Land Suitability Evaluation for Durian Cultivation in Universitas Muhammadiyah Mataram Educational Forest (KHDTK UMMAT)

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Abstract: The Forest Area with Special Educational Purposes (KHDTK) at Muhammadiyah University of Mataram, covering 93.55 hectares, has undergone enrichment with eucalyptus and agarwood plants since 2019. In 2024, further enrichment is planned with durian, avocado, jackfruit, and longan. However, concerns have arisen regarding the suitability of the KHDTK area for durian cultivation, necessitating a land suitability evaluation. This study aims to determine the suitability classes, limiting factors, and management recommendations for durian and other selected plants. Using a rigid grid method, a soil survey and evaluation were conducted, assessing 14 parameters related to soil, climate, and land. The findings indicate that the land suitability for durian falls into class S3, with limiting factors including coarse soil texture, low levels of nitrogen, phosphorus, and potassium, insufficient rainfall, and a slope of 16-30%. Recommended management strategies include the application of organic and NPK fertilizers, installation of pipe irrigation, and contour-aligned planting. Enrichment with durian in the KHDTK area is suggested to be developed. This study contributes to sustainable land management by providing scientific data for durian cultivation in KHDTK areas. In addition, the results can support the development of conservation-based agroforestry and agritourism.

Keywords: durian; KHDTK; land suitability evaluation; NTFP; UMMAT

INTRODUCTION

Background

The Forest Area with Special Educational Purposes (KHDTK) at Universitas Muhammadiyah Mataram spans 93.55 hectares. Its designation was formalized by the Indonesian Ministry of Environment and Forestry through Decree Number SK.6701/MENLHKPKTL/KUH/PLA.2/8/2019, issued on August 9, 2019 (Johari et al., 2022), can bee seen in Figure 1. On February 8, 2021, the KHDTK Batu Bolong was enriched with agarwood plants (Ibrahim et al., 2021). A tree-planting program was conducted on June 5, 2021, featuring species like sengon, mahogany, and agarwood (Alpiana et al., 2021). Additionally, an enrichment program for durian, avocado, and jackfruit trees took place on March 8, 2024. However, there are concerns from the local community that durian trees may not grow well or produce fruit in the KHDTK area, necessitating research to assess land suitability for these enrichment plants and identify any limiting factors that need to be addressed.

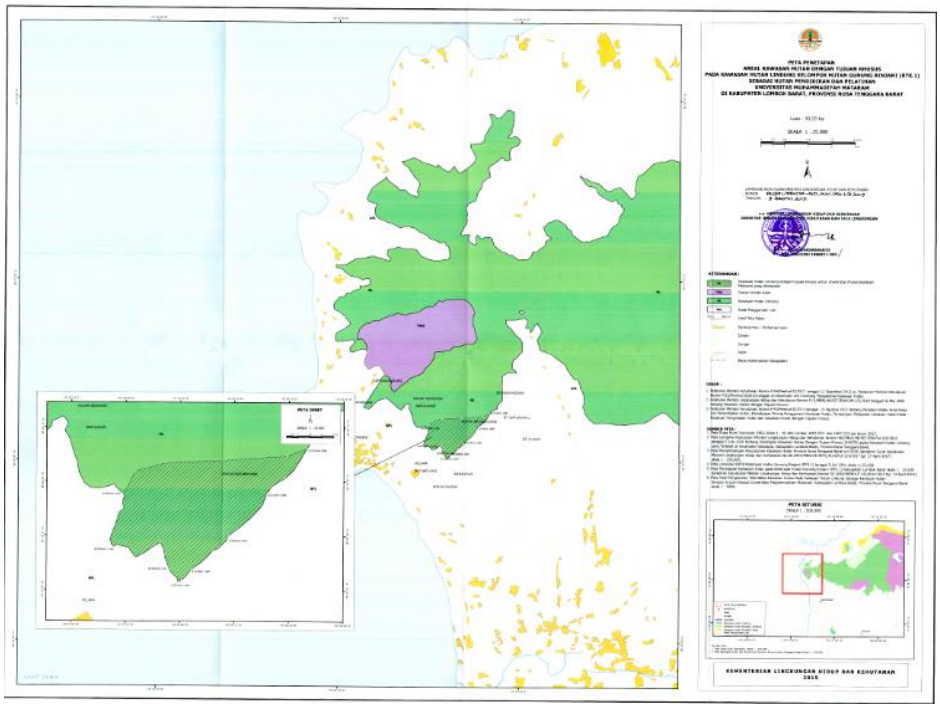

Figure 1. Map of The KHDTK UMMAT

Source: Indonesian Ministry of Environment and Forestry through Decree Number SK.6701/MENLHKPKTL/KUH/PLA.2/8/2019, issued on August 9, 2019.

Durian (*Durio zibethinus*) is one of the most economically valuable tropical fruits in Southeast Asia, known for its distinctive aroma and taste (Huy et al., 2023; Y Xuan et al., 2024). The demand for durian has seen significant growth, not only within its native region but also in international markets. As a result, the need to identify suitable land for durian cultivation has become increasingly important. Understanding the land's characteristics and its suitability for growing durian is essential for ensuring sustainable agricultural practices and maximizing yields. In this context, the Universitas Muhammadiyah Mataram Educational Forest (KHDTK UMMAT) presents a unique opportunity for such an evaluation.

The KHDTK UMMAT is the educational and research forest with a several possibility location for application of agroforestry systems in durian. Durian species need specific environmental factors, such as soil, climate, and topographical conditions for better growth (Pakasi et al., 2022; Wibowo et al., 2019), so only certain parts of the forest may be suitable for durians. Land suitability assessment is essential to ascertain the potential location/area for durian cultivation. This study aims to improve broader understandings within the realm of sustainable agricultural development by studying land suitability for growing durian in KHDTK UMMAT.

Literature on land suitability evaluation methods commonly highlights the integration of GIS and remote sensing technologies as effective tools for such assessments (Hermita et al., n.d.; Nardi et al., 2024). These technologies allow for the analysis of large areas of land based on various environmental parameters, including soil type, topography, and climate data.

Previous research has extensively examined land suitability for durian cultivation in various regions (Dhika et al., 2022; Ramadhan et al., 2023). For instance, studies conducted in Thailand and Malaysia (Fazlil Ilahi et al., 2024; Thorogood et al., 2022), where durian is a staple crop, have identified key factors such as soil pH, drainage, and altitude as critical determinants of suitability. In these studies, geographical information systems (GIS) were frequently used to map and assess land suitability, providing a model that could be applied to other regions with similar environmental conditions.

Other research has been done on the specific agroecological requirements of durian grown. In Indonesia, it is reported that rainfall patterns (Dhika et al., 2022; Pakasi et al., 2022), temperature ranges (Ramadhan et al., 2023) and soil fertility (Wibowo et al., 2019). According to Thorogood et al., 2022 the variability in the responses of durian to changing environmental factors from location to location (from West Java or Sumatra) are substantial, and accurate land evaluation for site suitability is merited. There is no research on land evaluation for the purpose of preparing a long-term management plan at the KHDTK UMMAT. The novelty of this research is that it can make groupings of land suitability in various land conditions (KHDTK 1 to KHDTK 8) for durian cultivation in the KHDTK UMMAT. The results can support the development of conservation-based agroforestry and agritourism in the KHDTK UMMAT

Objective

The objective of this study is to evaluate the suitability of land in KHDTK UMMAT for durian cultivation. Specifically, the research aims to determine the suitability classes, limiting factors, and management recommendations for durian and other selected plants. By conducting this evaluation, the study seeks to provide recommendations for potential cultivation zones, contributing to both the academic understanding of land suitability and the practical application of sustainable agroforestry practices within the educational forest.

RESEARCH METHODS

This study uses the land evaluation plus classification method, which includes the number of limiting factors in determining land suitability. For example, Class S3-3 represents marginal suitability (S3) with three limiting factors out of 14 variables. The land suitability analysis follows the matching method (Dumipto et al., 2019), where field survey and laboratory data are compared with the land suitability criteria for durian cultivation set by the Ministry of Agriculture (Djaenudin et al., 2011). The evaluation is based on the Ministry's guidelines for the ideal agroecosystem for durian cultivation, compared to the agroecosystem conditions in UMMAT KHDTK. Field parameters measured include temperature, rainfall, soil depth, slope, flood risk, and surface rocks, while laboratory tests assess soil texture, salinity, pH, drainage/porosity, CEC, and nutrient content (N, P, and K).

RESULTS AND DISCUSSION

Result

Agroclimatological conditions, especially soil properties at KHDTK Universitas Muhammadiyah Mataram can be seen in Table 1.

Table 1. Agroclimatological conditions KHDTK Universitas Muhammadiyah Mataram

No	Parameter	Average	Unit
1	Coarse Texture	77,78	%
2	Salinity	0,40	Milimhos/cm
3	pH	6,51	-
4	Drainage/Porosity	31,07	%
5	CEC	25,14	cmol
6	N	0,11	%
7	P	17,44	Ppm
8	K	7,59	Meq %
9	Temperature	21-32	Celsius
10	Rainfall	1731	mm/tahun

No	Parameter	Average	Unit
11	Depth	75-100	Cm
12	Slope	25%	%
13	Flood	0	F (0)
14	Surface rock	<5	%

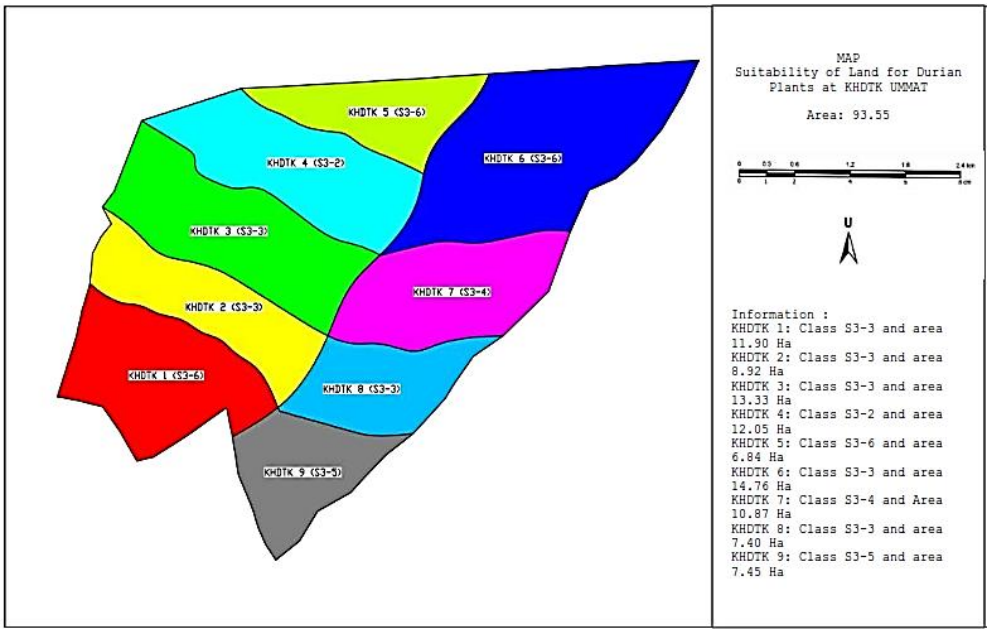

Figure 2. The Land Suitability Areas for KHDTK 1 to KHDTK 9

The land characteristics at KHDTK UMMAT, Batulayar Village, Batulayar District, West Lombok Regency were obtained from field observations, secondary data collection, and laboratory tests as follows:

a. Soil Texture

Soil texture describes the composition of fine soil particles (2 mm in diameter), such as sand, silt, and clay (Said et al., 2023). Texture samples were collected from the topsoil layer (0-30 cm depth), and the laboratory findings were compared to the USDA soil texture triangle diagram. Fine, somewhat fine, and medium soil textures are highly suitable (S1) for durian cultivation, whereas coarse texture is considered unsuitable (Amran et al., 2023; Pakasi et al., 2022; Ramadhan et al., 2023).

The soil texture at KHDTK UMMAT Batulayar Village is somewhat coarse, with 1) sand, 2) clayey sand, 3) sandy clay loam, 4) sandy clay, and 5) silty clay. Based on soil texture, KHDTK 6's land suitability class is categorized as moderately suitable (S2), while eight land units—KHDTK 1, KHDTK 2, KHDTK 3, KHDTK 4, KHDTK 5, KHDTK 7, KHDTK 8, and KHDTK 9—are classified as marginally suitable (S3), the area can be seen in Figure 2.

b. Soil Salinity

Salinity, expressed in millimhos per centimeter (mmhos/cm), is the term used to describe the amount of salt present in the soil. Soil salinity measurements yielded results ranging from 0.30 to 0.4 mhos/cm, with an average of 0.4 mhos/cm. Due to its elevation of 10 to 100 meters above sea level and its distance of 3-5 kilometers from the coast, the land at KHDTK UMMAT has low salinity. Every land unit in the KHDTK belongs to the highly suitable (S1) class of soil salinity suitability (Amran et al., 2023).

c. Soil pH

Using a pH scale, the acidity level of soil, or soil pH, is found. Even though pH varies, land management still heavily depends on it. Durian trees do best (S1 suitability) in soil that has a pH between 5.5 and 7.8, but they do not do well in soil that has a pH of 5.0 or higher (Amran et al., 2023; Ramadhan et al., 2023). The pH of the soil at KHDTK UMMAT is neutral, ranging from 5.90 to 7.51. The pH of the soil on all KHDTK land units is within the S1 suitability class.

d. Drainage / Soil Porosity

Drainage or soil porosity refers to the percentage of total pore space in the soil that can be occupied by water and air relative to the soil volume. In KHDTK UMMAT, soil porosity ranges from 26.26% to 35.87%. This indicates a fairly high water retention capacity; however, due to the soil's coarse to moderately coarse texture (highly porous), water does not remain for long (Seong II Yeom et al., 2019). All land units in KHDTK have a porosity suitability class of S1, indicating they are highly suitable.

e. Land CEC

The cation exchange capacity (CEC) refers to the quantity or capacity of cations that can be exchanged, or the number of cations (in milliequivalents) absorbed by the soil per unit weight (typically per 100 grams of soil). A higher CEC value means more cations can be exchanged, thereby increasing the availability of plant nutrients (me/100g) (Zgorelec et al., 2019). Durian plants grow optimally or are considered suitable (S1) when the CEC exceeds 16 (mg/100g) (Karim et al., 2017). The KHDTK UMMAT recorded an average CEC of 25.12 (mg/100g), its indicated that land units have a highly suitable classification (S1) for CEC values below 16 across all land units, from KHDTK 1 to KHDTK 9.

f. N-Total

N-total represents the potential nitrogen content in the soil that plants can absorb. Higher N-total levels generally have a positive impact on plant growth. Durian trees are highly suitable (S1) for growth on land with a medium N-total classification, but they are less suitable on land with a very low N-total classification (Djaenudin et al., 2011). The total nitrogen content in the soil is measured in a laboratory and expressed as a percentage.

The N-total content in KHDTK UMMAT falls into two categories: a very low classification (<0.10%) which is marginally suitable (S3) for 5 land units—KHDTK 2, KHDTK 3, KHDTK 5, KHDTK 8, and KHDTK 9. A low N-total classification (0.10%-0.20%), considered moderately suitable (S2), applies to 4 land units—KHDTK 1, KHDTK 4, KHDTK 6, and KHDTK 7.

g. P-available

Phosphate content (P_2O_5) is an element that plays a role in energy transfer. Phosphate content is available in the form of P_2O_5 ions which are measured in the laboratory and expressed in the form of 25% HCL (mg/100g). Durian plants are very suitable (S1) for growing on land that has a medium P_2O_5 classification and is less suitable if it is classified as very low (Djaenudin et al., 2011).

The P_2O_5 content in KHDTK UMMAT has 3 classifications, namely very low classification (<15 mg/100g) with classification according to marginal S3 totaling 7 land units, namely KHDTK 1, KHDTK 3, KHDTK 5, KHDTK 6, KHDTK 7, KHDTK 8 and KHDTK 9. The land units included in the class are quite suitable for S2 with moderate P-available (16-40 mg/100g) on 2 land units, namely KHDTK 2 and KHDTK 3. The land units in the class are very suitable S1 with high levels of P-available (41-60 mg/100g) namely and KHDTK 4.

h. K-available

Potassium plays a crucial role in the physiological and metabolic processes of plants. It affects nutrient uptake, respiratory regulation, transpiration, enzyme activity, and carbohydrate movement (Hakim, 1986). In laboratory measurements, potassium is expressed in me/100 g. Durian trees are highly suitable (S1) for cultivation on land classified with medium total potassium levels, but less suitable for land classified as very low (Djaenudin et al., 2011).

At KHDTK UMMAT potassium levels are classified into two categories: marginal S3 with very low available potassium (<10 mg/100g), which applies to 8 land units (KHDTK 1, KHDTK 2, KHDTK 3, KHDTK 5, KHDTK 6, KHDTK 7, KHDTK 8, and KHDTK 9), and sufficient S2 with moderate available potassium (11-20 mg/100g), which is only applicable to the KHDTK 4 unit.

i. Temperature

Durian plants thrive at average temperatures between 25-28°C and are unsuitable for temperatures exceeding 35°C or falling below 20°C (Djaenudin et al., 2011). According to data from BMKG and the West Lombok BPS for 2023, the highest average temperature in Batulayar Village, Batulayar District, West Lombok Regency is 32°C, while the lowest average is 21°C. Therefore, the temperature in this area is highly suitable (S1) for growing durian plants.

j. Rainfall

Durian plants thrive best in areas with annual rainfall between 2,000 and 3,000 mm. They are not suited for regions where rainfall is less than 1,250 mm or exceeds 4,000 mm per year (Djaenudin et al., 2011). In Batulayar Village, Batulayar District, West Lombok Regency, the average rainfall from 2014 to 2023 is 1,731 mm per year, indicating that the area is classified as moderately suitable (S2) for growing durian plants.

k. Soil Depth

The amount of soil also factors into plant health, since very little soil will not be able to supply enough water and nutrients for the depth of soil needed by a tree to develop. It also impacts the cultivation of land. Soil Shallow soil management may involve turning over the land which can result in inhibiting plant growth (Osman, 2013). One way to do it is to study the distribution of plant roots in order to define "the effective depth" of soil as area where the roots can find moisture and nutrients, since the shallow layers are often a solid rock and roots cannot penetrate deeper. The ideal soil depth for durian plants is >100 cm, while <50 cm is considered not suitable for cultivation (Djaenudin et al., 2011). The soils in KHDTK UMMAT are divided into three capability classes: very suitable (S1) with a soil depth > 100 cm that comprises four land units [KHDTK 1, KHDTK 2, KHDTK 8, and KHDTK 9]; suitable (S2) with a soil depth of at least 75–100 cm including four land units (KHDTK 3, KHDTK 4, KHDTK 6, and KHDTK 7); and marginally suitable (S3) with a depth of 50-75 cm, covering one land unit (KHDTK 5).

The depth of the soil greatly determines plant growth because shallow soil will be limited in its ability to provide water and other nutrients. Apart from that, it also really determines whether the land can be cultivated or not. Shallow soil management will actually turn the soil upwards, resulting in disruption of plant growth (Siswanto, 2006). The effective depth of the soil can be determined by observing the distribution of plant roots because in hard rock layers plant roots cannot penetrate (Wu et al., 2022).

The most suitable soil depth for durian plants is >100 cm and <50 cm is not suitable for growing (Djaenudin et al., 2011). The effective depth of soil in KHDTK UMMAT has 3 suitability classes, namely very suitable S1 with a depth of >100 cm totaling 4 land units, namely KHDTK 1, KHDTK 2, KHDTK 8 and KHDTK 9. Classes sufficient suitability

according to S2 with a depth of 75-100 cm totaling 4 land units KHDTK 3, KHDTK 4, KHDTK 6 and KHDTK 7. Suitability class according to marginal S3 with a depth of 50-75 cm totaling 1 land unit, namely KHDTK 5.

l. Calmness

The slope of a land surface is defined as the angle created by changes in elevation, expressed as a percentage (%) or as 100% for a vertical slope (90°). Slope measurements are typically taken in the field using tools such as an Abney level and a clinometer. Durian trees are highly suitable (S1) for cultivation on land with slopes less than 8%, but are unsuitable for slopes greater than 30% (Djaenudin et al., 2011).

At the KHDTK UMMAT, the land is categorized into three suitability classes. Class S1, which is very suitable, includes two land units (KHDTK 1 and KHDTK 2) with slopes less than 8%. Class S2, which is moderately suitable, includes one land unit (KHDTK 3) with slopes between 8-16%. Class S3, considered marginally suitable, comprises six land units (KHDTK 4, KHDTK 5, KHDTK 6, KHDTK 7, KHDTK 8, and KHDTK 9) with slopes ranging from 16-30%.

m. Flood

The risk of flooding is influenced by both the depth and duration of the flood. Data on flood depth and duration were collected through field interviews. Durian plants are highly suitable (S1) for land F(0), which is classified as having no flooding (Djaenudin et al., 2011). The risk of flooding at KHDTK UMMAT is minimal. According to interviews with local residents, there have been no flood incidents, making the area very suitable (S1) for the growth and development of durian plants.

n. Surface Rocks and Rock Outcrops

Surface rock refers to the percentage of rock present on the ground surface. To measure surface rock, a 1 m² grid can be used as a sample to assess the land. Observations are made based on the distribution of rocks within this grid. Soil with a high percentage of surface rock is not necessarily difficult to manage. Durian trees thrive in areas with less than 5% surface rock but are unsuitable for areas with more than 40% surface rock (Djaenudin et al., 2011).

At KHDTK UMMAT the surface rocks fall into the very suitable S1 category, with less than 5% surface rock, across 9 land units (KHDTK 1 – KHDTK 9). Rock outcrops refer to the percentage of rock in the soil solum that is exposed on the surface due to erosion (Zhang et al., 2023). To measure rock outcrops, a 1 m² grid is also used to sample the land, and observations are made based on the distribution of rock outcrops. Durian trees are well-suited to land with less than 5% rock outcrops but are not suitable for land with more than 25% rock outcrops (Djaenudin et al., 2011).

At KHDTK Muhammadiyah University of Mataram, the rock outcrops are categorized into two suitability classes: very suitable S1 with less than 5% rock outcrops, across 4 land units (KHDTK 1, KHDTK 2, KHDTK 3, and KHDTK 9), and suitable S2 with 5-15% rock outcrops, across 5 land units (KHDTK 4, KHDTK 5, KHDTK 6, KHDTK 7, and KHDTK 8).

Discussion

The suitability of land for durian cultivation at KHDTK UMMAT has been assessed based on nine land units. The nine land units are divided based on nine KHDTK sub-management units that have the right to use each faculty and postgraduate in the educational function. The map is not overlaid, but the delineation boundaries are made KHDTK 1 - KHDTK 9 using the GIS program on the KHDTK map according to the Minister of Forestry Decree, based on the field boundaries of each land unit. After obtaining the suitability class which is the result of matching field data and laboratory test data with standard data on

agroecosystem requirements for durian plant cultivation according to the Ministry of Agriculture guidelines developed by Djaenudin et al. (2011).

Table 2. Results of Evaluation of Land Suitability for Durian Plants

No	Parameter	Land Suitability Class																		Average	Code
		KHDTK 1		KHDTK 2		KHDTK 3		KHDTK 4		KHDTK 5		KHDTK 6		KHDTK 7		KHDTK 8		KHDTK 9			
1	Coarse Texture	89	S3	86	S3	92	S3	76	S3	86	S3	30	S2	76	S3	81	S3	84	S3	77.78	S3-8
2	Salinity	0.4	S1	0.4	S1	0.3	S1	0.45	S1	0.38	S1	0.4	S1	0.39	S1	0.45	S1	0.45	S1	0.40	S1
3	pH	5.96	S1	6.01	S1	6.81	S1	5.9	S1	7.02	S1	7.51	S1	6.47	S1	5.96	S1	6.98	S1	6.51	S1
4	Drainage/Porosity	30.2	S1	34.87	S1	35.87	S1	32.43	S1	26.3	S1	28.32	S1	29.51	S1	33.11	S1	28.8	S1	31.04	S1
5	CEC	16	S2	32	S1	24	S1	63	S1	16	S2	16	S2	23	S1	18	S2	20	S1	25.14	S2-4
6	N	0.17	S2	0.09	S3	0.09	S3	0.18	S2	0.1	S3	0.11	S2	0.11	S2	0.07	S3	0.08	S3	0.11	S3-5
7	P	10.5	S3	24.4	S2	17.12	S2	51.07	S1	10	S3	9.23	S3	13.26	S3	8.92	S3	12.4	S3	17.44	S3-6
8	K	5.42	S3	7.13	S3	6.59	S3	11.31	S2	5.54	S3	6.64	S3	9.14	S3	9.4	S3	7.1	S3	7.59	S3-8
9	Temperature										21-32										S1
10	Rainfall										1,731										S2
11	Depth	>100	S1	>100	S1	75-100	S2	75-100	S2	50-75	S3	75-100	S2	75-100	S2	>100	S1	>100	S1	75-100	S3-1
12	Slope	<8	S1	<8	S1	8-16	S2	16-32	S3	16-32	S3	16-32	S3	16-32	S3	16-32	S3	16-32	S3	25%	S3-6
13	Flood	F (0)	S1	F (0)	S1	F (0)	S1	F (0)	S1	F (0)	S1	F (0)	S1	F (0)	S1	F (0)	S1	F (0)	S1	F0	S1
14	Surface rock	<5	S1	<5	S1	<5	S1	5-15	S2	5-15	S2	5-15	S2	5-15	S2	5-15	S2	<5	S1	<5	S2-5
	Unit Class		S3-3		S3-3		S3-3		S3-3		S3-6		S3-3		S3-4		S3-5		S3-5		

The results of matching durian plant growth conditions to determine land suitability classes and the limiting factors for each land unit are shown in Table 2. All nine land units classified for durian cultivation fall into the marginal land suitability class (S3), covering an area of 93.55 hectares. The constraints for this marginal suitability class (S3) include coarse texture, low levels of Nitrogen, Phosphorus, and Potassium, and steep slopes. In contrast, the limiting factors for the somewhat suitable class (S2) are Cation Exchange Capacity (CEC), rainfall, soil infiltration, and surface rocks.

The following actions can be performed to enhance or correct the land quality for durian cultivation:

Methods for soil quality improvement:

a. Coarse texture (S3), organic fertilization with large doses of manure;
b. Contour plant steep slopes, use mechanical conservation techniques, such as bench terraces, embankments, and other measures to control surface runoff; and
c. Organic materials or chemical fertilizers with high N, P, and K content can be applied to address soil chemical limitations related to low levels of nitrogen (N), phosphorus (P_2O_5), and potassium (K_2O).

CONCLUSION

At KHDTK UMMAT, located in Batulayar Village, Batulayar District, West Lombok Regency, the land is categorized into nine units, all classified as marginally suitable (S3). The primary limitations for this marginal suitability include coarse soil texture, low levels of Nitrogen, Phosphorus, and Potassium, and steep slopes. For land classified as somewhat suitable (S2), the limiting factors are Cation Exchange Capacity (CEC), rainfall, soil depth, and surface rocks. To enhance land suitability for durian cultivation, management practices such as organic fertilization, high doses of N, P, and K chemical fertilizers, and planting enrichment crops, particularly durians along the contours, are recommended.

Land suitability class at KHDTK Muhammadiyah University of Mataram, Batulayar Village, Batulayar District, West Lombok Regency, has nine land units with all land suitability classes being marginal (S3). The limiting factors for the marginal suitability class (S3) are rough texture, low levels of Nitrogen, Phosphorus and Potassium and high slope. Meanwhile, the limiting factors for somewhat suitable (S2) are CEC, rainfall, into the soil and surface rocks. Management efforts are needed in the form of organic fertilization, high doses of N, P and K chemical fertilization, as well as planting enrichment plants, especially durian plants parallel to the contour.

SUGGESTION

Further studies on irrigation systems, integrated analysis of organic and chemical fertilization, soil reclamation and soil structure improvement are needed to enrich the understanding of land management techniques in the KHDTK UMMAT and provide more targeted solutions for the development of durian plantations and other crops., berisi saran untuk penyempurnaan penelitian.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest with any party related to the publication of this article because we are the management team of KHDTK UMMAT. The author declares that this paper is free from plagiarism.

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