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EROSION PREDICTION AND SOIL CONSERVATION TECHNIQUES IN THE ALUE GEUDEUBANG SUB WSTERSHED ACEH UTARA REGENCY

PREDIKSI EROSI DAN TEKNIK KONSERVASI TANAH DI SUB DAS VALUE GEDUNG KABUPATEN ACEH UTARA

Andriyana[1], Halim Akbar[1*], Khusrizal[1]

[1]Agroecotechnology Study Program, Faculty of Agriculture, Universitas Malikussaleh

*Correspondent Email: halim@unimal.ac.id

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Abstract

Erosion is the process of soil or soil particles being moved from one place to another by water. In the context of a watershed, erosion is a significant issue because it reduces soil productivity and increases sedimentation, thus reducing the lifespan of reservoirs. The goal of this research is to assess the predictive value of erosion in the Alue Geudubang Sub-watershed, Aceh Utara Regency. The research methodology involves a survey which includes a preparation stage, preliminary survey, main survey, data analysis, and presentation of results. Erosion prediction is calculated using the Universal Soil Loss Equation (USLE). The research findings indicate that the highest erosion prediction value is at SPL 10, where low-density mixed garden land, 0-8% slope, and Inceptisol soil type result in a value of 327.57 tonnes/ha/yr (ETol = 26.78 tonnes/ha/yr). Meanwhile, the lowest erosion prediction value is found at SPL 1 with forest land use, 0-8% slope, and Ultisol soil type, yielding a value of 5.01 tonnes/ha/yr (ETol = 16.17 tonnes/ha/yr). The recommended soil conservation technique for SPL 10 is to improve cropping patterns, such as planting high-density patterns combined with creating plant beds, to reduce the erosion rate to 9.83 tonnes/ha/yr (ETol = 26.78 tonnes/ha/yr).

Keywords : *Erosion, Erosion Tolerance, Soil Conservation Techniques*

Abstrak

Erosi merupakan proses bergeraknya tanah atau partikel-partikel tanah dari satu tempat ke tempat lain oleh air. Dalam konteks suatu Daerah Aliran Sungai (DAS), erosi merupakan masalah yang cukup signifikan karena dapat menurunkan produktivitas tanah dan meningkatkan sedimentasi sehingga memperpendek umur waduk. Tujuan dari penelitian ini adalah untuk mengkaji nilai prediksi erosi di Sub DAS Alue Geudubang, Kabupaten Aceh Utara. Metodologi penelitian ini meliputi survei yang meliputi tahap persiapan, survei pendahuluan, survei utama, analisis data, dan penyajian hasil. Prediksi erosi dihitung dengan menggunakan *Universal Soil Loss Equation* (USLE). Hasil penelitian menunjukkan bahwa nilai prediksi erosi tertinggi terdapat pada SPL 10, yaitu lahan kebun campuran dengan kepadatan rendah, kemiringan lereng 0-8%, dan jenis tanah Inceptisol sebesar 327,57 ton/ha/thn (ETol = 26,78 ton/ha/thn). Sementara itu, nilai prediksi erosi terendah terdapat pada SPL 1 dengan tata guna lahan hutan, kemiringan lereng 0-8%, dan jenis tanah Ultisol, yaitu sebesar 5,01 ton/ha/thn (ETol = 16,17 ton/ha/thn). Teknik konservasi tanah yang disarankan untuk SPL 10 adalah dengan memperbaiki pola tanam, seperti

penanaman pola rapat air yang dikombinasikan dengan pembuatan bedengan tanaman, sehingga laju erosi dapat ditekan hingga mencapai 9,83 ton/ha/thn (ETol = 26,78 ton/ha/thn).

Kata Kunci : Erosi, Toleransi Erosi, Teknik Konservasi Tanah

INTRODUCTION

The high rate of development and the increasingly rapid increase in population are part of land competition (Martanto *et al*., 2020). This will trigger land use that is not in accordance with land capabilities. Besides that, land use that does not include soil and water conservation methods will also have an impact on erosion (Rahmi *et al*., 2019). Another cause that accelerates the process of leaching and thinning of soil layers is due to land conversion, resulting in a reduction in soil organic matter which will result in poor physical and chemical properties of the soil (Anisah *et al*., 2021).

It is recognized that the conversion of forest land into other land use areas causes many problems such as erosion, decreased soil fertility, extinction of flora and fauna, floods, droughts and even global environmental changes (Mataputung *et al*., 2019). This problem gets worse over time as the forest area becomes smaller.

The Alue Geudubang sub-watershed is one of the sub-watersheds of the Krueng Keureuto watershed which is located in Aceh Utara Regency. The Alue Geudubang sub-watershed currently has land use consisting of oil palm plantations covering an area of 3,899.05 ha and mixed plantations covering an area of 1,674.87 ha, while the forest area is only around 486.90 ha (DLHK Aceh, 2021).

The Alue Geudubang sub-watershed is viewed from its land cover, the forest area has begun to decrease so that the natural absorption capacity is also increasingly depleted, this is due to the conversion of land from forest to state-owned oil palm plantations and community-owned oil palm plantations funded by the Management Agency Palm Oil Plantation Fund (BPDPKS) and used as mixed plantation land. The reality in the field, especially in community-owned oil palm plantations and mixed plantation land, does not follow the rules of soil conservation either vegetatively or mechanically. Planting plants without using soil conservation techniques can cause several problems, including soil erosion (Idjudin, 2012). Based on the problems that exist in the field, it is necessary to calculate erosion predictions and apply conservation techniques in the Alue Geudubang Sub-watershed, Aceh Utara Regency.

RESEARCH PURPOSES

This study aims to determine the predictive value of erosion and efforts to apply soil conservation techniques in the Alue Geudubang Sub-Watershed, Aceh Utara Regency

RESEARCH METHOD

Tools and materials

The research was conducted in the Alue Geudubang River Watershed Sub-Watershed, a part of the Krueng Keureuto Watershed located in the Aceh Utara Regency.

The tools used include soil type map, slope map, land use map, rainfall data, GPS (Geographic Positioning System), Abney level, soil drill, sample ring, meter, analytical scale, measuring flask, burette, 2 mm sieve, watch glass, shaker bottle, aluminium cup, stir bar, writing utensils, and a set of computer tools.

The materials used in this research include H_2O_2 10% and 30%, sodium pyrophosphate ($Na_4P_2O_7.10H_2O$), distilled water, $K_2Cr_2O_7$ 1N, H_2SO_4, H_3PO_7 85%, and $FeSO_4$ 1N.

The survey method was used for this research, and erosion calculations were done using the Universal Soil Loss Equation (USLE) :

$$A = R \times K \times L \times S \times C \times P$$

which includes factors such as rain erosivity (R), soil erodibility (K), length slope (L), slope steepness (S), land cover (C), and conservation practice (P).

Tolerable erosion (ETol).

Tolerable erosion (ETol) was calculated based on the Wood and Dent (1983). Tolerable erosion also measures the minimum depth of soil, rate of soil formation, equivalent depth and resource life with the following equation :

$$E_{Tol} = \frac{DE - D_{min}}{UGT} + LPT$$

The Erosion Tolerance (E-Tol) is measured in millimeters per year, and the Equivalent Depth (DE) is calculated as the product of De and fd. De represents the Effective Depth of soil in millimeters, and fd is the Soil Depth Factor based on Soil Sub Order. The minimum soil depth (Dmin) is also measured in millimeters. Additionally, we consider the Land Use Age (UGT) in years and the Soil Formation Rate (LPT).

RESULTS AND DISCUSSION

Land Map Units

Results and Discussion: Land Map Units (SPL) are obtained from the overlay of land use, soil type, and slope maps. The overlay resulted in the map shown in Table 1. The Soil and Slope Type (SST) map is the base map for determining observation points and collecting data in the field. Intensive observation for erosion predictions is required for SPL 1, 2, 3, 4, 6, and 10 can be seen in Table 1.

Table 1. Land Map Units in the Alue Geudubang Sub-Watershed

SPL	Slope (%)	Type of Soil	Land Use
1	0 - 8	Ultisol	Forest
2	9 - 15	Ultisol	Plantation
3	0 - 8	Ultisol	Mixed Garden
4	16 - 25	Ultisol	Plantation
5	0 - 8	Ultisol	Settlement
6	0 - 8	Ultisol	Plantation
7	0 - 8	Ultisol	Rice Field
8	0 - 8	Inceptisol	Rice Field
9	0 - 8	Inceptisol	Settlement
10	0 - 8	Inceptisol	Mixed Garden

Erosion predictions

The erosion predictions are calculated using the Universal Soil Loss Equation (USLE) for each land map unit (SPL) in the Alue Geudegang Sub-watershed. The table shows that the highest erosion prediction value is associated with scrubland and dry land agriculture can be seen in Table 2.

Table 2. Erosion Prediction Values for Each Land Map Unit

SPL	R	K	LS	C	P	A (ton/ha/th)
1	818,59	0,947	0,81	0,2	0,04	5,01
2	818,59	0,912	1,64	0,5	0,15	92,04
3	818,59	0,296	0,31	0,2	1,00	15,22
4	818,59	1,024	2,63	0,5	0,15	165,18
6	818,59	0,692	0,68	0,5	1,00	193,73
10	818,59	0,930	0,86	0,5	1,00	327,57

Land map unit 1 with forest land use, slope of 8.89%, Ultisol soil type has an erosion prediction value of 5.01 tonnes/ha/yr. Based on this data, the erosion prediction value is lower than the tolerance erosion value, namely 16.17 tonnes/ha/yr. This is in line with research by Rusnam *et al*., (2013), one of the reasons why forests have a low erosion prediction value is because forests have dense canopies and strong roots so their ability to withstand the erosivity of rain is very large.

Land map unit 2 with oil palm plantation land use managed by the government obtained an erosion prediction value of 92.04 tonnes/ha/yr (Etol = 27.31 tonnes/ha/yr). The high erosion prediction value at SPL 2 is due to the imperfect application of soil conservation techniques.

Bench terraces with imperfect construction will affect their effectiveness in preventing erosion. According to research by Anau *et al*., (2021), it shows that on agricultural land that implements bench terraces, there will be a very large reduction in sediment, so erosion will also be reduced.

Land map unit 3, whose land use is mixed plantation, namely planted with areca nut, banana and medicinal plants, results in erosion prediction calculations of 15.22 tonnes/ha/yr (Etol = 18.71 tonnes/ha/yr). The reason for the low erosion prediction value is due to the use of the land as a mixed plantation with high density. This is in line with research by Alviyanti (2006) where the intercropping farming system of peanuts and corn causes less erosion compared to the monoculture farming system of corn and monoculture peanuts.

Land map unit 4 with land use as oil palm plantations obtained an erosion prediction value of 165.18 tonnes/ha/yr (ETol = 25.02 tonnes/ha/yr). The high erosion prediction value at SPL 4 was due to the implementation of soil conservation techniques that were not perfect, plus the slope at SPL 4 is rather steep (26.67%.). According to Dewi *et al*., (2012) the slope and length of the slope greatly influence the amount of erosion that occurs, the greater the value of the slope and length of the slope, the greater the volume of surface flow that occurs and water entering the soil (infiltration) will decrease, resulting in erosion occurs.

Land map unit 6, which is used for oil palm plantations managed by the community, has an erosion prediction value of 193.73 tonnes/ha/yr (ETol = 24.96 tonnes/ha/yr). The high erosion value is due to the lack of soil conservation in the oil palm plantations. Additionally, the plant spacing does not follow the rules for planting oil palm, resulting in empty land without soil cover at SPL 6. This leads to the high erosion value. Aprisal and Junaidi (2010) noted that the low density of ground cover vegetation results in high surface flow rates, as there is a lot of open space on the ground. Land with dense vegetation generally absorbs more water and reduces the impact of rainwater due to the presence of litter on the ground surface and the existing plant canopy.

Land map unit 10 is used for mixed gardens planted with bananas and eggplants and has an erosion prediction value of 327.57 tonnes/ha/yr (ETol = 26.78 tonnes/ha/yr). The absence of conservation techniques applied to this unit has resulted in quite high erosion values. At SPL 10, the soil texture is dominated by dust, making it more easily carried by surface water. According to Lanyala *et al*., (2016), soil with a high dust content easily experiences erosion due to the fine particle size, which is easily carried away by water when it rains. Meanwhile, Rusdi *et al*., (2013) stated that fine sand and dust are soil particles that influence the soil's sensitivity to erosion. The soil will erode more easily with higher dust content and lower organic matter, and soil with a dust content of 40-60% is very sensitive to erosion.

Erosion Tolerance

Erosion Tolerance (E-Tol) is the maximum average soil erosion permitted to ensure that soil productivity is not reduced. The results of calculating E-Tol value can be seen in Table 3.

Table 3. Erosion Tolerance Values for Each SPL in the Alue Geudubang Sub-Watershed

SPL	De (mm)	fd	D	UGT	LPT	BD g/cm3)	A (ton/ha/thn)	ETol (ton/ha/thn)
1	1050	0,80	750	250	1	1,32	5,01	16,17
2	1200	0,80	500	250	1	1,27	92,04	27,31
3	850	0,80	500	250	1	1,29	15,22	18,71
4	1080	0,80	500	250	1	1,31	165,18	25,02
6	1100	0,80	500	250	1	1,28	193,73	24,96
10	1000	0,95	500	250	1	1,26	327,57	26,78

Soil Conservation Efforts

Efforts to minimize the predictive value of erosion can be achieved by implementing soil conservation techniques and plant management measures. According to Febrianti (2000), conservation action factors are measures that can be taken to reduce the rate of erosion on the land surface in consideration of rainfall, soil type, and slope, while also taking into account cropping patterns. These conservation actions are cost-effective and can be implemented to reduce soil loss annually. Land map units with an erosion prediction value lower than the tolerance erosion value must be maintained or subjected to soil conservation techniques to minimize soil loss as seen in Table 4.

Table 4. Erosion Prediction Values After Soil Conservation Actions in the Alue Geudubang Sub Watershed

SPL	R	K	LS	C	P	A ton/ha/thn	ETol (ton/ha/thn)	information
1	818,59	0,94	0,81	0,2	0,040	5,01	16,17	low
2	818,59	0,91	1,64	0,5	0,013	7,98	27,31	low
3	818,59	0,30	0,31	0,2	0,537	8,17	18,71	low
4	818,59	1,02	2,63	0,5	0,009	9,91	25,02	low
6	818,59	0,69	0,68	0,5	0,050	9,69	24,96	low
10	818,59	0,93	0,86	0,1	0,150	9,83	26,78	low

The erosion predictions for land map unit 1 are below the erosion tolerance value, indicating that soil and water conservation efforts are not necessary. Instead, it is important to maintain and protect the existing land use to prevent an increase in erosion.

Land map unit 2 with oil palm cultivation requires soil conservation measures as the current bench terraces are not fully effective in preventing erosion. Using palm fronds as mulch can help

reduce erosion from 92.04 tons/ha/year to 7.98 tons/ha/year. Another approach suggested by Akbar (2015) is to use mulch to protect the soil and create favorable conditions for microorganisms. Similarly, for land map unit 3 with mixed garden land use, the existing planting pattern needs to be maintained since the erosion prediction value is lower than the erosion tolerance value.

Land map unit 4, which is designated for oil palm plantation land use, shows a very high erosion prediction value of 165.18 tons/ha/year. This is primarily due to suboptimal soil conservation measures. The impact is significant due to the steep slope level at SPL 4, which is approximately 26.67%. Addressing this issue requires effective soil conservation measures. One possible solution is to plant peanuts in the bench terrace area to reduce the predicted rate of erosion. The peanuts planted would be part of intercropping activities. Peanuts can contribute to soil health by providing nitrogen, fostering beneficial bacteria for core crops, and offering shade for the soil from rainwater. The intercropping of peanuts should not adversely affect the growth of core crops (Ridaeny, 2019).

Land map unit 6, which is used for oil palm plantation, does not have any soil conservation measures in place. As a result, the predicted erosion value exceeds the tolerance limit at 193.73 tons/ha/year. However, it is possible to reduce the erosion prediction value to 9.69 tons/ha/year by implementing peanut strips within the oil palm plantations and utilizing the plant residues as mulch. This aligns with research by Sinukaban (2007), which suggests that strip planting can significantly reduce erosion and surface runoff. The study found that strip widths of 6 or 9 rows of plants can reduce surface runoff by 29.8% and 35% respectively, and erosion by 35.4% and 42.3% compared to areas without strips. It's worth noting that strip planting is only effective for land with a slope of no more than 8%. Additionally, incorporating mulch from plant residues can enhance soil fertility, structure, and water reserves, while also preventing weed growth and acting as a barrier against rainwater entering the soil (Daromes, 2021).

As for land map unit 10, which is used for mixed garden cultivation (bananas and eggplants) and lacks conservation measures, it displays the highest erosion prediction value at 327.57 tons/ha/year.

The erosion issue at SPL 10 can be mitigated through appropriate conservation measures. Recommendations include implementing a high-density planting pattern and creating beds for the plants. High-density planting patterns can help prevent erosion. Research by Supangat et al. (2018) demonstrated that high vegetation density can decrease runoff by 35% and sedimentation by 34% on post-logging land. Utilizing raised beds in conjunction with dense planting can also reduce erosion. Implementing raised beds followed by planting and cutting the slopes with appropriate planting distances can effectively minimize erosion. (Banuwa, 2013).

CONCLUSION

1. The highest erosion prediction is at SPL 10, where the land use is a mixed plantation with a slope of 8.89% and Inceptisol soil type. The erosion rate is predicted to be 327.57 tons/ha/year, with an E-Tol value of 26.78 tons/ha/year.

2. The lowest erosion prediction is at SPL 1, with forest land use, a slope of 8.89%, and Ultisol soil type. The erosion rate is predicted to be 5.01 tons/ha/year, with an E-Tol value of 16.17 tons/ha/year. Conservation measures needed: 2. Land map unit 1 with forest land use requires light conservation measures such as providing plant litter and the need for good maintenance and care of existing conditions so that erosion does not increase.
3. Land conservation measures that need to be carried out at SPL 2 are by providing leaf litter as mulch, SPL 3 by planting citronella plants, SPL 4 by intercropping with peanut plants, SPL 6 by making peanut strips in oil palm planting and using plant residues as mulch, as well as at SPL 10 by carrying out a high-density planting pattern and making beds for the plants to be planted.

REFERENCES

[DLHK] Dinas Lingkungan Hidup dan Kehutanan. 2021. Data Penutupan Lahan, Data Kemiringan Lereng, dan Data Jenis Tanah. Krueng Aceh, Provinsi Nanggroe Aceh Darusalam.

Akbar, H. 2015. Evaluasi Kemampuan Lahan dan Teknik Konservasi di DAS Krueng Seulimum Kabupaten Aceh Besar. Fakultas Pertanian. Universitas Malikussaleh. Aceh Utara. *Jurnal Agrium*. 12 (1) : 44-49.

Alviyanti, V. 2006. Kajian Erosi Dan Aliran Permukaan Pada Berbagai Sistem Tanam Di Tanah Terdegradasi. *Skrisi*. Departemen Pendidikan Nasional, Fakultas Pertanian, Universitas Jember.

Anau, R., Rumambi, D,., & Kalesaran, L. 2021. Pengaruh Teras Bangku Dalam Mengurangi Erosi Tanah Pada Lahan Pertanian Di Desa Ponompiaan Kabupaten Bolaang Mongondow. Jurusan Teknologi Pertanian. Fakultas Pertanian. Universitas Sam Ratulangi. Manado. Indonesia.

Anisah, A.P., Ju, B.A., Tang, A., Zikra, E., Weley, N.C., & Fitri, W. 2021. Dampak Alih Fungsi Lahan Terhadap Keberlanjutan Suplai Air Bersih Dalam Menjaga Ekosistem Darat. *Jurnal Syntax Admiration*, 2 (12), 2247-2259.

Aprisal & Junaidi. 2010. Prediksi Erosi dan Sedimentasi Pada BerbagaiPenggunaan Lahan di Sub DAS Limai Manis Pada DAS Kuranji KotaPadang. *Jurnal Solum*, VII, 61-67.

Daromes, M.S.B., Mawara, J.M., Sinolungan, M.T.M. 2021. Pengaruh MulsaBatang Jagung Dan Strip Rumput Terhadap Erosi Tanah Pada Lahan Kering.*Soil Environmental*, 21 (3), 12-17.

Dewi, I.G.A.S.U., Trigunasih, N.M., & Kusmawati, T. 2012. Prediksi Erosi dan Perencanaan Konservasi Tanah dan Air pada DAS Saba. *Jurnal Agroekoteknologi Tropika,* 1 (1).

Febrianti, V. 2000. Prediksi erosi tanah dengan penggunaan bahan organik untuk konservasi tanah di DAS Cisadane hulu. *Skripsi*. Fakultas Teknologi Pertanian Institut Pertanian Bogor.

Idjudin, A. A. 2012. Peranan Konservasi Lahan dalam Pengelolaan Perkebunan. *Jurnal Sumberdaya Lahan*, 5 (2), 103-116.

Lanyala, A.A.A., Hasanah, U., & Ramlan. 2016. Prediksi Laju Erosi Pada Penggunaan Lahan Berbeda di Daerah Aliran Sungai (DAS) Kawatuna Provinsi Sulawesi Tengah. *e-J Agrotekbis*, 4 (6), 633-641.

Martanto, R., Sufyendi, Y., & Kistiyah, S. 2020. Pola Konversi Penggunaan LahanUntuk Zonasi Ketahanan Pangan Berkelanjutan Di Daerah Istimewa Yogyakarta, Indonesia. *Skripsi*. Sekolah Tinggi Pertanahan Nasional,Yogyakarta.

Mataputung, S.M., Nurmawan, W., & Sumakud, M.Y.M.A. 2019. Inventarisasi Pola Agroforestri Di Desa Tonsea Lama Kecamatan Tondano Utara Kabupaten Minahasa. *Eugenia*, 25 (2), 46-53.

Rahmi, N. 2019. *Kajian Kondisi Fisik Tanah Akibat Alih Fungsi Lahan Hutan Menjadi Lahan Jagung Di Desa Songgajah Kabupaten Dompu*. (Skripsi di Terbitkan). Program Studi Teknik Pertanian, Fakultas Pertanian, UniversitasMuhammaddiyah Mataram, Indonesia.

Ridaeny, M.S. 2019. Pemanfaatan Lahan Pada Areal Tanam Kelapa Sawit Belum Menghasilkan (TBM) Dengan Membudidayakan Kacang Tanah. Program Studi Agribisnis, Fakultas Pertanian, Universitas Lancang Kuning, Riau.

Rusdi., Alibasyah, M.R., & Karim, A., 2013. Degradasi Lahan Akibat Erosi pada Areal Pertanian di Kecamatan Lembah Seulawah Kabupaten Aceh Besar. *J. Manajemen Sumberdaya Lahan*, 2 (3), 240-249.

Rusnam, E.G., Ekaputra & E. M. Sitanggang. 2013. Analisis spasial besaran tingkaterosi pada tiap satuan lahan di sub DAS Batang Kandis. *Jurnal Teknik Lingkungan UNAND*, 10 (2), 149-167.

Sinukaban, N. 2007. Konservasi Tanah dan Air Kunci Pembangunan Berkelanjutan. Direktorat Jendral RLPS dan Institut Pertanian Bogor.

Sulastri, Adnyana, I.W.S., Merit, I.N. 2015. Perencanaan Penggunaan Lahan Melalui Pendekatan Prediksi Erosi Dan Klasifikasi Kemampuan Lahan Di Daerah Aliran Sungai Koloh Pasiran Lombok Timur. *Ecotrophic*, 9 (1). 63- 71.