The influence of land cover variation on soil erosion vulnerability around coal mining concession areas in South Borneo

by Kehutanan turnitin

Submission date: 16-Jun-2024 10:45AM (UTC+0700)
Submission ID: 2403213870
File name: the_influence_of_land_cover_anggota.pdf (700.57K)
Word count: 5311
Character count: 27379

JOURNAL OF DEGRADED AND MINING LANDS MANAGEMENT
Volume 10, Number 2 (January 2023):4289-4295, doi:10.15243/jdmlm.2023.102.4289
ISSN: 2339-076X (p); 2502-2458 (e), www.jdmlm.ub.ac.id

Research Article

The influence of land cover variation on soil erosion vulnerability around coal mining concession areas in South Borneo

Supandi[1], Yudha Hardiyanto Eka Saputra[1], Yusanto Nugroho[2], Suyanto[2], Gusti Syeransyah Rudy[2], Pandu Yudha Adi Putra Wirabuana[3*]

[1] PT Borneo Indobara, Jln. Propinsi km 180, Angsana, Tanah Bumbu 72275, South Kalimantan, Indonesia
[2] Faculty of Forestry, Universitas Lambung Mangkurat, Jln. Jend. A. Yani km 36 Banjarbaru, South Kalimantan, Indonesia
[3] Faculty of Forestry, Universitas Gadjah Mada, Jln. Agro No. 1 Bulaksumur, Sleman 55281, Yogyakarta, Indonesia

[*]corresponding author: pandu.yudha.a.p@ugm.ac.id

Article history:
Received 25 September 2022
Accepted 9 December 2022
Published 1 January 2023

Keywords:
erodibility
slope
soil conservation
USLE
vegetation

Abstract

The availability of information about soil erosion vulnerability is necessary as a primary consideration to determine the effort of soil conservation, particularly in the coal mining area. This study aimed to estimate the potential risk of soil erosion from land cover variation in a coal mining concession site in South Borneo. Data were taken from 18 stations of soil erosion monitoring which were evenly distributed in each land cover. Soil erosion vulnerability was quantified using the Universal Soil Loss Equation (USLE) method. The comparison mean of soil erosion among land cover types was evaluated using the Kruskal-Wallis test and followed by the Nemenyi test with a significant level of 5%. Results found that the potential risk of soil erosion was significantly different among land covers ($p<0.05$). The highest soil erosion vulnerability was noted in the reclamation area of 1,012.3 t ha^{-1} year^{-1}, while the lowest risk of soil erosion was observed in plantation forests of 47.9 t ha^{-1} year^{-1}. Surprisingly, the potential risk of soil erosion in natural forests was four times higher than in oil palm plantations. Besides being located in hilly areas with high slope levels, the vegetation density in natural forests was relatively low. However, our study recorded there were two critical factors that highly correlated to soil erosion vulnerability, i.e., soil erodibility ($R = 0.89$; $p<0.05$) and slope length and steepness ($R = 0.85$; $p<0.05$).

To cite this article: Supandi, Saputra, Y.H.E., Nugroho, Y., Suyanto, Rudy, G.S. and Wirabuana, P.Y.A.P. 2023. The influence of land cover variation on soil erosion vulnerability around coal mining concession areas in South Borneo. Journal of Degraded and Mining Lands Management 10(2):4289-4295, doi:10.15243/jdmlm.2023.102.4289.

Introduction

Soil conservation has become the most critical issue in natural resource management, primarily in the tropics. It is inseparable from the high rate of land degradation over the last periods. The problem has some negative impacts on the environmental condition, such as soil fertility loss and food supply instability (Gomiero, 2016). To solve this problem, a soil conservation strategy is required to maintain land productivity (Nkegbe, 2013). However, this effort is only possible if the land managers have adequate information about the essential factors that influence land degradation, such as natural disturbance, soil erosion, forest fire, land conversion, and environmental contamination (Wijitkosum, 2021).

Among these factors, the potential risk of soil erosion becomes the most fundamental aspect that should be considered to determine the soil conservation scheme. In general, soil erosion is a natural mechanism that becomes part of ecosystem dynamics. It occurs slowly but can reduce soil fertility over continuous time (Achasov et al., 2019). Besides scraping the soil horizon, it also leaches several nutrients from the top soil layer (Bashagaluke et al., 2018). This process is caused by the dynamic activity of erosive agents, like water and wind, that interact with land components such as vegetation and topography (Issaka and Ashraf, 2017). Therefore, soil erosion over a long time can cause land degradation and lead to a food crisis since there are insufficient nutrients to support plant growth (Gupta, 2019). Thus, land productivity will decline along with increasing time. In this situation, the periodic monitoring of soil erosion vulnerability is highly required to minimize the risk of land degradation (Tsymbarovich et al., 2020). It will also help to determine the alternative treatments that can be applied to inhibit the rate of soil erosion, especially in the land with important functions for food estate and water catchment. This program has been applied in several commercial industries, including coal mining.

Coal mining is one of the biggest sectors that contributes to improving gross domestic products after the oil and gas industry. The use of open-pit systems for coal exploration consequently provides soil disturbance and increases the potential risk of soil erosion vulnerability. Therefore, the monitoring of soil erosion in coal mining concession areas is essentially required because it is one of the company's obligations related to environmental preservation. In this case, the information about soil erosion dynamics can be used to evaluate the company's compliance with maintaining environmental sustainability (Jiang et al., 2022). It also becomes one of the fundamental parameters for assessing the effectiveness of reclamation activity in post-mining zones (Ramli et al., 2020). The successful reclamation ideally can reduce the risk of soil erosion along with the time since there are vegetation density increments (Hu et al., 2020). However, the variation of land cover in coal mining sites does not only consist of production and reclamation zones.

Other land cover types with high variation in topography, such as natural forests, plantations, shrubs, etc. It indicates that the potential risk of soil erosion may vary in the coal mining concession area. Therefore, it is essential to document the soil erosion vulnerability from every land cover as a fundamental consideration to formulate alternative strategies for soil conservation in the coal mining site.

This study aimed to estimate the potential risk of soil erosion from different land covers around coal mining concession areas. First, soil erosion was quantified using the universal soil loss equation (USLE) method (Inoue et al., 2015). Then, further analysis was also conducted to investigate the most critical factor influencing the variety of soil erosion among land cover types.

Materials and Methods

Study area

The study site was located in a coal mining concession area managed by PT Borneo Indobara. This area has geographical coordinates in E115°39'00"-115°54'38" and S3°35'30"-3°36'30" (Figure 1). It is situated in Tanah Bumbu District, South Kalimantan Province. The total area reaches 24,100 ha, divided into four compartments to support the mining activities, i.e. Batulaki, Bunati, Kusan, and Girimulya. Although it was managed as a coal mining zone, other land uses still existed on this site, such as natural forests, oil palm plantations, shrubs, plantation forests, and reclamation blocks. Altitude ranges from 20 to 52 m above sea level. Hilly areas dominate land configuration with a slope level of 8-26%. The average daily temperature is 27.7 °C with a minimum of 22.7 °C and a maximum of 35.2 °C. The mean annual rainfall was 2,291.7 mm year$^{-1,}$ with an average air humidity of 82%. The highest rainfall intensity occurs from December to January. Dry periods are relatively more extended than four months from Juli to November.

Data collection

Spatial analysis using the overlay method was applied to identify the land variation in the coal mining concession area. Four kinds of maps were used to facilitate this step, i.e. concession area map, land cover map, rainfall map, and slope map. These data were obtained from PT Borneo Indobara, the holder of the mining concession site. Then, several sampling points were placed in every land variation using the purposive method. Two important factors were considered to determine the sampling positions, including the distribution of environmental monitoring stations and the type of land cover variation (Table 1).

Afterwards, several parameters were measured from each location, like land cover type, soil conservation method, and slope gradient. In addition, soil sampling was also implemented to asses soil depth, texture, structure, permeability, and soil organic matter (SOM). The quantification of soil depth was conducted by soil drilling. Afterwards, the soil sample was composited in each land cover and brought to the laboratory for quantifying their attributes. Soil texture was determined using the pipette method, while soil structure was assessed quantitatively using the hydrometer method. Soil permeability was evaluated using the constant head and falling head methods. SOM was estimated by Walkley and Black method (Estefan et al., 2013).

The potential risk of soil erosion was estimated using Universal Soil Loss Equation (USLE) (Girmay et al., 2020). It is an empirical method to quantify the average annual soil loss generated from rainfall and runoff (Boakye et al., 2020). It is commonly applied to estimate soil erosion vulnerability at a landscape level, such as in agriculture, forestry, plantations, etc. (Alewell et al., 2019). The detailed equation is expressed below:

$$A = R \times K \times LS \times C \times P$$

where A is the mean annual soil erosion (t ha^{-1} year^{-1}), R indicates the factor of rainfall-runoff erosivity (MJ mm ha^{-1} h^{-1} year^{-1}), K is the soil erodibility factor (t ha MJ^{-1} mm^{-1}), LS is the slope length and steepness factor, C is cover management factor, and P is the supporting soil conservation practice factor. The average soil erosion (A) was obtained on a grid-by-grid basis by integrating the respective data with GIS.

The rainfall erosivity factor (R) explains the ability of rain to cause erosion. It includes several rain characteristics such as drop size, intensity, frequency, and distribution (Dai et al., 2020). Higher R shows a high potential for soil detachment and transport. The R was derived from annual rainfall data using the Lenvain equation as follows (Limbong et al., 2021):

$$R = 2.21 \times Pi^{1.36}$$

where Pi is the amount of annual rainfall (mm).

Soil erodibility (K) indicates the degree of soil sensitivity and resilience to release from its aggregate caused by rainfall as the erosive agent. It is determined by considering several soil parameters like texture, structure, permeability, and soil organic matter (Olaniya et al., 2020). The high K implies the soil is exceptionally susceptible to detachment. The K was computed by using an equation from Wichmeier and Smith as presented below (Oda et al., 2022):

$$K = \{1.292\ (2.1 \times M^{1.44} \times (10^{-4}) \times (12\text{-}a) + 3.25 \times (b\text{-}2) \times 2.5 \times (c - 3)\} \times 10^{-2}$$

where M is soil texture derived from the relationship between soil fraction (very fine sand, silt, and clay), a indicates the percentage of soil organic matter, b is soil structure index, and c describes soil permeability index. The categories of soil structure and permeability index are presented in Tables 2 and 3.

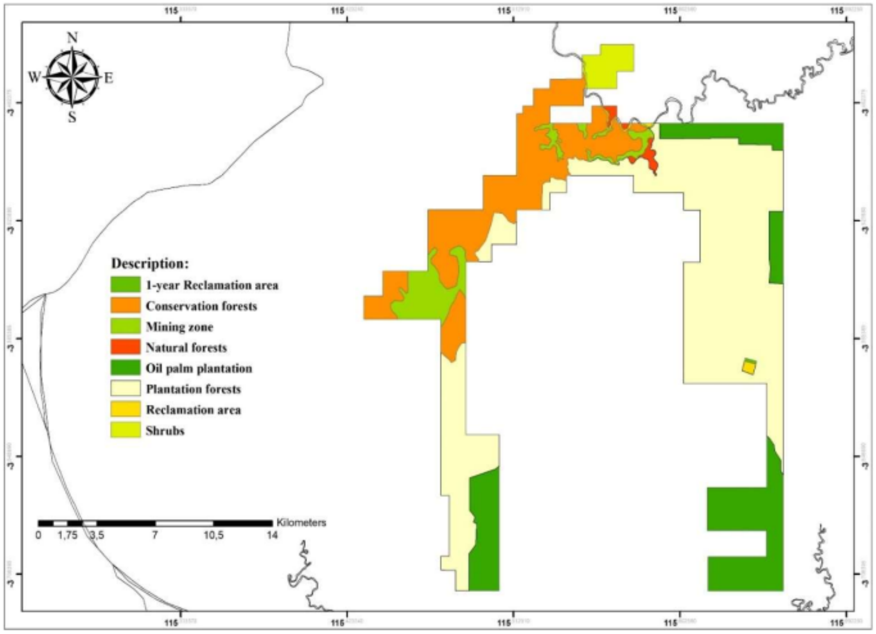

Figure 1. Location of coal mining concession area owned by PT Borneo Indobara in South Kalimantan.

Table 1. Land variation and number of monitoring stations for environmental assessment in PT Borneo Indobara.

Land variation	Symbol	Stations	C-factor*	P-factor**
Natural forests	NF	3	0.1	1
Oil palm plantation	OPP	3	1.5	0.35
Shrubs	SR	3	0.15	0.35
Plantation forests	PF	3	0.15	0.35
High conservation value forests	HCV	3	0.3	1
Reclamation	RA	3	1	0.35

Source: * Boakye et al. (2020);**Arsyad (2010).

Table 2. Classification of soil structure index for soil erodibility determination.

Soil structure	**Index value**
Very fine granular	1
Fine granular	2
Coarse granular	3
Clumpny, platey, blocky	4

Source: Arsyad (2010).

Table 3. Classification of soil permeability index for soil erodibility determination.

Soil permeability (cm h^{-1})	**Index value**
<0.5	6
0.5-2.0	5
2.0-6.3	4
6.3-12.7	3
12.7-25.4	2
>25.4	1

Source: Arsyad (2010).

The slope length and steepness factor (*LS*) describes the Impact of topography on soil erosion. It is calculated based on slope length (*L*) and steepness (*S*). The *LS* factor was quantified using a model from Wichmeier and Smith as expressed below (Harjianto et al., 2015):

$$LS = (L^{0.5} \times 10^{-2}) \times (1.38 + 0.965 \times S + 0.138 \times S^2)$$

Where *L* is slope length, m shows a constant of slope level, and *S* indicates the percentage of slope level. The m value is divided into three classes, namely, the slope lower than 3% (0.3), the slope between 3-4% (0.4), and the slope higher than 4% (0.5).

The cover management factor (*C*) demonstrated the proportion of soil loss under different land cover types. It reflects the effect of cropping and management practices on erosion. The *C* value implies the degree of soil exposure to raindrops. The high *C* factor generally indicates low vegetation cover; thus, soil erosion is high during rainfall (Boakye et al., 2020). The *C* factor used in this study is presented in Table 1.

The existence of conservation practice (*P*) is considered one of the factors in quantifying the potential risk of soil loss. The *P* shows the effectiveness of conservation efforts like contouring, strip-cropping, terraces, and contouring to inhibit the rate of runoff and erosion (Panagos et al., 2015). The *P*-factor commonly ranges between 1 and 0.01 for bare soils with no erosion measures and fully protected land surfaces, respectively (Arekhi, 2008). The range of P-factor used in this study is shown in Table 1.

Data analysis

Statistical analysis was conducted using R software version 4.1.2 with a significant level of 5%. The MASS and dplyr packages were selected to facilitate the data processing (O'Dell et al., 2020; Padilla-Martínez et al., 2020). The first step started with a descriptive test to assess the data attributes, i.e., mean, standard deviation, standard error, minimum, and maximum (Sadono et al., 2021). It was also done to evaluate the coefficient of variation and precision. Both parameters were commonly used to check the accuracy and precision of data (Santos and Dias, 2021). The next stage was related to assumption tests. Two assumption tests were used for data evaluation, including normality and homogeneity of variance tests (Ghasemi and Zahediasl, 2012; Beyene, 2016). The normality test was done using the Shapiro-Wilk test, while the homogeneity of variance test was processed using Bartlett's test (Wirabuana et al., 2021a). These tests were undertaken twice, wherein the first round was processed using the actual data, and the second round was done using natural logarithmic transformation from the data. However, the second round was only applied if the actual data did not follow normal distribution nor had heterogeneous variance. The outcome of the initial test indicated that the data did not fulfill both assumptions. Therefore, non-parametric tests using Kruskal Wallis and Nemenyi tests were applied to compare the average soil erosion vulnerability among land covers (Wirabuana et al., 2021b). The analysis of correlation was also used to test the relationship between erosivity factors and soil erosion vulnerability.

Results and Discussion

Soil characteristics

Summarized results of the observations reported that soil properties exceptionally varied among land covers (Table 4). This study found that the soil texture in natural forests, oil palm plantations, and high conservation value forests was predominantly by the sand fraction. In contrast, the clay fraction dominated soil texture in shrubs, plantation forests, and reclamation areas. The highest soil organic matter was noted in PF (1.79±0.34%), followed by SR (1.05±0.35%), NF (0.99±0.05%), HCV (0.93±0.03%), RA (0.81±0.43%), and OPP (0.65±0.29%). In addition, PF also indicated the highest permeability by around 4.77±1.43 cm h^{-1}. The distribution of soil fraction among land covers demonstrated different weathering intensities. Soil with higher clay content indicated a longer weathering process than soil dominated by a sand fraction (Alam et al., 2020). It also directly implied there was more intensive leaching caused by runoff. The leaching could reduce soil fertility because it loses several nutrients from the topsoil (Kuo et al., 2020). Nevertheless, this study noted plantation forests had the highest soil organic matter even though their soil was dominated by clay. It could happen because there was an amount of litterfall on the forest floor. Litterfall could be sourced from leaves or branches that decayed from trees.

Table 4. Soil attributes from land use and land cover classes in the study area.

Land variation	**Soil fraction**				**SOM (%)**	**Permeability (cm h^{-1})**
	Sand (%)	**Silt (%)**	**Clay (%)**	**Fine Sand (%)**		
NF	55.56±4.11	12.65±1.23	31.48±3.08	0.3±0.21	0.99±0.05	4.24±1.07
OPP	39.63±12.84	25.15±2.75	35.11±11.99	0.78±0.16	0.65±0.29	3.3±0.36
SR	14.06±4.25	29.71±4.91	54.33±3.04	1.91±0.88	1.05±0.35	4.44±0.24
PF	15.75±1.73	25.98±3.33	57.53±3.62	0.74±0.39	1.79±0.34	4.77±1.43
HCV	66.78±1.44	5.11±3.49	27.66±2.09	0.45±0.05	0.93±0.03	3.38±0.15
RA	34.46±1.44	11.00±1.11	53.61±2.71	0.93±0.6	0.81±0.43	1.14±0.15

Notes: NF (natural forests), OPP (oil palm plantations), SR (shrubs), PF (plantation forests), HCV (high conservation value forest), RA (reclamation area), SOM (soil organic matter).

In addition, a higher accumulation of organic matter can increase permeability because it can absorb water around three times higher than its mass (Gomyo and Kuraji, 2016). Thus, it could reduce the rate of runoff that stimulates soil erosion.

Erosivity factor

The rainfall erosivity factor (R) was equal in each land cover (Table 5). Nevertheless, there were different values of soil erodibility (K), slope length and steepness (LS), cover management (C), and conservation support practice (P).

The highest K and LS value was noted in RA, with each value of 0.22 and 11.96. Meanwhile, the most significant C factor was found in OPP with a value of 1.50. NF and HCV had an equal value of P factor (1.00), while the range of P factor in other land covers was also similar by approximately 0.35. A higher value of the erosivity factor would result in a more considerable risk of soil erosion (Girmay et al., 2020). The result indirectly addressed that the RA site probably had a higher risk of soil erosion than other locations since its LS factor was considerably higher than other land covers.

Table 5. Soil attributes from land use and land cover classes in the study area.

Land variation	**Average value of erosivity factor**				
	R (KJ mm ha^{-1} h^{-1} $year^{-1}$)	**K (t ha^{-1} KJ^{-1} mm^{-1})**	**LS**	**C**	**P**
NF	1080.24	0.17	6.73	0.10	1.00
OPP	1080.24	0.17	1.01	1.50	0.35
SR	1080.24	0.17	5.03	0.15	0.35
PF	1080.24	0.15	2.70	0.15	0.35
HCV	1080.24	0.16	1.08	0.30	1.00
RA	1080.24	0.22	11.96	1.00	0.35

Note: NF (natural forests), OPP (oil palm plantations), SR (shrubs), PF (plantation forests), HCV (high conservation value forest); RA (reclamation area).

Soil erosion vulnerability

The potential risk of soil erosion was significantly different among land covers (Table 6). The highest soil erosion was recorded in RA (1012.34±46.68 t ha^{-1} $year^{-1}$), while the lowest soil erosion vulnerability was found in PF (21.69±2.99 t ha^{-1} $year^{-1}$). Surprisingly, the soil erosion vulnerability in NF was almost four times higher than in OPP. It could happen because NF is located in a hilly area with a higher slope. This site also had an LS factor six times higher than OPP. Moreover, NF also had lower vegetation density due to the Impact of illegal logging. The declining vegetation density can increase the risk of soil erosion because no inhibitor layer can reduce rainfall kinetic energy (Zhao et al., 2020). When the rainfall drop interacts with the soil, it makes the soil particles detached (Boakye et al., 2020). This study also noted two erosivity factors significantly correlated with the variation of soil erosion in each land cover (Table 7), namely soil erodibility (*K*) and slope length and steepness (*LS*).

Table 6. Soil erosion vulnerability in every land cover around coal mining concession area.

Land variation	**Soil erosion (t ha^{-1} $year^{-1}$)**	**Label**
NF	120.34±32.68	C
OPP	34.09±9.27	B
SR	47.88±1.72	E
PF	21.69±2.99	F
HCV	57.15±16.21	D
RA	1012.34±46.68	A

Note: NF (natural forests), OPP (oil palm plantations), SR (shrubs), PF (plantation forests), HCV (high conservation value forest), RA (reclamation area).

Soil erodibility is principally related to the natural soil properties in the study area. Soil with low organic matter is generally more susceptible to erosion because it has low permeability and weak aggregate stability (Liu et al., 2019).

Table 7. Summary of correlation analysis between erosivity factor and soil erosion vulnerability in the study area.

Erosivity factor	Symbol	Correlation coefficient
Rainfall	R	$<0.001^{ns}$
Soil erodibility	K	0.894^{**}
Slope length and steepness	LS	0.852^{**}
Cover management	C	0.307^{ns}
Conservation support practice	P	-0.250^{ns}

Note: ns (non-significant), ** (significant).

In contrast, the higher organic matter accumulation will strengthen the soil aggregate and increase permeability. Thus it will be more resistant to runoff (Yaşar Korkanç and Şahin, 2021). On another side, higher *LS* indicates a more steep condition that can accelerate the runoff (Siswanto and Sule, 2019). Therefore, conservation support practice like terracing is required to inhibit the steep area's runoff rate.

Conclusion

This study concluded that the highest mean soil erosion in the study site was recorded in RA (1012.34±46.68 t ha^{-1} year^{-1}), while the lowest soil erosion vulnerability was found in PF (21.69±2.99 t ha^{-1} year^{-1}). Among erosivity factors, *K* and *LS* were two critical factors that highly correlated with the vulnerability of soil erosion in the study site. Based on these results, this study suggests that coal mining managers implement conservation support practices like terracing and land rehabilitation. The use of terracing will reduce the rate of runoff, particularly in the steep area. At the same time, the activity of land rehabilitation can increase vegetation density and supply more organic matter to improve soil aggregate and permeability. Further investigations should be conducted to measure the impacts of soil erosion on nutrient loss and land degradation around the coal mining area.

Acknowledgements

The authors address their gratitude to PT Borneo Indobara, which permitted and facilitated this study in its coal mining concession area. The authors also thank Mr. Kinanto Prabu and Mr. Chairul Anwar, who supported data collection.

References

Achasov, A.B., Achasova, A.A. and Titenko, A.V. 2019. Soil erosion by assessing hydrothermal conditions of its formation. *Global Journal of Environmental Science and Management* 5:12-21, doi:10.22034/gjesm.2019.SI.02.

Alam, S., Purwanto, B.H., Hanudin, E.K.O., Tarwaca, E.K.A. and Putra, S. 2020. Soil diversity influences oil palm productivity in ultramafic ecosystems, Southeast Sulawesi, Indonesia. *Biodiversitas-Journal of Biological Diversity* 21:5521-5530, doi:10.13057/biodiv/d211161.

Alewell, C., Borrelli, P., Meusburger, K. and Panagos, P. 2019. Using the USLE: Chances, challenges and limitations of soil erosion modelling. *International Soil and Water Conservation Research* 7:203-225, doi:10.1016/j.iswcr.2019.05.004.

Arekhi, S. 2008. Evaluating long-term annual sediment yield estimating potential of GIS interfaced MUSLE model on two micro-watersheds. *Pakistan Journal of Biological Sciences* 11:270-274, doi:10.3923/pjbs.2008.270.274.

Arsyad, S. 2010. *Soil and Water Conservation*. Second Edition. Bogor: IPB Press (*in Indonesian*).

Bashagaluke, J.B., Logah, V., Opoku, A., Sarkodie-Addo, J. and Quansah, C. 2018. Soil nutrient loss through erosion: Impact of different cropping systems and soil amendments in Ghana. *PLoS One* 13:1-17, doi:10.1371/journal.pone.0208250.

Beyene, K. 2016. Assessing univariate and multivariate homogeneity of variance: a guide for practitioners. *Journal of Mathematical Theory and Modeling* 6:13-17.

Boakye, E., Anyemedu, F.O.K., Donkor, E.A. and Quaye-Ballard, J.A. 2020. Spatial distribution of soil erosion and sediment yield in the Pra River Basin. *SN Applied Sciences* 2:1-12, doi:10.1007/s42452-020-2129-1.

Dai, Q., Zhu, J., Zhang, S., Zhu, S., Han, D. and Lv, G. 2020. Estimation of rainfall erosivity based on WRF-derived raindrop size distributions. *Hydrology and Earth System Sciences* 24:5407-5422, doi:10.5194/hess-24-5407-2020

Estefan, G., Sommer, R. and Ryan, J. 2013. Methods of soil, plant, and water analysis. International Center for Agriculture Research in the Dry Areas.

Ghasemi, A. and Zahediasl, S. 2012. Normality tests for statistical analysis: A guide for non-statisticians. *International Journal of Endocrinology and Metabolism* 10:486-489, doi:10.5812/ijem.3505.

Girmay, G., Moges, A. and Muluneh, A. 2020. Estimation of soil loss rate using the USLE model for Agewmariayam Watershed, northern Ethiopia. *Agriculture & Food Security* 9:1-12, doi:10.1186/s40066-020-00262-w.

Gomiero, T. 2016. Soil degradation, land scarcity and food security: reviewing a complex challenge. *Sustainability* 8:1-41, doi:10.3390/su8030281.

Gomyo, M. and Kuraji, K. 2016. Effect of the litter layer on runoff and evapotranspiration using the paired watershed method. *Journal of Forestry Research* 21:306-313, doi:10.1007/s10310-016-0542-5.

Gupta, G.S. 2019. Land degradation and challenges of food security. *Review of European Studies* 11:63, doi:10.5539/res.v11n1p63.

Harjianto, M., Sinukaban, N., Tarigan, S.D. and Haridjaja, O. 2015. Erosion prediction and soil conservation planning in Lawo watershed Indonesia. *Environmental Earth Sciences* 5:40–51.

Hu, Y., Yu, Z., Fang, X., Zhang, W., Liu, J. and Zhao, F. 2020. Influence of mining and vegetation restoration on soil properties in the eastern margin of the Qinghai-Tibet plateau. *International Journal of Environmental Research and Public Health* 17:1-12, doi:10.3390/ijerph17124288.

Inoue, N., Hamanaka, A., Shimada, H., Sasaoka, T. and Matsui, K. 2015. Fundamental study on assessment of soil erosion by the USLE method at rehabilitation area in an Indonesian coal mine. *Earth Science Research* 4:61-67, doi:10.5539/esr.v4n1p61.

Issaka, S. and Ashraf, M.A. 2017. Impact of soil erosion and degradation on water quality: a review. *Geology, Ecology, and Landscapes* 1:1-11, doi:10.1080/24749508.2017.1301053.

Jiang, H., Fan, G., Zhang, D., Zhang, S. and Fan, Y. 2022. Evaluation of eco-environmental quality for the coal-mining region using multi-source data. *Scientific Reports* 12:1-19, doi:10.1038/s41598-022-09795-5.

Kuo, Y.L., Lee, C.H. and Jien, S.H. 2020. Reduction of nutrient leaching potential in coarse-textured soil by using biochar. *Water* 12:1-15, doi:10.3390/w12072012.

Limbong, A., Barkey, R., Umar, A., Rijal, S., Nursaputra, M. and Chairil, A. 2021. Impact of climate and land use change on the erosion of the upstream Kelara Watershed. *IOP Conference Series Earth and Environmental Sciences* 807:1-14, doi:10.1088/1755-1315/807/2/022033.

Liu, M., Han, G. and Zhang, Q. 2019. Effects of soil aggregate stability on soil organic carbon and nitrogen under land use change in an erodible region in southwest China. *International Journal of Environmental Research and Public Health* 16:1-14, doi:10.3390/ijerph16203809

Nkegbe, P.K. 2013. Soil conservation and smallholder farmer productivity: an analytical approach. *Journal of Management and Sustainability* 3: 92-99, doi:10.5539/jms.v3n2p92.

O'Dell, D., Eash, N.S., Hicks, B.B., Oetting, J.N., Sauer, T.J., Lambert, D.M., Thierfelder, C., Muoni, T., Logan, J., Zahn, J.A. and Goddard, J.J. 2020. Conservation agriculture as a climate change mitigation strategy in Zimbabwe. International *Journal of Agricultural Sustainability* 18:250-265, doi:10.1080/14735903.2020.1750254.

Oda, M., Nwe, Y.Y. and Omae, H. 2022. Locally measured USLE K factor expands sustainable agricultural land in Palau. *F1000 Research* 9:1-18, doi:10.12688/f1000research.22229.4.

Olaniya, M., Bora, P.K., Das, S. and Chanu, P.H. 2020. Soil erodibility indices under different land uses in Ri-Bhoi district of Meghalaya (India). *Scientific Reports* 10: 1-13, doi:10.1038/s41598-020-72070-y.

Padilla-Martínez, J.R., Corral-Rivas, J.J., Briseño-Reyes, J., Paul, C., López-Serrano, P.M. and Gadow, K.V. 2020. Patterns of density and production in the community forests of the Sierra Madre Occidental, Mexico. *Forests* 11:1-14, doi:10.3390/f11030307.

Panagos, P., Borrelli, P., Meusburger, K., van der Zanden, E.H., Poesen, J. and Alewell, C. 2015. Modelling the effect of support practices (P-factor) on the reduction of soil erosion by water at European scale. *Environmental Science and Policy* 51:23-34, doi:10.1016/j.envsci.2015.03.012.

Ramli, M., Purwanto, Thamrin, M., Maemuna, and Asrafil, M. 2020. Analysis of soil erosion in mine area. *IOP Conference Series Material Science and Engineering* 875:1-8, doi:10.1088/1757-899X/875/1/012052.

Sadono, R., Wardhana, W., Wirabuana, P.Y.A.P. and Idris, F. 2021. Allometric equations for estimating aboveground biomass of *Eucalytpus urophylla* S.T. Blake in East Nusa Tenggara. *Journal of Tropical Forest Management* 27:24-31, doi:10.7226/jtfm.27.1.24.

Santos, C. and Dias, C. 2021. Note on the coefficient of variation properties. *Brazilian Electron Journal of Mathematics* 2:1-12, doi:10.14393/BEJOM-v2-n4-2021-58062.

Siswanto, S.Y. and Sule, M.I.S. 2019. The Impact of slope steepness and land use type on soil properties in Cirandu Sub-Sub Catchment, Citarum Watershed. *IOP Conference Series Earth and Environmental Sciences* 393:1-8, doi:10.1088/1755-1315/393/1/012059.

Tsymbarovich, P., Kust, G., Kumani, M., Golosov, V. and Andreeva, O. 2020. Soil erosion: an important indicator for the assessment of land degradation neutrality in Russia. *International Soil and Water Conservation Research* 8:418-429, doi:10.1016/j.iswcr.2020.06.002.

Wijitkosum, S. 2021. Factor influencing land degradation sensitivity and desertification in a drought prone watershed in Thailand. *International Soil and Water Conservation Research* 9:217-228, doi:10.1016/j.iswcr.2020.10.005.

Wirabuana, P.Y.A.P., Alam, S., Matatula, J., Harahap, M.M., Nugroho, Y., Idris, F., Meinata, A. and Sekar, D.A. 2021a. The growth, aboveground biomass, crown development and leaf characteristics of three eucalyptus species at initial stage of planting in Jepara, Indonesia. *Biodiversitas* 22: 2859-2869, doi:10.13057/biodiv/d220550.

Wirabuana, P.Y.A.P., Setiahadi, R., Sadono, R., Lukito, M. and Martono, D.S. 2021b. The influence of stand density and species diversity into timber production and carbon stock in community forest. *Indonesian Journal of Forestry Research* 8:13-22, doi:10.20886/ijfr.2021.8.1.13-22.

Yaşar Korkanç, S. and Şahin, H. 2021. The effects of mulching with organic materials on the soil nutrient and carbon transport by runoff under simulated rainfall conditions. *Journal of African Earth Sciences* 176:1-10, doi:10.1016/j.jafrearsci.2021.104152.

Zhao, J., Feng, X., Deng, L., Yang, Y., Zhao, Z., Zhao, P., Peng, C. and Fu, B. 2020. Quantifying the effects of vegetation restorations on the soil erosion export and nutrient loss on the loess plateau. *Frontiers in Plant Science* 11:1-13, doi:10.3389/fpls.2020.573126.

The influence of land cover variation on soil erosion vulnerability around coal mining concession areas in South Borneo

ORIGINALITY REPORT

16%	15%	8%	%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

MATCH ALL SOURCES (ONLY SELECTED SOURCE PRINTED)

5%

★ etheses.bham.ac.uk

Internet Source

Exclude quotes	On	Exclude matches	< 1%
Exclude bibliography	On		