

Evaluation of Land Suitability for Cempedak (*Artocarpus campeden* Spreng) in Batu Mandi and South Paringin Districts, Balangan Regency, South Kalimantan

Muhammad Rayhan Ghiffari¹, Nurlaila^{1,✉}, Nukhak Nufita Sari¹, Andin Muhammad Abduh², Ronny Mulyawan¹, Hikma Ellya¹, Rila Rahma Apriani¹

¹ Department of Agroecotechnology, Faculty of Agriculture, Lambung Mangkurat University, South Kalimantan, INDONESIA.

² Department of Soil, Faculty of Agriculture, Lambung Mangkurat University, South Kalimantan, INDONESIA.

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Corresponding Author:

✉ nurlaila@ulm.ac.id

(Nurlaila)

ABSTRACT

Land quality is a key determinant of fruit production, supporting nutrient supply, food security, and sustainable agriculture. This study evaluates potential changes to land suitability classes to improve land-use planning and spatial rearrangement, notably to support the development of cempedak cultivation in Batu Mandi and South Paringin Districts, Balangan Regency, South Kalimantan Province. The research was conducted from May to August 2025 using a matching method to link land characteristics to suitability criteria for cempedak, and the results were presented as ArcGIS maps. Results show both districts have considerable potential for cempedak development, although current conditions fall within unsuitable (N) and marginally suitable (S3) classes. In Batu Mandi District, actual suitability is S3 covering 11,238.48 ha, and N covering 1,541.61 ha. In South Paringin District, cempedak suitability is also S3, covering 6,953.21 ha. The main limiting factors include unsuitable soil texture, low base saturation, acidic soil pH, and low nutrient availability of P₂O₅ and K₂O. Improvement efforts involving adding pelleted compost and liming with high cultivation, and fertilising with moderate cultivation of triple superphosphate and KCl potentially increase suitability from S3 to S2 or even S1. Therefore, the land has the potential to become a cempedak planting area and produce maximum productivity.

1. INTRODUCTION

The quality of the land influences high productivity and the quality of fruits with good nutritional content, serving as a suitable growing medium. Fertile and healthy soil is a prerequisite for the growth of fruit crops, so a decision support system is needed to evaluate the quality of the land (Edwards *et al.*, 2016). Soil structure can also significantly impact the quantity and quality of agricultural produce, as well-structured soil can enhance organic matter, porosity, water infiltration, and nutrient cycling, thereby supporting sustainable productivity (Farmaha *et al.*, 2022). Therefore, effective strategies and practical decision support tools are necessary to analyze field conditions, determine optimal tillage timing, and achieve the best results.

Land management and food security are integral components of sustainable agricultural development, particularly in the use of local food resources, such as perennial fruit crops. One such crop is cempedak (*Artocarpus campeden* Spreng), locally known as *tiwadak*, which has significant economic and nutritional value in South Kalimantan Province. Balangan Regency is the largest producer of *tiwadak* in the province, with Batu Mandi District contributing

14,302.10 tons and South Paringin District producing 3,374.30 tons (BPS, 2024a). The high production of *tiwadak*, especially in Batu Mandi District, plays a strategic role in strengthening local food systems and enhancing community livelihoods through agricultural trade and value chains in Balangan Regency.

However, despite its substantial production potential, *tiwadak* productivity in Balangan Regency remains inconsistent and has not yet reached optimal levels. This instability is reflected in pronounced interannual fluctuations in production, particularly in Batu Mandi and South Paringin Districts. In Batu Mandi District, production increased significantly from 157.70 tons in 2020 to 13,482.60 tons in 2021. However, in 2022, there was a sharp decline to 3,543.30 tons. Furthermore, in 2023, it increased again to 14,302.10 tons (BPS, 2024b). In South Paringin District, production was recorded at 206.40 tons in 2020 and decreased to 35.80 tons in 2021. In 2022 and 2023, it experienced a significant increase from 64.40 tons to 3,374.30 tons (BPS, 2024c). These fluctuations indicate between high productivity potential and suboptimal production realization, underscoring the need for a cempedak land suitability evaluation in Balangan Regency, particularly in Batu Mandi and South Paringin Districts, to support optimal and sustainable development.

Beyond its role as a fresh fruit commodity, *tiwadak* also supports local agro-processing by using its fruit skins to produce *mandai*, a traditional fermented food. *Mandai* has gained attention as a potential functional food due to its nutritional value and the sustainable use of agricultural by-products through fermentation processes (Prabawa *et al.*, 2022). The linkage between high *tiwadak* production, *mandai* processing, and local livelihoods underscores the importance of land quality in supporting both primary production and downstream value addition. Therefore, a comprehensive land suitability evaluation for cempedak cultivation is essential to assess the appropriateness of existing land use and to support optimal, stable, and sustainable cempedak development in Balangan Regency, particularly in Batu Mandi and South Paringin Districts.

Land evaluation is the process of assessing the suitability of a land unit for a specific use, such as cempedak cultivation, which produces suitability classes and subclasses based on the lowest limiting factor. Referring to Liebig's Law of Minimums, plant growth is determined by the limiting factor with the lowest value, which becomes the primary basis for determining the suitability class. The assessment is carried out through surveys and in-depth studies of the land form, physical and chemical properties of the soil, vegetation, climate, and other supporting factors, and then compared with the technical manual of land evaluation (FAO, 1976). This evaluation employs a matching method that considers the relationship between land characteristics and plant growth requirements, taking into account aspects of management, conservation, and potential improvement actions (Ritung *et al.*, 2011).

The implementation of a land suitability evaluation system can support more accurate decision-making for the optimal and sustainable use of land of limited quality. Land suitability evaluation plays a crucial role in land use planning, the selection of optimal cultivation commodities, and the identification of required improvement measures to enhance land productivity (Krisanti & Setiawan, 2023). However, to date, no land suitability evaluation specifically for cempedak cultivation has been conducted in Balangan Regency, particularly in Batu Mandi and South Paringin Districts. This absence of site-specific suitability information represents a critical research gap.

Based on the description above, this study aims to evaluate changes in land suitability classes to support land-use planning and improve land rearrangements, exceptionally to maximize the development and productivity of cempedak cultivation in Batu Mandi and South Paringin Districts. In addition, this research is expected to provide scientific references for evaluating land suitability for cempedak cultivation in Balangan Regency.

2. MATERIALS AND METHODS

The research was conducted in Batu Mandi and South Paringin Districts, Balangan Regency, South Kalimantan Province, from May to August 2025, using field sampling based on the Land Mapping Unit (LMU). Spatially, the LMU in this study is determined through Geographic Information System (GIS) techniques, including components (administrative maps, land use maps, geological maps, slope maps, soil type maps, and topographic maps) with a scale of 1:50.000.

Field sampling was conducted according to the LMU distribution shown on the research location map (Figure 1). Sample points within each LMU were selected purposively to represent uniform land and environmental characteristics, such as soil type, slope gradient, and rainfall. Temperature data were measured directly in the field using a thermometer, slope gradient was measured using a clinometer, and rainfall data were obtained from the Central Statistics Agency of Balangan Regency (BPS, 2024a).

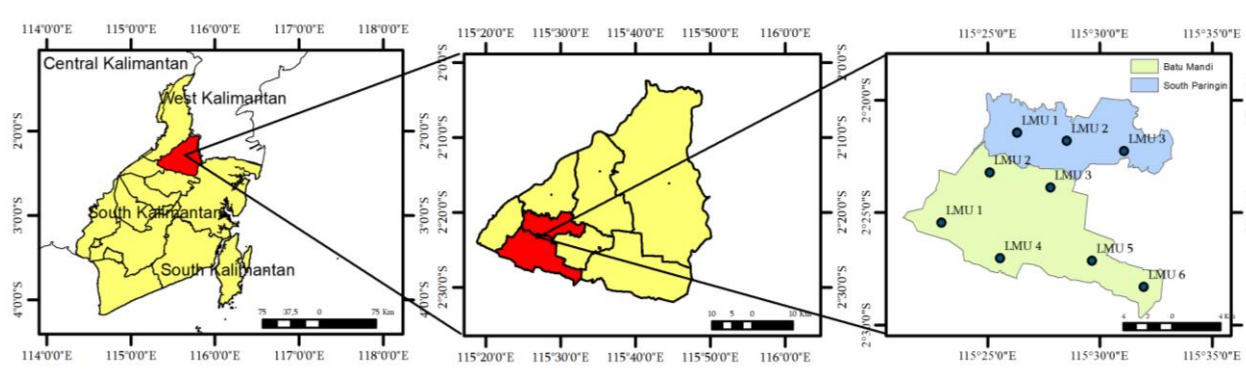


Figure 1. Map of research locations and sampling points

Samples obtained from the field were analyzed at the Laboratory of the Department of Soil, Faculty of Agriculture, Lambung Mangkurat University. The physical properties of the soil were analyzed, namely texture by the pipette method and soil chemical properties consisting of pH H₂O extract 1:5, C-organic by the Walkley & Black method, N-total method Kjeldahl, P₂O₅ and K₂O method HCl 25%, cation exchange capacity (CEC) and base saturation (BS) by NH₄-OAc method 1N pH 7. The laboratory analysis method of the physical and chemical properties of the soil refers to Technical Instructions Edition 3: Chemical Analysis of Soil, Crops, Water, and Fertilizers (Eviati *et al.*, 2023).

The determination of actual land suitability in each land unit in this study was carried out using the matching method between land quality and plant growth requirements, based on the land suitability criteria for cempedak fruit plants Table 1. Land with an appropriate order (S) is divided into three classes, namely very suitable (S1), moderately suitable (S2), and marginally suitable (S3), while non-appropriate order unsuitable (N) does not have a class division (Ritung *et al.*, 2011). Furthermore, the suitability of potential land is determined by considering efforts to improve the limiting factors in each land unit. The growing conditions for cempedak plants on actual land in Batu Mandi and South Paringin Districts are shown in Figure 2.



Figure 2. Growing conditions of cempedak plants on actual land suitability class: (a) S3 in South Paringin District, and (b) N in Batu Mandi District

After efforts to improve the limiting factors, a comparison was carried out with Table 1 the land suitability criteria for cempedak fruit plants. Furthermore, the results of the overlay produced a map of actual and potential land suitability for cempedak plants. Spatial data and land value attribute data are collected and then combined using ArcGIS software. Then, the integrated data are analyzed both descriptively and quantitatively, and the results are interpreted and presented in tables and figures. The flowchart of this research is shown in Figure 3.

Table 1. Criteria for the suitability of cempedak plants (*Artocarpus campeден Spreng*)

Land Characteristics	S1	S2	S3	N
Temperature (<i>tc</i>)				
Average temperature (°C)	22 – 28	28 – 34 18 – 22	34 – 40 15 – 18	> 40 < 15
Water availability (<i>wa</i>)				
Rainfall (mm)	1.000 – 2.000	500 – 1.000 2.000 – 3.000	250 - 500 3.000 – 6.000	< 250 > 6.000
Oxygen availability (<i>oa</i>)				
Drainage	good, medium	somewhat hampered	hampered somewhat fast	very hampered fast
Root media (<i>rc</i>)				
Texture	smooth, somewhat subtle	medium	somewhat rough	rough
Nutrient retention (<i>nr</i>)				
Soil CEC (cmol)	> 16	5 – 16	< 5	
Base saturation (%)	> 35	20 – 35	< 20	
pH H ₂ O	5.0 – 6.0	4.5 – 5.0 6.0 – 7.5	< 4.5 > 7.5	
C-organic (%)	> 1.2	0.8 – 1.2	< 0.8	
Nutrient availability (<i>na</i>)				
N total (%)*	Medium	Low	Very low	-
P ₂ O ₅ (mg/100g)*	Medium	Low	Very low	-
K ₂ O (mg/100g)*	Medium	Low	Very low	-
Erosion hazard (<i>eh</i>)				
Slope (%)	< 8	8 – 15	15 – 40	> 40
Erosion hazard	very light	light - medium	heavy	very heavy

Source: Ritung *et al.* (2011); *Eviati *et al.* (2023)

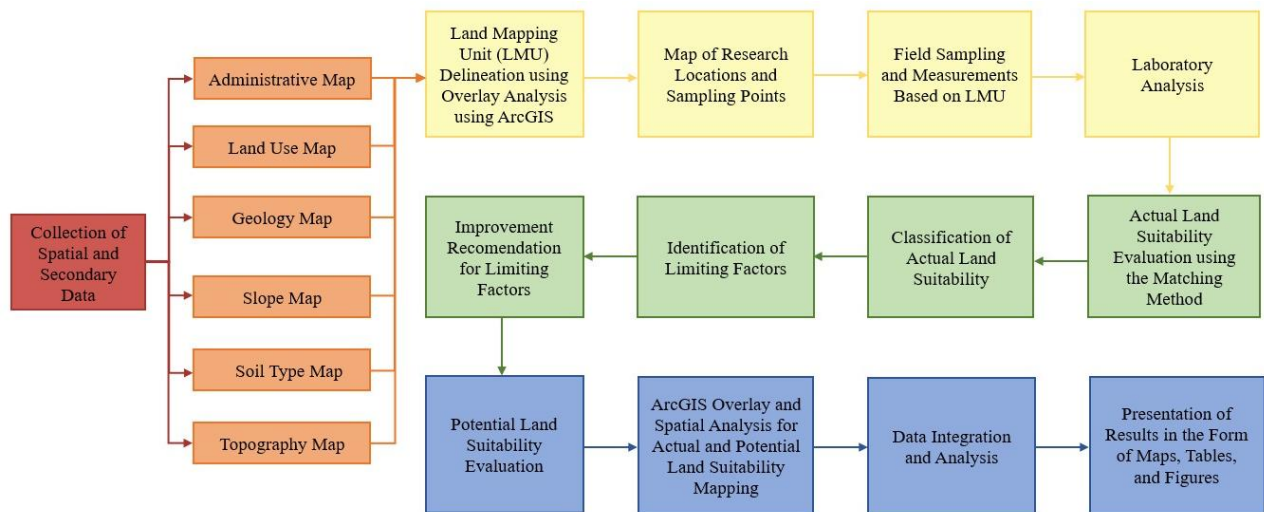


Figure 3. The research flowchart

3. RESULTS AND DISCUSSION

3.1. Determination of the Actual Land Suitability Class of Cempedak Plants

The suitability of the land used is based on the criteria for the actual land suitability of the cempedak plant, which consider the following factors: temperature (*tc*), water availability (*wa*), oxygen availability (*oa*), root media (*rc*), nutrient retention (*nr*), available nutrients (*na*), and erosion hazard (*eh*). These factors are the factors that most affect the growing conditions and land suitability criteria for cempedak crop land by referring to the Technical Guidelines for Land Evaluation for Agricultural Commodities, Revised Edition (Ritung *et al.*, 2011). The results of the evaluation of the actual land suitability of cempedak plants in Batu Mandi and South Paringin Districts, Balangan Regency, South Kalimantan Province, are presented in Tables 2 and 3.

Based on Table 2, on the LMU 1 land, the land is classified as N for texture (*rc*). In LMU 2 it shows that the land includes the S3 according to texture (*rc*), BS (*nr*), and P₂O₅ (*na*) content. The land in LMU 3 is S3 with the limiting factor BS (*nr*) and P₂O₅ (*na*) content. Then, LMU 4 also shows S3 for BS (*nr*), P₂O₅, and K₂O (*na*) content. Then, LMU 5 includes S3 *nr;na* land with BS limiting factor (*nr*) and P₂O₅ (*na*) content. LMU 6 also includes S3 to BS and pH (*nr*), as well as P₂O₅ (*na*) content. Thus, the results of the evaluation of the actual land suitability in Batu Mandi District, each LMU has the main limiting factors in the form of BS (*nr*) and P₂O₅ (*na*) content that appear in all LMUs, then followed by limiting factors such as soil texture (*rc*) in LMU 1 and LMU 2, K₂O (*na*) content in LMU 4, and pH (*nr*) in LMU 6. These factors need to be considered in determining the suitability of land for cempedak plants.

Based on Table 3, in LMU 1, the land is classified as S3 for texture (*rc*), BS (*nr*), and P₂O₅ content (*na*). LMU 2 shows land, S3 for BS (*nr*), P₂O₅, and K₂O (*na*) content. Land in LMU 3 is S3 for BS (*nr*) and P₂O₅ content (*na*), respectively. Thus, in the actual land suitability in South Paringin District, limiting factors in the form of BS (*nr*) and P₂O₅ (*na*) appear in all LMUs, and texture (*rc*) appears in LMU 1, and K₂O content (*na*) in LMU 2. These factors need to be considered in land use planning so that the level of land suitability can be determined precisely and support the success of cempedak cultivation in both districts.

Table 2. The suitability of the actual land of cempedak plants in Batu Mandi District

Land Characteristics	LMU 1	LMU 2	LMU 3	LMU 4	LMU 5	LMU 6
Temperature (<i>tc</i>)						
Average temperature (°C)	27	27	27	27	27	27
Water availability (<i>wa</i>)						
Rainfall (mm)	1561	1561	1561	1561	1561	1561
Oxygen availability (<i>oa</i>)						
Drainage	good	medium	good	medium	good	good
Root media (<i>rc</i>)						
Texture	rough	some-what rough	medium	medium	some-what subtle	very smooth
Nutrient retention (<i>nr</i>)						
Soil CEC (cmol)	25.15	29.51	36.01	36.37	34.91	45.49
Base saturation (%)	1.29	2.93	7.46	7.92	3.38	3.53
pH H ₂ O	4.5	4.6	5.2	5.2	4.5	4.1
C-organic (%)	1.44	3.15	1.99	1.54	8.12	19.17
Nutrient availability (<i>na</i>)						
N total (%)	0.12	0.14	0.13	0.13	0.18	0.28
P ₂ O ₅ (mg/100g)	2.02	3.80	7.98	8.36	4.86	6.40
K ₂ O (mg/100g)	15.03	16.00	10.70	9.71	22.37	37.23
Erosion hazard (<i>eh</i>)						
Slope (%)	0 – 2%	0 – 2%	0 – 2%	0 – 2%	0 – 2%	0 – 2%
Erosion hazard	very light	very light	very light	very light	very light	very light

Table 3. The suitability of the actual land of cempedak plants in South Paringin District

Land Characteristics	LMU 1	LMU 2	LMU 3
Temperature (tc)			
Average temperature (°C)	27	27	27
Water availability (wa)			
Rainfall (mm)	2738	2738	2738
Oxygen availability (oa)			
Drainage	good	good	good
Root media (rc)			
Texture	somewhat rough	medium	smooth
Nutrient retention (nr)			
Soil CEC (cmol)	24.64	32.25	33.15
Base saturation (%)	2.59	3.57	15.05
pH H ₂ O	4.6	5.0	5.6
C-organic (%)	1.78	1.70	2.33
Nutrient availability (na)			
N total (%)	0.24	0.19	0.16
P ₂ O ₅ (mg/100g)	3.04	14.83	10.90
K ₂ O (mg/100g)	16.60	8.22	17.24
Erosion hazard (eh)			
Slope (%)	0 – 2%	0 – 2%	0 – 2%
Erosion hazard	very light	very light	very light

Table 4. Suitability class of the actual lands, limiting factors, improvement efforts, and potential suitability for cempedak in Batu Mandi and South Paringin Districts

District	LMU	Land Suitability		Limiting Factors	Recommendation Input	Area (Ha)
		Actual	Potential			
Batu Mandi	1	<i>N rc</i>	<i>N rc</i>	Texture	Not doable	1,541.61
	2	<i>S3 rc, nr, na</i>	<i>S3 rc</i>	Texture, BS, P ₂ O ₅ available	Not possible for texture, addition of organic matter with a high cultivation level for BS, and fertilization with a medium cultivation level for P ₂ O ₅	3,982.26
	3, 4	<i>S3 nr, na</i>	<i>S2 rc</i>	BS, P ₂ O ₅ , and K ₂ O available	Adding organic matter with a high cultivation level for BS and fertilization with a medium cultivation level for P ₂ O ₅ and K ₂ O	3,471.7
	5, 6	<i>S3 nr, na</i>	<i>S1</i>	BS, pH, and P ₂ O ₅ available	Adding organic matter with a high cultivation level for BS, liming with a high cultivation level for pH, and fertilization with a medium cultivation level for P ₂ O ₅	3,784.52
South Paringin	1	<i>S3 rc, nr, na</i>	<i>S3 rc</i>	Texture, BS, P ₂ O ₅ available	Not possible for texture, addition of high cultivation level organic matter for BS, and medium cultivation level fertilization for P ₂ O ₅	1,456.13
	2	<i>S3 nr, na</i>	<i>S2 rc</i>	BS, P ₂ O ₅ , and K ₂ O available	Adding organic matter with a high cultivation level for base saturation and fertilization with a medium cultivation level for P ₂ O ₅ and K ₂ O	2,955.36
	3	<i>S3 nr, na</i>	<i>S1</i>	BS and P ₂ O ₅ available	Adding organic matter with a high cultivation level for base saturation and fertilization with a medium cultivation level for P ₂ O ₅	2,541.72

3.2. Improving Actual into Potential Land Suitability Based on Limiting Factors

Land suitability evaluation is necessary to assess the land's ability to cultivate cempedak plants. Table 4 shows the actual land suitability class, main limiting factors, recommendations for improvement, and potential suitability enhancements in Batu Mandi and South Paringin Districts. These efforts aim to improve land suitability by one to three levels. Limiting factors have a significant influence on plant growth, which is directly related to the actual suitability of the land (Rosmaiti *et al.*, 2019). Actual land suitability reflects current conditions without considering potential improvements or management of limiting factors.

3.2.1. Root Media (*rc*)

Based on Table 4, soil with a somewhat rough texture, such as sandy clay or coarse texture, like clay sand, is a limiting factor in evaluating land suitability for cempedak plants. According to the Revised Edition of the Technical Guidelines for Land Evaluation for Agricultural Commodities, soil texture is one of the permanent and limiting factors in evaluating land suitability that cannot be altered to improve the land suitability class (Ritung *et al.*, 2011). Coarse-textured soils have high drainage that affects the movement of water in the soil profile (Brown *et al.*, 2019). Previous research has shown that soil texture, water retention capacity, and porosity balance are interrelated. Soil texture and plant growth are primarily mediated by soil water retention, water availability, and physical structure. Soil texture governs pore-size distribution and water-holding capacity, which directly influence root development and the efficiency of water uptake by plants. Consequently, soil texture affects plant growth indirectly by controlling soil water retention and the availability of water within the root zone (Barros *et al.*, 2024).

3.2.2. Nutrient Retention (*nr*)

Based on Table 4, alkaline saturation is one of the factors that limit the suitability of cempedak planting land. Base saturation reflects the proportion of CEC occupied by the base cations (Ca^{2+} , Mg^{2+} , K^+ , and Na^+). Low BS can decrease fruit productivity by creating an acidic soil environment with toxic Al^{3+} and reduced nutrient availability, thereby inhibiting root development, restricting water and essential nutrient uptake, and disrupting physiological processes required for proper fruit formation and filling (Souza *et al.*, 2025). In other perennial fruit crops, such as mango, these conditions also affect nutrient availability, alkali balance, and soil dynamics, which directly affect fruit growth and yield (Cardoso *et al.*, 2017). The addition of organic fertilizers is one of the recommended efforts to improve low alkaline saturation and improve land suitability and fruit crop productivity (Irawan *et al.*, 2022). The application of 10 tons/ha pellet compost on ultisols can increase the BS value from 22.33% to 40.33% (Pasang *et al.*, 2019). Thus, the dose of pellet compost application has the potential to be applied to cempedak plantation land because it can increase the value of family planning from the S3 category, which is less than 20% and S2, with a value of 20–35% to the S1 category, which is more than 35%.

Based on Table 4, soil pH is a limiting factor in land suitability for cempedak plants. Soil with a pH of less than 4.5 is included in the S3 class for the growth of cempedak plants. To overcome low pH conditions, improvements can be made through liming, which raises pH and sustainably increases alkaline retention (Qin *et al.*, 2022). Soil pH is a central regulator of plant health. Acidic soils undermine soil quality, root function, nutrient uptake, and immune defenses. Conversely, correcting soil acidity restores physiological balance and enhances disease tolerance, even in already infected plants (Li *et al.*, 2020). Therefore, correcting soil acidity through liming and organic amendments is essential to improve soil fertility and plant performance. Applying 10 tons/ha of dolomite lime can raise the pH of ultisols from 4.08 to 5.36, creating more favorable conditions for plant growth (Nuraini *et al.*, 2021). Thus, based on the lime dosage, it has the potential to be applied to cempedak plant land to achieve S1 with a pH range of 5.0–6.0. However, applying dolomite at a rate of more than 10 tons/ha, which results in a soil pH of 4.88, is still classified as S2 and has not raised the pH to S1. Thus, the dolomite dose needs to be considered: if the dose is too high and the soil pH exceeds 6.0, the suitability class for the pH parameter can decrease to S2 and even to S3 if the soil pH exceeds 7.5.

3.2.3. Nutrient Availability (*na*)

In evaluating land suitability for cempedak fruit (Table 4), the nutrient content available, especially P_2O_5 , is a key factor determining the land suitability class (S1–S3) and the need for improvement actions. It is shown that the P_2O_5

content in the soil becomes the lowest barrier in the S3 category. Research conducted on other perennial orchards, such as apples, has shown that the application of inorganic fertilizer in the form of triple superphosphate at a dose of 160 kg/ha effectively increased the available P_2O_5 content in the soil to 27.6–44.97% (Nava *et al.*, 2017). This indicates that similar fertilization has the potential to optimize the availability of nutrients from P_2O_5 , which is actually S3 to S1 in the potential conditions of cempedak plantation land.

The content of K_2O as a nutrient available in the evaluation of the land suitability of cempedak fruit plants (Table 4) is also one of the determining factors for the level of land suitability class. Potassium (K) is central to plant growth, fruit development, nutrient efficiency, and disease resistance. The role of potassium in plant growth is evident in its ability to promote more vigorous plants, healthier roots, improved nutrient balance, reduced disease severity, and, ultimately, better fruit yield and quality (Bayındır & Küçükyumuk, 2025). Studies in lemon orchards show that variations in potassium (K) levels affect growth and production. K deficiency has been shown to reduce the size and quality of plants when these elements are not available in sufficient quantities (Papadakis *et al.*, 2023). Research conducted on other perennial fruit crops, such as cocoa with a relatively low potassium nutrient status, has shown that applying KCl fertilizer at a dose of 180 kg/ha has been proven to increase the potassium nutrient status from low to high (Amalia *et al.*, 2024). This indicates that the application of the same type of fertilization has the potential to increase the availability of K_2O nutrients in cempedak plants from an S3 to a suitable S1.

3.3. Potential Land Suitability Classes for Cempedak

The determination of potential land suitability classes for cempedak plants in Batu Mandi and South Paringin Districts was carried out by improving the lowest limiting factors in each LMU. It is then integrated and spatially processed using ArcGIS to create a map of potential land suitability. This process is crucial for the development of growth and productivity. Potential land feasibility assessments in this case have also been shown to be effective in producing suitability maps that can be applied to various tropical commodities, such as fruits and perennial crops, in both tropical and subtropical climates. For example, lychee, oranges, dragon fruit, cinnamon, pines, and macca have benefited from land suitability information that supports decision-making in optimizing land use and increasing agricultural production (Binh *et al.*, 2024).

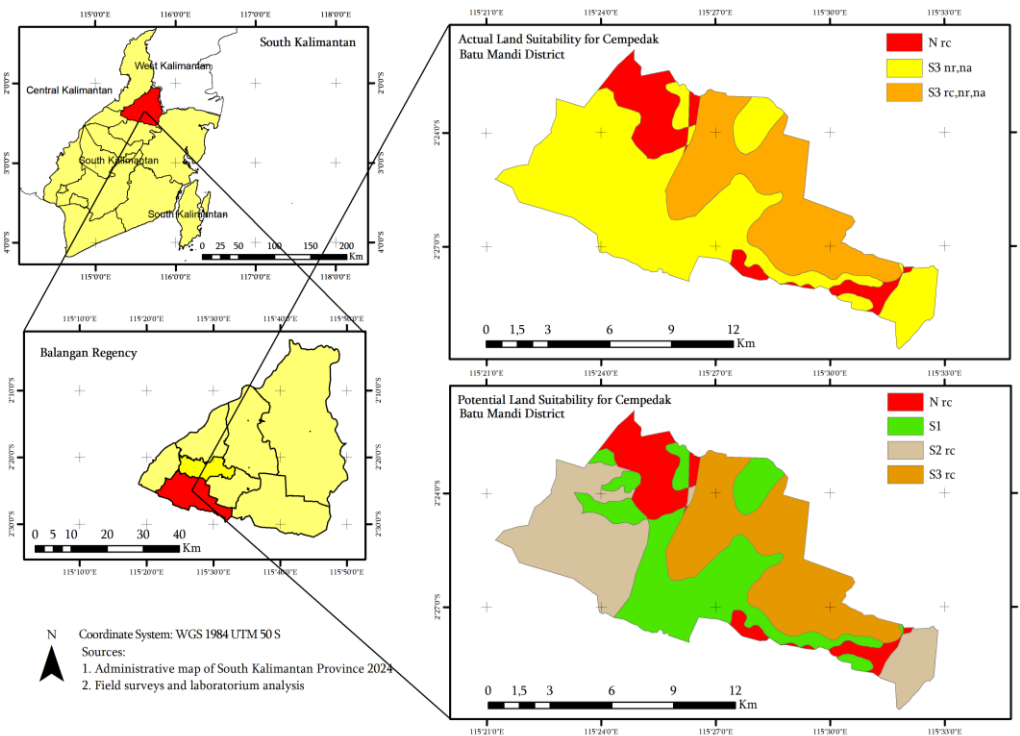


Figure 4. Map of the actual and potential land suitability of cempedak plants in Batu Mandi District

Based on Table 4 and Figure 4, after improvement efforts, Batu Mandi District exhibits several class differences for cempedak plant development. LMU 1, with an area of 1,541.61 ha, is classified as N due to its texture (*rc*) limiting factor, indicating no improvement efforts can be made. LMU 2, which has an area of 3,982.26 ha, is classified as S3, also because its texture (*rc*) remains a limiting factor, as no improvement efforts can be made. Meanwhile, LMU 3 and LMU 4, with an area of 3,471.7 ha, including S2, because the texture (*rc*) that has been in the S2 class since the beginning has become a limiting factor that cannot be easily addressed. Furthermore, LMU 5 and LMU 6 show an S1 class of 3,784.52 ha area under potential conditions. After improvement efforts, LMU 5 and LMU 6 have the potential to reach the S1 class. However, LMU 1 (N), LMU 2 (S3), LMU 3, and LMU 4 (S2) still face texture as limiting factors for land suitability that cannot be changed through various improvement efforts (Sari *et al.*, 2024). Therefore, optimizing improvement efforts for cempedak plants is essential to achieve sustainable land suitability in Batu Mandi.

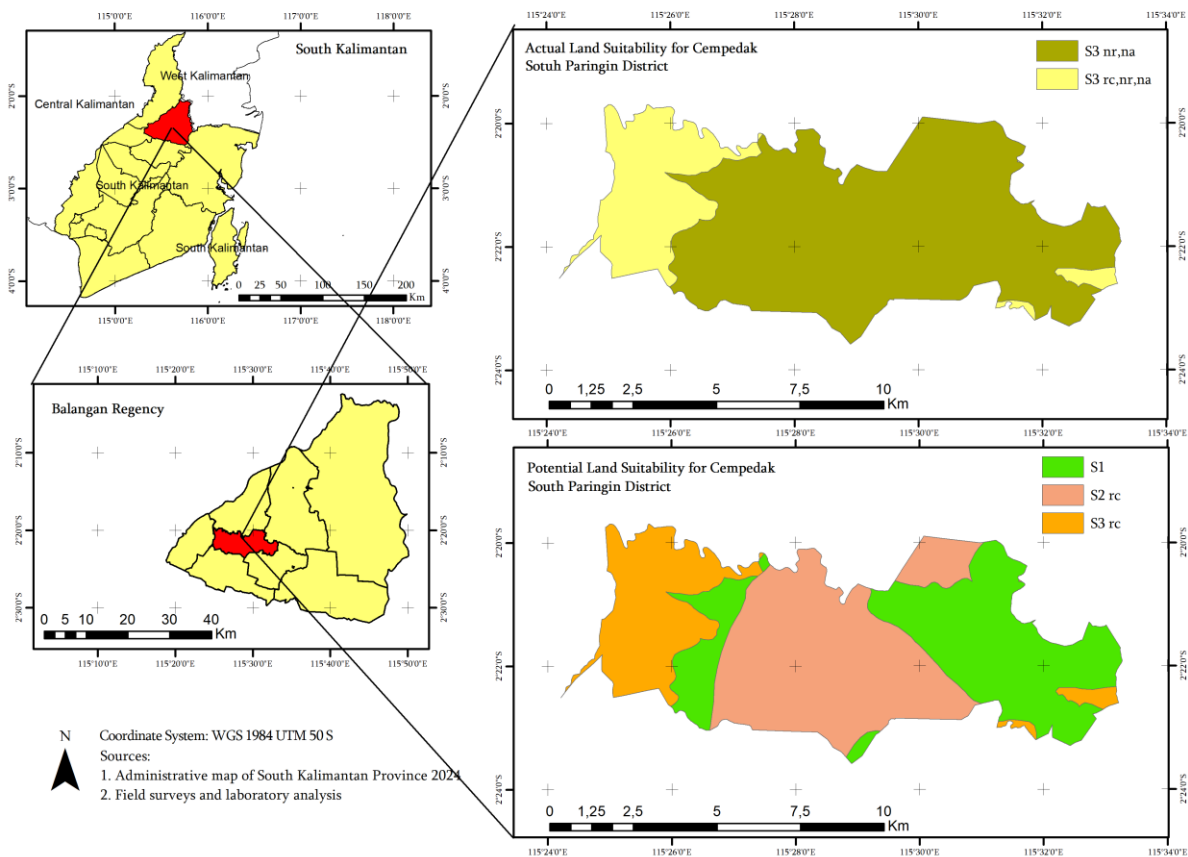


Figure 5. Map of actual and potential land suitability of cempedak plants in South Paringin District

Based on Table 4 and Figure 5, it is evident that, after repair efforts, South Paringin District also has considerable potential for the development of cempedak plants. In LMU 1, which has an area of 1,456.13 ha, the land is actually classified as S3, because texture (*rc*) still appears as a limiting factor. Moreover, texture is a limiting factor that cannot be improved. Meanwhile, LMU 2, which has an area of 2,955.36 ha, was classified as S2 from the beginning because texture (*rc*) has become a limiting factor that cannot be easily addressed. Moreover, texture is a limiting factor that cannot be improved. Furthermore, LMU 3 is classified as an S1 class with an area of 2,541.72 ha under potential conditions. Overall, after repair efforts, LMU 3 in South Paringin District has the potential to reach the S1 class. However, LMU 2 is still classified as S2 *rc*, and LMU 1 remains classified as S3 *rc* due to a texture-limiting factor. The evaluation approach based on GIS, as explained by Quinta-Nova & Ferreira (2020), plays an important role in providing a roadmap that supports more effective land use planning, so that the results of this evaluation can be a strategic basis for decision-makers in the development of cempedak crops in South Paringin and Batu Mandi Districts.

4. CONCLUSIONS

The results of the study indicate that Batu Mandi and South Paringin Districts have significant potential for cempedak plant development, although several limiting factors still constrain them. The actual land in Batu Mandi District is classified as N and S3, while the land in South Paringin District is categorized as S3. The main limiting factors include unsuitable soil texture, low BS values, acidic soil pH, and low available nutrients (P₂O₅ and K₂O), which affect nutrient absorption, growth, and plant productivity. Efforts to improve the limiting factors of land suitability class can be carried out through the addition of pellet compost and liming with high cultivation, and fertilisation with triple superphosphate and KCl at a moderate level of cultivation. Through the integrated cultivation of limiting factors, land potential can be increased by one to two classes, from S3 to S2 or even S1, thereby further supporting the development of cempedak planting areas and maximizing cempedak production in Batu Mandi and South Paringin Districts.

AUTHOR CONTRIBUTION STATEMENT

Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
MRG	✓	✓	✓		✓			✓	✓	✓	✓			✓
Nur	✓	✓		✓	✓	✓	✓		✓	✓		✓	✓	
NNS	✓	✓		✓	✓			✓	✓	✓		✓	✓	
AMA		✓	✓			✓		✓			✓			
RM						✓	✓							
HE						✓	✓							
RRA						✓	✓							

C: Conceptualization	Fo: Formal Analysis	O: Writing - Original Draft	Fu: Funding Acquisition
M: Methodology	I: Investigation	E: Writing - Review & Editing	P: Project Administration
So: Software	D: Data Curation	Vi: Visualization	
Va: Validation	R: Resources	Su: Supervision	

REFERENCES

Amalia, N.A., Saida, S., & Nontji, M. (2024). Evaluasi status kesuburan tanah pada lahan perkebunan tanaman kakao (*Theobroma cacao* L.) di Kecamatan Bissappu Kabupaten Bantaeng. *AGrotekMAS Jurnal Indonesia: Jurnal Ilmu Peranian*, 5(3), 322–327. <https://doi.org/10.33096/agrotekmas.v5i3.644>

Barros, T.H.da S., Uliana, M.V., Costa, J.de O., Farias-Ramírez, A.J., & Abreu Junior, C.H. (2024). How can the inflection point of the water retention curve and the soil physical attributes be used to forecast field capacity? *Pesquisa Agropecuaria Tropical*, 54, 1–7. <https://doi.org/10.1590/1983-40632024v5478125>

Bayındır, Ü., & Küçükçumuk, Z. (2025). The effects of potassium on plant nutrient concentration, plant development, and rhizoctonia rot (*Rhizoctonia solani*) in repper. *Horticulturae*, 11(5), 516. <https://doi.org/10.3390/horticulturae11050516>

Binh, N.T., Duyen, D.H., & Thuy, D.T. (2024). Application of GIS in land unit mapping and evaluation of land suitability for agriculture in Uong Bi District - Quang Ninh Province. *IOP Conference Series: Earth and Environmental Science*, 1345(1), 012017. <https://doi.org/10.1088/1755-1315/1345/1/012017>

BPS. (2024a). *Kabupaten Balangan Dalam Angka 2024*. Badan Pusat Statistik Kabupaten Balangan.

BPS. (2024b). *Kecamatan Batu Mandi Dalam Angka 2024*. Badan Pusat Statistik Kabupaten Balangan.

BPS. (2024c). *Kecamatan Paringin Selatan Dalam Angka 2024*. Badan Pusat Statistik Kabupaten Balangan.

Brown, P.J., McCarty, L.B., Quisenberry, V.L., Hubbard, L.R., & Addy, M.B. (2019). Influence of increasing fines on soil physical properties of u.s. golf association sand. *HortScience*, 54(11), 2063–2066. <https://doi.org/10.21273/HORTSC114110-19>

Cardoso, J.A.F., Lima, A.M.N., Cunha, T.J.F., Rodrigues, M.S., Hernani, L.C., Cunha, J.C., Do Amaral, A.J., & de Oliveira Neto, M.B. (2017). Changing in chemical and physical attributes of a sandy soil under irrigated mango cultivation in semiarid region. *Comunicata Scientiae*, 8(3), 404–413. <https://doi.org/10.14295/CS.v8i3.2544>

Edwards, G., White, D.R., Munkholm, L.J., Sørensen, C.G., & Lamandé, M. (2016). Modelling the readiness of soil for different methods of tillage. *Soil and Tillage Research*, 155, 339–350. <https://doi.org/10.1016/j.still.2015.08.013>

- Eviati, Sulaeman, Herawaty, L., Anggria, L., Usman, Tantika, H.E., Prihatini, R., & Wuningrum, P. (2023). *Petunjuk Teknis Edisi 3 Analisis Kimia Tanah, Tanaman, Air, dan Pupuk*. Kementerian Pertanian Republik Indonesia.
- FAO. (1976). *A Framework for Land Evaluation (FAO Soils Bulletin 32)*. Food and Agriculture Organization of the United Nations.
- Farmaha, B.S., Sekaran, U., & Franzluebbbers, A.J. (2022). Cover cropping and conservation tillage improve soil health in the Southeastern United States. *Agronomy Journal*, *114*(1), 296–316. <https://doi.org/10.1002/agj2.20865>
- Irawan, S., Antriyandarti, E., & Laia, D.H. (2022). A study the relationship of soil quality with land suitability for coconut (*Cocos nucifera* L.) development in Kebonagung Sub-District, Pacitan District. *IOP Conference Series: Earth and Environmental Science*, *1111*(1), 012013. <https://doi.org/10.1088/1755-1315/1111/1/012013>
- Krisanti, O.K., & Setiawan, A.W. (2023). Evaluasi kesesuaian lahan untuk tanaman buah-buahan di Desa Cukilan, Kecamatan Suruh, Kabupaten Semarang. *Jurnal Tanah dan Sumberdaya Lahan*, *10*(2), 203–213. <https://doi.org/10.21776/ub.jtsl.2023.010.2.3>
- Li, B., Wang, S., Zhang, Y., & Qiu, D. (2020). Acid soil improvement enhances disease tolerance in citrus infected by candidatus liberibacter asiaticus. *International Journal of Molecular Sciences*, *21*(10), 3614. <https://doi.org/10.3390/ijms21103614>
- Nava, G., Ciotta, M.N., & Brunetto, G. (2017). ‘Fuji’ apple tree response to phosphorus fertilization. *Revista Brasileira de Fruticultura*, *39*(1). <https://doi.org/10.1590/0100-29452017369>
- Nuraini, P., Budianta, D., & Fitri, S.N.A. (2021). Pengaruh pemberian dolomit dan pupuk kandang sapi terhadap pertumbuhan dan produksi tanaman kedelai (*Glycine max* (L.) Merr) di tanah ultisol. *AgriPeat*, *22*(01), 21–32. <https://doi.org/10.36873/agn.v22i01.3309>
- Papadakis, I.E., Ladikou, E.V., Oikonomou, A., Chatzistathis, T., & Chatzipirou, G. (2023). Exploring the impact of potassium on growth, photosynthetic performance, and nutritional status of lemon trees (cv. *Adamopoulou*) grafted onto sour orange and volkamer lemon rootstocks. *Sustainability*, *15*(22). <https://doi.org/10.3390/su152215858>
- Pasang, Y.H., Jayadi, M., & Neswati, R. (2019). Peningkatan unsur hara fosfor tanah ultisol melalui pemberian pupuk andang, kompos dan pelet. *Jurnal Ecosolum*, *8*(2), 86. <https://doi.org/10.20956/ecosolum.v8i2.7872>
- Prabawa, I.D.G.P., Purnomo, E.H., & Faridah, D.N. (2022). Canning of mandai, traditional fermented food from Indonesia, using thermal pasteurization. *Journal of Food Processing and Preservation*, *46*(11), 1–9. <https://doi.org/10.1111/jfpp.17137>
- Qin, X., Zhang, Y., Yu, R., Chang, X., Yao, Y., Qiu, Q., Li, H., & Wei, X. (2022). Biological conservation measures are better than engineering conservation measures in improving soil quality of eroded orchards in southern China. *Soil Science Society of America Journal*, *86*(4), 932–945. <https://doi.org/10.1002/saj2.20423>
- Quinta-Nova, L., & Ferreira, D. (2020). Land suitability analysis for emerging fruit crops in Central Portugal using GIS. *The Journal "Agriculture and Forestry"*, *66*(1), 41–48. <https://doi.org/10.17707/AgricultForest.66.1.05>
- Ritung, S., Nugroho, K., Mulyani, A., & Suryani, E. (2011). *Petunjuk Teknis Evaluasi Lahan untuk Komoditas Pertanian (Edisi Revisi)*. Balai Besar Penelitian dan Pengembangan Sumberdaya Lahan Pertanian, Badan Penelitian dan Pengembangan Pertanian.
- Rosmaiti, R., Saputra, I., & Yusnawati, Y. (2019). Evaluasi kesesuaian lahan untuk pengembangan tanaman jeruk (*Citrus*, sp) di Desa Jambo Labu Kecamatan Birem Bayeun Kabupaten Aceh Timur. *Jurnal Ilmiah Pertanian*, *16*(1), 64–73. <https://doi.org/10.31849/jip.v16i1.2430>
- Sari, L.N., Budiyo, S., & Purbajanti, E.D. (2024). Evaluasi kesesuaian lahan Kecamatan Karangmalang Kabupaten Sragen Jawa Tengah untuk pengembangan tanaman pangan. *Jurnal Ilmu-Ilmu Pertanian Indonesia*, *26*(1), 61–71. <https://doi.org/10.31186/jipi.26.1.61-71>
- Souza, I.N.d., Cristovam, M.E.P., Moraes, E.L., Modesto, V.C., Ribeiro, N.A.A., Girardi, V.A.M., de Souza Júnior, N.C., Matos, A. M.S., Salles, J.S., Gasparini, C.S., Borges, W.L.B., & Andreotti, M. (2025). Effects on soil fertility and crop productivity under residual agricultural gypsum and *Azospirillum brasilense* in cover crops in a consolidated no-tillage system. *Plants*, *14*(20), 1–21. <https://doi.org/10.3390/plants14203230>