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Soil Quality Analysis and Land Management Direction on Dry Land Areas in Tejakula and Buleleng Districts, Indonesia

Putu Agung Apriadi♥, Ni Made Trigunasih, and I Made Mega

Master of Dryland Agriculture Study Program, Faculty of Agriculture, Udayana University, Denpasar, Indonesia

♥Corresponding author email: agungapriadi111@gmail.com

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Abstract. Declining agricultural yields on drylands in Tejakula Subdistrict are largely attributed to poor soil management practices, highlighting the urgent need for comprehensive soil quality assessment. This study aims to evaluate soil quality, identify limiting factors, and map the spatial distribution of soil quality to guide appropriate land management strategies. The research was conducted from January to June 2024 across twelve sampling points in ten villages using a purposive sampling technique. Both disturbed and undisturbed soil samples were analyzed for physical, chemical, and biological indicators, including bulk density, porosity, soil texture, pH, C-organic, CEC, nutrients (N, P, K), and microbial biomass carbon (C-biomass). The Minimum Data Set (MDS) method and a weighted additive model were applied to calculate the Soil Quality Index (IKT). The results showed that all sampling sites were categorized as having very good soil quality, with IKT scores ranging from 16.3 to 19.6. The study concludes that although soil quality is generally high, targeted management interventions such as organic amendments and balanced fertilization are still necessary to address site-specific limiting factors and ensure land productivity.

Keywords: dryland agriculture; land management; soil quality

INTRODUCTION

Good soil quality is essential for supporting human activities, maintaining water availability, and sustaining agricultural yields. Assessing soil quality is essential for agricultural progress. One of the instruments to evaluate the impact of land management is the soil quality index (SQI) (Muñoz-Rojas, 2018). Soil quality assessment can provide information on the impact of crop management with the help of soil quality data. Soil quality information can also synchronize data from all land management parameters (Manurung et al., 2021).

On dry land in the Tejakula Sub-district, various commodities have so far been cultivated, such as cassava, corn, peanuts, mangoes, rambutan, bananas, durian, coconut, cloves, cocoa, cashews, coffee, and so on (Government of Buleleng Regency, 2022). Poor land management activities will reduce land productivity, resulting in substandard yields and indicating that the land needs to be fixed. Soil quality and fertility decline when land is not managed wisely (Sumarniasih *et al*., 2021). Mitigation can be implemented to sustain the land so that the soil quality is ideal for meeting plant nutrition. There are several indicators of soil quality, including physical, chemical, and biological properties of soil; besides these three main factors in assessing soil quality, no less critical are soil type, topography, and land use to develop an excellent agricultural sector (Rasyid, 2004).

According to the data, BPS Buleleng (2022) shows decreased agricultural yields from 2018-2022. The decline in agricultural yields mainly occurred in commodities that are generally cultivated on dry land, such as durian, which decreased from 1,933.6 tons to 335.4 tons, cayenne pepper, 72.4 tons to 1.5 tons, and turmeric, 4,000 tons to 500 tons. The decline in durian production from 2018-2022, a leading commodity in Tejakula District, is undoubtedly a problem that needs to be resolved.

Based on these data, this research is expected to provide information related to land conditions and appropriate land use

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efforts to the community. In addition, the utilization and management of land can be done appropriately and tailored to the existing level of soil quality. The soil quality data obtained can be used as a reference for soil management to improve soil quality and increase land productivity. Given the importance of soil quality in improving land productivity, this researcher is interested in researching soil quality analysis and land management direction on dryland in Tejakula District, Buleleng Regency.

METHODS

This research was conducted from January 2024 to June 2024 in the drylands of Tejakula Subdistrict and Soil Laboratory, Master of Dryland Agriculture Study Program, Faculty of Agriculture, Udayana University. The research location included ten villages in the Tejakula sub-district. Site selection was based on the presence of representative dryland conditions, diverse land uses, and accessibility. Villages were selected purposively to represent spatial and ecological variation across the subdistrict. Materials used for data collection included slope maps, soil quality, soil types, homogeneous land units, land use, and chemical and soil samples for laboratory analysis.

The sampling strategy applied a purposive sampling method, with sample points determined based on land use type, topographic variation, and soil map units. A total of 12 sampling points were established across homogeneous land units. At each point, both disturbed and undisturbed soil samples were collected. Disturbed samples were taken using a hoe and auger for chemical and physical analysis, while undisturbed samples were collected using stainless steel soil rings for bulk density and related analysis.

Data analysis tools in this study used a set of computer hardware with software such as qgis 3.8, Microsoft Excel 2019, Microsoft Word 2019, android phones (photos, GPS, determination of coordinate points, etc.), and the utilization of online altimeter applications. Field equipment used included Belgi drills, Abney levels, compasses, meters, and others, while laboratory equipment included pH meters, pipettes, sieves, scales, measuring cups, and others. The research method includes survey implementation, scoring, soil analysis in the laboratory, and determination of soil quality with indicators as a minimum data set (MDS), including soil volume weight, pH, soil texture, c-organic, nutrients (N, P, and K), CEC, K.B., and c-biomass.

Index calculations and indicator weightings were carried out using a were carried out using a weighted additive model, with weights assigned based on expert judgment and literature values. All scores were normalized to ensure comparability across indicators.

Potential biases may arise from site selection that was not random, which could affect generalizability. Additionally, the purposive nature of sampling, although ensuring coverage of key land types, may introduce subjectivity. Observational constraints due to accessibility, terrain limitations, and seasonal variability may also influence data accuracy.

Determination of Homogeneous Land Unit (SLH)

The digital data was processed by overlaying the land use map, slope class map, soil type map, and scale, adjusted to the administrative boundaries of Tejakula Sub-district to produce a map. The next step was to overlay the research area and conduct soil sampling. Homogeneous land unit maps were created using QGIS 3.8.3 *software*. The homogeneous land unit map and sampling points in the Tejakula sub-district are shown in Figure 1.

Data Preparation and Analysis

The soil sample preparation process includes removing gravel, plant debris, and plant roots from the samples and drying,

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pulverizing, and sieving. Soil samples are taken from the field and cleaned to remove gravel, plant debris, and plant roots. Measuring soil's physical, chemical, and biological qualities is part of the soil quality assessment. Ten MDS were measured using the method of Lal (1994). Soil quality analysis was carried out using the reference standard methods in Table 1.

Scoring and Determination of Soil Quality Index (Q.I.).

The data was analyzed to assess soil quality in the Tejakula sub-district using the Soil Quality Index (Q.I.). The first step was determining the limiting factors and assigning relative weights to the soil quality indicators based on Lal's method (1994). Soil quality is assessed based on soil properties that indicate soil functions or limiting factors for plant growth. These limiting factors range from extreme conditions to no limiting factors, weighted on a scale of 1 to 5.

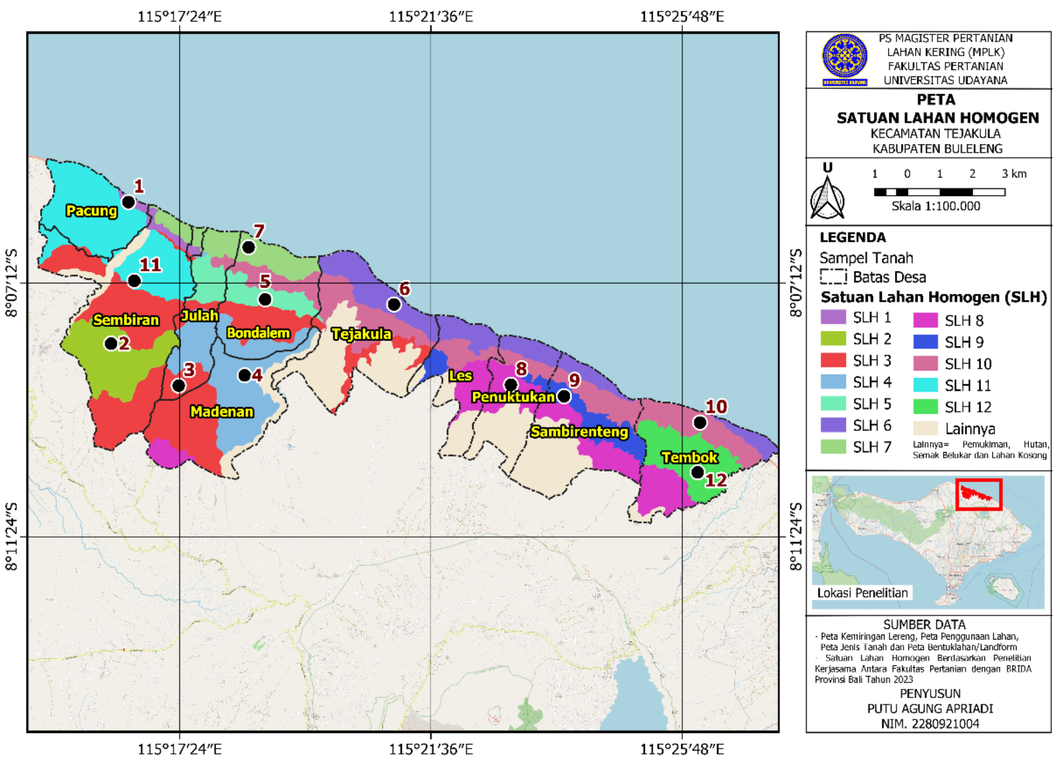

Figure 1. Map of Homogeneous Land Unit

The formula used is: IKT = SF + SK + SB

Description:

- IKT: Soil Quality Index
- S.F.: Soil physical properties parameter
- SK: Soil chemical parameters
- S.B.: Soil biological properties parameter

S.B. parameters analyzed included C-biomass. Soil chemical and nutrient properties (S.K.) included C-organic, pH, cation exchange capacity (CEC), and nutrients (N, P, K). Meanwhile, S.F. parameters include soil texture, volume weight, porosity, and field capacity moisture content. Limiting factors, relative weighting, and soil quality criteria are in Table 1 and Table 2. Determination of the IKT value is done by summing up the scores obtained at each SLH, as shown in Table 3.

Each soil quality indicator is classified based on its limiting level using a scoring scale from 1 to 5, where "1" represents no limitation (optimal condition) and "5" indicates an extreme limitation. Table 2 presents the classification criteria for each

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indicator, such as bulk density, pH, C-organic, CEC, nutrient content, and others, including their corresponding threshold values for assigning limitation scores. These scores are assigned to each observation point to reflect the degree of limitation for each parameter.

Table 1. Soil Quality Analysis Method

Parameters	Unit	Methods
Physical properties		
1. Soil texture	%	Pipette
2. *Bulk density*	g cm^{-3}	Ring sample
3. Porosity	%	Ring sample
4. Field capacity moisture content	%	Gravimetry
Chemical properties		
1. C-organic	%	Walkley & Black
2. pH		Potentiometry (H2O 1:2.5)
3. CEC	me 100 g^{-1}	Extraction NH4OAc 1N pH 7
4. K.B.	%	Extraction NH4OAc 1N pH 7
5. N total	%	Kjeldahl
6. P available, K available	Ppm	Bray- 1
Biological properties		
1. Microbial C-biomass	mg CO2 kg^{-1}	Soil respiration

Source: Lal (1994)

Table 2. Limiting Factors and Relative Weights of Soil Quality Indicators

		Limiting factors and relative weights				
		Without	Lightweight	Medium	Weight	Extreme
No.	Indicator	1	2	3	4	5
1	Volume Weight (g cm)$^{-3}$	<1.2	1.3-1.4	1.4-1.5	1.5-1.6	>1.6
2	Soil Texture	L	SiL. Si. SiCL	CL.SL	SiC. LS	S.C
3	Porosity (%)	>20	18-20	15-18	10-15	<10
4	Field capacity moisture content (%)	>30	20-30	8-20	2-8	<2
5	C-Organic (%)	5-10	3-5	1-3	0.5-1	<0.5
6	pH	6.0-7.0	5.8-6.0	5.4-5.8	5.0-5.4	<5.0
7	CEC (me/100g)	>40	25-40	17-24	5-16	<5
8	BIRTH CONTROL (%)	>70	51-70	36-50	20-30	<20
9	Nutrients (N, P, and K)					
	N- Total (%)	>0.51	0.51- 0.75	0.21-0.50	0.10-0.20	<0.10
	P-Available (ppm)	>35	26-35	16-25	10-15	<10
	K-Available (ppm)	>1.0	0.6-1.0	0.3-0.5	0.1-0.2	<0.1
10	C-Biomass (mg CO2 kg)$^{-1}$	>25	20-25	10-20	5-10	<5

Source: Lal (1994). Description: *L*= Loam; Si= *Silt*; S= *Sand*; *C*= Clay.

To obtain a comprehensive evaluation of soil quality, the scores from all indicators are summed to generate a cumulative weight, known as the Land Quality Index (IKT). Table 3 outlines the interpretation of IKT Values, categorizing land quality into five classes: very good, good, medium, bad, and very bad. This classification facilitates a clear assessment of overall soil suitability and helps prioritize land management strategies based on identified limitations.

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Table 3. Soil Quality Criteria Based on 10 MDS

Quality Land	Weighting Relative	Cumulative Weight (IKT)
Very good	1	<20
Good	2	20-25
Medium	3	26-30
Bad	4	31-40
Very Bad	5	>40

Source: Lal (1994)

Soil Quality Map Creation

Soil quality mapping aims to make information about soil quality in the study area easier to communicate. Its implementation is based on the soil quality data review results, which utilize QGIS 3.8.3 software to calculate the IKT in each SLH.

Land Management Directive

Soil management guidelines in the Tejakula sub-district are derived from the findings of potential and actual soil quality evaluations to improve soil quality on drylands. Knowing the constraints on farmland will help achieve optimal land utilization with the best land capability. A sustainable farming system can only be achieved by following good land management guidelines.

RESULTS AND DISCUSSION

Overview of the Research Location

Tejakula sub-district has an area of 97.68 km^2 and a coastal length of 27.23 km. Administratively, it consists of 10 villages with 60 hamlets and 15 Pakraman villages. Land use in the Tejakula sub-district consists of dry land or moor (4,892 ha), plantation (2,977 ha), forest land (1,630 ha), paddy field (5 ha), and other uses (269 ha). Dry land in the Tejakula Sub-district has the potential for annual crop cultivation. The primary agricultural commodities in this area are corn (1,923 tons), cassava (a production of 3,338 tons), and peanuts (119 tons). Horticultural crops, such as mango (5,035 tons), rambutan (4,150 tons), banana (1,329 tons), and durian (450 tons), are also well-developed. Plantations are dominated by coconut (33,393.75 tons), cloves (5,380,500 tons), cocoa (4,020.69 tons), cashew (2,266.05 tons), and coffee (1,838 tons) (Government of Buleleng Regency, 2022).

Soil quality analysis on dry land in the Tejakula Sub-district based on the Geographic Information System (SIG) was conducted on each SLH in the research location. Spatially the distribution of homogeneous land units (SLH) on dry land in Tejakula Sub-district, there are twelve SLHs namely SLH 1 in Pacung Village covering an area of 666 ha, SLH 2 in Sembiran Village covering an area of 1779 ha, SLH 3 in Julah Village covering an area of 471 ha, SLH 4 in Madenan Village covering an area of 1373 ha, SLH 5 in Bondalem Village covering an area of 669 ha, SLH 6 in Tejakula Village covering 1396 ha, SLH 7 in Les Village covering 769 ha, SLH 8 in Penuktukan Village covering 625 ha, SLH 9 in Sambirenteng Village covering 940 ha, SLH 10 in Tembok Village covering 1081 ha, SLH 11 in Sembiran Village covering 1779 ha, and SLH 12 is in Tembok Village covering 1081 ha.

Each SLH has almost the same characteristics, the only difference being the slope and land form. SLH I, II, III, IV, V, VI, VII, VIII, IX, X, XI, and XII have the same soil type, namely Regosol with a brown soil type.

Results of Analysis of Soil Quality Parameters and Limiting Factors

Based on laboratory analysis, soil physical properties such as texture, volume weight, porosity, and field capacity were examined. Soil chemical properties include CEC, base saturation, soil pH, N-total, P-available, K-available, and C-organic content. Meanwhile, soil biological

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properties were assessed from the C-biomass content.

Soil Physical Properties

Soil physical properties (S.F.) describe soil quality and are measured by texture, volume weight, porosity, and water capacity. (Cahyadewi *et al.*, 2016). Based on the evaluation of soil physical properties (table 4), it can be seen that the weighting of soil texture varies, ranging from no limiting factors to heavy limiting factors.

S.F. weighting is adjusted to the limiting factors and relative weights, according to Lal (1994). The weighting of soil texture indicates moderate to severe limiting factors in the various SLHs studied. The soil texture at SLH I, III, V, and XI is Sandy Clay Loam (CLS), which has a light limiting factor with a relative weight of 2. SLH VII, VIII, IX, X, and XII show a Sandy Clay (L.S.) texture with a heavy limiting factor and relative weight 4. SLH II has a Sandy Clay (C.S.) texture with a heavy limiting factor and a tendency weight of 4, while SLH VI with a Clayey Loam (CL) texture has a medium limiting factor and a relative weight of 3. SLH IV shows a Clayey Sand (S.L.) texture with a medium limiting factor and a relative weight 3.

Analysis of soil volume weight in SLH I, II, III, IV, V, VIII, IX, X, XI, and XII shows no limiting factor with a relative weight of 1, while SLH VII has a mild limiting factor with a relative weight of 2. SLH VI shows a moderate limiting factor with a relative weight of 3. The soil volume weight at the research site could be higher because most of it is classified as clay, which results in a smaller volume weight. Clay is a soil type with a high pore space, resulting in a lower volume weight (Pratiwi & Nurcholis, 2014). (Pratiwi & Nurcholis, 2023). The results of the soil porosity analysis show no limiting factors in all SLH with a relative weight of 1. The porosity value is included in the very high criteria because most soil texture is in the Loam category, which is good at retaining water and has many micropores. The porosity value can indicate the ease with which the soil can absorb water (Bintoro *et al*., 2017). Meanwhile, the analysis of field capacity moisture content in all SLH shows a very high value with a relative weight of 1, where the dominance of clay texture makes it easier for the soil to store water; the clay texture can also provide good nutritional capabilities. (Solekhah *et al.*, 2024).

Soil Chemical Properties

Soil chemical properties (S.K.) are one indicator that shows the soil quality of land, which is assessed through the parameters of CEC, K.B., pH, Nutrients (N-total, P-available, K-available), and C-organic. The results of the CEC weighting based on the results of the Laboratory test analysis show that the soil in the Tejakula Sub-district is partly classified as heavy to extreme. However, several SLHs have a relatively lightweight CEC. This is because the soil texture is dominated by the Sandy Loam soil type, and more sand in the soil results in a lower CEC. Low CEC can also reflect low organic matter content (Puja & Atmaja, 2018).

The soil K.B. illustrates that drylands in the Tejakula Subdistrict in each SLH have no limiting factors, with an overall K.B. value of 1. The base saturation in the research location is also classified as very high, which can be caused by the significant base content at a neutral pH. Soil pH analysis shows no pH limiting factor in all SLHs in the study site, with a relative weight of 1. Neutral pH conditions make the soil in each SLH ideal for crop cultivation. The nature of nitrogen is easily leached and difficult to bind to soil colloids, resulting in low N content in SLH. While the low N content can also be influenced by other factors, such as the elevation factor, the higher the elevation will increase nitrogen because organic matter at higher elevations is relatively higher. (Muliana, 2022).

The soil P-availability parameter shows the results of the weighting of the extreme, very low, high, and very high limiting

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factors in each SLH. P-availability in SLH IV, V, VII, IX, X, XI, and XII shows no limiting factor for P-availability with a relative weight of 1. P-availability in SLH II, III, and VIII is classified as a mild limiting factor with a relative weight of 2. SLH I is classified as low, with a relative weight of 4, and the one with the most extreme limiting factor is SLH VI, with a relative weight of 5. It should be noted that the P-available element will be directly proportional to the soil pH; if the soil pH increases, the P element will be more available in the soil (Oktabriana & Syofiani, 2021). At the same time, the weighting results on the soil K-Available parameter explain that the quality or quality of soil in all SLH has a limiting factor, which is very high with a relative weight of 1.

The weighting for soil C-organic is set based on the limiting factor and relative weighting, according to Lal (1994). The results show that in Tejakula Sub-district, each SLH has a moderate and light limiting factor, while the SLH with a light limiting factor is SLH VIII with a weight of 3.22%, classified as light with a value of 2. Meanwhile, apart from SLH VIII, they all have a moderate relative weight. SLH has a medium relative weight. The C-organic content is more in the medium relative weight because it is influenced by the soil texture, which is dominated by clay, which allows C-organic from decomposed plant residues and other nutrients to be bound by soil colloids (Susila, 2013). The parameters of soil chemical properties in Tejakula District in SLH are presented in Table 5.

Table 4. Results of Soil Physical Properties Analysis

SLH	Texture	Volume Weight (g/cm)$^{-3}$	Porosity (%)	Field Capacity Moisture Content (%)	Total
I	Sandy Clay Loam (SCL)$_{(3)}$	1.191$_{(1)}$	46.95$_{(1)}$	34.37$_{(1)}$	6
II	Sandy Clay (S.C.)$_{(4)}$	0.999$_{(1)}$	39.93$_{(1)}$	37.67$_{(1)}$	7
III	Sandy Clay Loam (SCL)$_{(3)}$	0.884$_{(1)}$	57.21$_{(1)}$	33.26$_{(1)}$	6
IV	Loamy Sand (L.S.)$_{(4)}$	0.906$_{(1)}$	63.93$_{(1)}$	32.70$_{(1)}$	7
V	Sandy Clay Loam (SCL)$_{(3)}$	0.831$_{(1)}$	54.46$_{(1)}$	35.53$_{(1)}$	6
VI	Clayey Loam (CL)$_{(3)}$	1.407$_{(3)}$	26.60$_{(1)}$	35.55$_{(1)}$	8
VII	Sandy Loam (S.L.)$_{(3)}$	1.332$_{(2)}$	34.38$_{(1)}$	31.89$_{(1)}$	7
VIII	Sandy Loam (S.L.)$_{(3)}$	1.073$_{(1)}$	51.75$_{(1)}$	32.61$_{(1)}$	6
IX	Sandy Loam (S.L.)$_{(3)}$	1.139$_{(1)}$	50.41$_{(1)}$	30.33$_{(1)}$	6
X	Sandy Loam (S.L.)$_{(3)}$	1.025$_{(1)}$	55.45$_{(1)}$	34.01$_{(1)}$	6
XI	Sandy Clay Loam (SCL)$_{(3)}$	1.119$_{(1)}$	43.65$_{(1)}$	35.02$_{(1)}$	6
XII	Sandy Loam (S.L.)$_{(3)}$	0.915$_{(1)}$	58.80$_{(1)}$	34.20$_{(1)}$	6

Source: Results of soil analysis in the laboratory

Biological Properties of Soil

Soil biological properties required in determining soil quality based on the method of Lal (1994) is the soil C-biomass value. Soil C-biomass can be analyzed through many methods. The method used in this study is the determination of C-biomass based on the analysis of respiration of microorganisms in soil samples based on the method of Anderson & Domsch (1978). The analysis of respiration, which was then converted into C-biomass, showed that the C-biomass in the entire SLH was very high, with a relative score of 1. The C-biomass data showed that the activity of microorganisms in the entire SLH was classified without limiting factors. The high C-biomass in SLH means that land

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management is good enough to maintain the content in the soil. (Triadiawarman et al., 2022). Continuous drainage improvements can be carried out to maintain C-biomass consistency (Sagala et al., 2021). Parameters of soil biological properties in Tejakula District in SLH can be seen in Table 6.

Table 5. Results of Soil Chemical Analysis

SLH	C-organic (%)	CEC (me 100g-)[1]	BIRTH CONTROL (%)	pH	Nutrition N-Total (%)	P-available (ppm)	K-available (ppm)	N. P. K	Total
I	2.02(3)	12.25(4)	88.14(1)	6.9(1)	0.03(5)	14.36(4)	147.91(1)	3.3	12.3
II	2.18(3)	30.22(2)	94.82(1)	6.9(1)	0.05(5)	27.50(2)	242.99(1)	2.6	9.6
III	2.53(3)	24.02(3)	93.69(1)	6.7(1)	0.07(5)	27.00(2)	238.12(1)	2.6	10.6
IV	1.58(3)	10.98(4)	96.30(1)	7.6(1)	0.03(5)	77.20(1)	281.29(1)	2.3	11.3
V	2.60(3)	37.30(2)	92.86(1)	7.1(1)	0.06(5)	39.20(1)	268.12(1)	2.3	9.3
VI	2.57(3)	28.39(2)	86.82(1)	6.7(1)	0.02(5)	6.37(5)	177.71(1)	3.6	10.6
VII	1.99(3)	10.83(4)	98.11(1)	6.8(1)	0.03(5)	350.11(1)	355.06(1)	2.3	11.3
VIII	3.22(2)	16.95(4)	97.56(1)	6.8(1)	0.07(5)	32.13(2)	301.39(1)	2.6	10.6
IX	2.78(3)	10.19(4)	96.00(1)	6.8(1)	0.06(5)	70.74(1)	318.61(1)	2.3	11.3
X	2.43(3)	14.97(4)	100.00(1)	6.7(1)	0.05(5)	63.79(1)	337.29(1)	2.3	11.3
XI	2.76(3)	36.25(2)	98.68(1)	6.6(1)	0.07(5)	65.57(1)	228.34(1)	2.3	9.3
XII	2.87(3)	11.18(4)	98.00(1)	6.5(1)	0.07(5)	45.57(1)	267.21(1)	2.3	11.3

Source: Results of soil analysis in the laboratory

Table 6. Analysis of Soil Biological Properties

SLH	C-Biomass (mg CO2kg)-1	Total
I	103.2728(1)	1
II	199.3688(1)	1
III	275.0444(1)	1
IV	185.7552(1)	1
V	172.1416(1)	1
VI	76.0456(1)	1
VII	55.2248(1)	1
VIII	192.562(1)	1
IX	41.6112(1)	1
X	137.7072(1)	1
XI	40.8104(1)	1
XII	159.3288(1)	1

Description: Relative weight and limiting factor: (1) None, (2) Mild, (3) Moderate, (4) Severe, and (5) Extreme.

Soil Quality Index (Q.I.)

MDS is a data set that has been reduced from soil quality indicators and can describe soil functions optimally to form IKT (Ramadhona & Arifandi, 2020). Based on the analysis of the IKT criteria with the MDS method applied to SLH in Tejakula District, soil quality was found to be outstanding. Excellent soil quality was found in all SLH, namely I, II, III, IV, V, VI, VII, VIII, IX, X, XI, and XII, with consecutive values of 19.3, 17.6; 17.6, 19.3; 16.3; 19.6; 19.3; 17.6; 18.3; 18.3; 16.3; and 18.3. Soil quality describes the capacity of soil to provide functions required by humans or natural ecosystems over a long period. (Karlen et al., 2001).

Drylands in Tejakula Sub-district have excellent soil quality, influenced by medium to high organic matter content, high soil moisture, nutrient imbalance, less than ideal soil conditions, inappropriate fertilizer use, low pH, and soil density. According to Febriana *et al*., (2024) high

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moisture and low organic matter content throughout SLH can have an impact on the pH and availability of nutrients in the soil, so it can inhibit plant growth and productivity, which affects overall soil quality. Another factor that makes Tejakula Sub-district have excellent soil quality is the neutral soil pH in all SLH, which indicates optimal conditions.

The difference in the IKT value of soil in each SLH in the dry land of Tejakula Subdistrict is caused by differences in the parameters of P-available, texture, CEC, and C-organic between SLH. Meanwhile, other soil quality indicators such as volume weight, porosity, field capacity moisture content, base saturation, pH, N-total, K-available, and C-biomass did not significantly affect soil quality at the research site. The lower the IKT value, the fewer limiting factors there are, which means the soil quality is better. (Harahap et al., 2018). Proper management can improve soil quality (Sardinia *et al.*, 2014). Generally, a sound system of soil management can improve soil quality in terms of physical, chemical, and biological aspects (Hasibuan *et al.*, 2023). Analysis of the Soil Quality Index in Tejakula Sub-district Villages for each SLH is presented in Table 7.

Table 7. Soil Quality Index Analysis of Villages in Tejakula Sub-district

SLH	Village	IKT	Soil Quality
I	Pacung	19.3	SB
II	Sembiran	17.6	SB
III	Julah	17.6	SB
IV	Madenan	19.3	SB
V	Bondalem	16.3	SB
VI	Tejakula	19.6	SB
VII	Bondalem	19.3	SB
VIII	Bookmarking	17.6	SB
IX	Sambirenteng	18.3	SB
X	Wall	18.3	SB
XI	Sembiran	16.3	SB
XII	Wall	18.3	SB

Source: results of analysis of each homogeneous land unit
Description: S.B.: Very Good

Soil Quality Map

Soil quality mapping in Tejakula Sub-district through QGIS *software* version 3.8.3 shows excellent quality. The mapping begins by assigning a score to each SLH based on soil quality and tabulating the scores to obtain an outstanding quality category. Excellent soil quality is characterized by a green polygon (Irwansyah, 2013). The results of the soil quality map are presented in Figure 2.

Land Management Directive

Soil management direction in the Tejakula sub-district is based on the analysis of soil quality and limiting factors. Good land management is critical in improving soil quality or condition and sustainably increasing agricultural productivity (Lisa *et al.*, 2022). The soil management system and appropriate fertilizers must be considered to improve soil quality. Soil management directions can be seen in Table 8.

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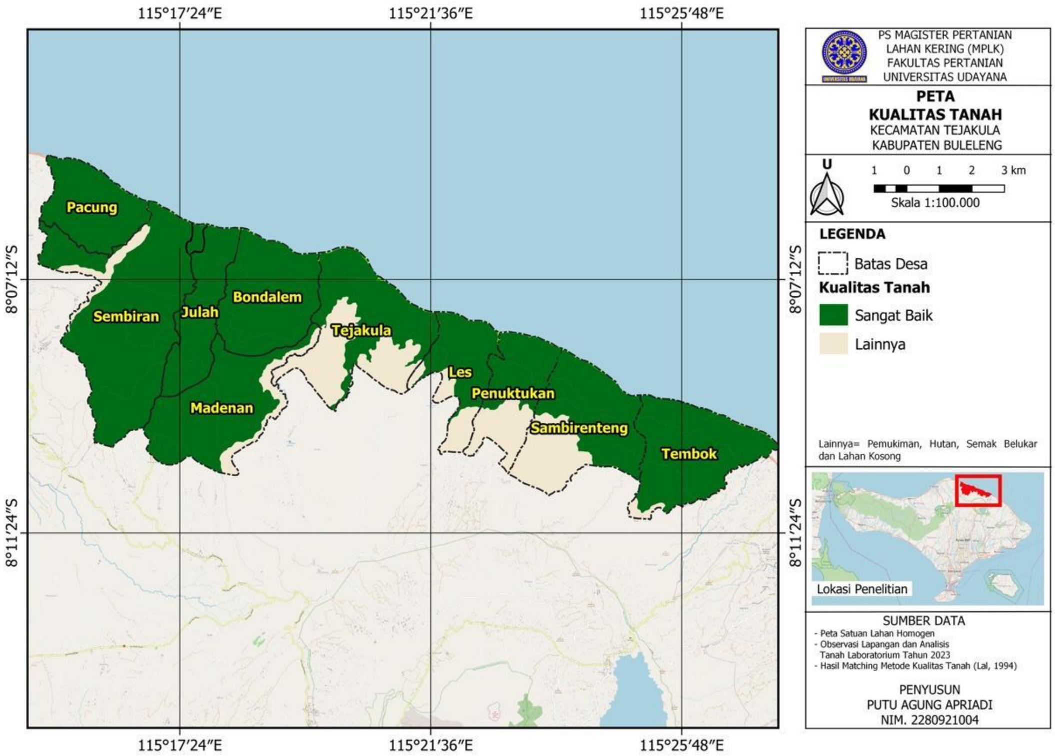

Figure 2. Soil Quality Map in Tejakula Sub-district, Buleleng Regency

Table 8. Land Management Direction in Tejakula Sub-district

SLH	Village	Limiting Factors	Management Direction
I	Pacung	N-Total and P-Available	Urea and TSP/SP 36
II	Sembiran	N-Total and P-Available	Urea and TSP/SP 36
III	Julah	N-Total and P-Available	Urea and TSP/SP 36
IV	Madenan	N-Total	Urea
V	Bondalem	N-Total	Urea
VI	Tejakula	N-Total and P-Available	Urea and TSP/SP 36
VII	Bondalem	N-Total	Urea
VIII	Bookmarking	N-Total and P-Available	Urea and TSP/SP 36
IX	Sambirenteng	N-Total	Urea
X	Wall	N-Total	Urea
XI	Sembiran	N-Total	Urea
XII	Wall	N-Total	Urea

Source: Data analysis in the laboratory

The recommended fertilizers are organic fertilizers made from animal manure and composted leaf litter, Urea, and SP-36 fertilizers. Compost or manure fertilizer is recommended for all SLH studied; However, the C-organic content in most SLH is moderate on average; the provision of organic fertilizer is still essential in influencing the soil's physical, chemical, and biological properties. Manure or compost increases the soil's capacity to hold water, thus providing more water for plants. A map of soil management guidelines on farmland in the Tejakula Sub-district can be seen in Figure 3.

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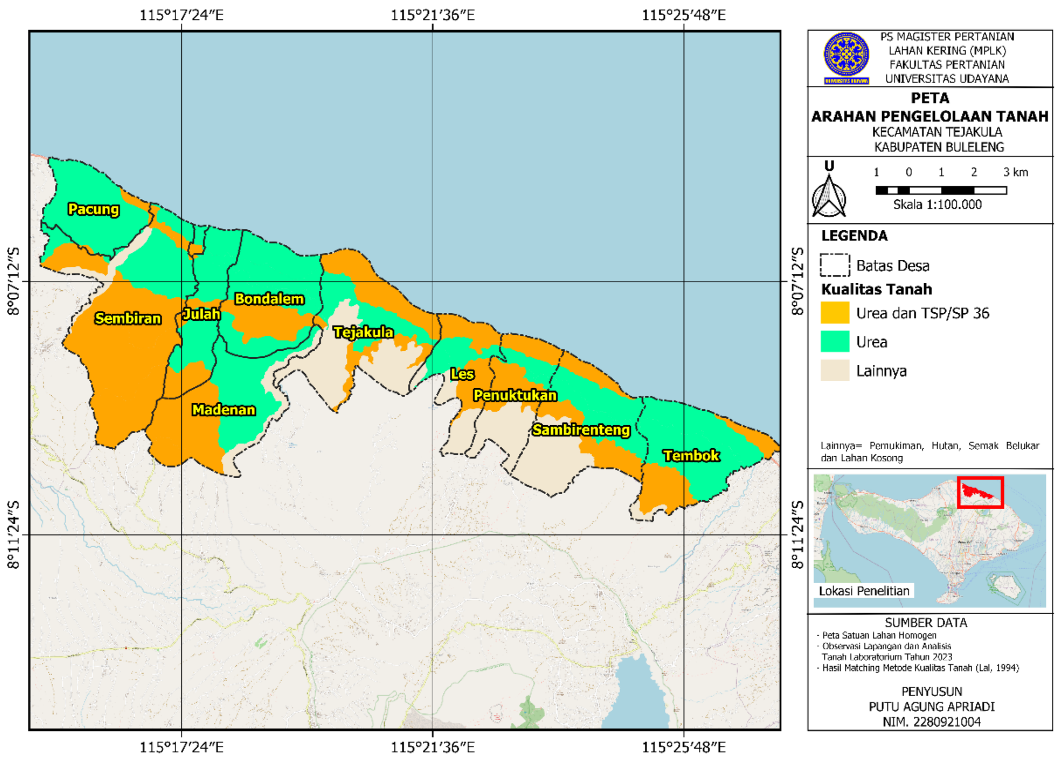

Figure 3. Land Management Directive Map of Agricultural Land Tejakula District Buleleng Regency

CONCLUSION

The study concludes that the overall soil quality in the drylands of Tejakula Subdistrict is classified as very good, based on the Soil Quality Index (IKT) values obtained through the Minimum Data Set (MDS) and weighted additive model. All 12 homogeneous land units (SLH) across villages such as Pacung, Sembiran, Julah, Madenan, and others demonstrated high IKT exchange capacity (CEC), total nitrogen (N-total, available phosphorus (P-Available), and organic carbon (C-organic) levels. Recommended land management strategies to improve or sustain soil quality include the application of organic fertilizers (manure or compost), Urea, and SP-36, tailored to specific limitations of each site.

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