainable agriculture.

In the development of corn cultivation, it is necessary to study the land characteristicsin swamp areas. Swamp areas usually contain pyrite, which can change into acid sulphate soil by oxidizing with air.This process can cause a decrease in the potential of hydrogen (pH)[8]. pH 5.5 to 8.2 is suitable for corn cultivation, so acid sulphate soils are not suitable for corn cultivation[9]. Apart from the problem of pyrite in swamp areas, several other land characteristic parameters are used to determine the land suitability for corn cultivation [9]. Therefore, it is mandatory to identify the characteristics of the land in the Dadahup swamp irrigation area to analyze the suitability of the land for corn cultivation.

2 Material and Method

This study location was carried out in Block A5 Right of the Dadahupswamp irrigation area with an area of 835.36ha, as shown in **Figure 1**. The method used in analyzing land suitability for corn cultivation was by matching land characteristics with land suitability class criteria based on FAO. According to FAO,land suitability was divided into four classifications as Class S1 (Highly suitable), Class S2 (Moderately suitable), Class S3 (Marginally Suitable), and Class N (Non-suitable)[10].The classification of land suitability for corn cultivation based on land characteristics can be seen in **Table 1**[9].

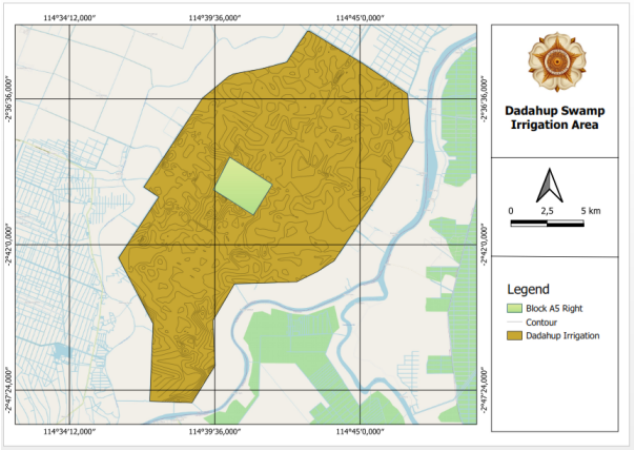

Fig 1. Location of block A5 right

Table 1. Land suitability of corn.

Land Characteristics	Land Suitability Class			
	S1	**S2**	**S3**	**N**
Temperature (˚C)	25-27	27-30	30-35	>35
		18-25	15-18	<15
Water availability (Rainfall) (mm)	400-900	300-400	130-500	<150

Table 1. Land suitability of corn (continued).

Land Characteristics	Land Suitability Class			
	S1	**S2**	**S3**	**N**
		900-1200	1200-1400	>1400
Oxygen availability (Drainage)	Slightly Obstructed	Slightly fast, moderate	Obstructed	Highly obstructed
Root media (Texture)	Fine, slightly fine, medium	-	Slightly coarse	Coarse
Peat thickness (cm)	<60	60-140	140-200	>200
Cation-exchange capacity (cmol)	>16	≤16		
Base Saturation (%)	>50	35-50	<35	
pH H_20	5.5-8.2	5.3-5.5 8.2-8.5	<5.3 >8.5	
Soil Organic Carbon (%)	>0,4	<0,4		
Toxicity (Salinity) (dS/m)	<0.8	8-12	12-16	>16
Sulfidic Hazard (cm)	>100	75-100	40-75	<40

Soil samples have been taken at the research site as primary data. Soil sampling data collection is required to obtain the value of land suitability parameters based on **Table 1**.There were seven soil sample points, as shown in **Figure 2**. The first step in collecting the soil sample wasto peel off the top of the soil where there were still plants or plant roots. Then the soil samples wereobtainedusing a soil drill intoa depth of 30 cm. The soil samples were tested directly in the field and the laboratory. Soil parameters tested directly in the field were oxygen availability, root media, pHH_2O, and sulfidic hazard. The methods are used in testing soil samples in the study site, shown in**Table 2**.

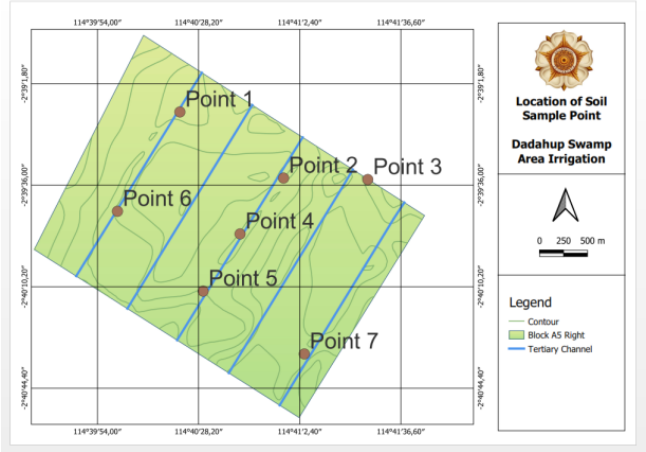

Fig 2. Location of the soil sample

Table 2. Method of testing soil samples in the field.

Land Characteristics	Method
Oxygen availability	Based on soil color

Table 2. Method of testing soil samples in the field (continued).

Land Characteristics	Method
Rooting medium	Based on the type of soil
pH H_20	Used pH meter
Sulfidic hazard	Poured Hydrogen Peroxide solution

Meanwhile, the soil samples tested in the laboratory were cation-exchange capacity, base saturation, soil organic carbon, and toxicity using the method shown in **Table 3**.

Table 3. Method of testing soil samples in the laboratory.

Land Characteristics	Method
Cation-exchange capacity	Extracted of NH4OAc 1 M pH 7,0
Base Saturation	Calculated
Soil Organic Carbon	Walkey and Black
Toxicity	Calculated

In addition to the primary data above, secondary data collection was also carried out. The secondary data obtained were temperature, rainfall, and peat thickness. Temperature and rainfall data were obtained from the Dadahup climatology station located in block A1 of the Dadahup swamp irrigation area with coordinates 02º 39' 45" South Latitude 114º 38' 40" East Longitude. Temperature data wereobtained from 2017 to 2022, and rainfall data from 2018 to 2022. Meanwhile, peat thickness data wereprovided by from Balai Wilayah Sungai Kalimantan II[2].

All the data collected was made into a map using QGIS. Because the data obtained were only from seven soil sample points, the Inverse Distance Weighted (IDW) method was used to make the map. It judges the value of unsampled data based on the sample data through interpolation[11].

3 Result and discussion

The following are the results of the analysis carried out, as shown in **Table 4**.

Table 4. The result of measuring the characteristics of the land.

Land Characteristics	The Result of measurement						
	Location of Soil Sample						
	1	2	3	4	5	6	7
Temperature (˚C)	33.3	33.3	33.3	33.3	33.3	33.3	33.3
Water availability (Rainfall) (mm)	2245	2245	2245	2245	2245	2245	2245
Oxygen availability (Drainage)	Slightly Obstructed	Slightly Obstructed	Slightly Obstructed	Slightly Obstructed	Slightly Obstructed	Slightly Obstructed	Slightly Obstructed

Table 4. The result of measuring the characteristics of the land (continued).

Land Characteristics	The Result of measurement						
	Location of Soil Sample						
	1	2	3	4	5	6	7
Root media (Texture)	Slightly Fine	Slightly Fine	Slightly Fine	Slightly Fine	Slightly Fine	Slightly Fine	Slightly Fine
Peat thickness (cm)	18	15	59	25	27	20	57
Cation-exchange capacity (cmol)	49.39	58.85	64.86	61.32	44.11	53.11	67.34
Base Saturation (%)	3.46	1.95	3.81	6.67	7.30	3.52	3.22
pH H_20	6.8	6.8	6.4	6.6	6.5	6.8	6.7
Soil Organic Carbon (%)	1.50	1.62	5.12	6.01	3.25	1.24	1.16

Land Characteristics	The Result of measurement						
	Location of Soil Sample						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Toxicity (Salinity) (Ds/m)	0	0	0	0	0	0	0
Sulfidic Hazard (cm)	60	100	30	30	50	60	60

A more detailed explanation of the results of the land suitability analysisis as follows:

3.1 Temperature

The temperature affects corn productivity. Every increase in temperature causes a decrease in water, so corn productivity can also be decreased[12].The temperature required for corn cultivation is between 25 ºC to 30 ºC. Based on an analysis of temperature data from 2017 to 2022, the average temperature value in the Dadahup swamp irrigation area was 33.3 ºC, as shown in **Table 4**. Hence, it is classified asmarginally suitable (S3) for the corn, as shown in **Figure 3**.

3.2 Water availability

The water availability is calculated based on the amount of rainfall that occurs during the year. The rainfall per year suitable for corn cultivation is between 300 mm to 400 mm and 900 mm to 1200 mm. Based on the analysis of rainfall data from 2018 to 2022, the average rainfall in the Dadadupswamp irrigation area was 2245 mm per year, as shown in **Table 4**. This happens because of a monsoonal rainfall pattern in this study area[13]. Hence, itis classified asnot suitable (N)for the corn, as shown in**Figure 4**.

The Dadahup irrigation area has low land elevation, so high rainfall may make the inundated land. Inundated land can inhibit the growth of corn. Based on the previous study in Kaliwungu Village, corn productivity with inundated land was 10.17 tons/ha. In comparison, corn production with regularly irrigated land was 12.10 tons/ha[14]. Corn productivity was lower on inundated land than on regularly irrigated because the supply of oxygen in the roots was hampered by water. A good drainage system should be designed to preventcorn from being submerged.

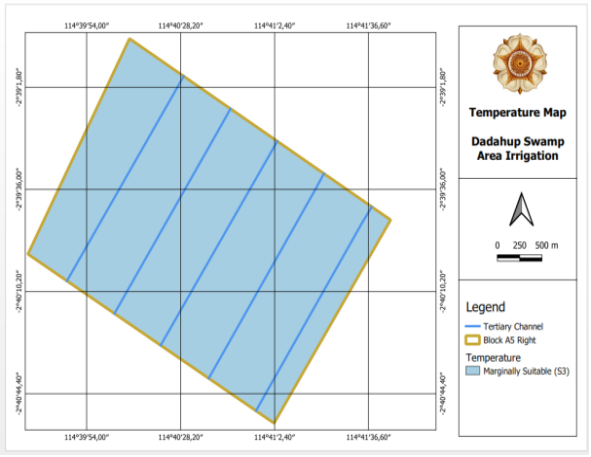

Fig 3. Temperature Map

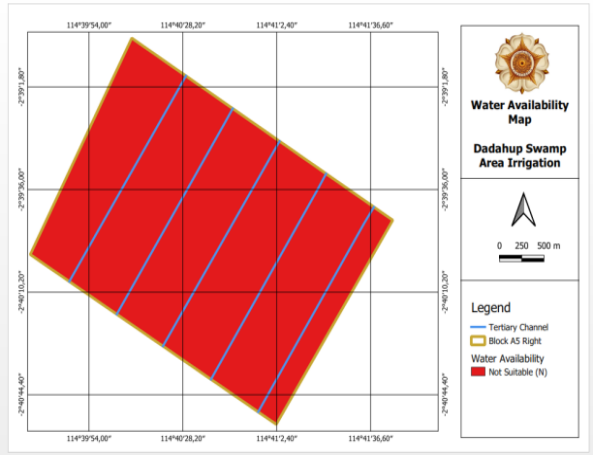

Fig 4. Water Availability Map

3.3 Oxygen availability

Oxygen availability (Drainage) is the percolation rate of water into the soil on the aeration of the air in the soil [9]. Data wereobtained from visual observation of the colours of the soil at the research location. The soil colours at the study site are mostly grey and brown, which isclassifiedasslightly obstructed based on oxygen availability classifications [9], as shown in **Table 4**. Hence, itis classified ashighly suitable (S1) for the corn,as shown in **Figure 5**.

3.4 Root media

The root media (Texture) is related to the holding ability of the soil to retain the water[9].The type of soil in the study area is silt. Silt soil types are classified as slightly fine soil texture classesbased on root media classifications [9], as shown in **Table 4**. Soil texture classes highly suitable for corn are fine, rather fine, and medium. Hence, itis classified ashighly suitable (S1) for the corn,as shown in **Figure 6**.

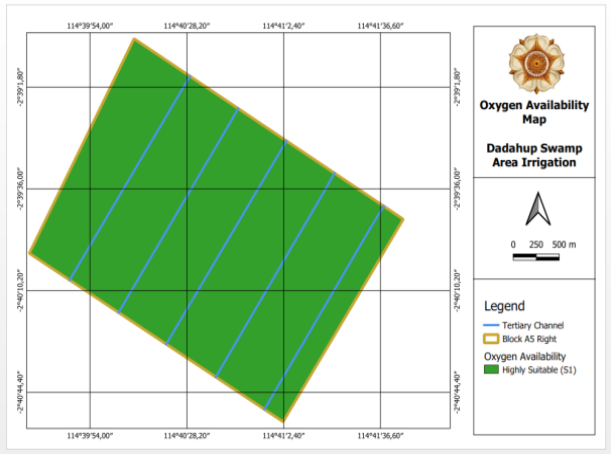

Fig 5. Oxygen Availability Map

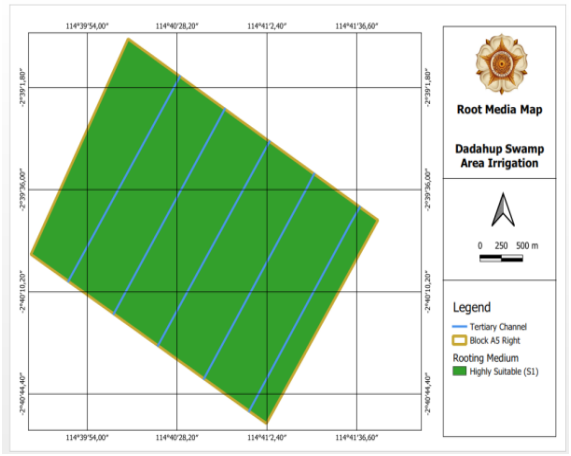

Fig 6. Root media Map

3.5 Peat thickness

In managing swamp land, we mustbe careful of the peat. It is necessary to keep the peat not being exposed to the air. Peat has irreversible dry properties, so when exposed to air, peat will dry out. The dry peat can burn, thereby increasing greenhouse gas emissions [15]. The thickness of peat suitable for corn cultivation ranges from 0 cm to 140 cm. Based on the secondary data obtained, the peat's thicknessin the research locationwas 15 cm to 59 cm, as shown in **Table 4**[2]. Hence, itis classified as highly suitable (S1) for the corn,as shown in**Figure 7**.

3.6 Cation-exchange capacity

The suitable cation-exchange capacity value for corn cultivation is greater than 16 cmol/kg. Based on the test results in the laboratory, the cation-exchange capacity values range from 44.11 to 67.34 cmol, as shown in **Table 4**.Hence, itis classified as highly suitable (S1) for the corn,as shown in **Figure 8**.

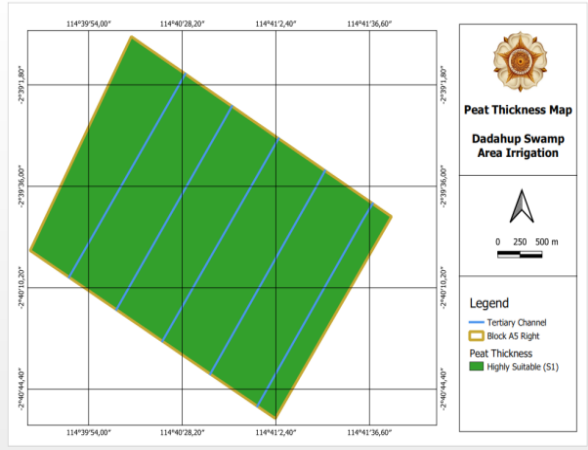

Fig 7. Peat Thickness Map

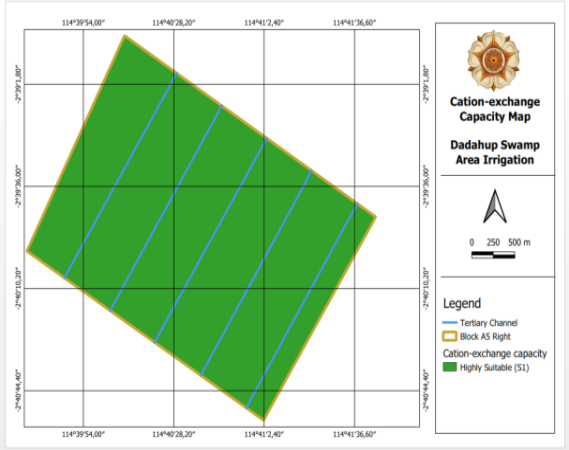

Fig 8. Cation-exchange capacity Map

3.7 Base saturation

The base saturation suitable for corn cultivationis greater than 35%. Based on the results, the base saturation value obtained ranges from 1.95% to 7.3%, as in **Table 4**.Hence, itis classified as marginally suitable (S3) for the corn, as shown in**Figure 9**.

3.8 pH H_2O

pH H_20 isthe hint of soil chemical fertility related to soil nutrients [16]. The pH value based on measurement in the field was between 6.4 and 6.8,as shown in**Table 4**.The pH value suitable for corn cultivation ranges from 5.3 to 8.2. Hence, itis classified ashighly suitable (S1),as shown in**Figure 10**.

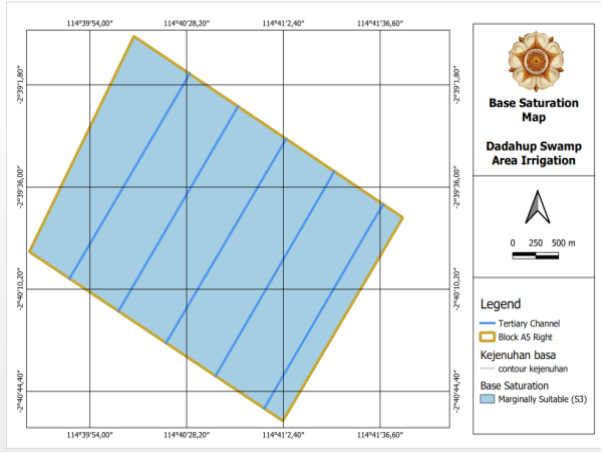

Fig 9. Base Saturation Map

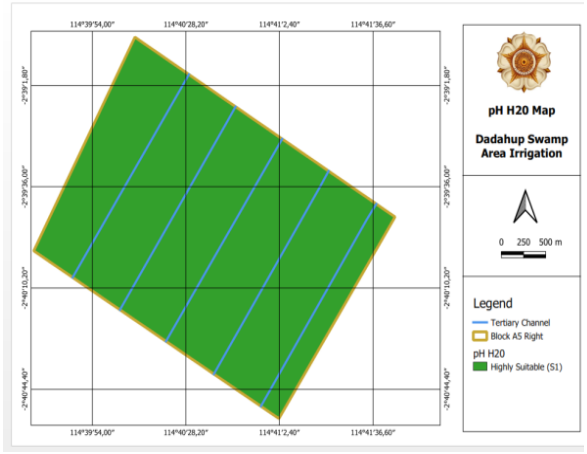

Fig 10.pH H_20 Map

3.9 Soil organic carbon

Soil organic carbon content suitable for corn cultivation is greater than 0.4%. Based on the results, it was found that the soil organic carbon content was 1.16% to 5.12%, as in **Table 4**.Hence, itis classified ashighly suitable (S1),as shown in**Figure 11**.

3.10 Toxicity

suitable for corn are smaller than 0.8 dS/m. Based on the laboratory results, salinity was not foundin the Dadahupswamp irrigation area, as in **Table 4**.Hence, itis classified ashighly suitable (S1),as shown in**Figure 12**.Toxicity is related to the salinity content dissolved in the water. Salinity valuesthatare

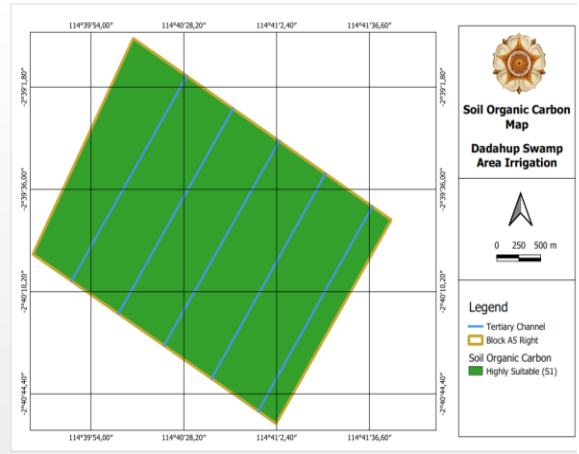

Fig 11. Soil Organic Carbon Map

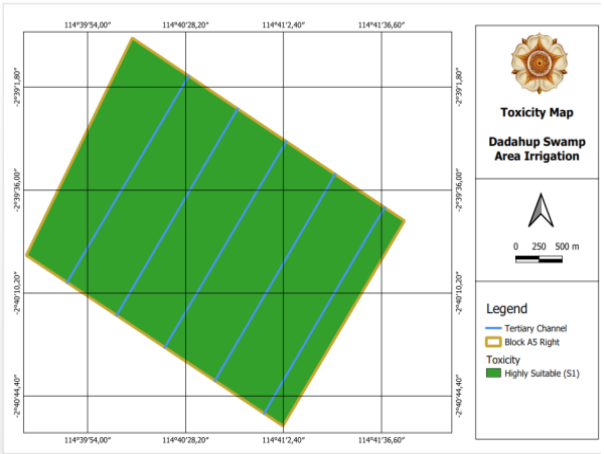

Fig 12. Toxicity Map

3.11 Sulfidic hazard

Sulfidic hazard is related to pyrite. Based on pyrite testing in the field, pyrite was found at 30 cm to 100 cm from topsoil, as shown in **Table 4**. The suitable depth of pyrite for corn cultivation is greater than 75 cm from the topsoil. Hence, itis classified into three classesthat aremoderately suitable (S2), marginally suitable (S3), and not suitable (N), as shownin

Figure 13. Pyrite exposed to air can cause soil to become acid sulphate soil which can cause low pH.Based on previous research,mitigation can be made to overcome acid sulphate soil problems throughleaching. Based on experiments in laboratory, leaching can increase pH from 3.88 to 4.3 within 15 days [17]. The water needed in one-day for leaching was 2.25 million m^3in the Belanti irrigation area [18]. So, leaching should be done in 2 weeks during land preparation and ensure sufficient water for leaching. Besides that, the lime application is another way to improve pH. Dolomite, one of the lime materials, can increase pH from 2.69 to 7.29 within 15 days after the treatment[19]. The combination of 4 tons ha^{-1} of ground magnesium limestone and 0.25 tons ha^{-1} of organic fertilizer on acid sulphate soils increased PH from 3.79 to 6.36[20].

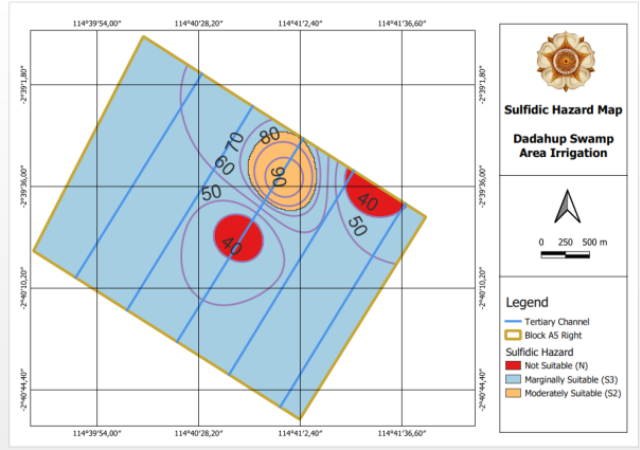

Fig 13. Sulfidic Hazard Map

4 Conclusion

Based on the analysis result, seven parameters of land characteristics are suitable for corn cultivation. These parameters are oxygen availability, root media, peat thickness, cation-exchange capacity, pH H_20, soil organic carbon, and toxicity. At the same time, two parameters of land characteristicsare marginally suitable, which are temperature and base saturation.Because temperatures are around 33.3 ºC and low base saturation was smaller than 7.3%.

Two parameters of land characteristicsare not suitable for corn cultivation. These parameters are water availability and sulfidic hazard. Water availability is related to rainfall,with anaverage rainfall of 2245 mm/year. Then,the sulfidic hazard is related to the depth of pyrite found beinglowerthan 75 cm from topsoil. A good drainage system planning needs to be done so that corn is not submerged in water. In addition, other mitigations of the pyrite effect are leaching and increasing soil fertility with lime dan organic fertilizer application.The impact of this study is that it can be useful in designing corn cultivation so that it contributes to the food estate program.

Thank you to BWS Kalimantan II for providing data and also to Balai Teknik Rawa for assisting in data collection at the research location.

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