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Optimizing Idle Land for the Development of Oil Palm Commodity Plantations in North Buton Regency, Southeast Sulawesi Province, Indonesia

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The purpose of this study is to optimize idle land in North Buton Regency for oil palm plantation development. The study used a land suitability evaluation, which compared land characteristics derived from field observations and laboratory testing to the requirements established in Minister of Agriculture Regulation Number 131/Permentan/OT.140/12/2013. These findings were subsequently included into the North Buton Regency Spatial Plans and validated via public discussions. The study found 1,569.7 hectares of idle land in the Kulisusu, West Kulisusu, and Bonegunu sub-districts, with an emphasis on preserving ecosystems during land optimization. The land suitability evaluation found that 88.29% (1,385.9 ha) of the area is classified as S2, 3.70% (58.06 ha) as S3, and 8.01% (125.74 ha) as inappropriate (class N). The potential land evaluation findings reveal an increase of 91.99% (1,443.96 ha) for class S2 and 8.01% (125.74 ha) for class S3. Despite a minor difference in alignment with spatial plans, with only 1,367.69 ha (87.13%) matching, the community has voiced great support for using idle land for oil palm agriculture. The analysis indicates that the identified vacant land is ideal for oil palm plantation development, with great economic potential in the region.

Keywords: Idle land, land suitability evaluation, oil palm, optimizing land, North Buton.

INTRODUCTION

Oil palm is one of the top agricultural commodities (Yuslaini *et al.*, 2023; Purba *et al.*, 2024; Ibrahim *et al.*, 2024). This plant is native to West Africa (Rival *et al.*, 2014) and has recently witnessed rapid development in tropical regions (Sulaiman *et al.*, 2023; Lai *et al.*, 2024), owing to rising demand (Ritchie and Roser, 2021) as a raw resource for food and fuel (Jatmiko *et al.*, 2023; Mukherjee and Sovacool, 2024). Indonesia has a tropical climate, which has made palm oil a superior commodity since 2008 (Syahza and Asmit, 2020; Hidayat *et al.*, 2023), and it has become the world's largest producer and exporter of palm oil as a biofuel to replace fossil fuels (Hennings *et al.*, 2022), accounting for 48% of total global palm oil production (Jayed *et al.*, 2011; Hasan *et al.*, 2012; Murphy, 2014; Rahmat *et al.*, 2024). In 2008, total palm oil production was over 18 million metric tons with a plantation area of 9.10 million ha. By 2023, production is expected to reach 46.98 million metric tons with a plantation area of 15.43 million ha, representing a 161% increase in total production and a 69.56% increase in plantation area (BPS, 2024; Amri *et al.*, 2023).

The government established Law No. 7 of 2007 regulating energy to lessen reliance on petroleum (Dillon *et al.*, 2008), which is becoming increasingly limited (Hersaputri *et al.*, 2023; Putri *et al.*, 2023). The adoption of this regulation stimulates the development of palm oil-based biofuels, which account for 20% of national energy consumption (Pleanjai and Gheewala, 2009). Aside from sustaining energy supply, this industry is a driver of the national economy (Masitah *et al.*, 2023; Hariyanti and Syahza, 2024; Mulyani *et al.*, 2024). Oil palm has become a very important crop economically (Mukherjee and Sovacool, 2024; Purnomo *et al.*, 2024). Oil palm farms make a significant contribution to Indonesia's regional economy, particularly in terms of job creation (Sarzynski *et al.*, 2020; Yuslaini *et al.*, 2023). This is demonstrated by increased farmer income (Sambodo, 2009; Fahmi *et al.*, 2023), increased purchasing power (Barbier, 2020), and decreased poverty (Liu *et al.*, 2021; Asnawi *et al.*, 2023). This demonstrates that this area is a worthwhile investment today and in the future (Rauf *et al.*, 2024). One of

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strategy for increasing palm oil production is extensification. Extensification is a practice that aims to increase harvest area by opening up previously unmanaged or idle land (Hennings *et al*., 2022; Suwandi *et al*., 2024). North Buton Regency has a considerable amount of idle land that could be used to create new oil palm plantations. However, to achieve optimal results while maintaining environmental preservation, extensification efforts must assess land suitability by the requirements for growing oil palm plants. One approach is to optimize idle land for the development of oil palm plantation commodities.

MATERIALS AND METHODS

Study Site: Administratively, the study site is in North Buton Regency, Southeast Sulawesi Province. Astronomically, it is situated around 04°15'00" - 05°15'00" south latitude and 122°45'00" - 123°30'00" east longitude (Figure 1). This investigation is conducted at an altitude of 0-1,061 meters above sea level (BPS, 2024). The study was conducted from October to December 2023.

TOOLS AND MATERIALS

The tools used for this study are:

Soil Drill: Used to collect soil samples at various depths.

Abney Level: Used to measure slopes in the landscape correctly.

GPS is used to capture the coordinates of the geographic location of sampling correctly.

Plastic Sample Bags: To store and send soil samples, Roll Meter: Used to measure distances in the field, Stationery is used to take field notes and collect data, Soil Type Maps: Provided baseline information on the distribution of various soil types in the study region.

DEM (Digital Elevation Model) Data: Used to assess terrain and create slope maps, Landform Maps: Aided in identifying various geomorphological units in the research region, Land Cover Maps: Used to determine present vegetation and land use, which is required for the creation of the Land Unit Map.

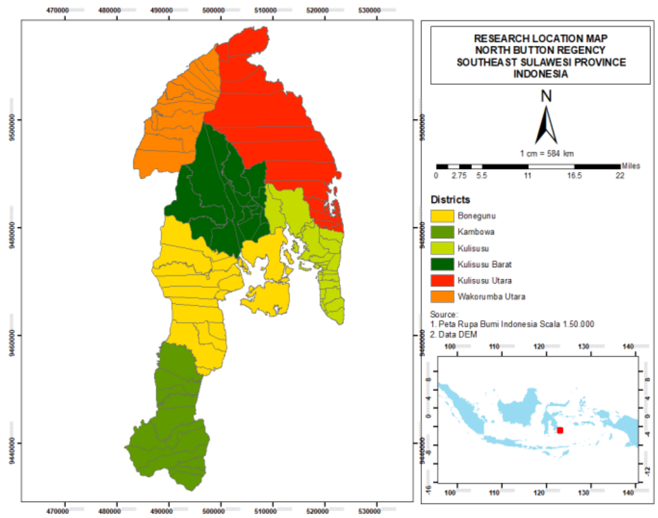

Figure 1. Research location map.

Sampling: The sample framework consisted of overlaying slope maps, landform maps, soil type maps, and land cover maps to designate discrete land units. This technique yielded the identification of 25 distinct geographical units (Figure 2). Soil samples were taken from each land unit, with 3-5 samples per unit depending on its size and variability. Samples were collected from the top 0-30 cm of soil depth, which is crucial for determining soil properties relevant to oil palm growth. The samples were subsequently examined at the Soil Science Testing Laboratory, Faculty of Agriculture, Halu Oleo University.

Data Analysis: The study used the matching method to compare land characteristics obtained through observations and laboratory tests to the criteria outlined in Minister of Agriculture Regulation Number 131/Permentan/OT.140/

Table 1. Guidelines for the cultivation of oil palm.

Sr.	Land characteristic	Land Suitability			
		S1 (very suitable)	S2 (suitable)	S3 (quite suitable)	N (not suitable)
1	Rainfall (mm)	1750-3000	1750-1500	1500-1250	<1250
2	Dry month (month)	1	1-2	2-3	>3
3	Height above sea level	0-200	200-300	300-400	>400
4	Slope (S) (%)	<8	8-15	15-30	>30
5	Rocks on the surface & in the ground	<3	3-15	15-40	>40
6	Effective depth (cm)	>100	100-75	75-50	<50
7	Drainage Class	Good, moderate	a bit hampered; rather fast	Hampered; Fast	Very fast; very hampered; flooded
8	Soil Texture	Clay, dusty, sandy clay loam; dusty clay loam; clayey clay	Clay; sandy clay; sandy loam; clay	Clayey sand; dust	Heavy clay, sand
9	Soil pH	5,0-6,0	4,0-5,0 and 6,0-6,5	3,5-4,0 and 6,5-7,0	<3,5 and >7,0

12/2013 concerning Guidelines for the Cultivation of Oil Palm (Table 1). Land appropriateness was determined by assessing key parameters such as soil texture, drainage, pH, and slope. The study findings were combined with a forest area map and the North Buton Regency Spatial Planning Map using GIS software to create a final map demonstrating the land's viability for oil palm development. Furthermore, the study evaluated the community's willingness to participate in oil palm farming through surveys and public consultations, ensuring that social concerns were accounted for in the final recommendations.

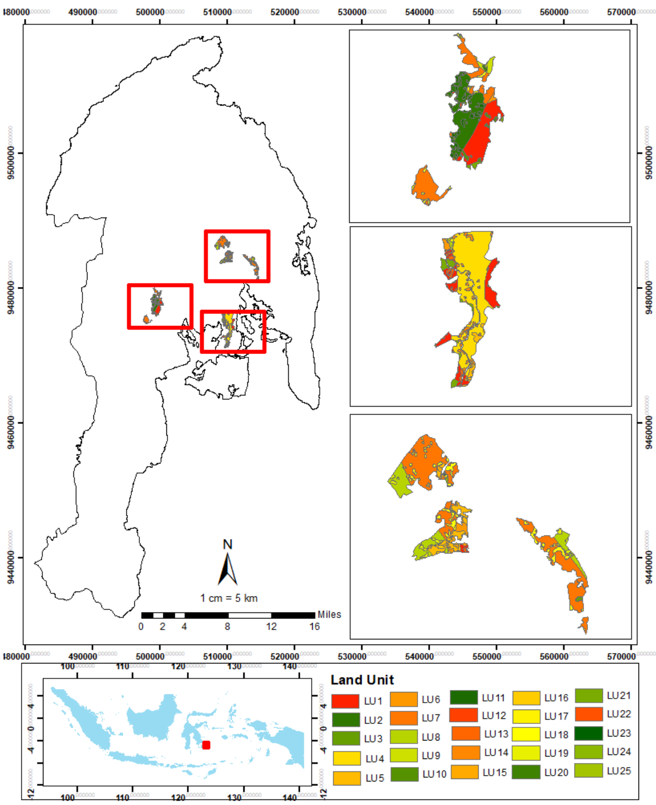

Figure 2. Land unit analysis.

RESULTS

***Idle Land Distribution*:** Idle land is defined as land that has been unproductive or underutilized for 5-20 years. The analysis revealed that idle land in North Buton Regency was distributed throughout three districts: Kulisusu, West Kulisusu, and Bonegunu, totaling 1569.7 ha. Langere Village, Bonegunu District, accounts for 501.39 ha (31.94%) of the total area of idle land, Soloy Agung Village, West Kulisusu District, has 389.11 ha (34.79%), and Rahmat Baru Village, West Kulisusu District, has the smallest area (Table 2 and Figure 3). A vast expanse of idle land has the potential to develop into oil palm plantations. Farmers in Kulisusu District, in particular, had established oil palm cultivation enterprises, although only during the seeding and clearing stages of planting.

Table 2. Distribution of idle land in North Buton.

Sr.	Districts	Area		
		Village	Ha	%
1	Kulisusu	Triwacuwacu	270,73	17,25
		Waculaea	298,62	19,02
2	Kulisusu Barat	Soloy Agung	389,11	24,79
		Rahmat Baru	5,21	0,33
		Lapandewa	30,59	1,95
3	Bonegunu	Langere	501,39	31,94
		Ronta	74,07	4,72
Total			1.569,7	100,00

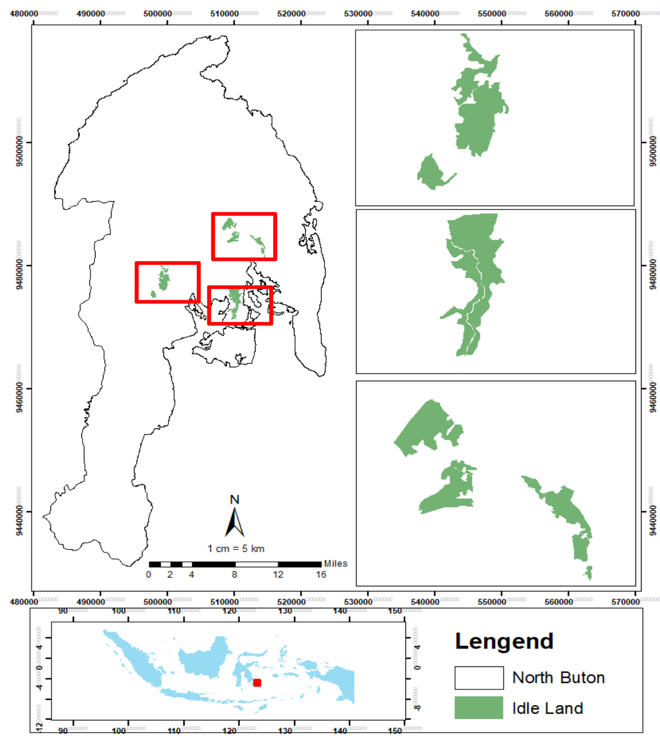

Figure 3. Distribution of idle land in North Buton.

***Land Use on Idle Land*:** This region's idle land uses include shrubs, secondary dry land forest, mixed dryland agriculture, and open land (Table 3). In North Buton Regency, mixed dry land agriculture covering an area of 694.66 ha or 44.25% of the idle land area, followed by secondary dry land forest ethnicities (411.79 ha, 26.23%), shrubs (368.93 ha, 23.50%), dry land farming (87.02 ha, 5.54%), and open land (7.3 ha, 7.3%). The community has abandoned mixed dry land agriculture for 5-7 years, secondary dry land forest for 10 years, shrubs for 20 years, dry land agriculture for 10 years,

Table 3. Land use on idle land in North Buton Regency.

Sr.	Land Use	Land Unit (LU)	Area	
			Ha	%
1	Shrubs	LU-4, LU-13, LU-14	368,93	23,50
2	Secondary dry land forest ethnicities	LU-1, LU-2, LU-10, LU-11, LU-21	411,79	26,23
3	Dry land farming	LU-5, LU-15, LU-16, LU-22, LU-23	87,02	5,54
4	Mixed dry land agriculture covering	LU-6, LU-7, LU-8, LU-9, LU-17, LU-18, LU-19, LU-20, LU-24, LU-25	694,66	44,25
5	Open land	LU-3, LU-12	7,3	0,47
Total			1.569,7	100,00

and open land for five. If this area is optimized, palm oil productivity will rise in the future.

Land Suitability**:** Land suitability is essential for cultivating oil palm plants. The land suitability factors are rainfall (Rf), dry month (Dm), height above sea level (SL), slope (S), rocks on the surface and in the ground (RS), effective depth (ED), drainage class (DC), soil texture (ST), and soil pH (pH). Rainfall is vital for plant growth. Rainfall data for this site were acquired from Lasalimu station. The annual rainfall is 2038 mm/year, with two dry months. This demonstrates that rainfall is included in class S1, whereas dry months are included in S2. This area is classified as S1 with a height above sea level ranging from 18 to 78 meters (<200). The slope at this location is generally (84.86%) flat (0-8%) located on land units LU-1, LU-2, LU-3, LU-4, LU-5, LU-6, LU-7, LU -8 and LU-9 or referred to in classes S1, 8-15 and class S2 (8-15%) are located on land units LU-10, LU-11, LU-12, LU-13, LU-14, LU -15, LU-16, LU-17, LU-18, LU-19 and LU-20, as well as S3 class (15-25%) located at LU-21, LU-22, LU-23, LU-24, and LU-25. Rocks on the surface and in the ground less than 3, effective depth greater than 120, and Good Drainage Class indicate that this location is classified as S1 (Table 4). The soil texture in this region is dominated by sandy loam (59.06%), clay (24.94%), clay loam (9.16%), and silty loam (6.85%). Sandy loam is found in land units LU-4, LU-6, LU-7, LU-18, LU-19, LU-20, LU-21, LU-23, LU-24, and LU-25, whereas clay is found in land units LU-1, LU-3, LU-8, LU-9, LU-10, LU-11, LU-12, LU-13, LU-16, and LU-

Table 4. Results of field and laboratory observations based on land units.

No	LU	Rf	Dm	SL	S	RS	ED	DC	ST	pH
1	LU-1	2.038	2	21	0-8	<3	>120	Good	Clay	5.0-6.0
2	LU-2	2.038	2	46	0-8	<3	>120	Good	Clay loam	5.0-6.0
3	LU-3	2.038	2	37	0-8	<3	>120	Good	Clay	5.0-6.0
4	LU-4	2.038	2	26	0-8	<3	>120	Good	Sandy loam	6.1-6.5
5	LU-5	2.038	2	40	0-8	<3	>120	Good	Dusty loam	5.0-6.0
6	LU-6	2.038	2	42	0-8	<3	>120	Good	Sandy loam	6.6-7.0
7	LU-7	2.038	2	21	0-8	<3	>120	Good	Sandy loam	5.0-6.0
8	LU-8	2.038	2	76	0-8	<3	>120	Good	Clay	5.0-6.0
9	LU-9	2.038	2	12	0-8	<3	>120	Good	Clay	6.1-6.5
10	LU-10	2.038	2	18	8-15	<3	>120	Good	Clay	
11	LU-11	2.038	2	43	8-15	<3	>120	Good	Clay	6.1-6.5
12	LU-12	2.038	2	32	8-15	<3	>120	Good	Clay	5.0-6.0
13	LU-13	2.038	2	23	8-15	<3	>120	Good	Clay	5.0-6.0
14	LU-14	2.038	2	27	8-15	<3	>120	Good	Dusty loam	>7
15	LU-15	2.038	2	58	8-15	<3	>120	Good	Dusty loam	5.0-6.0
16	LU-16	2.038	2	57	8-15	<3	>120	Good	Clay	6.1-6.5
17	LU-17	2.038	2	18	8-15	<3	>120	Good	Clay loam	6.6-7.0
18	LU-18	2.038	2	46	8-15	<3	>120	Good	Sandy loam	>7
19	LU-19	2.038	2	48	8-15	<3	>120	Good	Sandy loam	>7
20	LU-20	2.038	2	26	8-15	<3	>120	Good	Sandy loam	>7
21	LU-21	2.038	2	29	15-25	<3	>120	Good	Sandy loam	6.1-6.5
22	LU-22	2.038	2	29	15-25	<3	>120	Good	Clay	6.1-6.5
23	LU-23	2.038	2	42	15-25	<3	>120	Good	Sandy loam	>7
24	LU-24	2.038	2	34	15-25	<3	>120	Good	Sandy loam	>7
25	LU-25	2.038	2	78	15-25	<3	>120	Good	Sandy loam	>7

22. This indicates that this land unit is designated as S2 class. Class S1 land units include land units LU-2 and LU-17 with clay loam soil texture, as well as land units LU-5, LU-14, and LU-15 with dusty loam soil texture.

Based on soil pH, this region has an acid pH (5.0-6.0) of 64.22%, which is dispersed throughout land units LU-7, LU-2, LU-8, LU-1, LU-10, LU-15, LU-13, LU-3, LU-5, and LU-12 and is classed as S1. Class S2 comprises land units LU-4, LU-16, LU-11, LU-9, LU-21, and LU-22. S3 classes are located at LU-6 and LU-17. Class N is located at LU-24, LU-18, LU-25, LU-19, LU-14, LU-23, and LU-20 (Table 4). This data is then overlayed with spatial analysis to identify actual and potential suitability.

DISCUSSION

***Actual Land Suitability*:** The results of the evaluation of actual land suitability for oil palm production by optimizing idle land in North Buton Regency are based on Minister of Agriculture Regulation Number 131/Permentan/OT.140/12/2013 of 2013. Table 5 shows three suitability classes: S2 (1385.9 ha, 88.29%), S3 (58.06 ha, 3.70%), and N (125.74 ha, 8.01%). This demonstrates that this area is dominated by S2 class suitability, with just a small percentage of the unsuitable land utilized for oil palm agriculture. As a result, only 1443.96 ha of the 1569.7 idle land can be developed, accounting for 91.99%. The actual land suitability class S2 is limited by dry month circumstances, soil texture, slope, and pH (Figure 4). The actual land suitability class S3 is limited by Soil acidity and slope grade. Soil acidity is the limiting factor in the real land suitability class N. Based on these limiting constraints, management intervention is required to raise the land suitability class to a potential land suitability class. Increasing the land suitability class is conceivable if the limiting variables, or hurdles, may be increased to meet the required land use needs (Rahmawaty *et al*., 2023).

The limiting factors for dry months and soil texture are difficult to manage; hence they are classified as limiting factors requiring extensive management. Slope and soil pH are limiting considerations even with moderate management. The input for managing factors limiting slope is the construction of terraces, and for factors limiting soil pH is the use of organic materials. The slope has a direct effect on soil depth and a significant impact on nutrient runoff (Gyabah *et al*., 2023; Keson *et al*., 2023) stating that slope and characteristics are essential factors in plant cultivation. This is influenced by the slope factor, which impacts plant productivity. As a result, it is critical to manage land use effectively by land conditions in plant cultivation. This statement is also consistent with (Moisa *et al*., 2022) research, which found that to increase agricultural production, land suitability is a prerequisite for carrying out sustainable agriculture. By matching suitable land, remedial actions can be taken if there is land that does not meet the conditions for plant growth. Figure 5.3 shows the complete findings of the study of actual land suitability for oil palm growth in North Buton Regency.

***Potential Land Suitability*:** The evaluation of potential land suitability for oil palm plantations in North Buton Regency focuses on slope and soil fertility management. Slope factors can be increased by creating terraces tailored to the demands of oil palm trees, while factors limiting soil fertility can be enhanced by organic material fertilizing. This is done to upgrade the quality of actual land to potential land by raising the class one level. The potential land suitability for oil palm plantation expansion yielded a class increase from S3 to S2 of 1443.96 ha (91.99%) and a class increase from N to S3 of 125.74 ha (8.01%) (Table 6 and Figure 5). Increasing the potential land adaptability class is accomplished through processing inputs such as creating terraces on land with a

Table 5. Actual land suitability in North Buton Regency.

Sr.	Suitability	LU	Limiting Factor	Area	
				Ha	%
1	S2	LU-5	Dry month (Dm)	68,62	4,37
		LU-1, LU-2, LU-3, LU-7, LU-8, LU-9	Dry month (Dm) and soil texture (ST)	913,33	58,19
		LU-15	Dry month (DM) and slope (S)	11,78	0,75
		LU-10, LU-12, LU-13	Dry month (Dm), soil texture (ST) and slope (S)	26,23	1,67
		LU-4	Dry month (Dm) soil texture (ST) and pH Soil (pH)	326,35	20,79
		LU-11, LU-16	Dry month (Dm), soil texture (ST), slope (S) and pH Soil (pH)	39,59	2,52
2	S3	LU-6, LU-17	pH Soil (pH)	26,12	1,66
		LU-21, LU-22	pH Soil and Slope (S)	31,94	2,03
3	N	LU-14, LU-18, LU-19, LU-20, LU-23, LU-24, LU-25	pH Soil (pH)	125,74	8,01
Total				1.569,7	100,00

slope of more than 15% and employing organic materials on land with a pH greater than 7.0. The limiting criteria for S2 in general are dry months and soil texture, both of which are difficult to regulate.

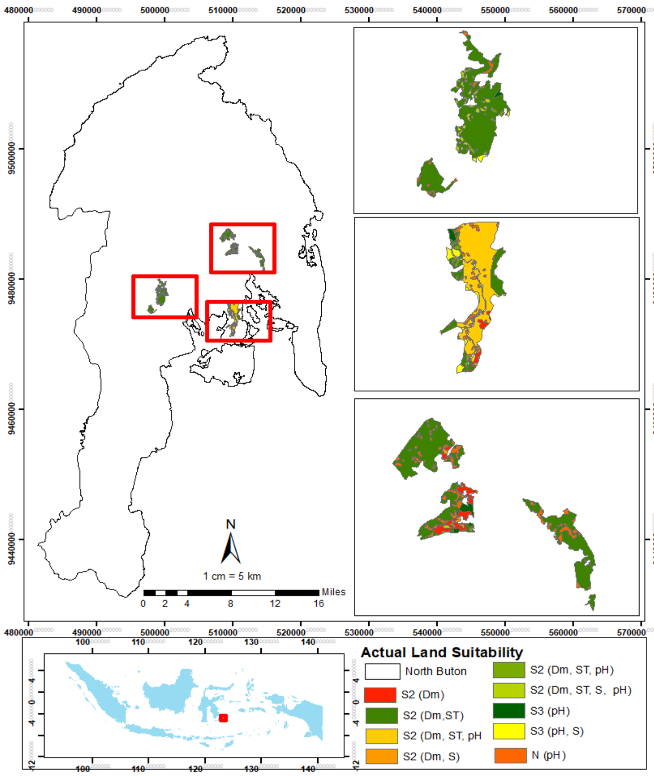

Figure 4. Actual land suitability.

***Suitability of Potential Land with Regional Spatial Planning*:** The potential for oil palm plantations is also assessed through an assessment of government policies. Regional government policy analysis is conducted on the Regional Spatial Planning component, which focuses on space allocation, particularly for agricultural and plantation development. In this regard, North Buton Regency has a Regional Spatial Plan, as stated in North Buton Regency Regional Regulation Number 5 of 2012, titled North Buton Regency Spatial Planning Plan for 2012-2032. The overlay analysis of potential land for oil palm development with the North Buton Regency Regional Spatial Plan reveals that only 87.13%, or 1,367.69 ha, of idle land, has the potential to be optimized for the development of oil palm commodities. This is because 12.87% of the idle land mentioned in the spatial pattern plan for irrigation is 6.12 ha, settlements are 3.15 ha, and rice fields are 192.76 ha. As a result, this land is unsuitable for oil palm plantations.

***Community's Willingness to Optimize Idle Land for Oil Palm Plants*:** Oil palm is a relatively new plantation crop in the North Buton Regency. The interview results revealed that 89.29% of respondents were eager to develop idle land with palm oil commodities for a variety of reasons. 55.36% of respondents stated that palm oil is a profitable long-term commodity, 25.0% that oil palm maintenance is relatively simple, 3.57% that there is marketing access, and 5.36% that they wanted to try a new commodity. Interviews with respondents revealed that 10.71% were unwilling to develop idle land for oil palm due to low capital (5.36%) and a lack of understanding about how to produce oil palm (5.36%). The findings of this study are consistent with the statement (Ruml *et al*., 2022) that oil palm plants provide good earnings after four to five years of planting, therefore farmers seeking quick returns prefer other types of plants to invest in. Meanwhile, marketing access was the cause with the lowest percentage, at 3.57%. Furthermore, noted that market forces allow for careful analysis of opportunities and dangers when carrying out oil palm agricultural activities. On the other hand, many are unwilling to maximize idle land for oil palm development due to a lack of finance and knowledge of oil palm development. As a result, the government's responsibility is to provide money and intensive training programs for oil palm farming, which will generate Gross Regional Domestic Product for North Buton Regency.

Table 6. Potential land suitability in North Buton Regency.

Sr.	Suitability	LU	Management Inputs	Area	
				Ha	%
1	S2	LU-5, LU-15, LU-17	Terracing and organic material	82,8	5,27
		LU-1, LU-2, LU-3, LU-7, LU-8, LU-9, LU-10, LU-12, LU-13, LU-4, LU-11, LU-16	Terracing and organic material	1.305,5	83,17
		LU-6	Organic material	23,72	1,51
		LU-21, LU-22	Terracing and organic material	31,94	2,03
2	S3	LU-14, LU-18, LU-19, LU-20, LU-23, LU-24, LU-25	Terracing and organic material	125,74	8,01
Total				1.569,7	100,00

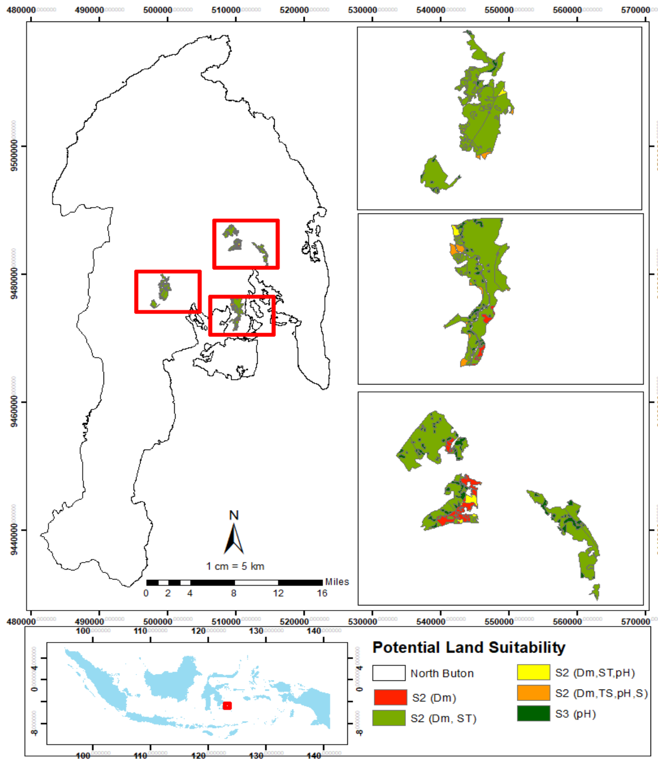

Figure 5. Potential land suitability.

***Conclusion*:** The idle land potential for developing oil palm plantations in North Buton Regency is 1,569.7 hectares, which includes Kulisusu, West Kulisusu, and Bonegunu districts. The potential land suitability evaluation yielded results for the S2 class (1,443.96 ha, 91.99%) and the S3 class (1,125.74 ha, 8.01%). Local government policy is consistent with the spatial pattern of 1,367.69 ha (87.13%), and the community's readiness to use land for oil palm plantations obtained an 89.29% positive answer. This has the potential to boost the economy of the North Buton Regency. Future studies should concentrate on optimizing land usage using agroforestry models, sustainable land management, and community participation in certification programs. Furthermore, investigating economic diversification, technical advancements, and resolving social concerns like as gender roles and land conflicts can help to foster long-term and inclusive development in the palm oil industry.

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