Jurnal Pertanian Terapan of JURNAL ROCE (AGROSCIENCE)
https://jurnal.rocewisdomaceh.com/index.php/roce *e-ISSN : 3032-4505*
Vol. 2, No. 2, Thn. 2025
https://doi.org/10.71275/roce.v2i1.122

SOIL ERODIBILITY ANALYSIS AND SOIL CONSERVATION TECHNIQUE IN THE BAWANG GAJAH SUB-WATERSHED, CENTRAL ACEH REGENCY

ANALISIS ERODIBILITAS TANAH DAN TEKNIK KONSERVASI TANAH DI SUB-DAS BAWANG GAJAH KABUPATEN ACEH TENGAH

Halim Akbar[1], Rini Fitri[2]

[1] Program Agroecotechnology Studies, Faculty of Agriculture, Malikussaleh University
[2]Program Landscape Architecture Studies, Faculty of Landscape Architecture and Environmental Technology, Trisakti University.

Correspondent Email: halim@unimal.ac.id

Abstract

Soil erodibility is the ease with which soil is destroyed by the force of falling raindrops and/or surface runoff. This study aims to determine the soil erodibility value and soil conservation techniques in the Bawang Gajah sub-watershed. The method used in this study is a survey method consisting of preparation, preliminary survey, primary survey, data analysis, and presentation of results. Soil erodibility values were calculated using the Wischmeier and Smith equation. The results of the soil erodibility analysis showed that low soil erodibility values ranging from 0.27, 0.28, and 0.37 were found in Land Mapping Unit (LMU) 2, 4, 5, and 10, moderate soil erodibility values of 0.43 and 0.51 are found in LMU 6 and 7, high soil erodibility values of 0.61 and 0.64 are found in LMU 3 and 11. Very high soil erodibility values of 0.82 and 0.92 are observed in LMU 9 and 14, respectively. The conservation techniques that must be implemented on LMU 2, 4, 5, and 10 are planting ground cover vegetation, applying mulch, and practicing crop rotation. The conservation techniques to be applied to LMU 6 and 7 are a combination of agroforestry and contour terraces, along with the planting of vetiver grass. The soil conservation techniques that must be applied at LMU 3 and 11 are agroforestry and reforestation, as well as the construction of contour terraces for the rehabilitation of eroded areas, while at LMU 9 and 14, the soil conservation measures implemented are the construction of terraces equipped with diversion channels, terrace channels, and drainage channels.

Keywords: Soil Erodibility, Soil Conservation, Bawang Gajah Sub-Watershed

Abstrak

Erodibilitas tanah adalah tingkat kemudahan kerusakan tanah akibat kekuatan jatuhnya air hujan dan/atau limpasan permukaan. Penelitian ini bertujuan untuk menentukan nilai erodibilitas tanah dan teknik konservasi tanah di Sub-DAS Bawang Gajah. Metode yang digunakan dalam penelitian ini adalah metode survei yang terdiri dari persiapan, survei pendahuluan, survei utama, analisis data, dan penyajian hasil. Nilai erodibilitas tanah dihitung menggunakan persamaan Wischmeier dan Smith. Hasil analisis erodibilitas tanah menunjukkan nilai erodibilitas tanah rendah berkisar 0,27, 0,28, dan 0,37 terdapat pada Satuan Pemetaan Lahan (SPL) 2, 4, 5, dan 10, nilai erodibilitas tanah sedang 0,43 dan 0,51 terdapat pada SPL 6 dan 7, nilai erodibilitas tanah tinggi 0,61 dan 0,64 terdapat pada SPL 3 dan 11, serta nilai erodibilitas tanah sangat tinggi 0,82 dan 0,92 terdapat pada SPL 9 dan 14. Teknik konservasi yang harus

https://jurnal.rocewisdomaceh.com/index.php/roce e-ISSN : 3032-4505
Vol. 2, No. 2, Thn. 2025
https://doi.org/10.71275/roce.v2i1.122

diterapkan pada SPL 2, 4, 5, dan 10 adalah penanaman vegetasi penutup tanah, pemberian mulsa, dan rotasi tanaman. Teknik konservasi yang harus diterapkan pada SPL 6 dan 7 adalah kombinasi agroforestri dan teras kontur + penanaman rumput vetiver. Teknik konservasi tanah yang harus diterapkan pada LMU 3 dan 11 adalah agroforestri dan reboisasi, serta pembuatan teras kontur untuk rehabilitasi lahan tererosi, sedangkan pada LMU 9 dan 14, tindakan konservasi tanah yang diterapkan adalah pembuatan teras yang dilengkapi dengan saluran pengalihan, saluran teras, dan saluran drainase.

Kata Kunci: Erodibilitas Tanah, Konservasi Tanah, Sub-DAS Bawang Gajah.

INTRODUCTION

Land use changes in a watershed, such as forest conversion and agricultural expansion, continue to this day. The increased intensity of land use changes negatively impacts the hydrological conditions of a watershed, including erosion. Erosion occurs due to the force of falling raindrops and surface runoff. In most tropical rainforests, such as those in Indonesia, erosion is primarily caused by the force of falling raindrops and surface runoff. The Bawang Gajah sub-watershed, covering an area of 11,535.27 hectares, currently has critical land classes, including 1,027.65 hectares of potentially critical land, moderately critical land covering 3,479.22 hectares, critical land covering 6,366.28 hectares, and severely critical land covering 662.11 hectares (BPDAS Aceh, 2023).

Critical land is land that has undergone degradation, thereby reducing its ecological capacity and function to support life. Sparse vegetation cover, thin soil layers, and reduced soil fertility typically characterize critical land. One of the key factors influencing the essential occurrence of land is the high level of soil erodibility.

Soil erodibility refers to the ease with which soil can be broken down by the force of falling raindrops and/or surface runoff (Arsyad, 2010). Soil erodibility is a natural property of soil that indicates its susceptibility to erosion caused by water forces. The higher the soil erodibility, the greater the potential for soil degradation if not balanced with proper management.

One approach to managing critical land in areas with high soil erodibility is the application of soil conservation techniques such as terrace construction, contour terraces, planting groundcover vegetation, and increasing soil organic matter content. These efforts aim to improve soil structure, reduce surface runoff velocity, and enhance water absorption capacity, thereby mitigating erosion rates. With the right approach, soil with high erodibility can still be managed sustainably and productively. Based on the above issues, it is necessary to assess soil erodibility and apply soil conservation techniques in the Bawang Gajah sub-watershed of Aceh Tengah District.

RESEARCH OBJECTIVES

This study aims to determine the soil erodibility value and soil conservation techniques in the Bawang Gajah Sub-Watershed, Central Aceh Regency.

https://jurnal.rocewisdomaceh.com/index.php/roce *e-ISSN : 3032-4505*
Vol. 2, No. 2, Thn. 2025
https://doi.org/10.71275/roce.v2i1.122

RESEARCH METHODS

Tools and Materials

The tools used in this study consisted of a GPS (Global Positioning System), soil borer, Abney level, sample rings, soil type maps, land slope maps, land use maps, land unit maps (DLHK, 2024), rainfall data (BMKG Malikussaleh, 2025), machetes, knives, plastic bags, label paper, and writing tools. The materials used in this study were undisturbed soil, disturbed soil, 30% sodium pyrophosphate ($Na_2P_2O_7$), 10% H_2O, concentrated H_2SO_4, 85% H_3PO_7, 10% H_2O_2, 1 N K_2CrO_7, $FeSO_4$ N, and distilled water. The method used in this study was a survey method consisting of four stages: preparation, preliminary survey, primary survey, and data analysis and presentation.

Soil erodibility (K) was calculated using the Wischmeier & Smith (1978) equation:

$$100K = \{1.292\ (2.1\ M1.44\ (10-4)\ (12 - a) + 3.25\ (b - 2) + 2.5\ (c - 3)\}$$

where : K = soil erodibility; M = soil texture class (% fine sand + % silt) (100% – % clay); a = % organic matter; b = soil structure; and c = soil permeability.

RESULTS AND DISCUSSION

Land Mapping Unit

The land mapping unit (LMU) is the base map (working map) for field observations on intensive observation plots within each land unit map. The LMU is derived from the overlay of soil type maps, topographic maps, and land use maps, resulting in 14 land use units (Table 1). Among the 14 LMUs, intensive observations were conducted only on LMUs 2, 3, 4, 5, 6, 7, 9, 10, 11, and 14.

Table 1. Land Map Unit in The Bawang Gajah Sub-Watershed

LMU	Slope (%)	Soil Type	Land Use
1	25-40	Inceptisol	Water bodies
2	0-8	Inceptisol	Mixed gardens
3	15-25	Entisol	Monoculture farming
4	15-25	Ultisol	Monoculture farming
5	>40	Inceptisol	Mixed gardens
6	15-25	Entisol	Mixed gardens
7	15-25	Ultisol	Mixed gardens
8	>40	Inceptisol	Settlements
9	>40	Inceptisol	Rainfed rice fields
10	>40	Ultisol	Mixed gardens
11	25-40	Entisol	Rainfed rice fields
12	>40	Inceptisol	Protected forests
13	>40	Entisol	Protected forests
14	25-40	Entisol	Mixed gardens

Soil Erodibility Calculation

Soil sensitivity to erosion (soil erodibility) refers to how easily soil is eroded (Asdak, 2002). Soil erodibility values indicate the degree of soil vulnerability to the destructive power of rainwater. The higher the soil erodibility value, the more easily the soil is eroded. Soil erodibility values are also influenced by the physical and chemical properties of the soil, such as texture, structure, permeability, and organic matter content.

The analysis results show that soil erodibility values in the Bawang Gajah sub-watershed range from low to very high, influenced by a combination of factors including soil texture, slope, soil type, and land use (Table 2).

Table 2. Soil Erodibility Values in the Bawang Gajah Sub-watershed

LMU	Slope (%)	Land Cover	Erodibility Value
2	4	Mixed Farming	0.27
3	22	Monoculture Farming	0.61
4	24	Monoculture Farming	0.28
5	42	Mixed Farming	0.37
6	24	Mixed Farming	0.43
7	24	Mixed Farming	0.51
9	42	Rainfed Rice Fields	0.92
10	44	Mixed Farming	0.28
11	26	Rainfed Rice Fields	0.64
14	35	Mixed Farming	0.82

Table 2 above shows that LMU 2, 4, 5, and 10 have low soil erodibility values, ranging from 0.27 to 0.37. The low soil erodibility values are due to the soil texture, which ranges from sandy loam to loam, as well as the land use, which consists of mixed gardens with better vegetation cover, thereby protecting the soil surface from rain impact. Additionally, the slope gradient (44% at LMU 10) can still hinder surface runoff due to the dense vegetation cover, and this should be addressed to prevent increased soil erodibility in the future. This aligns with research findings (Wang *et al*., 2022; Dai *et al*., 2023), which indicate that vegetation cover influences soil erosion.

The soil erodibility values at LMU 6 and 7 are classified as moderate (0.43 and 0.51). Both LMUs have sandy loam soil texture and a slope gradient of 24%, with mixed garden land use. The moderate soil erodibility values at LMU 6 and 7 are due to farmers in these locations not incorporating soil conservation techniques into their agricultural practices. This, combined with the steep slope gradient, increases surface flow energy, which has the potential to exacerbate erosion. Additionally, the Entisol and Ultisol soil types found in LMU 6 and 7 tend to have less stable soil structure, making the soil more susceptible to erosion.

High soil erodibility values were obtained at LMU 3 and 11, ranging from 0.61 to 0.64. Both LMUs have relatively steep slopes (22% at LMU 3 and 26% at LMU 11) and sandy loam soil texture. In LMU 3, the use of land for monoculture agriculture limits the vegetation covering the soil surface, making the soil more susceptible to direct exposure to the kinetic energy of rainfall. The use of monoculture agriculture also indirectly causes damage to soil structure due to the impact of rainfall, which in turn reduces organic matter content, weakens soil aggregates, and makes the soil more prone to erosion by water. On the other hand, rainwater impact also compacts the surface soil structure, which reduces soil porosity. Meanwhile, LMU 11, where the land is used for rain-fed rice fields, can affect soil erodibility due to several factors, including the wet and dry cycle, which can damage soil structure. During the dry season, the soil dries out, causing shrinkage and cracks, which makes the soil structure more susceptible to breakdown when exposed to rainwater impact. Additionally, steep slopes can increase the risk of erosion if conservation efforts are not implemented.

Land mapping units 9 and 14 have very high soil erodibility values, ranging from 0.82 to 0.92. Unit 9 has rain-fed rice fields, a 42% slope, a clay loam texture, and Inceptisol soil type. Inceptisol soil is a young soil still undergoing initial profile development, characterized by a relatively unstable soil structure and soil aggregates that easily break apart when exposed to heavy rainfall. Additionally, Inceptisol soil generally has a low organic matter content (especially in rain-fed rice fields), which reduces the soil's ability to bind soil particles. Furthermore, the extremely steep slope (42%) accelerates surface water flow during rainfall, increasing the kinetic energy of flowing water. As a result, soil particles are more easily dislodged and carried away by water. Overall, the variation in soil erodibility values in the Bawang Gajah Sub-Watershed indicates a correlation between soil texture, slope gradient, soil type, and land use.

The high and low values of soil erodibility in the Bawang Gajah sub-watershed indicate a correlation between soil texture, slope, soil type, and land use. Land with steep slopes, sandy soil texture, and minimal natural vegetation cover tends to have higher erodibility levels. Therefore, for LMU with high to very high erodibility values, soil conservation techniques such as terracing, soil cover vegetation, and contour-based soil management are necessary to control erosion rates.

Soil conservation techniques can be applied to LMU 2, 4, 5, and 10 through the planting of ground cover vegetation, mulching, and crop rotation management. This aims to maintain soil moisture, reduce erosion, and enhance soil fertility. This aligns with the findings of Suprayogo et al. (2020), who noted that maintaining ground cover vegetation and agroforestry systems can preserve soil structure. Additionally, Nesa *et al*. (2024) reported that continuous mulching can reduce runoff by 47.4% and soil loss by 76.2%.

For LMU 6 and 7, the conservation measures to be implemented are a combination of agroforestry and contour terraces aimed at slowing surface water flow (Suprayogo *et al*., 2020). Xuan et al. (2023) further add that planting vetiver grass is highly beneficial as a vegetative barrier on slopes to bind soil.

Conservation techniques that can be applied to LMU 3 and 11 include agroforestry and reforestation, as well as the construction of contour terraces for rehabilitating eroded areas or integrating mechanical and vegetative strategies (Hananto *et al*., 2023). Furthermore, Ariyanti et al. (2016) added that the combination of contour terraces + Nephrolepis biserrata groundcover plants can reduce surface runoff by 95.7%, and this combination also demonstrates high effectiveness in maintaining moisture and promoting infiltration.

For LMU 9 and 14, the recommended conservation techniques involve mechanical conservation through the construction of terraces equipped with diversion channels, terrace channels, and effective drainage channels to control runoff and sedimentation (Wahyudi, 2022).

Furthermore, the recommended conservation solutions for rain-fed rice fields include planting cover crops or secondary crops during the dry season (rather than leaving the land fallow), adding organic mulch to improve soil aggregation, and reducing intensive soil cultivation, especially when the soil is wet.

CONCLUSION

1. The soil erodibility value (K) in the Bawang Gajah sub-watershed varies between 0.27 and 0.92. This variation in K values is influenced by factors such as soil texture, soil structure, organic matter content, and soil permeability.
2. Locations with the highest K values are found at LMU 9 (0.92) and LMU 14 (0.82), which are categorized as soils with very high susceptibility to erosion.
3. Locations with low K values, such as LMU 2, LMU 4, 5, and LMU 10, are relatively more resistant to erosion.
4. Soil conservation techniques that need to be implemented in LMU 2, 4, 5, and 10 include planting ground cover vegetation, applying mulch, and practicing crop rotation. The conservation techniques to be applied in LMU 6 and 7 are a combination of agroforestry and contour terraces, along with planting vetiver grass. Soil conservation techniques that must be applied in LMU 3 and 11 are agroforestry and reforestation, as well as the construction of contour terraces for the rehabilitation of areas affected by erosion, while in LMU 9 and 14, soil conservation measures include the construction of terraces equipped with diversion channels, terrace channels, and drainage channels.

REFERENCES

Ariyanti, M., Yahya, S., Murtilaksono, K., Suwarto, & Siregar. (2016). The effect of Nephrolepis biserrata ground cover plants and gulud terraces on surface runoff and oil palm (*Elaeis guineensis* Jacq.) growth. Jurnal Kultivasi, Vol. 15 No. 2.

Arsyad, S. (2010). Soil and Water Conservation. Bogor: IPB Press Series.

Asdak, C. (2002). Hydrology and River Basin Management. Yogyakarta: Gadjah Mada University Press.

[BPDAS Aceh] Aceh Watershed Management Agency. (2023). Database and information. Krueng Aceh Watershed Management Agency. Aceh Province.

[BMKG] Meteorology, Climatology and Geophysics Agency. (2025). Climate data. Malikussaleh Station, North Aceh.

Dai, R., Dai, C., Hou, S., He, Q., Liu, B., Huang, M., ... & Xu, X. (2023). Opportunities and challenges of hydrotalcite-related electrocatalysts for seawater splitting: a systematic perspective from materials synthesis, characterization, and application. Journal of Materials Chemistry A, 11(38), 20383–20407.

[DLHK] Department of Environment and Forestry. (2024). Land Use Data. Aceh Province.

Hananto, A., Ruslan, M., & Kadir, S. 2023. Erosion Hazard Levels in Forest and Land Rehabilitation in the Riam Kiwa Sub-Watershed, Banjar Regency. Journal of Tropical Forestry, Vol. 10 (2).

https://jurnal.rocewisdomaceh.com/index.php/roce e-ISSN : 3032-4505
Vol. 2, No. 2, Thn. 2025
https://doi.org/10.71275/roce.v2i1.122

Nesa, M. M., Propa, S. M., Sen, S., & Abdullah, H. M. (2024). Land Use Change and Soil Erosion: Challenges and Way Forward to Management. In Climate Change and Soil-Water-Plant Nexus: Agriculture and Environment (pp. 547-571). Singapore: Springer Nature Singapore.

Suprayogo, D., van Noordwijk, M., Hairiah, K., Meilasari, N., Rabbani, A.L., Ishaq, R.M., & Widianto, W. (2020). Infiltration-Friendly Agroforestry Land Uses on Volcanic Slopes in the Rejoso Watershed, East Java, Indonesia. Journal Land, 9(8), 240.

Wahyudi. (2022). Soil Conservation Techniques and Their Implementation on Degraded Lands in Forest Areas. Journal of Environmental Science & Technology, Vol. 6, Iss. 2.

Wang, G., Ren, Y., Bai, X., Su, Y., & Han, J. (2022). Contributions of beneficial microorganisms in soil remediation and quality improvement of medicinal plants. Plants, 11(23), 3200.

Wischmeier, WH and Smith. DD. (1978). *Predicting Rainfall Erosion Losses. A guide to conservation planning*. USDA. Agric. Eng 29: 458 – 462.

Xuan, W., Zhenyu, L., Yongjun, C., & Yongsheng, Y. (2023). Influence of Vetiver Root Morphology on Soil–Water Characteristics of Plant-Covered Slope Soil in South Central China. Sustainability, Vol. 15, No. 2: 1365.