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Land Suitability Evaluation for Sugar Palm (*Arenga pinnata* Merr.) in Nagari Labuah Gunuang, West Sumatra, Indonesia

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ABSTRACT

An evaluation of the suitability of land for sugar palm cultivation was conducted to assess the land's ability to support maximum growth and production. Palm cultivation in Nagari Labuah Gunuang, Limapuluh Kota Regency, has not been optimal because the plants still grow wild without regard to land suitability. This study aims to determine the actual and potential land suitability classes and map land suitability for palm cultivation development. This study employed a field survey using the purposive sampling method on four land units, with sample point criteria selected based on overlay results and representing each land map unit. Additionally, soil sampling was conducted at a depth of 0–60 cm, followed by laboratory analysis. Land suitability was evaluated using a matching method that matched land characteristics with the requirements for palm tree growth. Spatial analysis was then performed using ArcGIS software to produce a land suitability map. The results showed that land suitability classes in Nagari Labuah Gunuang varied. Land units 1 and 4 were classified as unsuitable because they had a slope of more than 40%, while land units 2 and 3 were classified as marginally suitable with a slope of 15–25%. The main limiting factor on land units 2 and 3 is the risk of erosion. After improvement measures such as terrace construction and planting of ground cover crops, the potential suitability class of land units 2 and 3 can be upgraded to moderately suitable. The development of sugar palm cultivation in Nagari Labuah Gunuang can be carried out on land units 2 and 3.

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INTRODUCTION

Sugar palm (*Arenga pinnata* Merr.) is a significant perennial crop extensively cultivated in Indonesia and across Southeast Asia, where it serves multiple purposes. Its importance lies not only in the economic realm, as it generates income through various products, including palm sugar, fibers, fruits, and starch, but also in its contribution to rural livelihoods. The cultivation of sugar palm is integral to community-based agroforestry systems in Indonesia, which are recognized for their ecological benefits, including erosion control, carbon sequestration, and biodiversity preservation in upland ecosystems (Pramanik, 2016). However, the productivity of sugar palm plantations has been observed to lag behind its biological potential, primarily due to traditional cultivation practices and insufficient understanding of land suitability factors for optimal growth (Rajesh et al., 2023).

Land suitability assessment plays a pivotal role in agricultural planning. It examines the congruence between land characteristics and crop needs, thus guiding sustainable land management practices. The Food and Agriculture Organization (FAO) articulated a systematic framework for land evaluation, emphasizing the alignment of land qualities—such as climate, soil properties, and topography—with crop ecological requirements. In Indonesia, national guidelines have further refined this framework (Djaenudin et al., 2016). Djaenudin et al. (2003) categorized land suitability into actual and potential classes, where actual suitability denotes land's current capacity without enhancements, while potential suitability reflects its capability following appropriate interventions. These classifications are crucial for developing sustainable land-use systems, particularly in regions with complex environmental challenges (Aginthini et al., 2023).

Despite the widespread cultivation of sugar palm in Indonesia, there is a notable scarcity of scientific investigations examining its suitability for land use, particularly in hilly and mountainous regions. Research has predominantly focused on the socio-economic aspects of sugar palm cultivation or its post-harvest processing, while biophysical suitability assessments have received less attention. This deficiency presents a critical issue, as sugar palms often thrive in marginal lands that may not align with their ecological requirements for optimal growth. Consequently, many farmers depend on experiential knowledge rather than scientifically substantiated land management strategies (Neupane et al., 2018). As a result, agricultural development initiatives may fall short of achieving desired production outcomes, particularly when expansion occurs in areas prone to steep slopes, shallow soils, or erosion risks (Zolekar & Bhagat, 2015).

Nagari Labuah Gunuang in West Sumatra, Indonesia, exemplifies a typical upland area where sugar palm cultivation is prevalent. The region's landscape presents diverse topographical challenges, including steep slopes that can impede root development and exacerbate erosion risks (Neupane et al., 2018). Despite the cultural and economic significance of sugar palm in this community, systematic evaluations of the land's biophysical suitability for its cultivation remain limited. This lack of analysis hinders the identification of optimal cultivation practices and potential areas for expansion or improvement (Gumma et al., 2016).

Conducting a thorough land suitability evaluation in this region is paramount for several reasons. First, it can enhance sustainable land-use planning by pinpointing areas with the highest production potential and those that necessitate conservation measures (Rajesh et al., 2023; Patel et al., 2024). Second, it undergirds scientific validations for management practices such as terracing, mulching, and erosion control, which are crucial in fragile upland ecosystems (Raza et al., 2017). Third, it helps prevent land degradation, which is particularly critical in uplands where soil erosion and nutrient depletion are prevalent (Rusdi et al., 2015). Ultimately, aligning land suitability assessments with national agricultural development objectives fosters sustainability, effective community resource management, and the optimal cultivation of local crops (Parveen & Kumar, 2012).

The integration of geospatial technologies, especially Geographic Information Systems (GIS) and remote sensing, significantly bolsters the precision and efficiency of land evaluation processes. GIS-based mapping facilitates the integration of diverse land characteristics—such as elevation, slope, drainage, and soil properties—into spatial models that inform decision-making (Lemieux et al., 2023). This approach is particularly beneficial in hilly terrains, such as Nagari Labuah

Gunuang, where capturing topographic variability is essential for successful perennial crop cultivation (Widiatmaka, 2016). Despite the advantages offered by GIS applications in land suitability analysis, a literature gap exists regarding structured assessments specifically targeting sugar palm using such frameworks. Most existing research is descriptive and does not adhere to standardized methodologies set forth by the FAO or national guidelines (Li et al., 2017). Therefore, there is an urgent need for reliable, science-based evaluations that yield actionable insights for farmers and development initiatives.

Against this backdrop, the current study aims to evaluate the actual and potential land suitability for sugar palm (*Arenga pinnata* Merr.) in Nagari Labuah Gunuang, utilizing the FAO evaluation framework in conjunction with advanced GIS analysis. The study will focus on identifying key limiting factors, including slope, erosion risk, soil properties, and rooting depth, and recommending suitable land management strategies to enhance potential suitability. By bridging the existing knowledge gap with scientifically rigorous information, this research aims to promote sustainable sugar palm cultivation, bolster the livelihood of local communities, and inform agricultural planning in upland regions.

MATERIALS AND METHODS

This research was conducted in Labuah Gunung Village, Lareh Sago Halaban District, Lima Puluh Kota Regency. Subsequently, soil sample analysis was conducted at the Soil Laboratory, Faculty of Agriculture, Andalas University. The research materials consisted of soil samples, soil sampling equipment (including plastic and rubber bands), and chemical materials for laboratory analysis.

This research is in the form of a field survey. Soil sampling was carried out using a purposive sampling method, with sample points selected based on the overlay results and representing each land map unit. Soil sampling is conducted at three depths: 0-20 cm, 20-40 cm, and 40-60 cm. Assessment of land suitability for cultivating sugar palm in Labuah Village Mountain was conducted using a semi-detailed map method. Assessment is based on the Technical Guidelines for Commodity Land Evaluation in Agriculture (2011 revision), which categorizes suitability into levels such as order, class, subclass, and unit (Djaenudin *et al*., 2011).

1. Making Land Unit Maps and Determining Sample Points

The land unit map was created by merging (overlaying) three maps: a soil type map, a land use map, and a slope map, using ArcGIS 10.8 software at a scale of 1:50,000. From the results of the map merger, four land units were identified, from which six sample points were subsequently selected. Land units one and four each had one sample point, while land units two and three each had two sample points (Table 1).

Table 1. Amount taking point sample

No	Unit Land	Amount Point Sample	Wide (Ha)	Coordinate
1	Ept, V, Hp	1	474	100°43.158”E 0°17.250”S
2	Ept, I V, Pt	2	474	100°43.158”E 0°17.250”S
3	Ept, I V, Kc	2	414	100°43.465”E 0°16.507”S
4	Ept, V, Br	1	77	100°43.158”E 0°17.250”S
	Total	6	1,439	

Ept (Inceptisol); Slope Land: IV: 15-25%, V : > 40%; Hp (Forest), Pt (Dry Land Agriculture), KC (Garden) Mixed), Br (Brush).

2. Secondary Data Collection

Secondary data collection was conducted as an initial step to gather supporting information for the research. The secondary data search was conducted by identifying and accessing reliable sources through government agencies, research institutions, and official data portals. The secondary data obtained included supporting maps of Nagari Labuah Gunuang (maps, soil type maps, land use maps, and slope maps). In addition, elevation data at the research location and rainfall data for Lareh Sago Halaban District for the last 5 years, sourced from the Badan Meteorologi, Klimatologi, dan Geofisika (BMKG) in Sicincin, West Sumatra. Air temperature in each land unit was obtained by using the *Braak formula*:

$$t = 26{,}3°C - \frac{(0{,}61°C \times h)}{100}$$

Information:

t : temperature air

26.3 : temperature average annual

0.61. : temperature gradient every 100 increase m

h : altitude

3. Pre-Survey

Pre-survey activities help check land units, identify the location of sample collection coordinate points, monitor the physical aspects of the research location, and check land units such as land slope, soil type, with a base map resulting from interpretation at the research location (land unit map at a scale of 1 50,000).

4. Main survey

Soil sampling and field observations were based on a sample point map, which was then operated using a map navigation, direction, and position application. Soil sampling was carried out in stages using a Belgian drill, in the form of disturbed samples at every 20 cm layer until reaching a depth of 60 cm at each predetermined point. Observations were also carried out around the sampling location by paying attention to several land condition parameters, such as drainage (oxygen availability), root environment (soil depth and coarse material content), erosion potential (slope and erosion level), potential for inundation (flooding), and land readiness level (%). The details of the observation parameters are as follows:

a. Drainage

Drainage observations were conducted by calculating the permeability or infiltration rate around the sample points. Drainage observations were conducted using 20–30 cm tall PVC pipes with a diameter of 10 cm, which were then inserted into the ground and then filled with water until a stable condition was achieved, thus determining the infiltration rate. This data is crucial for evaluating the soil's ability to drain water. Consistency in drainage observations is crucial to ensure that each plot of land is protected from water saturation (BBSDLP, 2011).

b. Coarse Material

The coarse material content was assessed by calculating the percentage of gravel, small stones, or rock fragments larger than 2 mm in size in the soil sample, as these can impact plant growth. The process began by weighing 100 grams of coarse material and then sifting it through a 2 mm sieve. The portion remaining on the sieve was reweighed, and the results were expressed as a percentage

c. Soil Depth

Soil depth is determined by rotating and gradually pushing a Belgian drill into the soil until it reaches a barrier layer, such as rock. Then, the depth of the drill bit is measured with a tape measure to determine the effective soil depth. Effective soil depth is defined as the depth at which plant roots can penetrate the soil without encountering resistance.

d. Slope

Slope determination is based on a slope class map, and the data are then grouped according to the applicable slope category and expressed as a percentage (%). Slope is one of the primary factors that determines erosion. Slopes are grouped according to their degree of incline, which will affect how quickly erosion occurs.

e. Erosion Hazard

The likelihood of erosion can be predicted based on rainfall data and actual ground conditions by observing signs of erosion, such as uniform erosion on the surface, the formation of small grooves, and the development of large gullies.

f. Flood Hazard

Flood-prone areas can be determined through direct field surveys by creating soil profiles and observing for rust spots on the soil. The flood hazard level is indicated by the symbol Fx,y, where x represents the depth of inundation and y represents the duration of the flood.

g. Surface Rock

Surface rock refers to the percentage of small to large rocks that are above the ground and not integrated with soil particles. Observations are made by observing rocks exposed on the surface or separated from soil aggregates in the area around the sampling point.

h. Rock Outcrop

A rock outcrop is a condition where rock sections are exposed on the ground surface due to erosion. Observations are made by counting the number of rocks that are partially embedded and partially visible on the site's surface. Each exposed rock should be documented through photographs and simple sketches to record its position, shape, and approximate size relative to its surroundings. This data can then be used to map the distribution and frequency of rock occurrences in the area, providing a quick overview of the surface geology.

5. Preparation for Soil Analysis in the Laboratory

Soil samples collected from all land units were air-dried for two weeks to reduce the water content. They were then sieved using a 2 mm sieve to separate coarse particles and obtain a fine fraction ready for analysis. The soil analysis method is presented in the table below, while the laboratory analysis is.

Table 2. Parameter characteristic physics and chemistry land

No	Parameter	Unit	Method Analysis
1	Characteristic physics land • Texture	Class	Pipette and sieve
2	Characteristic chemistry land		
	• pH	-	Electrometry
	• C- organic	%	Walkey and Black
	• Cation language	me/100 g land	Washing NH4OAC
	• KTK clay	me/100 g land	Formula= (KTK land/100% clay) x 100

Source: Djaenudin *et al.*, (2011)

6. Data Analysis

The results of the physical and chemical soil properties tested in the laboratory were compiled into a table and then compared against the growing conditions of sugar palm trees, resulting in a land suitability classification and identifying limiting factors in each land unit that require improvement, if necessary.

RESULTS AND DISCUSSION

A. Description of Nagari Gunuang Village

Labuah Gunuang Village is located at coordinates 00°19’40” - 00°16’15”S and 100°41’20” - 100°41’50”E. Situated between valleys and rivers, Labuah Gunuang Village has significant potential in the agricultural and water resources sectors. The availability of these natural resources supports sustainable agricultural activities and food security for the local community. Furthermore, the topography and geography of Labuah Gunuang Village also influence settlement patterns, land use, and infrastructure development. The geography of Labuah Gunuang Village is presented in Table 3.

Table 3. Geography of Labuah Gunuang Village

Description	Information
An area	1.666 ha
Height	480 masl
Temperature	24-26˚C
Limit Region	
• North	• Sitanang District
• South	• Tanah Datar Regency
• West	• Batu Payuang Village
• East	• Tanjung Gadang and Halaban Sub-districts

Source: BPS Limapuluh Kota (2023).

Labuah Gunuang Village has seven hamlets (jorong): Simpang Empat Balai Jaring, Simpang Empat, Kayu Tanam, Lareh Nan Panjang, Dusun Nan Enam, Talaweh, and Simpang Empat Kabindu. Each jorong has unique characteristics and contributes to the community's cultural diversity and economic activities. Geographically, this village is situated at an elevation of approximately 480 meters above sea level, with relatively cool air temperatures and rainfall within the optimal range for the growth of sugar palms. Additionally, some areas of the land are still forested and scrubland. Therefore, Labuah Gunuang Village is believed to have significant potential for extensive development and cultivation of sugar palm (BPS Lima Puluh Kota, 2023).

1. Land Units

The total land unit area at the study site was 1,439 ha, comprising four land units and six sample points (Table 4). Each land unit has distinct characteristics, both in terms of area and slope.

The geographic conditions throughout the land units are dominated by very steep and steep topography. This naturally occurs following the geographical conditions of Nagari Labuah Gunuang. Most of the study land units are located in hilly and mountainous areas, making them prone to landslides and potentially high erosion risks. Therefore, exceptional management is required to ensure optimal land use.

Table 4. Land Units in Labuah Gunuang Village

No	Land Unit	Class slope	Wide (Ha)	Wide (%)
1	Ept, V, Hk	Very steep	474	31
2	Ept, IV, Pt	Steep	474	31
3	Ept, IV, Kc	Steep	414	31
4	Ept, V, Br	Very Steep	77	7
	Amount		1,439	100

Ept (Inceptisol); Slope Land: IV: 15-25%, V : > 40%; Hk (Conservation Forest), Pt (Dry Land Agriculture), Kc (Plantation) Mixed), Br (Brush).

2. Land Use

Land use in the research location varies significantly, with most areas utilized for a combination of dryland agriculture and rice paddy farming. Land use is dominated by plantation crops, including rubber, oil palm, and cocoa. Additionally, some of the land is used for residential areas, while the rest remains in its natural state, consisting of shrubs and forests that have not been fully utilized. This variation demonstrates that the land's potential can still be further developed through more targeted and sustainable use. This is in line with the opinion of Natalia *et al*. (2024). Land utilization refers to the process of using land based on its physical, chemical, and environmental characteristics, which are tailored to its intended function, such as agriculture, residential areas, or forestry.

3. Land Type

Nagari Labuah Gunuang has only one soil order, namely Inceptisol, which is evenly distributed throughout the land unit. Inceptisol is classified as a young soil with characteristics of a clay and dust texture, a relatively thick solum of about 1-2 meters, and a blackish-brown color. It contains relatively high organic matter and can retain water well. Overall, the physical and chemical characteristics of this Inceptisol soil are very supportive of the growth of sugar palm plants, in line with the opinion of Puturuhu (2011), that Inceptisol soil is still able to support the growth of sugar palm even though it is classified as young soil and is located on a rather steep slope, as long as it is appropriately managed.

4. Rainfall

Rainfall plays a crucial role in maintaining water availability, which supports the growth of sugar palm trees. Over the past five years, total rainfall recorded reached 11,733 mm (Table 5).

Table 5. Total rainfall in Lareh Sago Halaban District

Year	Rainfall Amount (mm)
2020	1986
2021	1997
2022	1973
2023	2727
2024	3050
Total rainfall Rain	11,733
Flat flat rainfall Rain	2,347

Source: BMKG Sicincin (2024)

The results of rainfall data measurements obtained an average of 2,347 mm. The highest rainfall was recorded in 2024, at 3,050 mm, while the lowest rainfall was recorded in 2022, at 1,973 mm. This variation indicates that rainfall conditions are still within the range suitable for plant needs, as sugar palm plants can grow optimally with rainfall of 2000-3000 mm per year, provided the rain is distributed evenly. This indicates that the average rainfall at the study location is still within the optimal range, so it does not pose obstacles to growth, as its water needs can be met evenly throughout the year. Rainfall in all land units falls within the category of quite suitable (S2).

5. Temperature Air

Air temperature is an important indicator of sugar palm growth. The air temperature in each land unit in Nagari Labuah Gunuang ranges between 18 and 22°C (Table 6).

Table 6. Air temperature in Nagari Labuah Gunuang

No	Unit Land (SL)	Temperature air °C	Height (masl)	Class Compliance
1	Ept, V, Hk	18,87	1.219	S2
2	Ept, IV, Pt	20,44	962	S2
3	Ept, IV, Kc	21,66	762	S1
4	Ept, V, Br	22,33	651	S1

Ept (Inceptisol); Slope Land: IV: 15-25%, V : > 40%; Hk (Conservation Forest), Pt (Dry Land Agriculture), Kc (Plantation) Mixed), Br (Brush)

Labuah Gunuang Village experiences varying air temperatures, influenced by altitude, geographic location, and differences in the angle of sunlight. The topography of Labuah Gunuang Village is primarily characterized by hills and valleys, resulting in typically cooler temperatures. According to Effendi (2009), sugar palm trees require temperatures between 20°C and 25°C to flower and fruit properly. Although the air temperature in land unit 1 is less than ideal, sugar palm trees can still grow, although their growth is not as optimal as in warmer temperatures. Furthermore, water availability, soil fertility, and land management techniques must also be considered to maintain maximum sugar palm productivity.

B. Characteristic Physics And Soil Chemistry

Soil physical and chemical properties reflect the analysis results of parameters such as soil texture, soil water content, soil pH, organic carbon, cation exchange capacity, and base saturation. This data is used to provide a more comprehensive description of the soil characteristics at the research site.

Soil Texture

Soil texture is defined by the percentages of sand, silt, and clay. At the research location, soil texture is quite varied. Land unit 1 has a sandy clay loam texture class with relatively acceptable criteria, land unit 2 has a dusty clay suitability class with moderate criteria, land unit 3 has a dusty clay suitability class with moderate criteria, and land unit 4 has a dusty clay texture class with rather acceptable criteria. The higher proportion of dust is caused by inappropriate soil cultivation, which damages the soil structure and is influenced by wind and high rainfall. Sugar palm plants grow ideally in a balanced soil texture (sand, dust, clay). This balance is important for storing water, nutrients, and minerals that support the growth of plantation vegetation. According to Utomo *et al*. (2016), variations in speed, infiltration capacity, dispersion level, soil fertility, and erosion hazard will affect the proportion of the three soil constituent fractions.

Acidity Land (pH H_2O)

The soil acidity at the research site was predominantly acidic, with a pH range of 4.45–5.62 (Table 7). This acidity level is crucial for helping plant roots absorb essential nutrients optimally. The pH value of the soil in Nagari Labuah Gunuang has two characteristics: acidic and slightly acidic. Acidic soil is caused by high rainfall, which results in the continuous leaching of nutrients, leading to the accumulation of ions.

Hydrogen (H^+) and aluminum ions (Al^{3+}) increase in abundance. The pH value of H2O can still be increased to neutral levels by liming, including the addition of dolomite. This aligns with the opinion of Basuki et al. (2019) that dolomite functions to neutralize the acidity of Inceptisol soils and improve nutrient availability, thereby supporting optimal plant growth and yield.

Table 7. pH H_2O land in Nagari Labuah Gunuang

No	Unit land (SL)	pH H_2O	Criteria	Class suitability
1	Ept, V, H k	4.45	Sour	S3
2	Ept, IV, Pt	5.49	Sour	S2
3	Ept, IV, Kc	5.62	Rather sour	S2
4	Ept, V, Br	4.8	Sour	S2

Ept (Inceptisol); Slope Land: IV: 15-25%, V : > 40%; Hk (Conservation Forest), Pt (Dry Land Agriculture), Kc (Plantation) Mixed), Br (Brush)

C- Organic Land

The availability of organic carbon (Organic C) is one of the primary factors in determining soil fertility. The organic C content at the research location ranged from 0.92 to 3.53% (Table 8). The higher the organic C content, the lower the soil fertility. The more organic the soil, the better it is at providing the nutrients plants need to grow optimally.

Table 8. C-organic land in Nagari Labuah Gunuang

No	Unit land (SL)	C-organic (%)	Criteria	Class suitability
1	Ept, V, Hk	3.53	Tall	S1
2	Ept, IV, Pt	0.92	Very low	S2
3	Ept, IV, Kc	2.33	Currently	S1
4	Ept, V, Br	2.65	Currently	S1

Ept (Inceptisol); Slope Land: IV: 15-25%, V : > 40%; Hp (Conservation Forest), Pt (Dry Land Agriculture), Kc (Garden) Mixed), Br (Brush)

C-organic value in land unit 2 was caused by vegetation, which is less dense with steep slope conditions, so that it accelerates leaching in the top layer of soil rich in organic matter; therefore, it can reduce the soil's ability to store water and nutrients. In addition, the excessive use of chemical fertilizers that are not balanced with the provision of organic matter reduces the activity of microbes, such as bacteria, and others; this is a triggering factor for low C-organic content. Based on data from the West Java Provincial Plantation Service (2018), the classification of land suitability for sugar palm plants in land units 1, 3, and 4 is still in class S1 (very suitable) for planting sugar palm. In contrast, Land Unit 2 requires improvement efforts, including the addition of organic matter and the implementation of soil conservation techniques, to increase fertility and reduce erosion. Therefore, implementing systematic and planned improvement efforts is key to restoring soil function and preventing further degradation.

Capacity Swap Cation (CEC)

Soil with a high CEC (Central Tolerance Capacity) has the ability to retain more cations, thus providing sufficient nutrients for sugar palm plants, especially during early growth and production. However, the CEC criteria at the research site were dominated by low criteria (Table 9).

Table 9. KTK land and clay in Nagari Labuah Gunuang

No	Land unit (SL)	KTK Soil (me/100 g soil)	Criteria	KTKLiat (me/100g land)	Suitability Class
1	Ept, V, Hk	32.43	Tall	60.59	S1
2	Ept, IV, Pt	15.82	Low	40.32	S1
3	Ept, IV, Kc	14.00	Low	37.13	S1
4	Ept, V, Br	16.42	Low	27.70	S1

Ept (Inceptisol); Slope Land: IV: 15-25%, V : > 40%; Hk (Conservation Forest), Pt (Dry Land Agriculture), Kc (Plantation) Mixed), Br (Brush)

The Capacity Value Swap Cation (CEC) is low. This is caused by the low organic matter content, which prevents the soil from retaining nutrients effectively. In contrast, a higher Cation Exchange Capacity (CEC) value is associated with greater amounts of organic matter, and the soil texture tends to be finer. This is in line with Utomo *et al*. (2016); the finer the soil texture, the more colloids the soil will contain, resulting in a higher CEC. However, overall, the Cation Exchange Capacity (CEC) value is still within the tolerance limits that support optimal growth of sugar palm plants, as long as it is supplemented by sufficient soil depth, water availability, and good drainage.

Base Saturation

The base saturation value (BSV) in the land unit ranges from 44% to 48% and falls within the moderate criteria. For the cultivation of sugar palm plants (Table 10), this reflects the availability of optimal base nutrients with a slightly acidic pH. Acidic. This pH level facilitates nutrient absorption and supports root development, enabling healthy and productive palm trees to thrive.

Table 10. Base Saturation land in Nagari Labuah Gunuang

No	Unit land (SL)	KB (%)	Criteria	Class Compliance
1	Ept, V, Hk	44	Tall	S1
2	Ept, IV, Pt	47	Very low	S2
3	Ept, IV, Kc	48	Currently	S1
4	Ept, V, Br	44	Currently	S1

Ept (Inceptisol); Slope Land: IV: 15-25%, V : > 40%; Hk (Conservation Forest), Pt (Dry Land Agriculture), Kc (Plantation) Mixed), Br (Brush)

The land suitability classification for sugar palm plants in land units 1, 2, 3, and 4 is included in class S1 (very suitable) (West Java Provincial Plantation Service, 2018). Criteria: This base saturation indicates that the soil tends to have a low pH, as explained by Hardjowigeno (2015), who stated that base saturation is directly proportional to the soil's acidity level. Differences in base saturation values are also influenced by varying pH conditions and the base cations produced by organic matter.

C. Land Conditions

Land conditions in Nagari Labuah Gunuang generally exhibit relatively uniform characteristics across all observed land units, except for variations in slope levels. The survey was conducted directly at the research site, specifically around the soil sampling area, to obtain a clear picture of the land's potential and limitations. Information from each parameter serves as an important reference in evaluating land suitability, enabling more precise and targeted land use. The land condition parameters observed included coverage of drainage, coarse material content, soil depth, the presence of rocks on the surface, rock outcrops, slopes, and potential erosion and flood hazards (Table 11).

Table 11. Results of observations of land conditions in Nagari Labuah Gunuang

Land Conditions	Unit Land (SL)			
	SL 1	SL 2	SL 3	SL 4
Drainage	Good	Good	Good	Good
Material rough	< 15% A little	< 15% A little	< 15% A little	< 15% A little
Depth land	> 100	> 100	> 100	> 100
Rock on the surface	< 0.01	< 0.01	< 0.01	< 0.01
Outcrop rock	< 2	< 2	< 2	< 2
Slope	> 40%	15-25%	15-25%	> 40%
Danger erosion	Very heavy	Heavy	Heavy	Very heavy
Danger flood	F0	F0	F0	F0

Drainage

Drainage found in land units 1 to 4 is classified as good and smooth. This is evidenced by the absence of rainwater pooling on the soil surface, the homogeneous and bright soil color in the root zone, and the absence of ash spots. This is supported by a relatively medium soil texture, ranging from clay to sandy loam. These conditions prevent sugar palm plants from developing root rot disease and allow them to absorb nutrients optimally. Based on land criteria from the West Java Provincial Plantation Service (2018), the drainage in the study area is classified as S1

Coarse Material

The coarse material content in land units 1 to 4 is relatively low (<15%), meaning the soil is quite fine and contains little gravel or rock fragments. This is advantageous for the sugar palm, as its root system can grow freely without obstruction from coarse particles. Based on land criteria from the West Java Provincial Plantation Service (2018), the coarse material in all land units falls into the S1 (Very Suitable) category for sugar palm growth.

Depth Land

In land units 1 to 4, the soil depth exceeds 100 cm, making it ideal for sugar palm growth, as the roots can spread optimally. Based on land criteria from the West Java Provincial Plantation Service (2018), this research area falls into category S1 (Very Suitable). The thicker the soil, the more room the roots have to grow and absorb water and nutrients.

Outcrop & Surface Rock

The presence of rocks in land units 1 to 4 is minimal, as indicated by the minimal number of rocks scattered across the land surface. This indicates that all land units have conditions that are very supportive for plant growth, because the soil can be optimally managed without any obstacles from outcrops and surface rocks. Based on land criteria from the West Java Provincial Plantation Service (2018), outcrops and surface rocks in all land areas are included in S1 (Very Suitable).

Slope

Land units 1 and 4 have slopes > 40%, which are at high risk of erosion and nutrient leaching, so they are classified as class N (not suitable) for sugar palm plants without further processing. Meanwhile, land units 2 and 3 with slopes of 15-25% allow for sugar palm cultivation by applying soil conservation techniques such as terracing and planting ground cover plants. Based on land criteria from the West Java Provincial Plantation Service (2018), the slopes of land units 1 and 4 are included in category N (Not suitable) while land units 2 and 3 are included in category S2 (Quite suitable).

Danger of Erosion

Land units 1 and 4 are categorized as having a very high erosion risk, with slopes exceeding 40%, making them highly susceptible to erosion. Conversely, land units 2 and 3 are at high risk of erosion, with slopes ranging from 15% to 25%. These land conditions present a significant challenge in arable cultivation, as erosion can remove the top layer of soil. In the soil, reduce the content of organic matter and essential nutrients that plants need. Therefore, there is a need to implement soil conservation practices. Based on land criteria from the West Java Provincial Plantation Service (2018), the erosion hazard of land units 1 and 4 is categorized as N (Not suitable), while land units 2 and 3 are categorized as S2

Flood Danger

All land units at the research site are classified as F0, indicating no risk of flooding. This condition is ideal for cultivating sugar palm trees. Having land without standing water is highly beneficial because it supports the optimal development of the sugar palm's root system. Preventing excessive waterlogging also aims to ensure that soil nutrients are not readily leached, thus maintaining their availability for the sugar palm. According to the West Java Provincial Plantation Service (2018), the flood risk for all land units falls into the S1.

D. Land Evaluation

Land suitability evaluation aims to objectively assess the potential of each land unit and identify its limiting factors. The results of this land suitability evaluation serve as a reference for determining the grouping of crops to be planted, classifying them into subclasses, and then determining the most dominant limiting constraints. This method allows for more precise land management and optimal agricultural yields.

The land conditions in Nagari Labuah Gunuang have advantages, including adequate water availability, good drainage systems, and suitable soil depth. However, several constraints also exist, including the slope of the land, which can potentially cause erosion, and variations in soil pH values that require appropriate management for optimal sugar palm growth (Table 12).

Table 12. Land Characteristics and Quality in Nagari Labuah Gunuang

Land Quality/Characteristics Land	Class Unit Land			
	SL 1	SL 2	SL 3	SL 4
Temperature (tc)				
Temperature average (°C)	18.87	20.44	21.66	22.33
Availability of water (wa)				
Rainfall Rain (mm)	2,347	2,347	2,347	2,347
Availability of oxygen (OA)				
Drainage	Good	Good	Good	Good
Media roots (re)				
Texture	Rather Fine	Currently	Currently	Rather Fine
Material rough (%)	< 15	< 15	< 15	< 15
Depth land (cm)	> 100	> 100	> 100	> 100
Retention Hara (nr)				
KTK clay (cmol)	60.59	40.32	37.13	27.70
Saturation language (%)	44	47	48	44
pH H2O	4.45	5.49	5.62	4.8
C-organic (%)	3.53	0.92	2.33	2.65
Danger erosion (eh)				
Slope (%)	> 40	15-25	15-25	> 40
Danger erosion	Very heavy	Heavy	Heavy	Very Heavy
Danger flood (fh)				
Puddle	F0	F0	F0	F0
Preparation land (lp)				
Rock in surface (%)	< 0.01	< 0.01	< 0.01	< 0.01

Evaluation Compliance Land Current

Nagari Labuah Gunuang has four distinct land types, each with its own classification. Through field observations and laboratory analysis, comprehensive information was obtained regarding the actual suitability of each land unit for sugar palm plants. As for further explanation, carry on about each unit of land served in the following description, starting from land units 1 to 4.

a. Unit Land 1

Analysis were conducted using the *matching method.* The evaluation results showed that the actual land suitability class was N (not suitable), with subclass N_{eh}, with the main limiting factor being high erosion potential.

b. Unit Land 2

The actual land suitability for sugar palm plants in land unit 2 is classified as S3 (marginally suitable), with subclass S3eh, the limiting factor being erosion hazard

c. Unit Land 3

Land unit 3 has class suitability land S3 with a sub-class of S3, which includes marginal land due to a relatively high level of erosion.

d. Unit Land 4

The actual material suitability in land unit 4 has a land suitability classification of N (Not Suitable) with subclass N_{eh} which is classified as not suitable for the erosion hazard limiting factor. The actual land suitability results of Nagari Labuah Gunuang are presented in Table 13.

Table 13. Suitability land for the current in Nagari Labuah Gunuang

Quality Land/ Land Characteristics	Class Unit Land			
	SL 1	Sl2	SL 3	SL 4
Temperature (tc)				
Temperature average (°C)	S2	S2	S2	S2
Availability water (wa) Rainfall Rain (mm)	S2	S2	S2	S2
Availability oxygen (OA) Drainage	S1	S1	S1	S1
Media roots (re)				
Texture	S1	S1	S1	S1
Material rough (%)	S1	S1	S1	S1
Depth land (cm)	S1	S1	S1	S1
Retention Hara (nr) KTK clay (cmol)	S1	S1	S1	S1
Saturation language (%)	S1	S1	S1	S1
pH H2O	**S3**	S2	S2	S2
C-organic (%)	S1	S2	S1	S1
Danger erosion (eh) Slope (%)	**N**	**S3**	**S3**	**N**
Danger erosion	**N**	**S3**	**S3**	**N**
Danger flood (fh)				
Puddle	S1	S1	S1	S1
Preparation land (lp) Rock in surface (%)	S1	S1	S1	S1
Outcrop rock (%)	S1	S1	S1	S1
Class Compliance Land	**N**	**S3**	**S3**	**N**
Sub-Class Land Suitability	$\mathbf{N_{eh}}$	$\mathbf{S3_{eh}}$	$\mathbf{S3_{eh}}$	$\mathbf{N_{eh}}$

Information: S1 (In accordance), S2 (Enough In accordance), S3 (In accordance Marginal), N (No In accordance), eh (factor barrier erosion hazard)

Evaluation Compliance Potential Land

Evaluation of land suitability in Nagari Labuah Gunung reveals an improvement in quality after addressing limiting factors, with further enhancements still possible. Evaluation of previously produced marks for suitability of potential land. The potential land suitability class for land units 2 and 3 can be upgraded one level by improving constraints that are still possible to minimize. Land units 1 and 4, because they have a land suitability class of N, cannot be upgraded or improved. Limiting factors at the research site in Nagari Labuah Gunuang include temperature, water availability, and erosion hazard.

The inhibiting factor that can be improved (*modifiable*) is pH. H_2O and the danger of erosion. The inhibiting factors that cannot be improved are temperature and water availability, as these are natural phenomena beyond our control. The following are management and improvement efforts that can be made to these factors.

a. Land Unit 1

Land unit 1 is categorized as unsuitable due to the steep slope and high erosion risk. This is a major obstacle to land utilization because it does not meet the requirements for growing sugar palm trees on a flat or gentle slope, namely <8, with an erosion hazard classified as very high or low. This is because Unit Land 1 covers a region with very high slopes (>40%), and the risk of erosion is classified as very severe. Thus, the cultivation of sugar palm plants is not recommended in land unit 1 and cannot be increased or is declared unsuitable (N) with subclass N_{eh}.

b. Unit Land 2

On unit land, 2 indicates the suitability subclass S3 TC, WA, EH, which means Marginally Suitable. The main constraints that limit it are average temperature ($_{Tc}$), rainfall ($_{Wa}$), and erosion risk ($_{Eh}$). The land unit has the characteristics of a rather steep slope, with a slope ranging from 15% to 25%. The limiting factors of temperature and water availability cannot be overcome because they are natural characteristics of the environment. However, the limiting factors of slope and erosion risk can be improved by planting legume cover crops and implementing terracing. With these improvements, land unit 2 can be upgraded to the S2 class category (quite suitable).

c. Unit Land 3

In land unit 3, the land suitability class is S3 with subclass S3 $_{tc, wa, eh}$ is marginally suitable with factors inhibiting land suitability consisting of air temperature (average temperature), water availability (rainfall intensity), and erosion risk (related to slope conditions and erosion potential) with percentage the slope 15 -25 %, this slope is included in the rather steep category. Factors such as barrier temperature and water availability cannot be improved as previously explained. Meanwhile, limiting factors such as slope and potential erosion hazards can be remediated by applying legume cover crops and constructing terraces. With these remedial measures, Land Unit 3 has the potential to be upgraded to class S2.

d. Unit Land 4

Table 14. Suitability of land potential in Nagari Labuah Gunuang

Quality Land/ Land Characteristics	Class Unit Land			
	SL 1	SL 2	SL 3	SL 4
Temperature (tc)				
Temperature average (°C)	S2	S2	S2	S2
Availability of water (AW) Rainfall Rain (mm)	S2	S2	S2	S2
Availability of oxygen (OA) Drainage	S1	S1	S1	S1
Media roots (re)				
Texture	S1	S1	S1	S1
Material rough (%)	S1	S1	S1	S1
Depth land (cm)	S1	S1	S1	S1
Retention Hara (nr) KTK clay (cmol)	S1	S1	S1	S1
Saturation language (%)	S1	S1	S1	S1
pH H2O	**S2**	S1	S1	S1
C-organic (%)	S1	S1	S1	S1
Danger erosion (eh) Slope (%)	**N**	**S2**	**S2**	**N**
Danger erosion	**N**	**S2**	**S2**	**N**
Danger flood (fh) Puddle	S1	S1	S1	S1
Preparation land (lp) Rock in surface (%)	S1	S1	S1	S1
Outcrop rock (%)	S1	S1	S1	S1
Class Compliance Land	**N**	**S2**	**S2**	**N**
Sub Class Land Suitability	**N_{eh}**	**$S2_{tc,wa,eh}$**	**$S2_{tc,wa,eh}$**	**N_{eh}**

Description: S1 (Appropriate), S2 (Quite Appropriate), S3 (Marginally Appropriate), N (Not Appropriate), tc (factor barrier temperature), wa (factor barrier availability water), eh (factor erosion hazard barrier).

Potential land suitability in Unit 4 has a class that does not align with the factor of barrier danger, erosion, and steep slopes. This erosion potential is influenced by the high slope, exceeding 40%. This prevents land unit 4 from being improved, and further cultivation of sugar palm plantations is not recommended. This opinion aligns with the Ministry of Education and Culture (2019), which states that developing areas with slopes above 40% is environmentally irresponsible and can lead to a high potential for landslides.

The potential land suitability classes in land units 2 and 3 in Nagari Labuah Gunuang were deemed quite suitable for sugar palm cultivation due to their steep slopes and low to moderate erosion risk (Table 14). Land units 1 and 4 were deemed unsuitable for sugar palm cultivation.

CONCLUSIONS

1. Labuah Gunuang Village has varying land suitability classes for sugar palm. Land units 1 and 4 have a suitability class of unsuitable (N), and land units 2 and 3 have a suitability class of marginal (S3).
2. The actual land suitability class for land units 1 and 4 is classified as unsuitable (N) for sugar palm cultivation due to a slope exceeding 40%. The actual land suitability class for land units 2 and 3 is in the S3 (Marginally Suitable) category, with slopes ranging from 15% to 25%. After implementing improvement efforts, the potential land suitability class for both land units was successfully increased to S2 (reasonably suitable). Additionally, temperature and rainfall are limiting factors in these land units.
3. Improving the land suitability class for sugar palm cultivation in Labuah Gunuang village can be selectively increased on land that has a less supportive land suitability class, by considering the necessary land improvement efforts.

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