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Evaluation of the Suitability of Irrigated Paddy Fields (*Oryza sativa* L.) in the Kelingi Irrigation Area, Tugumulyo District, Musi Rawas Regency

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ABSTRACT

Rice is a strategic staple food whose productivity is influenced by land suitability. This study aims to determine the level of land suitability class for irrigated lowland rice (Oryza sativa L.) in the Kelingi Irrigation Area, Tugumulyo District, Musi Rawas Regency. The study was conducted using a survey method that refers to the level of limiting factors reviewed from land characteristics. Data from field observations and laboratory analysis data were matched with the criteria for land suitability classes for irrigated lowland rice. The actual land suitability class for lowland rice crops is moderately suitable (S2) covering an area of 5,225 ha (51.41%), marginally suitable (S3) covering an area of 4,626 ha (45.52%), while marginally suitable (S3) with a slope of >8% covering an area of 312 ha (3.07%) is recommended for annual crops. The main limiting factors are water availability, land slope class and soil fertility. The limiting factor of soil fertility, still allows for further improvement of its suitability class, by providing balanced fertilizer and to increase the soil pH, agricultural lime can be provided (low input), to overcome the slope of the land, light terracing can be made (medium input), while to overcome water shortages, irrigation channels can be built/rehabilitated.

1. INTRODUCTION

Rice is the main crop in Indonesia because the majority of the population consume rice as the main food. To achieve maximum results, rice plants need to be planted in rice fields that suit their growth requirements and needs (Sabudu *et al*., 2021). Establishing land suitability classes is very important for collecting data that provides information about the quality of land characteristics. This makes it possible to determine land suitability classes and their limiting factors, which are the basis for planning necessary land management and improvements (Suoth & Tendean, 2023).

Land suitability analysis is very important for sustainable planning and management of land resources and is used to assess land potential for certain land uses (Adrian *et al*., 2022; Jayasinghe *et al*., 2019). As the population increases, the need for shelter and nutrition also increases, which is one of humanity's most critical problems. These pressures seriously threaten land resources, such as land degradation. Sustainable use will only be possible through land use that is in accordance with its potential (Hidayatulloh & Hidayat, 2022).

Increasing rice production can be successful through intensive or extensive farming. Intensive agriculture seeks to maximize available rice land by increasing rice production inputs. Expansion is an effort to expand rice fields to other places. This research examines rice fields and requires a reference in decision making to determine the potential of rice fields (Rahayu & Herawati, 2021). Land suitability evaluation for irrigated agriculture involves the interpretation of data relating to soil, topography, vegetation, etc.; to match land characteristics with plant growth needs (Widiatmaka *et al*., 2016, 2015). Land evaluation is a process of projecting potential land use based on comparing the needs of land use types with land characteristics. Inappropriate use, not potential, initially results in degradation of natural resources and then gives rise to social and economic problems (insufficient food supplies, production disruptions, etc.) (Pramanik, 2016).

Land suitability evaluation needs to be carried out as a strategic step to ensure that agricultural land use is carried out optimally, sustainably, and in accordance with the biophysical characteristics of the available land. The mismatch between plant needs and land conditions is often the main cause of low productivity and increased risk of natural resource degradation. In the context of agricultural development that is efficient and adaptive to climate change and land pressure due to population growth, this evaluation plays an important role in identifying land potential and constraints, determining necessary technical interventions, and supporting data-based decision making. In addition, evaluating land suitability also helps prevent inappropriate land use, which can cause environmental damage and economic losses. Therefore, this study provides a scientific foundation for land use planning that supports food security and sustainable agricultural development.

The Kelingi Irrigation Area, located in Tugumulyo District, Musi Rawas Regency, is a rice production center with the support of a technical irrigation system. The Kelingi Irrigation Area falls under the authority of the central government, as regulated in the Regulation of the Minister of Public Works and Public Housing (Permen PUPR) Number 14/PRT/M/2015 concerning Criteria and Determination of Irrigation Area Status which was issued on April 21 2015. The Kelingi Irrigation Area was initially designed to support a rice planting pattern three times a year (IP 300) on an area of 10,163 ha. However, actual conditions show a decrease in the area of functional irrigated land to only 5,472.46 ha, which has a direct impact on planting patterns and land productivity. Currently, most land can only be planted twice (IP 200), and in some locations only once (IP 100) per year. Land productivity also shows variability, with yields ranging from 3.5 to 5.5 ton/ha, reflecting differences in land conditions and management capacity at each location. This variation indicates that not all areas of Kelingi Irrigation Area are suitable for intensification of the IP 300 planting system as planned in the initial design. Therefore, a comprehensive land suitability evaluation is needed to identify existing biophysical potentials and limitations, as a basis for formulating appropriate, adaptive and sustainable land use strategies in order to support food security and efficient land resource management in this region.

This research aims to evaluate the level of suitability of irrigated rice fields in the Kelingi Irrigation Area. It is hoped that the results of this evaluation can be a basis for consideration in making decisions on land management and sustainable agricultural planning in Musi Rawas Regency.

2. RESEARCH MATERIALS AND METHODS

This research was carried out in April 2025 in the Kelingi Irrigation Area, which is located in Tugumulyo District, Musi Rawas Regency, South Sumatra (Figure 1). The tools used in this research include a Global Positioning System (GPS) to determine the coordinates and elevation of the sampling location, a soil drill for taking soil samples, meters, soil knives, plastic bags, labels, rubber bands, stationery, as well as laboratory equipment for analyzing the physical and chemical properties of soil. The materials used include chemicals for soil analysis, as well as administrative maps, irrigation system maps and physiographic maps as references for mapping research locations.

Soil samples were taken from five soil map units (SPT), where each SPT took three sample points which were then composited into one. Determination of collection points was carried out purposively by considering a combination of irrigation system maps, physiographic conditions of the land, and current land use patterns. Aspects such as variations in topography, distance from primary and secondary irrigation channels, and intensity of rice cultivation were the basis for consideration in obtaining samples that represent land heterogeneity. Based on the results of the map overlay, the Kelingi Irrigation Area consisted of two main land units, namely Tanjung (TNJ) and Muara Beliti (MBI), each of which had different physiographic characteristic, parent materials, and soil types. The TNJ land unit was in an alluvial plain system with non-volcanic river sand plain physiography, formed from young river alluvium and fan bank, and was

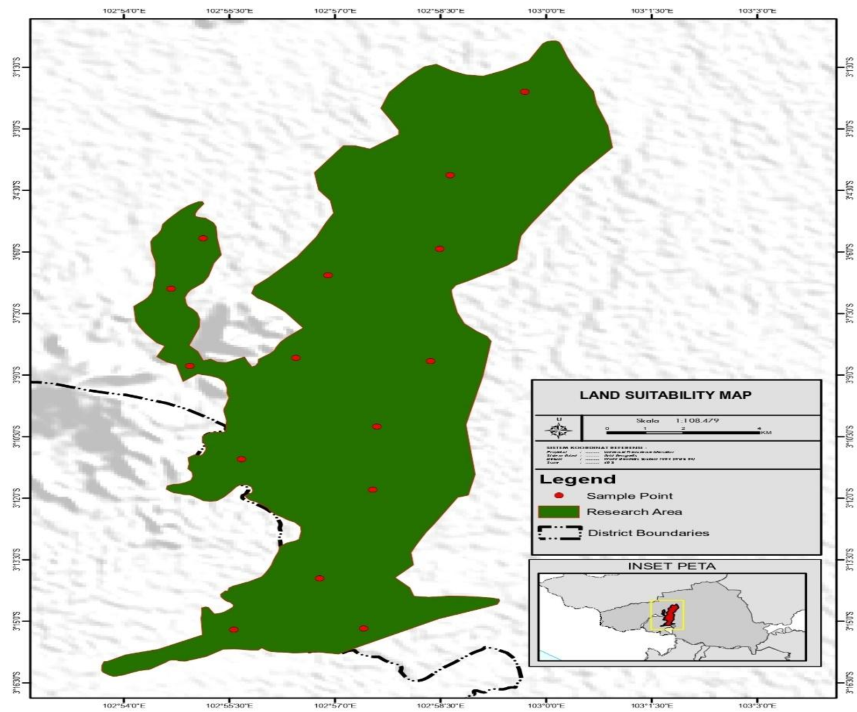

Figure 1. Map of research locations and sampling points

dominated by Fluvaquents and Tropaquepts soils which reflect poor drainage conditions and high water saturation due to tidal influences. Meanwhile, the MBI land unit was located on rocky tufa plains that were wavy to undulating, formed from siltstone, mud and sandstone, with more developed soil types such as Tropudults, Dystropepts and Haplortox. In general, soil types identified in this region included Fluvaquents (young mineral soils saturated with water and contained deep organic matter), Tropaquepts (soils with water saturation for more than six months and no diagnostic horizons except cambic), Dystropepts (young soils from the Inceptisols order that are starting to show horizon differentiation and have a base saturation of 35–50%), and Tropudults (old soils from the Ultisols order characterized by horizons). argillic, shallow solum depth, and massive rock parent material) (Table 1).

Data obtained from analysis in the laboratory, data from field observations are arranged in tabular form and then matched with the criteria for land suitability for paddy fields (Hardjowigeno & Widiatmaka, 2007). Determining the land suitability class is determined by the heaviest limiting (inhibiting) factors. Data analysis was carried out by comparing data from observations of land properties (physical and chemical) against the criteria for land suitability for rice crops. Land suitability is classified into two levels, namely order and class. At the order level, land is divided into suitable (S) and unsuitable (N). At the class level, suitable land (S) is further divided into very suitable (S1), moderately suitable (S2), and marginally suitable (S3), while unsuitable land consists of currently unsuitable (N1) and

Table 1. Description of Land Systems in D.I. Surround Tugumulyo

Symbol	Name	Physiography	Parent Material	Soil Type	Area	
					Ha	%
TNJ	Cape / Alluvial Plain	Non-volcanic river sand plains	Young river alluvium; fan-shaped alluvium	Fluvaquents, Tropaqepts	6.324	62.2
MBI	Estuary Beliti / Plains	Plains of tufa rocky sediments that are undulating to undulating	Shale, siltstone; tuft, mudstone, sandstone, young river alluvium, old sand, and gravel	Tropudults, Dytropepts, Haplortox	3.839	37.8
Total Area					10.163	100

permanently unsuitable (N2). Table 2 detailed land characteristics along with criteria for each suitability class. The results of this analysis are used to map the distribution of land suitability classes and identify the main limiting factors, so that they become the basis for planning optimal and sustainable land management in the Kelingi Irrigation Area.

Table 2. Criteria for assessing the suitability of irrigated rice fields (*Oryza sativa*)

Land Characteristics	S1	S2	S3	N
Temperature (*tc*)				
Average temperature (°C)	24 - 29	22 - 24 / 29 - 32	18 - 22 / 32 - 35	< 18 / > 35
Water availability (*w*)	Irrigation	Irrigation	Irrigation	-
Humidity (%)	33 - 90	30 - 33	< 30	-
Rooting media (*rc*)				
Drainage (*d*)	A bit hampered	Hampered	Very hampered	Fast
Texture	Smooth. somewhat subtle	Currently	A bit rough	Rough
Coarse material (%)	< 3	3 - 15	15 - 35	> 35
Soil depth (cm)	> 50	40 - 50	25 - 40	< 25
Peat				
Thickness (cm)	< 40	40 - 100	100 - 140	> 140
Maturity	Saprik	Saprik. hemik	Hemik	Fibrik
Nutrient retention (*nr*) (*n*)				
Soil CEC (cmol/kg)	> 16	5 - 16	< 5	-
Base saturation (%)	> 50	35 - 50	< 35	-
pH H_2O	5.5 - 7.0	4.5 - 5.5	< 4.5	-
pH H_2O (alternative)	7.0 - 8.0	> 8.0	-	
Sulfidic hazards (*xs*)				
Sulfide depth (cm)	> 100	75 - 100	40 - 75	
Landslide risk (*eh*)				
Slope (%) (*s*)	< 3	3 - 8 (on the terrace)	8 - 30 (on the terrace)	
Landslide risk	Very light	Light	Moderate	
Danger of flooding/inundation during planting period (*fh*)				
Puddle height (cm)	≤ 25	25 - 50	50 - 75	
Duration of inundation (day)	Without	< 7	7 - 14	
Land preparation (*lp*)				
Rocks on the surface (%)	< 5	5 - 15		

Source: Djaenudin *et al.* (2011)

3. RESULTS AND DISCUSSION

3.1. Soil and Environmental Characteristics

The results of the analysis of land characteristics in five soil map units (SPT) in the Kelingi Irrigation Area show that there are variations in biophysical conditions that influence the level of land suitability for rice cultivation. The average temperature ranges from 25.6°C (SPT1) to 28°C (SPT4), which is still within the optimal range for rice growth. All locations receive their water supply from an irrigation system, with relatively high humidity (78%–89%), supporting the humid conditions required by plants. However, all SPTs experience obstructed drainage conditions, even SPT5 is classified as very obstructed, which has the potential to reduce soil aeration and microbial activity. The effective soil depth is shallow, between 51–59 cm, with a low coarse material content (2.1%–2.8%), which can limit root development and water holding capacity.

From the aspect of soil fertility, the cation exchange capacity (CEC) value shows a medium to high range (13.94–20.27 cmol/kg), and base saturation is between 35.29% and 51.38%. The soil pH value is classified as acidic (5.1–5.8), which indicates the need for liming to increase the efficiency of nutrient absorption. The sulfidic hazard is not a limitation because the entire SPT has a sulfidic layer at a depth of >100 cm. The slope factor shows an increase from 2% (SPT1 and SPT2) to 10% (SPT5), with the potential landslide danger ranging from very light to moderate. The height and duration of standing water during the planting period is still within the tolerance limits of rice plants, although at SPT3 and SPT4 it tends to be higher and longer. The entire land does not have surface rocks, thus supporting land cultivation activities. These characteristics show that although in general the land has potential for rice cultivation, special management efforts are required such as improving drainage, land conservation, and soil amelioration to overcome limiting factors and increase productivity in a sustainable manner.

Table 3. Results of land characteristics analysis in each SPT

Land Characteristics	SPT1	SPT2	SPT3	SPT4	SPT5
Temperature (*tc*)					
Average temperature (°C)	25.6	26	27.8	28	27.6
Water availability (*wa*)	Irrigation	Irrigation	Irrigation	Irrigation	Irrigation
Humidity (%)	78	81	89	87	81
Rooting Media (*rc*)					
Drainage	Hampered	Hampered	Hampered	Hampered	Very hampered
Texture					
Coarse material (%)	2.4	2.1	2.4	2.7	2.8
Soil depth (cm)	57	59	52	51	52
Nutrient retention (*nr*)					
Soil CEC (cmol/kg)	14.55	13.94	17.93	20.27	17.84
Base saturation (%)	37.52	35.29	50.28	51.38	50.91
pH H_2O	5.4	5.1	5.6	5.8	5.6
Sulfidic hazards (*xs*)					
Sulfide depth (cm)	101.6	103.1	101.2	108.8	107.2
Landslide risk (*eh*)					
Slope (%)	2	2	5	7	10
Landslide risk	Very light	Very light	Light	Light	Moderate
Danger of flooding/inundation during planting period (*fh*)					
Puddle height (cm)	20.5	19.3	21.8	23.4	18.9
Duration of inundation (day)	2	2	3	2	2
Land preparation (*lp*)					
Rocks on the surface (%)	0	0	0	0	0

3.2. Suitability of Land for Lowland Rice (*Oryza sativa* L.)

Evaluation of land suitability for food crops is determined by the land resources that support it, namely climate, soil, topography and hydrology. These land resources are interconnected with one another, because the physical condition of the land evaluated in the field will provide information that the land has potential for the development of food crops. In this sense, because land has limiting factors, we must consider the input that will be provided so that land productivity can be increased. The results of the evaluation of actual and potential land suitability for paddy fields in the Kelingi Irrigation Area are presented in Table 4. The results of the evaluation of potential land suitability classes

Table 4. Results of actual and potential land suitability assessment for paddy fields in Tugumulyo Irrigation Scheme

No SPT	Land Suitability		Limiting Factors	Recommended Input	Recommendation	Area	
	Actual	Potential				Ha	%
1, 2	S2*nw*	S1	Water availability and soil fertility	Construction of drainage and fertilization channels	Irrigated Paddy Rice	5,225	51.4
3, 4	S3*ws*	S2	Water availability and land slope < 8%	Light irrigation and terracing		4,626	45.5
5	S3*s*	S3	Water availability, and land slope > 8%	Heavy irrigation and terracing	Perennials	312	3.1
Total						**10.163**	**100**

Note: *s*: land slope; *n*: soil fertility; *d*: drainage; *w*: water availability; S1: Very suitable, S2: Fairly suitable, S3: Almost suitable.

show that actually, Soil Map Units (SPT) 1, 2, 3, 4 and 5 fall into the category sufficiently suitable (S2) to marginally suitable (S3) with the limiting factors of water availability (*w*), soil fertility (*n*), and land slope class (*s*). Water availability has a significant impact on the sufficiency of water needed to meet plant needs, which is an important factor in rice growth. The growth stages of rice consist of three different phases, namely the growth phase, seedling formation phase, and grain and grain formation phase (Ezward *et al*., 2018). The height of standing water has a significant impact on rice growth, where water management according to the needs of rice plants can produce optimal harvest results. The use of standing water in rice fields is generally carried out at the growth stage of rice plants. However, if waterlogging lasts for more than two months, this can cause the soil to become loose and increase the risk of erosion and landslides. Lack of water in rice fields can also have a negative impact on rice production (Mustofa *et al*., 2022).

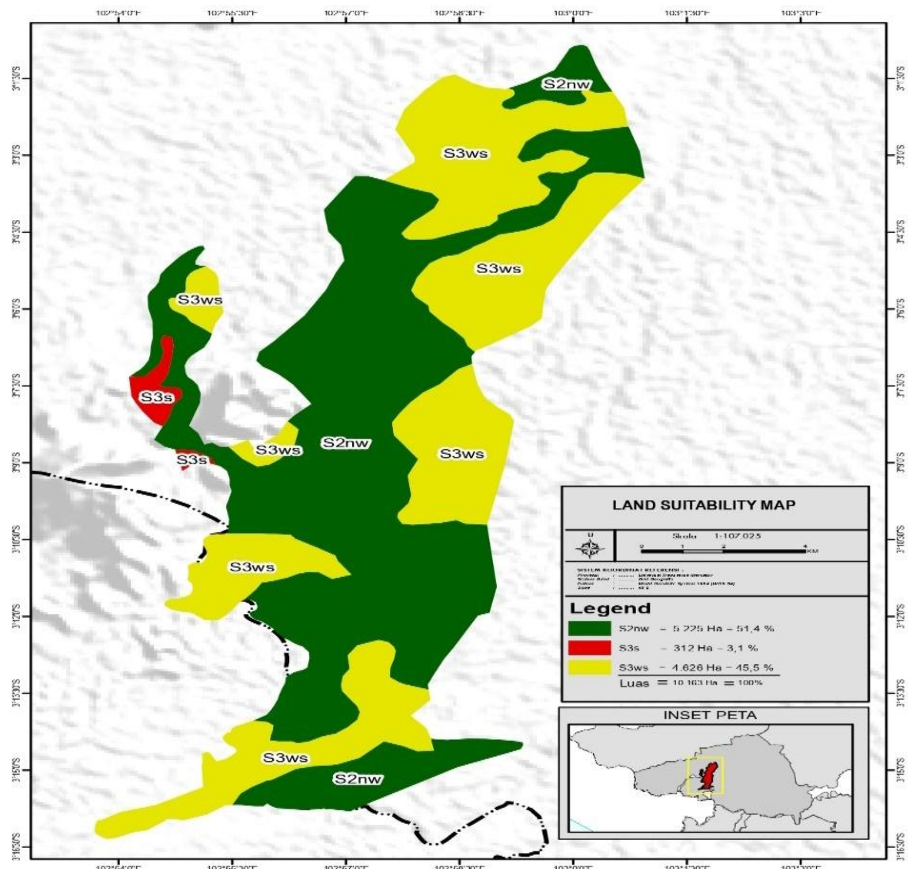

Figure 2. Land suitability class map of Tugumulyo Irrigation Scheme

Soil fertility is a factor that is closely related to the availability of soil nutrients. The nutrients contained in the soil have a significant influence on the formation of a sustainable agricultural system. Optimal management of nutrients can increase soil fertility levels, which is an important basis for the realization of sustainable agriculture (Safitri, 2020). Management of soil elements is an important aspect in modern agriculture to ensure sustainable rice production. One method commonly used is fertilization. Fertilization aims to provide nutrients necessary for plant growth, including rice (Susanti *et al*., 2024; Xu *et al*., 2024). However, excessive use of fertilizer can have a negative impact on environmental balance, especially in relation to soil acidity levels. Soil conditions that are too acidic can inhibit plant growth and reduce crop yields. Therefore, wise and appropriate management is needed to maintain the balance of nutrients in the soil. This includes regular monitoring of fertilizer requirement levels, selecting the right type of fertilizer, and implementing efficient fertilization techniques. Thus, proper fertilization will support sustainable rice production and maintain the balance of the soil environment (Maro'ah *et al*., 2022).

In evaluating land for irrigated rice farming, slope is one of the critical parameters that influences agricultural productivity and sustainability. Slopes with a slope of less than 3% are considered very suitable for lowland rice cultivation that depends on irrigation. This is because low slopes provide more stable conditions for water supply, minimize soil erosion, and facilitate the even distribution of irrigation water throughout the land. Therefore, in the context of irrigated lowland rice farming, land with a slope below 3% is considered optimal conditions to support effective growth and production of rice plants (Ariyanti *et al*., 2022). The slope level has the potential to influence the availability of nutrients in the soil. The steeper the slope, the less nutrient content is available. This phenomenon has a significant impact on agricultural productivity, especially on the growth of rice plants. Limited availability of nutrients due to steep slopes can inhibit the growth of rice plants and ultimately affect the number of grains produced. Therefore, understanding the relationship between slope slope and nutrient content in the soil is important in optimizing rice production, especially in the context of sustainable agriculture (Felix *et al*., 2020).

Based on the results of the land suitability evaluation, the SPT-1 and SPT-2 land units which cover 5,225 hectares or around 51.4% of the study area, are categorized as lowlands and valleys with a slope of less than 3 percent, and are included in the sufficiently suitable (S2) land suitability class with the main constraints being water availability during the dry season and low soil fertility. These obstacles can still be overcome through the application of appropriate technology and land management, such as balanced fertilization based on nutrient requirements (Coggins *et al*., 2025; He *et al*., 2024) and rehabilitation and optimization of irrigation networks (Chen *et al*., 2022; Tang *et al*., 2023). Technical modifications to limiting factors can significantly increase land suitability classes (Mir *et al*., 2025; Mostafa *et al*., 2023). Thus, the potential for increasing the suitability class to the Very Suitable (S1) category is very possible, supporting sustainable lowland rice productivity in this region.

The SPT-3 and SPT-4 lands which cover an area of around 4,626 hectares or 45.5% of the study area are categorized as sufficiently suitable (S2) with the main obstacles being limited water availability and a land slope of less than 8%. These obstacles can be overcome through the application of moderate to high technical inputs, such as the creation of small terraces which function to control erosion and increase soil water retention (Yu *et al*., 2024). In addition, high input intervention in the form of irrigation canal rehabilitation can significantly increase water availability, so that the land suitability class can be upgraded to marginally suitable (S3) without conditions or even sufficiently suitable (S2). However, if irrigation canals are rehabilitated but the main water source is insufficient, then this effort will not necessarily be effective in increasing water availability for agricultural land. In conditions like this, utilizing groundwater through building wells can be a viable alternative, this is because the groundwater table is at a relatively shallow depth and the discharge is stable (Haryanto *et al*., 2017). However, groundwater use needs to consider technical and sustainability aspects, including the potential for lowering groundwater levels, drilling and pumping costs, and the impact on the surrounding environment. SPT 5 covers an area of 312 ha (3.1%), falls into the suitable marginal (S3) category, with limiting factors such as water availability and land slope (> 8%). It is still possible for land with this suitability to be improved in its suitability class with high input (high cost), namely by making connected terraces or horseshoes and farming roads can be made by following contour lines, as well as the water availability factor which is quite difficult, so it is not recommended for irrigated rice plants and will be sufficiently suitable (S2) for perennial crops.

4. CONCLUSION

The actual land suitability class for irrigated rice crops based on the land unit map is sufficiently suitable (S2) for land covering an area of 5,225 ha (51.41%) in SPT 1 and SPT 2, marginally suitable (S3) covering an area of 4,626 ha (45.52%) in SPT 3 and SPT 4, while for land measuring 312 ha (3.07%) in SPT 5 it is recommended for perennial crops. The main limiting factors are water availability, land slope class (slope class) and soil fertility status which is included in the low criteria. The limiting factors for soil fertility, it is still possible to increase the suitability class further, by providing balanced fertilizer and to increase the soil pH, agricultural lime can be given (low input), to overcome the slope of the land, light terraces can be made (medium input), while to overcome water shortages, irrigation canals can be made or rehabilitated (high input). Therefore, it is recommended that a feasibility study be carried out on the use of groundwater as an additional source of irrigation as well as the application of land conservation technology and improvement of soil fertility to optimize land use for lowland rice cultivation.

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