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Study of Soil Potential and Degradation Levels in Support of Rehabilitation Planning in The Batur Lake Catchment Area (CA)

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ABSTRACT: Lake Batur is one of 15 national priority lakes experiencing environmental degradation and increased sedimentation due to land conversion to dryland agriculture on steep slopes. This study aims to analyze the potential, status of soil degradation, and develop rehabilitation guidelines in the Lake Batur DTA. The methods used include field surveys, soil sampling from 10 Homogeneous Land Units (SLH), and laboratory analysis using the criteria of Government Regulation No. 150 of 2000. Spatial analysis results show that an area of 2,410.47 ha (23.60%) has high damage potential, dominated by slopes >40%. In reality, the status of soil damage is classified as Slight Damage (R.I) with the main limiting parameters including low water content, excessive permeability, and low organic carbon. Rehabilitation guidelines emphasize a vegetative approach through agroforestry and civil engineering techniques in the form of terracing and retaining dams.

KEYWORDS: Soil Damage, Land Degradation, Forest and Land Rehabilitation, DTA Lake Batur.

I. INTRODUCTION

Lake Batur is a multifunctional lake that is used for agriculture, fisheries, and tourism in Bangli Regency. The lake's water system is closed with no outlet, so the quality and quantity of water are highly dependent on the conditions of the surrounding catchment area (1). Currently, Lake Batur faces a serious problem in the form of an increasing sedimentation rate from 5,980.47 m^3 in 2019 to 6,348.48 m^3 in 2021 (2). The main trigger is the dynamics of land cover change. Data shows that between 2018 and 2022, the area of dryland agriculture in this region has increased dramatically from 1,613 ha to 3,654 ha^2. The conversion of natural forest cover to seasonal agricultural land on steep slopes without conservation measures has reduced the physical, chemical, and biological health and sustainability of the soil. Therefore, this study was conducted to map the potential damage and analyze the actual status of soil damage as a basis for formulating a Forest and Land Rehabilitation Plan (RHL).

II. RESEARCH METHOD

The research location was in the Lake Batur Catchment Area in Bangli Regency. This study uses a combination of spatial analysis (*Geographic Information System*) and laboratory tests. Soil Damage Potential Analysis: conducted using the scoring and overlay methods from 4

(four) base maps: land cover map, soil type map, slope map, and rainfall map. Soil Damage Status Analysis: based on soil sample testing in the laboratory with reference to the standard criteria of Government Regulation No. 150 of 2000. Disturbed and undisturbed soil samples were taken from 13 points representing the largest Homogeneous Land Units (SLH) in the Lake Batur DTA. Laboratory Test Parameters: These include soil depth, surface rockiness, pH, electrical conductivity (EC), organic carbon, moisture content, bulk density, porosity, permeability, and total microorganisms.

III. RESULTS

3.1. General Conditions

The Batur Lake Catchment Area (DTA) is geographically located in Bangli Regency with a total area of 10,211.06 ha. Physiographically, this area is a volcanic landscape in the form of a caldera surrounded by residual hills (igir) (1). Based on

administrative divisions, there are 16 villages within the DWA area, with South Batur Village being the largest (15.13%). Hydrologically, this DWA is divided into 6 sub-DWA areas, with the Melilit sub-DWA covering the largest area, namely 37.53% (2).

3.2. Soil Damage Potency

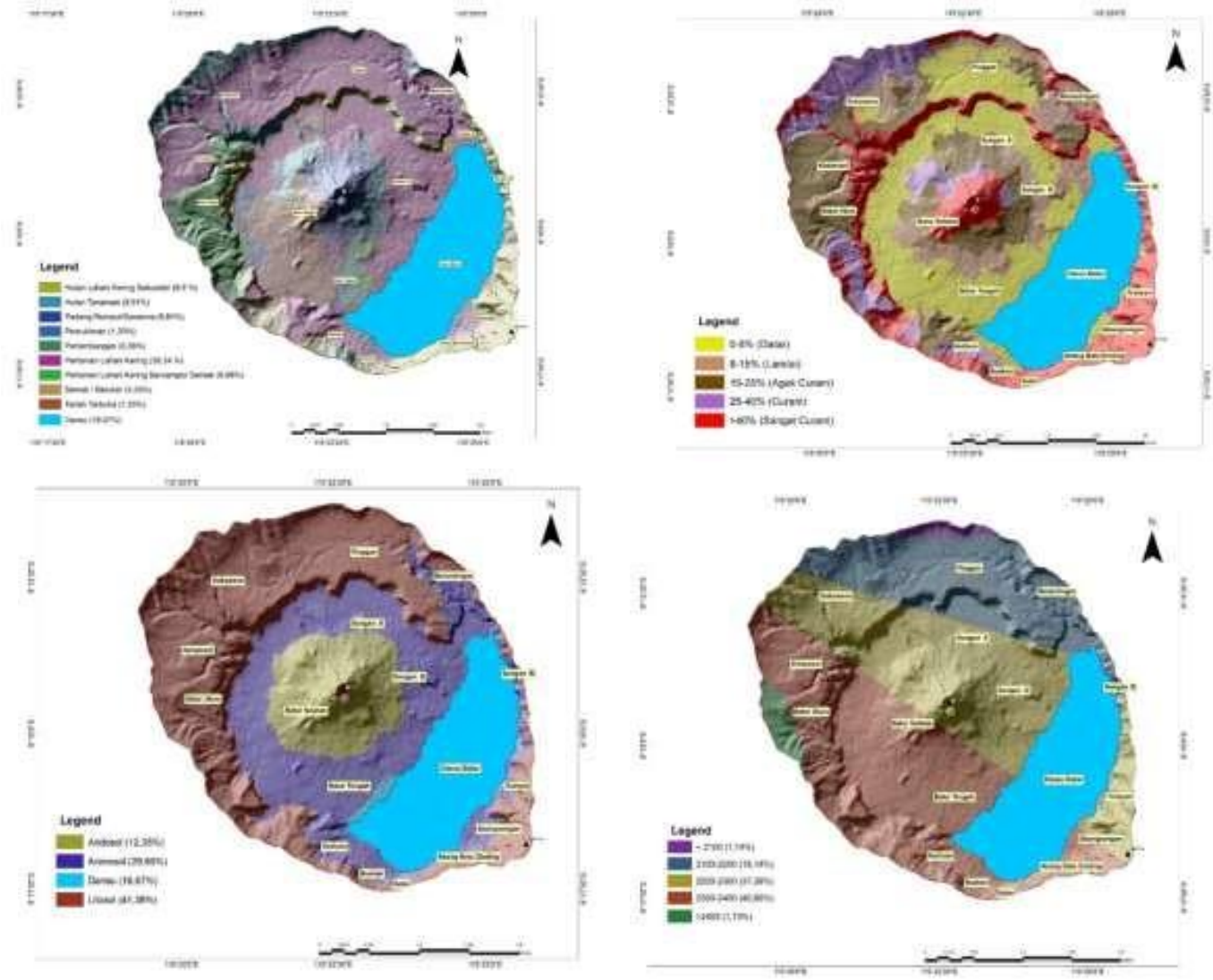


Figure 1.
Land Cover, Slope, Soil Type, and Rainfall in the Batur Lake Catchment Area

The results of the map overlay calculation show that the area of land with a "High" potential for damage reaches 2,410.47 ha, or 23.60% of the total DTA of Lake Batur. The majority of this high potential for damage is located in areas with very steep slopes (>40%).

No	Kode Potensi	Klas Potensi	Luas (Ha)	%
1	PR I	Sangat Ringan	1.632,40	15,99
2	PR II	Ringan	119,02	1,17
3	PR III	Sedang	6.050,16	59,25
4	PR IV	Tinggi	2.410,47	23,60
	Luas Ha		**10.212,06**	**100,00**

3.3. Distribution of Potential Soil Damage

The distribution of potential soil damage is found in six Sub-DTA areas in Lake Batur. The Sub-DTA area surrounding the lake has the largest area of potential damage, namely 1,122.42 ha.

Sub DTA	Potensi Kerusakan	Kode Prioritas	Luas (ha)
Balingkang	Sedang	PR III	1.562,67
	Tinggi	PR IV	315,70
Gede Tampuriang	Ringan	PR II	103,15
	Sedang	PR III	1.067,50
	Tinggi	PR IV	75,71
Kedisan	Sedang	PR III	200,09
	Tinggi	PR IV	503,54
Melilit	Ringan	PR II	15,87
	Sedang	PR III	2.680,57
	Tinggi	PR IV	1.122,42
Serongga	Sedang	PR III	539,34
	Tinggi	PR IV	81,18
Trunyan	Tinggi	PR IV	311,92
Tubuh Air	Sangat Ringan	PR I	1.632,40
	Luas Total		10.212,06

3.3. Actual Soil Damage Status (Laboratory Conditions)

Laboratory test results determined that the soil at 10 SLH points was generally classified as slightly damaged (R.I). There were three main parameters that exceeded the critical threshold (damaged), namely: water content, soil solum, organic C, and permeability.

Sampel	pH	DHL	C Organik	Kadar Air	Berat Volume	Berat Jenis Partikel	Porositas	Permeabilitas	Total Mikroorganism
	H2O	mmhos/cm	%	KU (%)	g/cm³	g/cm³	%		(Cfu/g)
1	7,27	0,13	1,58	1,05	1,11	2,78	59,98	34,76	3.5×10^7
2	6,96	0,13	3,18	2,10	1,07	2,75	61,02	33,78	3.9×10^7
3	6,67	0,10	3,20	2,52	0,95	2,64	63,93	16,99	3.1×10^7
4	6,92	0,35	3,58	2,16	0,98	2,57	61,77	17,33	4.5×10^7
5	7,02	0,71	1,19	1,36	1,25	2,55	51,08	36,35	3.6×10^7
6	6,76	1,45	1,58	1,63	1,05	2,58	59,25	30,57	2.5×10^7
7	6,93	0,20	4,02	3,10	1,03	2,66	61,42	14,95	5.1×10^7
8	6,93	0,11	1,98	1,69	1,23	2,77	55,68	36,44	3.9×10^7
9	6,83	0,20	1,59	1,93	1,19	2,73	56,62	35,44	4.1×10^7
10	6,81	0,13	1,18	1,25	1,05	2,59	59,52	28,20	3.7×10^7

3.4. Forest and Land Rehabilitation Planning

Forest and Land Rehabilitation is an effort to restore, maintain, and improve the function of forests and land in order to increase their carrying capacity, productivity, and role in maintaining life support systems (3).

Rekom Vegetatif	Rekom Sipil teknis	Di luar Kawasan	Di dalam Kawasan			Luas (Ha)
		APL	HL	HPT	TWA	
HR-Agr	BI-GP-T-SPA	341,39				341,39
HR-Agr-Pt	BI-GP	769,11				769,11
Ri	BI-GP-DPN				70,00	70,00
	BI-GP-T-SPA			5,28	80,28	85,56
Ri-Pt	BI-GP		509,59		523,25	1.032,84
Ri-Ragr	BI-GP-T-SPA		51,96		0,98	52,94
Ri-Ragr-Pt	BI-GP		33,94		24,69	58,63
Luas (Ha)		1.110,50	595,49	5,28	699,21	2.410,47

There are five rehabilitation patterns that can be implemented, namely outside the area, rehabilitation activities can be carried out in the form of community forests (HR), agroforestry (Agr) and slope reinforcement (Pt), while in forest areas, intensive reforestation (Ri), agroforestry reforestation (Ragr) and slope reinforcement can be implemented. Recommendations for civil engineering rehabilitation activities based on data analysis indicate that there are five activities that can be implemented, namely corridor cultivation (BI), gully plugs (GP), terraces (T), drainage channels (SPA), and retaining dams (DPn) (9).

IV. DISCUSSION

SLH 1 has a high potential for damage caused by land cover in the form of secondary dryland forests with slopes >40 percent and dryland agriculture has the second highest potential for damage on slopes of 25-40 percent, with a potential for soil damage covering an area of 542.03 ha or 22 percent of the total area of potential soil damage. The results of the calculations show that the category of high damage potential is most influenced by the slope class. The steeper the slope of an area, the higher the potential for soil erosion. The steeper the slope of the soil, the greater the speed of water flow on its surface, resulting in greater erosion of the soil (4).

All 10 SLH samples experienced severe damage to their moisture content. The highest moisture content was 3.1 percent in secondary dryland forest cover with vegetation dominated by pine trees. Forest and pine forest land use is thought to have high organic matter content, so that organic matter in the form of leaves, twigs, and so on that have not yet decomposed and cover the soil surface protect the soil from the destructive force of falling raindrops (5). Very fast permeability: the soil in the Lake Batur DTA area is dominated by lithosol, which is soil with a predominantly coarse sand texture that is very porous (6). Permeability tests showed that the water permeability reached 34.756 cm/hour, far exceeding the maximum threshold of 8.0 cm/hour. This causes rainwater to immediately disappear into the lower layers and cannot be retained by the soil.

Soil porosity in land cover is relatively high, resulting in very fast soil permeability. The higher the porosity, the greater the hydraulic conductivity (7). Organic carbon below 2% in open soil and dryland agriculture indicates that the soil has been degraded and has lost its natural nutrients. Low organic carbon is caused by the absence of trees that provide organic matter such as litter from fallen branches or leaves, as well as a lack of land cover such as shrubs, grasses, and others (8). The highest microorganism population was found in sample 7 (Secondary Dryland Forest) at 5.1 x 10^7 cfu/g. Forest vegetation (including secondary forests) has a significant effect on increasing the content of organic carbon, total nitrogen, and soil pH. The thick layer of litter on the forest floor acts as a sustainable “storehouse” of energy.

High damage potential and slighty degraded soil conditions require integrated RHL intervention combining vegetative and civil engineering techniques. Vegetative Approach: Focused on the application of multi-strata (layered) planting. For land outside forest areas, the recommended patterns are Community Forests (HR) and agroforestry, combining layered ground cover plants, fruit trees, and grasses (9).

Technical Civil Approach: Given the steep slopes and the nature of sandy soil that easily drains water (rapid permeability), planting must be supported by the development of soil and water conservation infrastructure. Required activities include the construction of terraces (sengkedan), sediment retention dams, ravine control structures, and the provision of drainage channels and slope reinforcement (10).

V. CONCLUSION

Based on the results of the study, the Batur Lake DTA has 2,410.47 ha (23.60%) of land with high potential for damage, concentrated in areas with very steep slopes (>40%) and covered with dry forest mixed with shrubs and dry agricultural land. Physical and chemical parameter tests determined that the status of soil damage in the field was at a mild level, caused by the soil's poor water retention capacity, excessive permeability, and a decrease in organic carbon in arenosol soil types. Saving Lake Batur DTA from the threat of sedimentation requires comprehensive rehabilitation measures that integrate the planting of agroforestry systems with the construction of physical soil conservation structures (terraces and retaining dams) in parallel.

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