

Mapping the Potential and Status of Land Damage on Agricultural Land in Selemadeg Timur District, Tabanan Regency, Bali

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ABSTRACT: Selemadeg Timur District is one of the agricultural areas in Tabanan Regency that is experiencing increasing pressure from land intensification, while spatial data mapping the potential and status of land damage in this district remain limited. This study aims to map the potential of land damage and its distribution, and to evaluate the actual status of land damage and its distribution on agricultural land in Selemadeg Timur District. Land damage potential was assessed through scoring and weighting of four thematic maps — land use, soil type, slope gradient, and rainfall — referring to the guidelines of the State Ministry of Environment of the Republic of Indonesia (2009), with the overlay of these maps used to delineate nine homogeneous land units (HLU). Land damage status was analyzed based on physical, chemical, and biological soil parameters referring to the Regulation of the Minister of Environment No. 07 of 2006. The results showed that the study area is dominated by a light category of land damage potential (PR.II), covering 3,993.8 ha, while the moderate category (PR.III) covers 700.54 ha, concentrated on land units with steeper slopes (15–25%) under mixed-garden cultivation. The actual status of land damage is generally classified as lightly damaged (R.1) across most homogeneous land units, with soil permeability and texture identified as the main limiting factors, while other physical, chemical, and biological parameters remain undamaged. The resulting maps of land damage potential and status provide a spatial basis for prioritizing soil conservation efforts in the district.

KEYWORDS: *land damage mapping, land damage potential, land damage status, soil physical properties, Selemadeg Timur*

I. INTRODUCTION

Soil is a vital natural resource, living space, environmental medium, and production factor including biomass production that supports human life and other living organisms, so its existence needs to be maintained and preserved. Land use that exceeds its carrying capacity, such as intensive farming on steep slopes without adherence to conservation principles, or continuous chemical input beyond recommended limits, can trigger physical, chemical, and biological soil damage and accelerate land degradation. The main causes of land damage in Indonesia generally include: (1) natural geomorphological factors such as geology, soil type, and topography, which are prone to triggering erosion, flooding, landslides, and drought; (2) climatic factors, particularly high rainfall that increases erosivity; and (3) human factors, namely land management and utilization that exceed the carrying capacity of the region, compounded by farming practices inconsistent with soil and water conservation principles due to farmers' limited knowledge and awareness.

Land damage refers to changes in the basic properties of soil that exceed the established standard criteria of soil damage, which include surface rock, solum depth, bulk density, soil texture, permeability, total porosity, pH, electrical conductivity, and microbial population. Land prone to soil damage generally exhibits low fertility due to a thinning topsoil layer and reduced organic matter content. The Government of Indonesia has taken preventive and control measures through Government Regulation No. 150 of 2000 concerning the Control of Land Damage for Biomass Production, which underscores the importance of systematically mapping both the potential and the actual status of land damage as a basis for conservation planning.

Selemadeg Timur District, Tabanan Regency, still retains a considerable area of agricultural land, comprising paddy fields, dry fields, and mixed gardens. According to statistical data, land use in the district is dominated by mixed gardens, followed by paddy fields, dry fields/plantations, and settlements, with the dominant soil types being yellowish-brown Latosol and, along the coastal zone, greyish-brown Regosol. However, spatial maps of land damage potential and actual land damage status in this district have not yet been published by local government agencies. Based on this condition, the authors conducted a study to map the potential

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of land damage and its distribution, and to evaluate the actual status of land damage and its distribution on agricultural land in Selemadeg Timur District, in order to obtain spatially explicit information that can support soil damage mitigation efforts in the area.

II. RESEARCH METHODS

This study was conducted from September 2025 to June 2026 on agricultural land in Selemadeg Timur District, Tabanan Regency, Bali (8°29'47"–8°31'58" S and 115°1'59"–115°4'3" E), and at the Soil and Environmental Science Laboratory, Faculty of Agriculture, Udayana University. The district covers approximately 54.78 km², comprising 10 administrative villages, 72 hamlets, and 32 traditional villages.

This study employed a quantitative survey-based design combined with laboratory analysis, supported by field observation and semi-structured farmer interviews to obtain supporting information on land-use history. Homogeneous Land Units (HLU) were delineated through the overlay of land-use, slope, and soil-type maps using QGIS software, producing nine HLU (HLU I–IX). Soil sampling used a purposive sampling technique, with composite disturbed samples taken diagonally at five points within each HLU, and undisturbed samples taken using ring samplers to represent actual topsoil physical conditions.

Land damage potential was assessed through a scoring and weighting method applied to four thematic maps land use, soil type, slope gradient, and rainfall referring to the guidelines of the State Ministry of Environment of the Republic of Indonesia (2009). Rating values ranged from 1 to 5 and were multiplied by a weighting value for each thematic map, then summed to obtain the total potential score and corresponding damage-potential class for each HLU.

The actual status of land damage was evaluated based on physical, chemical, and biological soil parameters referring to the Regulation of the Minister of Environment No. 07 of 2006, comprising: solum depth (Belgian auger), surface rock (visual observation), soil texture (pipette method), bulk density (ring sample method), permeability (De Boodt/Darcy method), total porosity (calculated from bulk density), pH (pH meter), electrical conductivity (EC meter), and microbial population (pour plate method). C-organic content was analyzed as a supporting parameter using the Walkley and Black method. Each parameter was scored against the standard damage criteria and summed to determine the damage status class of each HLU, which was then compiled into a spatial distribution map using QGIS.

III. RESULT AND DISCUSSION

The study area was divided into nine Homogeneous Land Units (HLU I–IX), which were delineated through the spatial overlay of land use, soil type, and slope maps. This approach allows areas with similar biophysical characteristics to be grouped into relatively uniform land units, providing a more reliable basis for assessing soil conditions and evaluating the spatial distribution of soil degradation. Each HLU represents a unique combination of environmental factors that may influence soil properties, land management practices, and ecosystem functions.

The dominant soil type across the study area is yellowish-brown Latosol, which occurs in almost all HLUs and reflects the widespread distribution of highly weathered tropical soils. Latosols are generally characterized by good physical structure but are susceptible to nutrient depletion under intensive cultivation if not managed properly. In contrast, greyish-brown Regosol is found only in HLU II, which is located along the coastal zone. This soil type is relatively young and less developed, with distinct physical and chemical characteristics that differentiate it from the inland Latosol-dominated areas.

Topographic conditions also vary among the homogeneous land units, with slope gradients ranging from flat to gently sloping (0–8%) in HLU I, II, V, and VIII, to moderately sloping (15–25%) in HLU IV, VII, and IX. Differences in slope play an important role in controlling runoff, soil erosion, water infiltration, and land management suitability. Steeper areas generally have a higher potential for soil degradation due to increased erosion risk, whereas flatter areas are more suitable for agricultural activities but may experience other limitations depending on soil characteristics and management practices.

The spatial extent of each HLU differs considerably. HLU I and HLU V constitute the largest land units, covering 2,194.55 ha and 1,681.47 ha, respectively, indicating that these landscape conditions dominate the study area. Conversely, HLU IX represents the smallest unit, occupying only 2.25 ha. The variation in the size of homogeneous land units reflects the heterogeneity of the landscape and provides a representative framework for evaluating soil degradation status and associated environmental characteristics across the study area.

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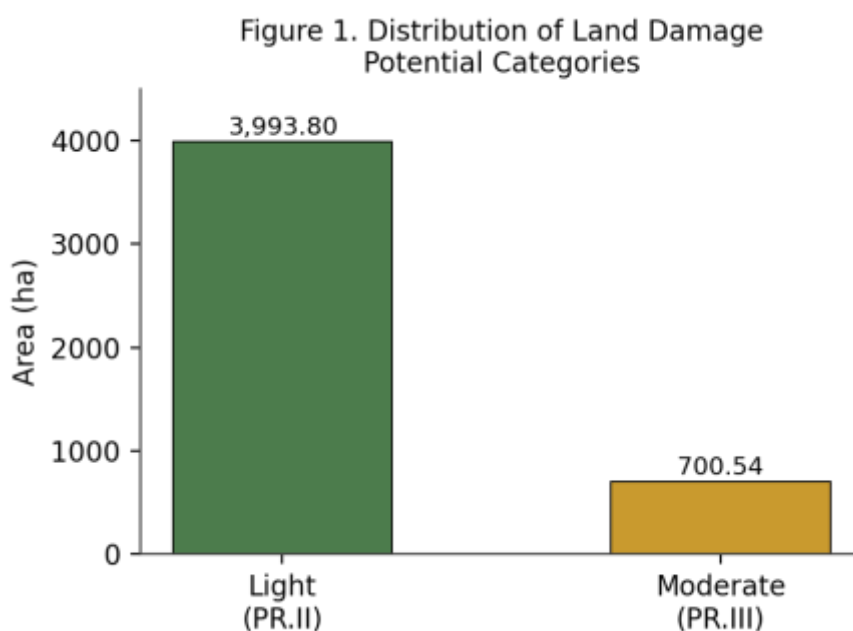
Table 1. General Characteristics of Homogeneous Land Units

HLU	Area (ha)	Soil Type	Slope (%)	Land Use
I	2,194.55	Latosol	0–8	Conventional paddy field
II	97.59	Regosol	0–8	Conventional paddy field
III	161.68	Latosol	8–15	Conventional paddy field
IV	319.05	Latosol	15–25	Conventional paddy field
V	1,681.47	Latosol	0–8	Mixed garden (conventional)
VI	302.93	Latosol	8–15	Mixed garden (conventional)
VII	700.54	Latosol	15–25	Mixed garden (conventional)
VIII	17.94	Latosol	0–8	Mixed garden (organic)
IX	2.25	Latosol	15–25	Paddy field (organic)

A. Potential of Land Damage

Weighting of the land-use map showed that paddy fields have a very light damage potential with a lower score, while mixed gardens are classified as light with a higher score — indicating that mixed-garden cultivation exerts relatively greater pressure on soil condition than paddy fields. Weighting of the soil-type map classified Inceptisol and Entisol as having high damage potential, as both are young soils with shallow solum and poorly developed structure, making them more susceptible to erosion and fertility degradation. Weighting of the slope map showed that scores increase with slope steepness, reflecting a higher risk of erosion and soil loss on steeper land, while the annual rainfall of 2,000–3,000 mm across the study area acts as a consistent driving factor for degradation through surface runoff and erosion.

The combined scoring resulted in the study area being dominated by the light category of land damage potential (PR.II), covering 3,993.8 ha, while the moderate category (PR.III) covers 700.54 ha, concentrated on land units with slopes of 15–25% under mixed-garden cultivation (HLU IV, VI, VII). This indicates that although the area is generally stable, land units with steeper slopes and mixed-garden use require more conservative management to prevent further degradation (Figure 1).



B. Status of Land Damage

The actual status of land damage in the study area is generally classified as lightly damaged (R.1), with permeability identified as the dominant limiting factor across all nine HLU recorded at a relative frequency of 100% in the very-severely-damaged category while soil texture contributed a lighter degree of damage with a relative frequency of 11.1%. Other physical, chemical, and

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biological parameters, namely bulk density, total porosity, solum thickness, surface rock, pH, electrical conductivity, and microbial population, were generally in an undamaged condition. This indicates that land degradation in the study area is more strongly driven by disturbance to soil physical properties, particularly permeability, than by chemical or biological properties.

At the land-unit level, HLU I, VI, VII, and IX show damage influenced by a combination of permeability, total porosity, and texture, while HLU II, III, IV, and VIII are limited by permeability and total porosity together, and HLU V is limited by permeability alone. HLU II, located in the coastal zone with sandy-dominated Regosol, records a moderate damage status (R.2) as a result of its coarser texture and low water-holding capacity, distinguishing it from the other eight HLU, which fall under the light damage category (R.1).

Table 2. Relative Frequency of Soil Damage Parameters

Parameter	Relative Frequency (%)	Score	Damage Status
Permeability	100	4	Very severely damaged
Texture	11.1	1	Lightly damaged
Bulk density	0	0	Undamaged
Total porosity	0	0	Undamaged
Solum thickness	0	0	Undamaged
Surface rock	0	0	Undamaged
pH	0	0	Undamaged
Electrical conductivity	0	0	Undamaged
Microbial population	0	0	Undamaged

IV. CONCLUSIONS

Mapping of land damage potential on agricultural land in Selemadeg Timur District shows that the area is predominantly in the light category (PR.II, 3,993.8 ha), with moderate-category areas (PR.III, 700.54 ha) concentrated on steeper (15–25%) mixed-garden land requiring more conservative management. The resulting map of actual land damage status shows that the district is generally light (R.1), with soil permeability and texture as the main limiting factors, while other physical, chemical, and biological parameters bulk density, total porosity, solum thickness, surface rock, pH, electrical conductivity, and microbial population remain undamaged, reflecting a dominance of physical over chemical or biological degradation. These maps provide a spatial basis for prioritizing soil conservation efforts such as mulching, terracing, and cover cropping, together with improvement of soil permeability through organic matter addition, particularly on land units with slopes of 15–25% under mixed-garden cultivation in Selemadeg Timur District.

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