Baghdad Science Journal

Volume 23 | Issue 1 Article 18

1-1-2026

Study of Soil Erodibility in Its Relationship with Coffee Plant Productivity Based on Agroforestry in Silaen Sub-district, Toba Regency

Fitra Syawal Harahap
Natural Resources and Environmental Management Study Program, Postgraduate School, Universitas Sumatera Utara, Kampus USU Padang Bulan, Medan 20155, North Sumatra, Indonesia AND Agrotechnology Study Program, Faculty of Science and Technology, Universitas Labuhanbatu. North Sumatra, Indonesia, fitrasyawalharahap@gmail.com

Rahmawaty Rahmawaty
Natural Resources and Environmental Management Study Program, Postgraduate School, Universitas Sumatera Utara, Kampus USU Padang Bulan, Medan 20155, North Sumatra, Indonesia AND Faculty of Forestry, Universitas Sumatera Utara, Kampus 2 USU Kuala Bekala, Pancur Batu, Deli Serdang, North Sumatra, Indonesia, rahmawaty@usu.ac.id

Abdul Rauf
Natural Resources and Environmental Management Study Program, Postgraduate School, Universitas Sumatera Utara, Kampus USU Padang Bulan, Medan 20155, North Sumatra, Indonesia AND Agroecotechnology Study Program, Faculty of Agriculture, Universitas Sumatera Utara, Kampus USU Padang Bulan, Medan 20155, North Sumatra, Indonesia, a.raufismail@gmail.com

Rahmanta Rahmanta
Natural Resources and Environmental Management Study Program, Postgraduate School, Universitas Sumatera Utara, Kampus USU Padang Bulan, Medan 20155, North Sumatra, Indonesia AND Agribusiness Study Program, Agribusiness Study Program, Faculty of Agriculture, Universitas Sumatera Utara. Kota Medan 20155, North Sumatra, Indonesia, rahmanta@usu.ac.id

Delvian Delvian
Natural Resources and Environmental Management Study Program, Postgraduate School, Universitas Sumatera Utara, Kampus USU Padang Bulan, Medan 20155, North Sumatra, Indonesia AND Faculty of Forestry, Universitas Sumatera Utara, Kampus 2 USU Kuala Bekala, Pancur Batu, Deli Serdang, North Sumatra, Indonesia, delvian@usu.ac.id

How to Cite this Article

Harahap, Fitra Syawal; Rahmawaty, Rahmawaty; Rauf, Abdul; Rahmanta, Rahmanta; Delvian, Delvian; and Badaruddin, Badaruddin (2026) "Study of Soil Erodibility in Its Relationship with Coffee Plant Productivity Based on Agroforestry in Silaen Sub-district, Toba Regency," *Baghdad Science Journal*: Vol. 23: Iss. 1, Article 18.
DOI: https://doi.org/10.21123/2411-7986.5140

Study of Soil Erodibility in Its Relationship with Coffee Plant Productivity Based on Agroforestry in Silaen Sub-district, Toba Regency

Authors
Fitra Syawal Harahap, Rahmawaty Rahmawaty, Abdul Rauf, Rahmanta Rahmanta, Delvian Delvian, and Badaruddin Badaruddin

BAGHDAD SCIENCE JOURNAL 2026;23(1):236–248

SPECIAL ISSUE ARTICLE

Study of Soil Erodibility in Its Relationship with Coffee Plant Productivity Based on Agroforestry in Silaen Sub-district, Toba Regency

Fitra Syawal Harahap [1,2], **Rahmawaty** [1,3,*], **Abdul Rauf** [1,4], **Rahmanta** [1,5], **Delvian** [1,3], **Badaruddin** [1,6]

[1] Natural Resources and Environmental Management Study Program, Postgraduate School, Universitas Sumatera Utara, Kampus USU Padang Bulan, Medan 20155, North Sumatra, Indonesia
[2] Agrotechnology Study Program, Faculty of Science and Technology, Universitas Labuhanbatu. North Sumatra, Indonesia
[3] Faculty of Forestry, Universitas Sumatera Utara, Kampus 2 USU Kuala Bekala, Pancur Batu, Deli Serdang, North Sumatra, Indonesia
[4] Agroecotechnology Study Program, Faculty of Agriculture, Universitas Sumatera Utara, Kampus USU Padang Bulan, Medan 20155, North Sumatra, Indonesia
[5] Agribusiness Study Program, Agribusiness Study Program, Faculty of Agriculture, Universitas Sumatera Utara. Kota Medan 20155, North Sumatra, Indonesia
[6] Sociology Study Program, Faculty of Social and Political Sciences, Universitas Sumatera Utara, Medan, Indonesia

ABSTRACT

Coffee plants (*Coffea* sp.) are currently a plantation crop in great demand among farmers in Silaen Sub-district. However, the soil conditions in Silaen Sub-district are dominated by sandy soil, which can trigger soil sensitivity to high erosion potential. One of the efforts to mitigate the decline in coffee production can be done through estimating the soil erodibility index in Silaen Sub-district. This research aims to estimate the soil erodibility index and obtain its relationship with agroforestry-based coffee production in Silaen Sub-district, Toba Regency. The method for determining land boundaries using land map units (SPL) in the form of land use, soil type, and slope. The parameters used are soil texture (M), organic matter (a), structure (b), and permeability (c), as well as coffee beans. Statistical analysis of data takes the form of correlation tests and data regression tests. The results of data analysis show that the highest wet weight of coffee cherries is found at SPL 8 with plantation land use, Typic Hapludands soil type, and land slope of 8–15%. The wet weight value of coffee fruit at SPL 8 is 2.19 t ha^{-1} with an erodibility value of 0.39. The lowest wet weight of coffee beans is found at SPL 2 with the use of moorland, Andic Eutrudepts soil type, and land slope of 8–15%. The average value of wet weight of coffee beans at SPL 2 is 0.15 t ha^{-1}with an erodibility value of 0.28 while the results of the regression test R^2 value of 0.11. So this shows that soil erodibility affects the wet weight of coffee fruit by 11%. Application of conservation techniques, namely making terraces, so that the effectiveness of terracing, organic mulch, and agroforestry in suppressing erodibility for 5–10 years can increase crop yields.

Keywords: Coffee plant production, Soil erodibility index, Soil type, Sandy soil, Toba regency

Introduction

Coffee is a plantation commodity that is in great demand. This is because coffee has become a lifestyle, driven by the demands of modernization. Coffee can now support the process of social interaction, and as a drink or food that can be eaten in leisure time.[1] The demand for coffee products from Indonesia in the international market is increasing because Indonesia

Received 18 March 2025; revised 28 September 2025; accepted 2 October 2025.
Available online 1 January 2026

* Corresponding Author.
E-mail addresses: fitrasyawalharahap@gmail.com (F. S. Harahap), rahmawaty@usu.ac.id (Rahmawaty), a.raufismail@gmail.com (A. Rauf), rahmanta@usu.ac.id (Rahmanta), delvian@usu.ac.id (Delvian), Badaruddin@usu.ac.id (Badaruddin).

International Conference on Discoveries in Applied Sciences and Applied Technology (DASAT2025)
https://doi.org/10.21123/2411-7986.5140

has various types of coffee that are high-quality and popular throughout the world.

Soil erodibility is one of the main indicators in determining the level of soil susceptibility to erosion, which has a direct impact on agricultural productivity, particularly coffee crops. Agroforestry, as a land use system that combines timber crops with agricultural crops, has been recognized globally as a sustainable approach to reduce soil erosion while increasing land productivity.[1] Soil erodibility (K-factor) is a key parameter in assessing soil susceptibility to erosion in coffee Agroforestry Systems. Although agroforestry systems are considered sustainable, recent studies show that 45% of coffee grounds in North Sumatra are experiencing moderate to severe soil degradation.[2] Previous research by[3] revealed that coffee agroforestry can reduce erosion by up to 60%, but these findings have not been validated for the specific conditions of Silaen Sub-District. It is noted that demand for Indonesian coffee exports in 2018–2020 continues to increase. There is also an increase in interest in coffee in Indonesia. In 2015, there was an increase in coffee consumption in Indonesia by 8% compared to the level of consumption in the rest of the world, which was only 6%.[3] In fact, land in Silaen Sub-district, Toba Regency, is at great risk of soil erosion. Nearly 40–50% of coffee plant productivity in Silaen Sub-district has decreased due to ongoing soil erosion in the area. The ability of soil erosion in Silaen Sub-district is influenced by the activities of implementing the agricultural zone system and smallholder plantations.[4] The plants other than rice that are being cultivated are secondary crops, namely corn and cassava. This can be seen from the position of Silaen Sub-district. The implementation of an agroforestry system has been tried, thus creating soil constituent materials that have relatively aggressive particles, which means they have a texture of sand to dust.[5,6] Sandy soil texture has a high sensitivity to erosion. The higher the percentage of very fine sand and dust, the higher the erodibility value of a land. The characteristics of the land in Silaen Sub-district have steep to steep land slopes, which can increase the destructive power of water flowing on the surface of the land, thus increasing the value of erodibility as an aspect of erosion.[7] Based on previous research, steeper land slopes increase soil erodibility. The high erodibility value significantly impacts the depletion of land nutrients, particularly nitrogen, due to runoff. There are three primary factors contributing to nitrogen loss in the soil: leaching through water drainage, evaporation, and plant absorption.[8] Recent studies have shown that soil erodibility is influenced by factors such as soil texture, organic matter content, and vegetation structure in the context of coffee agroforestry, interactions between canopy cover, root system, and Land Management play an important role in maintaining soil stability however, research examining the direct relationship between soil erodibility and coffee productivity in this region is still limited. The condition of land in Silaen Sub-district, Toba Regency, is well known, so it is necessary to carry out research on soil erodibility in Silaen Sub-district to determine soil erodibility and provide basic data for appropriate land planning and management, especially for directions for managing coffee fields so that productivity is optimal. There are several models that can be used to estimate soil erodibility, one of which is the model is known as K-USLE (General Soil Loss Equation).

Soil erodibility is a critical factor in the sustainability of coffee farming because it directly affects soil fertility, water availability, and the stability of rooting ecosystems, so that coffee lands with high erodibility are vulnerable to permanent degradation. Modeling in Brazil shows that without conservation measures, coffee grounds lose 2–5 tons of soil/ha / year, decreasing long-term productivity. Global studies show that agroforestry is able to reduce erosion by up to 60% compared to monoculture.[9] However, its implementation in wet tropical regions such as North Sumatra still faces unique challenges due to topographic variability, high rainfall intensity, and heterogeneous land management practices.[10]

The estimation of the soil erodibility index in Silaen Sub-district, Toba Regency, is expected to mitigate the condition of the land from the dangers of erosion. So it is a consideration for conservation activities to estimate the decline in creation due to soil being sensitive to erosion.[11] This research aims to estimate the soil erodibility index and analyze the influence of the soil erodibility index on coffee production in people's coffee plantations in Silaen Sub-district, Toba Regency.

Materials and methods

The study area

This research was carried out on coffee plantations in Silaen Sub-district, Toba Regency, and in the laboratory from August to November 2024, which is presented in Fig. 1 at coordinates N: 02°18' 2°27'; E: 99°1199°18' with an altitude of 900 to 1,500. Laboratory analysis was carried out at the Soil Department Laboratory, Faculty of Agriculture, Universitas Sumatera Utara (USU), Medan, North Sumatra, Indonesia.

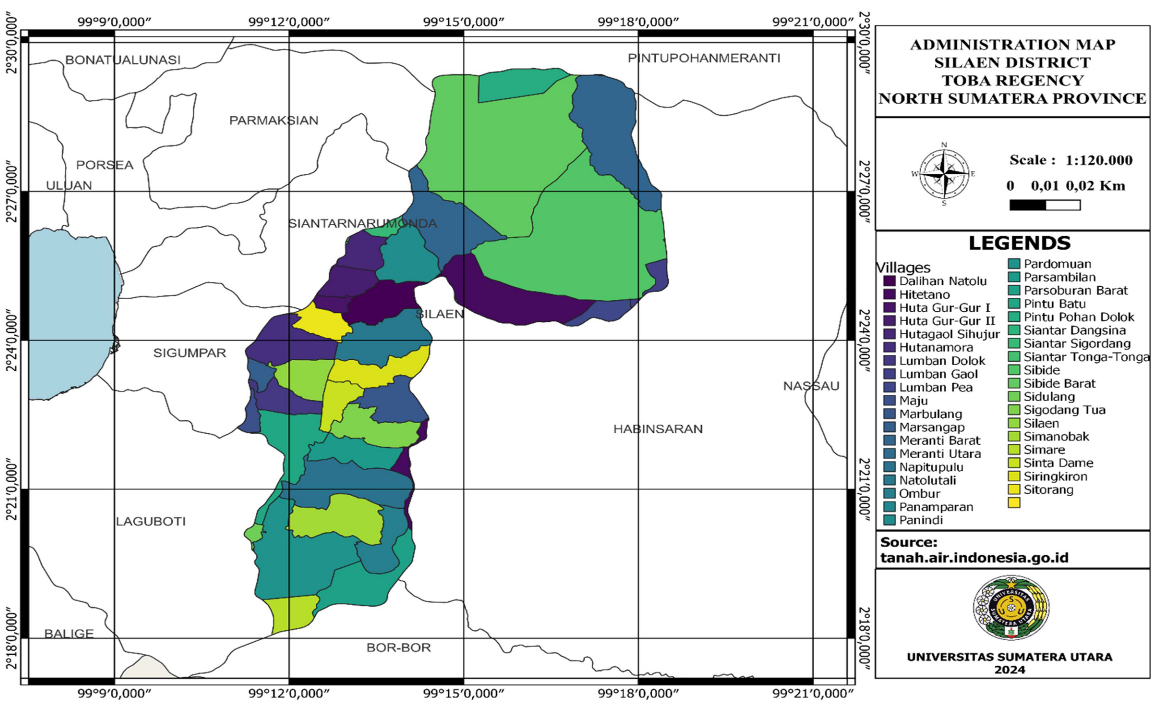

Fig. 1. Map of Study Site.

Methods

Pre-survey research activities were carried out to collect and create basic maps in the form of Land Map Units (SPL), which were based on land slope maps, land use maps, and soil type maps. Pre-survey activities were also carried out by searching for coffee plantations in each Land Map Unit (SPL) and determining survey points. Land Map Units (SPL) are presented in Fig. 2.

Data analysis

Laboratory analysis is carried out to determine soil characteristics that cannot be observed directly in the field, such as permeability, texture, and organic matter. The parameters analyzed in the laboratory are soil texture (pipette method), soil structure (qualitative method), permeability (constant head permeameter method), and organic C (Walkley and Black method). After obtaining the results of the laboratory analysis, a classification of the structural parameters and soil permeability is carried out so that they can be used in calculating soil erodibility. Soil structure classes and soil permeability are presented in Table 1.

Determination of soil erodibility values was carried out using the K-USLE erodibility prediction model. The K-USLE soil erodibility prediction model is a method that has been widely applied and is still used today by practitioners for land planning and soil conservation purposes.[12] The following is the K-USLE erodibility equation:

$$100\ K = 1.292\ (2.1.M\ 1.14\ (10)\ (12 - a) + 3.25\ (b - 2) + 2.5\ (c - 3) - 4$$

Information:

- K = Soil erodibility
- M = (% dust + % very fine sand) × (100 - % clay)
- a = Percentage of organic matter (% Corganic × 1.724)
- b = Soil structure class
- c = Soil permeability class code

Table 1. Soil structure class and soil permeability.

Parameter	Class	Information	Value
Soil Structure	Very fine granular		1
	Fine Granular		2
	Medium Granular- Coarse		3
	Blocky, solid, and flat		4
Permeability (cm jam-1)	> 12,5	Fast	1
	12,5–6,25	Rather Fast	2
	6,25–2.01	Currently	3
	2,00–0,51	A bit slow	4
	0,50–0,125	Slow	5
	< 0,125	Very slow	6

After obtaining the erodibility value results, a classification of the erodibility value is carried out. Class classification Data analysis. After carrying out pre-survey activities, field surveys, and laboratory

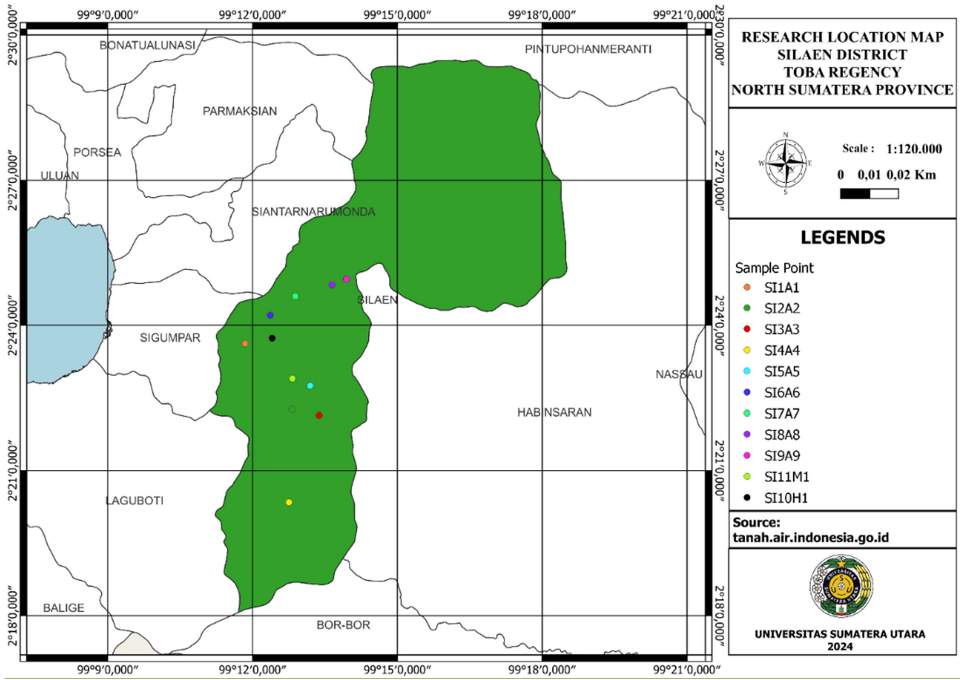

Fig. 2. Research location land map unit.

Table 2. Number of soil samples in land units.

SPL	Number Of Samples	Depth (cm)	Description
SPL 1	2	0–20, 20–40	Slope Area
SPL 2	3	0–20	Flat Area
SPL 3	2	0–20, 20–40	Near the patron tree
SPL 4	2	0–20	Eroded Soil
SPL 5	2	0–20	Control (non-agroforestri)
SPL 6	2	0–20, 20–40	Slope Area
SPL 7	2	0–20	Flat Area
SPL 8	2	0–20, 20–40	Near the patron tree
SPL 9	2	0–20	Eroded Soil
SPL 10	2	0–20	Control (non-agroforestri)
SPL 11	2	0–20	Slope Area

analysis, data analysis was carried out by looking at the results of the survey and laboratory analysis and obtaining the results of the soil erodibility value.[13,14] Soil sampling. Samples were taken at 3 different depths:[9] Top layer: 0–20 cm (active root zone), Middle layer: 20–40 cm (transition zone). Soil sampling was done at a depth of 0–20 cm for permeability observation. Analysis of soil texture, soil structure, and soil organic matter using ordinary soil samples in the middle and bottom layers was then composited. In addition, observations were made on the fresh weight of coffee berries as a parameter of coffee plant production. Soil sampling and observation of coffee plants were carried out using the stratified random sampling method to create observation plots measuring 10 m × 10 m at each research point based on three main criteria:[10] Slope gradient class (0–8%; 8–15%; 15–30%; >30%), Agroforestry type (simple, medium, complex), Age of coffee plants (<5 years; 5–10 years; >10 years). The basis for soil sampling is that if there is a high variation in SPL, take 2–3 samples per SPL to represent land heterogeneity, and if the land map unit is homogeneous, just take one sample per SPL, as presented in Table 2.

Statistical tests in the form of normality test to see the distribution of data, correlation test to analyze the relationship of physical and chemical properties of soil used as a parameter with the wet weight of coffee fruit and soil erodibility value, and regression test to determine the pattern of relationships between variables by using the selection of statistical methods of Non-Linear Regression Analysis (quadratic) Model: $y = \beta_0 + \beta_1 x + \beta_2 x^2 + \epsilon$ Where y: coffee productivity (ton/ha) x: soil erodibility value Table 3. Pearson

Table 3. Erodibility grade class.

Class	K value	Erodibility Level
1	0,00–0,10	Very Low
2	0,11–0,21	Low
3	0,22–0,32	Currently
4	0,33–0,44	Somewhat High
5	0,45–0,55	Tall
6	0,56–0,64	Medium–High

correlation test: used if the data is normal and the correlation is a linear relationship between productivity and erodibility, and the regression test to determine the pattern of relationships between variables using RStudio and Microsoft Excel

Results and discussion

Soil erodibility is an indicator of erosion balance, which can measure the level of soil sensitivity to grain and water flow. The K-USLE method used to determine soil erodibility is influenced by several soil physical and chemical factors, including soil texture (percentage of sand, dust, and clay), soil structure, soil permeability, and soil organic matter.[15,16] Determination of erodibility values is determined based on analysis of the physical and chemical properties of the soil based on the required parameters. The results of the erodibility parameter analysis are presented in Tables 4 and 5.

Soil texture is one of the parameters in determining the value of soil erodibility. Based on the results of laboratory analysis, it was found that the lowest percentage value of very fine sand was located at SPL 10, namely 19.18%, and the highest percentage of very fine sand content was located at SPL 5, namely 33.57%. The lowest sand percentage value is at SPL 11, namely 62.43%, and the highest percentage value is at SPL 2, amounting to 87.05%. The lowest dust percentage value is at SPL 2, which is 7.17%, and the highest dust percentage value is at SPL 5, which is 20.28%. The lowest clay percentage value is at SPL 2, namely 5.78%, and the highest percentage value is at SPL 5 at 21.38%. Based on these results, it can be seen that most of the land has a smaller clay percentage compared to the percentage of dust, sand, and very fine sand.

This shows that most of the land has soil that is sensitive to erosion.[17,18] For the high dust content can indicate that the soil is sensitive to erosion, because the dust particles have no charge, so that no bonds are created between the particles[19] being eroded, so that the soil particles in the top layer are carried away and lost by erosion or buried by new material carried by water or wind. Soil structure observations were tried qualitatively in the field, based on observations that obtained lumpy and granular results. Structure is the physical character of soil that describes the spatial layers of soil particles that combine or bond together to form aggregates as a result of pedogenesis.[20,21]

Soil structure is related to soil aggregates and influences the sensitivity of the soil to the amount of erosion that will occur.[22] The greater the value of the soil structure coefficient, the greater the possibility of erosion. On the other hand, if the structure coefficient value is small, the soil's sensitivity to erosion will be low.[23] The soil structure should have sturdy aggregates so that they are not easily destroyed by raindrops and surface flows. A stable soil structure has a low sensitivity to erosion, and soil pores are not easily blocked by fine soil particles, so that soil infiltration is quite large and reduces surface runoff. Granular soil structures have a large infiltration capacity.[24]

Soil that has a granular structure has many large pores because the particles do not have a large binding energy between each other, so soil with a large infiltration capacity is more resistant to erosion. Soil with a high level of aggregation is one that has a granular structure because the level of water absorption is greater than in soil without structure, or the layers of primary grains are denser.[25] The presence of organic matter tends to improve soil structure and has the potential to increase soil permeability, soil water holding capacity, and soil fertility. Based on the results of laboratory analysis, it was found that the lowest percentage value of organic material content was located at SPL 2, namely 1.23%, and the highest percentage of organic material content was located at SPL 10, which was 2.85%. Soil organic matter is material that comes from plant remains, such as stems, twigs, and leaves, as well as animal remains in the soil that have undergone decomposition.[26]

Organic material can be used as mulch, which plays a role in covering the soil surface. Organic mulch, which comes from organic material that has not been decomposed, can play a role in protecting the soil from splashing rainwater so that it can limit surface runoff.[27] Soil that has a lot of organic matter will have good soil characteristics, such as a stable soil aggregate. This is because organic materials can improve the physical characteristics of the soil and can function as an adhesive.[28] If the organic material is low, then there will be a reduction in the aggregate binding agent, which can cause the soil aggregate to be easily damaged and create smaller soil aggregates so that they are easily subject to dispersion by destructive forces such as raindrops, and the possibility of erosion will continue to be large. The results of the soil permeability analysis show that at SPL 10,

Table 4. Results of analysis of soil erodibility parameters.

SPL	Soil Texture Fraction (%)				Texture Class	Structure	Organic Ingredients (%)	permeability (cm/jam)
	Very Fine Sand	Sand	Dust	Look				
1	28.75	73.85	16.58	9.57	Sandy Loam	Blocky	1.46	15.17
2	26.25	87.05	7.17	5.78	Clayy Sand	Granular	1.23	20.03
3	32.75	69.70	19.47	10.83	Sandy Loam	Blocky	1.33	13.89
4	27.6	71.33	1585	12.82	Sandy Loam	Blocky	1.6	16.29
5	33.57	58.33	20.28	21.38	Sandy Loam	Granular	1.65	12.05
6	27.02	71.50	13.47	15.03	Sandy Loam	Gumpal	1.51	12.94
7	32.57	65.77	17.43	16.8	Sandy Loam	Blocky	1.64	12.35
8	29.08	64.42	18.68	16.9	Sandy Loam	Blocky	2.35	10.07
9	30.82	71.8	18.43	9.77	Sandy Loam	Blocky	2.25	14.49
10	19.18	82.5	8.40	9.10	Sandy Loam	Blocky	2.85	5.22
11	29.85	62.43	20.05	17.52	Sandy Loam	Granular	2.01	9.89

Table 5. Results of analysis of soil erodibility parameters.

Structure	Organic Ingredients (%)	Permeability (cm/jam)
Blocky	1.46	15.17
Granular	1.23	20.03
Blocky	1.33	13.89
Blocky	1.6	16.29
Granular	1.65	12.05
Gumpal	1.51	12.94
Blocky	1.64	12.35
Blocky	2.35	10.07
Blocky	2.25	14.49
Blocky	2.85	5.22
Granular	2.01	9.89

the lowest permeability value is 5.22 centimeters per hour, which is categorized again. The highest permeability value is at SPL 2 at 20.03 centimeters per hour, which is categorized as lightning.[29] Permeability is influenced by several aspects, such as soil texture, soil structure, soil aggregate stability, porosity, pore dimension distribution, and organic matter content.[30] Permeability has a fairly large influence on erodibility. The permeability value continues to increase, so the soil erodibility value will continue to decrease. This happens because large permeability can reduce the amount of surface flow.[31] Reduced surface flow is caused by a lot of water being infiltrated, so that water enters the ground. The decrease in surface flow rate can lead to a lower value of soil sensitivity to erosion because more water in the land is absorbed into the soil through the soil infiltration process.[32]

Soil erodibility and coffee plant productivity

The erodibility value has an influence on the productivity of coffee plants. Erodibility will affect plant roots, which influence productivity through texture, organic matter, structure, and soil permeability. Erodibility influences the productivity index of a plant.[33] This shows that the level of erodibility will affect the productivity of coffee plants in Silaen Sub-district, Toba Regency. Coffee productivity can be seen based on the wet weight of the coffee fruit. Based on the results of the analysis of the information obtained, it is known that the highest wet weight of coffee cherries is at SPL 8 with plantation land use, Typic Hapludands soil type, and land slope of 815%. The wet weight value of coffee cherries at SPL 8 is 2.18 t ha with an erodibility value of 0.37. The lowest wet weight of coffee beans is at SPL 2 with the use of dry land, Andic Eutrudepts soil type, and land slope of 8–15%. The average value of the wet weight of coffee beans at SPL 2 is 0.12 t ha with an erodibility value of 0.26. The results of determining the erodibility value and productivity of coffee plants at each SST are presented in Table 4. Based on the results of the analysis of the information obtained, it is known that the highest fresh weight of coffee berries is in SPL 8 with plantation land use, Typic Hapludands soil type, and land slope of 8–15% so that the fresh weight value of coffee berries is 2.18 t ha^{-1} with an erodibility value of 0.37. The lowest fresh weight of coffee beans is in SPL 2 with dry land use, Eutrudepts Andic soil type, and land slope of 8–15% so that the fresh weight value of coffee berries is 0.12 t ha^{-1} with an erodibility value of 0.26. The results of determining the erodibility value and productivity of coffee plants in each SPL are presented in Table 6.

The slope of the land has an influence on the productivity of coffee plants. Usually, a land slope of $<25\%$ will support the development of coffee plants compared to a land slope 25%. This is related to the rate of erosion, where the large slope of the land will increase surface flow so that erosion continues to be large and disrupts the development of coffee plants. Not only that, land cover can also influence the productivity of coffee plants.[34,35] The use of plantation land has a role in controlling erosion and maintaining and revising soil quality compared to the use of dry land. This proves that the quality of the soil in plantation land use is better for development and

Table 6. Erodibility and productivity values coffee plants in silaen sub-district.

No	Land Map Units	Erodibility (USLE)	Wet Weight Coffee Fruit (t ha^{-1})
1	1	0.39	1.10
2	2	0.26	0.12
3	3	0.45	0.66
4	4	0.35	0.82
5	5	0.41	1.30
6	6	0.33	0.46
7	7	0.39	0.82
8	8	0.37	2.18
9	9	0.40	0.83
10	10	0.27	0.40
11	11	0.38	1.75

better supports plant productivity compared to dry land use.[36]

As a result of the soil types on the land observed, it is known that there are two types of soil, namely Andisols and Inceptisols Fig. 3. Soil types, Inceptisol and Andisols, are developing soils. Inceptisols soil has an ideal total pore space compared to Andisols soil. This allows a lot of water to be stored in Inceptisol soil and can support plant growth and development.[37] The pore space types between Andisols and Inceptisols have different characteristics. Most of the pore spaces of Andisols soils mainly consist of large pore spaces, which cause less efficient movement of fluids in the soil, while the pore spaces of Inceptisols soils have a more complex structure, especially in the form of small pore spaces. This has an impact on better performance in fluid movement in the soil, plant growth, and development.[38]

The pore space types between Andisols and Inceptisols have different characteristics. Most of the pore spaces of Andisols soils mainly consist of large pore spaces, which cause less efficient movement of fluids in the soil, while the pore spaces of Inceptisols soils have a more complex structure, especially in the form of small pore spaces. This has an impact on better performance in fluid movement in the soil.[39]

The relationship between soil erodibility and coffee plant productivity.

Erodibility is one of the factors that determines coffee plant productivity. Results of correlation analysis of erodibility values and productivity of coffee plants, taken from 11 SST SPL observations in Silaen Sub-district, Toba Regency. The results of the correlation test carried out on soil erodibility and coffee plant productivity, with a coefficient value using an r-table at a level of 5%, namely 0.52. This shows that soil erodibility has a significant relationship to soil erodibility in Silaen Sub-district, Toba Regency. This means that the greater the erodibility value, the greater the wet weight of the coffee fruit. Based on previous research, there is a positive relationship between soil erodibility and plant productivity. This is due to the fact that soil with erodibility up to a certain value has more ability to retain nutrients and water, which can help plant productivity.[40] The results of the analysis show that there is an influence of soil erodibility on coffee plant productivity.

The non-linear regression results show a value of $y= 2.938x+0.\ 7043$, where y is the productivity of the coffee plant and x is the soil erodibility value. Based on the graph and regression equation Fig. 4, it is known that the productivity of coffee plants increases up to an erodibility value of 0.40 and experiences a reduction in productivity when the erodibility value exceeds 0.40. Based on the results of the regression test, it is known that the R value is 0.11. This shows that soil erodibility affects the wet weight of coffee cherries by 11%. This relationship between soil erodibility and coffee plant productivity is due to the influence of erodibility on texture, organic matter, structure, and soil permeability.[41,42] The increase in erodibility to 0.40 was accompanied by an increase in very fine sand and dust, organic matter, structure, and permeability reduction. An increase in erodibility of more than 0.40 is accompanied by a decrease in soil organic matter and an increase in soil permeability. The greater the percentage of sand and dust, the more the soil will continue to decrease in soil density. A stable structure will also reduce soil density.

The results of the analysis show the influence of soil erosivity on coffee plant productivity. The results of the non-linear regression show the value of $y = 2.938x + 0,7043$ where y is the productivity of the coffee plant and x is the value of soil erodibility. Based on the graph and regression equation Fig. 4, the value of soil erodibility can be interpreted that if the erodibility value is 0.37 ($x = 0.37$) then the predicted number of coffee plant productivity is 2.18 t ha^{-1} ($y = 2.18$), and if the erodibility value is 0.45 ($x = 0.45$) then the predicted number of coffee plant productivity is 0.66 t ha^{-1} ($y = 0.66$). Based on the graph and regression equation Fig. 4, an increase in

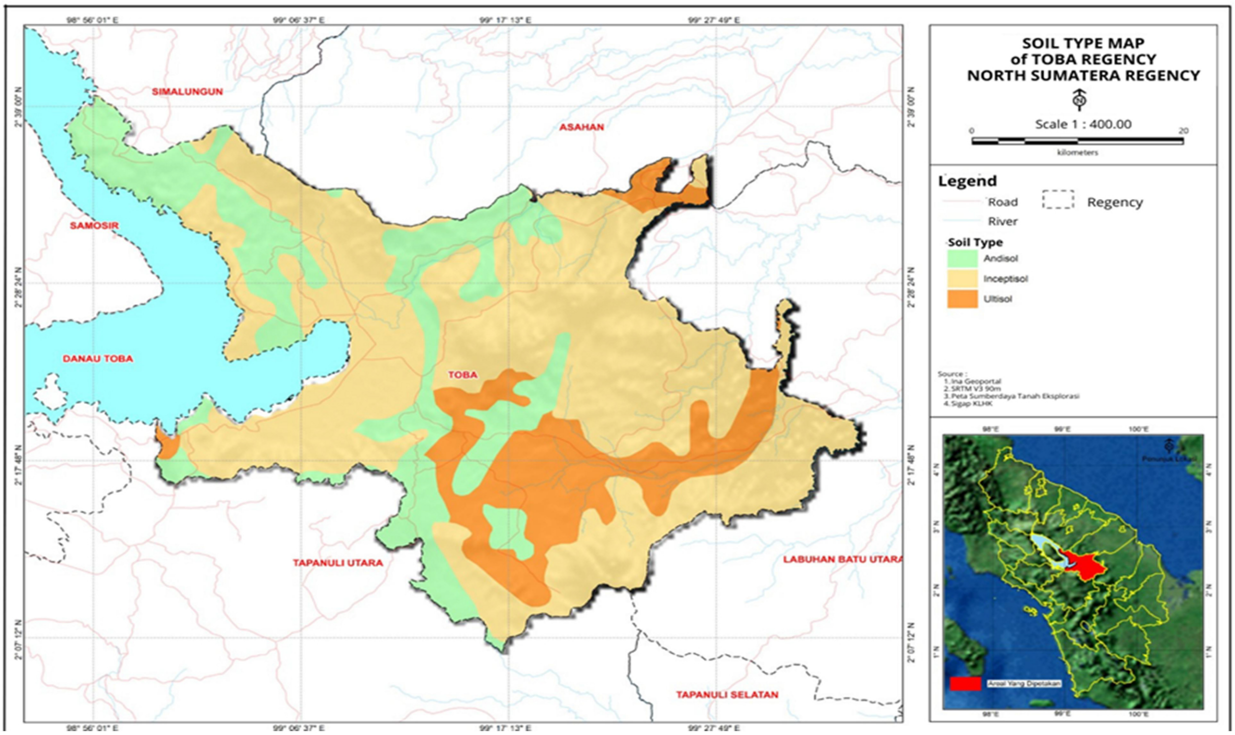

Fig. 3. Map of Soil Types in Toba Regency.

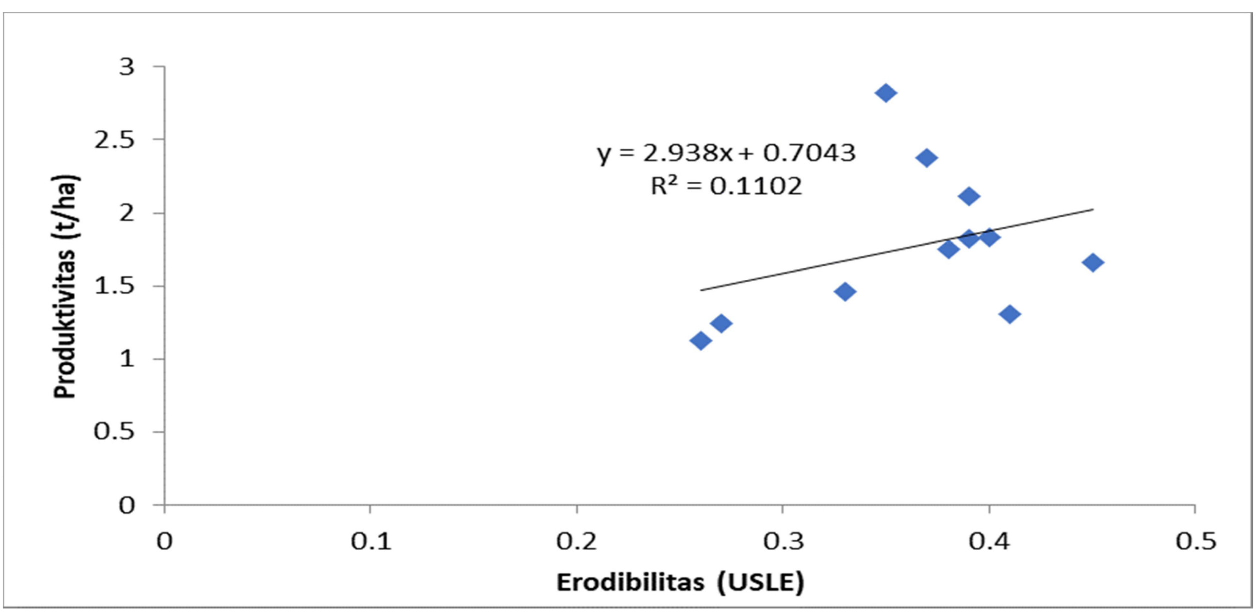

Fig. 4. Effect of erodibility on coffee plant productivity.

erodibility up to 0.37 is accompanied by an increase in very fine sand and silt, organic matter, structure, and a decrease in permeability. An increase in erodibility above 0.37 is accompanied by a decrease in soil organic matter and an increase in soil permeability. The higher the percentage of sand and silt, the more the soil will decrease its density.[43] A stable structure will also reduce soil density.[44] Soil erodibility is a critical factor in the sustainability of coffee farming as it directly affects soil fertility, water availability, and the stability of rooting ecosystems. Statistical analysis showing erodibility (>0.37) and coffee productivity (decrease from 3.58 ton/ha^{-1} to 2.12 ton/ha^{-1}) proved that soil degradation has a real impact on crop yields, so that soils with high erodibility lose topsoil rich in organic matter and nutrients such as N,

Table 7. Erodibility response to soil physical and chemical properties that influence coffee productivity.

No	Land Map Units	Erodibility Class	Erodibility	Land Map Units + Dust (%)	Organic Material (%)	Structure	Permeability
1	2	Medium	0.26	Medium	1.23	Granular	20.03
2	10	Medium	0.27	Medium	2.85	Blocky	5.22
3	6	Somewhat High	0.33	Somewhat High	1.51	Blocky	12.94
4	4	Somewhat High	0.35	Somewhat High	1.60	Blocky	16.29
5	8	Somewhat High	0.37	Somewhat High	2.35	Blocky	10.07
6	11	Somewhat High	0.38	Somewhat High	2.01	Granular	9.89
7	7	Somewhat High	0.39	Somewhat High	1.64	Blocky	12.35
8	1	Somewhat High	0.39	Somewhat High	1.46	Blocky	15.17
9	9	Somewhat High	0.4	Somewhat High	2.25	Blocky	14.49
10	5	Somewhat High	0.41	Somewhat High	1.65	Granular	12.05
11	3	High	0.45	High	1.33	Blocky	13.89

Table 8. Erodibility response to soil physical and chemical properties that influence coffee productivity.

Organic Material (%)	Structure	Permeability
1.23	Granular	20.03
2.85	Blocky	5.22
1.51	Blocky	12.94
1.60	Blocky	16.29
2.35	Blocky	10.07
2.01	Granular	9.89
1.64	Blocky	12.35
1.46	Blocky	15.17
2.25	Blocky	14.49
1.65	Granular	12.05
1.33	Blocky	13.89

P, K as essential elements for coffee growth. Studies show that erosion of 10 cm of topsoil can reduce productivity by up to 50% in plantation crops.[45] Coffee grounds with high erodibility are prone to permanent degradation. Modeling in Brazil shows that without conservation measures, coffee grounds lose 2–5 tons of soil/ha year, lowering long-term productivity.[46]

The results of erodibility response to soil physical and chemical properties that influence coffee productivity in land map units are presented in Tables 7 and 8.

High organic matter can improve soil aggregation, promote water infiltration, and reduce erosion. Soil texture, which refers to the ratio of sand, dust, and clay particles, also affects the soil's ability to retain water and air, as well as the ease with which the soil erodes. Soil permeability, or the ability of soil to absorb water, also plays a role in controlling surface flow and erosion, so increasing organic matter, improving soil structure, and improving soil permeability are key to reducing erodibility and improving soil health in coffee plants. An understanding of the role of each of these factors is important in sustainable coffee Land Management.

The increasingly dense soil will affect the root space for plants to grow and develop. Coffee plants planted at higher soil densities have a lower number and length of roots than coffee plants planted at lower soil densities.[43] The higher the soil density, the lower the productivity of the coffee plant. This is because coffee requires a large root area to get the many nutrients it needs. If the soil is too dense, the roots of the coffee plant cannot take in all the nutrients it needs. Apart from that, soil that is too dense can also reduce the water flow that coffee plants need for optimal bean productivity.[44] An increase in the percentage of organic material will increase the productivity of coffee plants. Increasing coffee plant productivity is indicated by increasing nitrogen, phosphorus, and potassium content in the soil. Overall, this shows that increasing the value of organic matter in the soil can increase the productivity of coffee plants.[47] In general, increasing the permeability value can increase the productivity of coffee plants, but this is different for coffee fields in Silaen Sub-district, Toba Regency. Silaen Sub-district, Toba Regency has relatively high rainfall ranging from 2001–2500 mm year. Increasing the value of soil permeability reduces the availability of nutrients for plants. This is caused by a faster rate of infiltration, which causes a decrease in the availability of nutrients in the soil, so that a decrease in nutrient availability can reduce the productivity of coffee plants.[48]

Conclusion

Land in Silaen Sub-district, Toba Regency has medium, high, and predominantly slightly high erodibility values. The erodibility values obtained were influenced by organic matter, texture, structure, and permeability of the soil in Silaen Sub-district, Toba Regency. Soil erodibility and productivity values in Silaen Sub-district, Toba Regency have a significant relationship with each other. The erodibility value has an 11% effect on coffee productivity, with statistical analysis showing erodibility (>0.37) and coffee productivity (decrease from 3.58 ton/ha^{-1} to 2.12 ton/ha^{-1}) proving that soil degradation has a real impact on crop yields, so that soils with high erodibility lose the top layer in Silaen Sub-district, Toba Regency. Application of conservation techniques, namely making terraces, to assess the effectiveness of terracing, organic mulch, and agroforestry in suppressing erodibility for 5–10 years, and increasing crop yields.

Acknowledgement

This paper is part of the research on the Professor's Study Center Scheme. Thanks to Universitas Sumatera Utara (USU) for research funding.

Authors' declaration

- Conflicts of Interest: None.
- We hereby confirm that all the Figures and Tables in the manuscript are our original work. Furthermore, any Figures and images that are not our own have been included with the necessary permission for republication, which is attached to the manuscript.
- No animal studies are present in the manuscript.
- No human studies are present in the manuscript.
- Ethical Clearance: The project was approved by the local ethical committee at Universitas Sumatera Utara, Kampus USU Padang Bulan, Medan 20155, North Sumatra, Indonesia.

Authors' contributions

F.S.H R.W, and A.R. R.M. contributed to the study design, data analysis, drafting, and manuscript editing. D.E.L. and B.D.N. contributed to the design, sampling, data collection, data input, manuscript preparation, and editing. R.W. and A.R. contributed to editing the latest manuscript. The authors read and approved the manuscript.

Funding statements

Funding from Universitas Sumatera Utara (USU), Contract Number: 379/UN5.2.3.1/PPM/KP-TALENTA/2022, date: August 9, 2022.

References

1. Gomes VM, Miranda JMS, Silva LJ, Teixeira MV, Teixeira G, Schossler K, *et al.* A global meta-analysis of soil carbon stock in agroforestry coffee cultivation. Agronomy, J. Sylva Lestari 2025;15(2):480. https://doi.org/10.3390/agronomy15020480.
2. Mursyid H, Suryanto P, Fadhilla S, Silmia B, Wibowo FAC. Diversity and ecophysiological performance of coffee under dry-field and homegarden agroforestry in Yogyakarta. J Sylva Lestari. 2025;13(1):75–89. https://doi.org/10.23960/jsl.v13i1.1005.
3. Kamaruzzaman K, Salleh SA, Pardi F, Abdullah MF, Foronda V, Bergonio EL, *et al.* Review of environmental monitoring in freshwater lakes using geospatial techniques (remote sensing and GIS). Geocarto Int. 2025;40(1). https://doi.org/10.1080/10106049.2024.2448978.
4. De Souza IMD, Borges WLB, Juliano PHG, Modesto VC, Girardi VAM, *et al.* Methodologies for agricultural gypsum application recommendations in no-tillage systems on tropical sandy soils. Agronomy. 2025;15(2):416. https://doi.org/10.3390/agronomy15020416.
5. Hartoyo APP, Karlinasari L, Setiajiati F, Wijayanto AK, Rifana HZ, Madani HN, *et al.* Estimating vegetation density dynamics, tree diversity, and carbon stock in the agroforestry system of the community forest in Bogor Regency, Indonesia. J Sylva Lestari. 2025;13(1):120–144. https://doi.org/10.23960/jsl.v13i1.989.
6. Rahmawaty, Ismail MH, Rauf A, Batubara R, Sitorus EW, Simamora Z, *et al.* Land characteristics and land suitability assessment for Styrax sp. in Humbang Hasundutan Regency, North Sumatra, Indonesia. Heliyon. 2023;9(7):e16936. https://doi.org/10.1016/j.heliyon.2023.e16936.
7. Viana CM, Freire D, Abrantes P, Rocha J, Pereira P. Agricultural land systems importance for supporting food security and sustainable development goals: A systematic review. Sci Total Environ. 2022;806:150718. https://doi.org/10.1016/j.scitotenv.2021.150718.
8. Escobar LA, Castillo SMA, Mas JF, Hernández SJL, López MJO. Identification of coffee agroforestry systems using remote sensing data: A review of methods and sensor data. Geocarto Int. 2024;39(1). https://doi.org/10.1080/10106049.2023.2297555.
9. Pretty JN, Bharucha ZP, Hattam B, Morison JIL, Rahman AHPM, Benton TG. Sustainable intensification in agricultural systems. Ann Bot. 2014;114(8):1571–1596. https://doi.org/10.1093/aob/mcu205.
10. Susila AB, van Noordwijk M, Hairiah K. Agroforestry systems for sustainable coffee production in tropical landscapes. Agrofor Syst. 2019;93(2):345–358. https://doi.org/10.1007/s10457-018-0221-y.
11. Rahmawaty, Batubara R, Rauf A, Frastika S, Batubara R, Rauf A. Mapping of land suitability for rambutan (Nephelium lappaceum) in community agroforestry land at Gunung Ambat Village and Simpang Kuta Buluh Village. Trop Soils. 2020;25(2):107–117. https://doi.org/10.5400/jts.2020.v25i2.107-117.
12. Fu Y, Lu Y, Heitman J, Ren T. Root influences on soil bulk density measurements with thermo-time domain reflectometry. Geoderma. 2021;403:115195. https://doi.org/10.1016/j.geoderma.2021.115195.
13. Lamare RE, Singh OP. Effect of cement dust on soil physico-chemical properties around cement plants in Jaintia Hills, Meghalaya. Environ Eng Res. 2020;25(3):409–417. https://doi.org/10.4491/eer.2019.099.
14. Depecker J, Vandelook F, Jordaens K, Dorchin A, Katshela BN, Broeckhoven C, *et al.* Comparative pollinator conservation potential of coffee agroforestry relative to coffee monoculture and tropical rainforest in the DR Congo. Agric Ecosyst Environ. 2025;379:109375. https://doi.org/10.1016/j.agee.2024.109375.

15. Parron LM, Peixoto RTG, da Silva K, Brown GG. Traditional yerba mate agroforestry systems in Araucaria forest in Southern Brazil improve the provisioning of soil ecosystem services. Conservation. 2024;4:115–138. https://doi.org/10.3390/conservation4010009.
16. Subhanil G, Himanshu G, Prabhat D. Analytical study of seasonal variability in land surface temperature with NDVI, NDWI, NDBI, and NMDI. J Appl Remote Sens. 2022;13(2):1–17. https://doi.org/10.1117/1.JRS.13.024518.
17. Osman O, Semih E, Filiz D. Use of Landsat land surface temperature and vegetation indices for monitoring drought in the Salt Lake Basin area, Turkey. Sci World J. 2024;14(1):55–71. https://doi.org/10.1155/2024/142939.
18. Himanshu G, Subhanil G, Anindita D, Neetu G. Seasonal evaluation of downscaled land surface temperature: A case study in a humid tropical city. Heliyon. 2022;5(6):e01923. https://doi.org/10.1016/j.heliyon.2022.e01923.
19. Chen X, Wang J, Wei Y, Zhou X, Chen F, Tian Z, *et al.* Geospatial variation of granitic soil erodibility along a hydrothermal gradient in the gully region. Catena. 2024;245:108343. https://doi.org/10.1016/j.catena.2024.108343.
20. Mozaffari H, Rezaei M, Ostovari Y. Soil sensitivity to wind and water erosion as affected by land use in southern Iran. Earth. 2021;2(2):287–302. https://doi.org/10.3390/earth2020017.
21. Budiaman A, Hardjanto, Ilham QP, Maharani CP. Agroforestry harvesting residue: A case study in private forests in Probolinggo, East Java, Indonesia. J Sylva Lestari. 2023;12(1):86–99. https://doi.org/10.23960/jsl.v12i1.809.
22. Rahmawaty, Frastika S, Rauf A, Batubara R, Harahap FS. Land suitability assessment for Lansium domesticum cultivation on agroforestry land using matching method and GIS. Biodiversitas. 2020;21(8):3683–3690. https://doi.org/10.13057/biodiv/d210835.
23. Santana DB, Bolleli TDM, Lense GHE, Silva LFPM, Sestras P, Spalevic V, *et al.* Estimate of water erosion in coffee growing areas in Serra da Mantiqueira, Minas Gerais State, Brazil. Agric For. 2021;67(2):75–88. https://doi.org/10.17707/AgricultForest.
24. Andrade V, Casas A, Balslev H, Mora F. The role of wild palms in agroforestry systems in the Neotropics: A review. People Nat. 2024;6(6):2200–2227. https://doi.org/10.1002/pan3.10741.
25. Rahmawaty, Amelia I, Rauf A, Ismail MH, Gandaseca S. Profitability of coffee-based agroforestry system to support farmers' income in Toba Regency, North Sumatra Province, Indonesia. IOP Conf Ser Earth Environ Sci. 2024;1352(1):012041. https://doi.org/10.1088/1755-1315/1352/1/012041.
26. Muslih AM, Nisa A, Sugianto, Arlita T, Subhan. The role of urban forests as carbon sink: A case study in the urban forest of Banda Aceh, Indonesia. J Sylva Lestari. 2022;10(3):417–425. https://doi.org/10.23960/jsl.v10i3.604.
27. Zeng C, Li T, He B, Feng M, Liang K, Xu Q, *et al.* Vegetation succession increases soil organic carbon density and decreases soil erodibility in a karst trough valley experiencing farmland abandonment. Catena. 2024;246:108359. https://doi.org/10.1016/j.catena.2024.108359.
28. van Oijen M, Haggar J, Barrios M, Büchi L, Cerda R, Cerretelli S, Torres Lopez ER, de Melo Virginio Filho E, Toro Ospina AM. Ecosystem services from coffee agroforestry in Central America: estimation using the CAF2021 model. Agroforest Syst. 2022;96(7):969–981. https://doi.org/10.1007/s10457-022-00755-6.
29. Wolo P, Mulyana S, Wardoyo R. Decision support system for suitability of horticultural agricultural plant types with land conditions using interpolation profile matching. JUITA. 2023;11(1):133–134. https://doi.org/10.26418/juita.v11i1.16546.
30. Sepúlveda RB, Carrillo AA. Soil erosion and erosion thresholds in an agroforestry system of coffee and mixed shade trees in Northern Nicaragua. Agric Ecosyst Environ. 2022;210:25–35. https://doi.org/10.1016/j.agee.2015.04.032.
31. Gomes LC, Bianchi FJJA, Cardoso IM, Fernandes RBA, Fernandes EI, Schulte RPO. Agroforestry systems can mitigate the impacts of climate change on coffee production: A spatially explicit assessment in Brazil. Agric Ecosyst Environ. 2020;294:106858. https://doi.org/10.1016/j.agee.2020.106858.
32. Chittapun S, Limbipichai S, Amnuaysin N, Boonkor R, Charoensook M. Effects of using cyanobacteria and fertilizer on growth and yield of rice. J Appl Phycol. 2017;29:119–137. https://doi.org/10.1007/s10811-017-1138-y.
33. Mawlidan N, Ismail MH, Gandaseca S, Rahmawaty, Yaakub NF. Detecting canopy openings in logged-over forests: A multi-classifier analysis of PlanetScope imagery. South For. 2024;86(1):30–41. https://doi.org/10.2989/20702620.2023.2273478.
34. Hanisch AL, Pinotti LCA. Co-creating strategies to optimize traditional silvopastoral systems in Southern Brazil. Conserv. 2024;4:65–81. https://doi.org/10.3390/conservation4010005.
35. Nonglait ML, Khundrakpam N, Deka P. Farmers' income and the driving forces for the switch from shifting cultivation to settled agriculture in Meghalaya, India. Caraka Tani J Sustain Agric. 2023;39(1):65–80. https://doi.org/10.20961/carakatani.v39i1.76129.
36. Fahad S, Chavan SB, Chichaghare AR, Uthappa AR, Kumar M, Kakade V, *et al.* Agroforestry systems for soil health improvement and maintenance. Sustainability. 2022;14(22):14877. https://doi.org/10.3390/su142214877.
37. Sharma PK, Kumar S. Soil structure and plant growth. In: Soil physical environment and plant growth: Evaluation and management. Cham: Springer; 2023. p. 125–154. https://doi.org/10.1007/978-3-031-28057-3_5.
38. Cassamo CT, Draper D, Romeiras MM, Marques I, Chiulele RR, Ramalho JC, *et al.* Impact of climate changes on suitable areas for Coffea arabica production in Mozambique: Agroforestry as an alternative management system. Agric Ecosyst Environ. 2023;346:108341. https://doi.org/10.1016/j.agee.2022.108341.
39. Samrin S, Millang S, Ridwan, Daud M. Land productivity and land equivalent ratio of agroforestry system in Marena Customary Forest, Enrekang Regency, South Sulawesi Province. J Sylva Lestari. 2024;12(2):532–548. https://doi.org/10.23960/jsl.v12i2.877.
40. Hayati I, Marwan H, Wilia W. Biodiversity and microorganisms variation of endemic duku (Lansium domesticum Corr.) rhizosphere in wet and dry sites in Jambi, Indonesia. Baghdad Sci J. 2024;21(4):1191. https://doi.org/10.21123/bsj.2022.5999.
41. Yudina AV, Fomin DS, Kotelnikova AD, Milanovskii EY. From the notion of elementary soil particle to particle-size and microaggregate-size distribution analyses: A review. Eurasian Soil Sci. 2022;51:1326–1347. https://doi.org/10.1134/S1064229318110091.
42. Anas M, Liao F, Verma KK, Sarwar MA, Mahmood A, *et al.* Fate of nitrogen in agriculture and environment: Approaches to improve nitrogen use efficiency. Biol Res. 2020;53(1):1–20. https://doi.org/10.1186/s40659-020-00312-4.
43. Nimmo ER, Laverdi R, de Carvalho AI. The role of public history and environmental oral history in supporting conservation through agroecology. Conserv. 2024;4:82–97. https://doi.org/10.3390/conservation4010006.
44. Pimentel D, Whitecraft M, Scott ZR, Zhao L, Satkiewicz P, Scott TJ, *et al.* Soil erosion: A food and environmental threat.

Environ Dev Sustain. 2006;8(1):119–137. https://doi.org/10.1007/s10668-005-1262-8.

45. Vaast P, de Souza JR, Alves BMJR, Martinez RA. Coffee and shade trees show complementary use of soil water in a traditional agroforestry ecosystem. Agric Ecosyst Environ. 2016; 219:1–11. https://doi.org/10.1016/j.agee.2015.12.002.
46. Ma Y, Liu Y, Rodrigo CJ, López VM, Shi Z, Wu GL. Artificially cultivated grasslands decrease soil detachment and erodibility on alpine degraded hillslopes. Soil Tillage Res. 2024;243:106176. https://doi.org/10.1016/j.still.2024.106176.
47. Adewopo JB, Silveira ML, Xu S, Gerber S, Sollenberger LE, Martin TA. Management intensification impacts on soil and ecosystem carbon stocks in subtropical grasslands. Soil Sci Soc Am J. 2023;78:977–986. https://doi.org/10.2136/sssaj2013.12.0523.
48. Sadiq FK, Yaqub MT, Maniyunda LM, Alalwany AKAM, Abubakar F, Anyebe O. Soil classification and land suitability evaluation for tomato cultivation using analytic hierarchy process under different land uses. Heliyon. 2025;11(1):e41681. https://doi.org/10.1016/j.heliyon.2025.e41681.

دراسة قابلية تآكل التربة وعلاقتها بإنتاجية نبات البن اعتمادًا على نظام الزراعة الحرجية (الأغروفورستري) في ناحية سيلاين، قضاء توبا

فيترا شوال حرحب[1,2]، رحماواتي[1,3]، عبد الرؤوف[1,4]، رحمانتا[1,5]، ديلفيان[1,3]، بدار الدين[1,6]

[1] برنامج دراسات إدارة الموارد الطبيعية والبيئة، كلية الدراسات العليا، جامعة سومطرة الشمالية، حرم *USU* بادانغ بولان، ميدان 20155، سومطرة الشمالية، إندونيسيا.
[2] برنامج دراسات التكنولوجيا الزراعية، كلية العلوم والتكنولوجيا، جامعة لابوهانبوتو، سومطرة الشمالية، إندونيسيا.
[3] كلية الغابات، جامعة سومطرة الشمالية، الحرم الثاني *USU* كوالا بيكالا، بانكور باتو، ديلي سردانغ، سومطرة الشمالية، إندونيسيا.
[4] برنامج دراسات التكنولوجيا الزراعية البيئية، كلية الزراعة، جامعة سومطرة الشمالية، حرم *USU* بادانغ بولان، ميدان 20155، سومطرة الشمالية، إندونيسيا.
[5] برنامج دراسات الأعمال الزراعية، كلية الزراعة، جامعة سومطرة الشمالية، مدينة ميدان 20155، سومطرة الشمالية، إندونيسيا.
[6] برنامج دراسات علم الاجتماع، كلية العلوم الاجتماعية والسياسية، جامعة سومطرة الشمالية، ميدان، إندونيسيا.

الخلاصة

تُعدّ نباتات البن (Coffea sp.) من المحاصيل الزراعية التي يزداد الإقبال عليها من قِبل المزارعين في ناحية سيلاين. إلا أنّ ظروف التربة في هذه الناحية يغلب عليها الطابع الرملي، الأمر الذي يزيد من حساسية التربة لارتفاع احتمالية التعرية. ومن بين الجهود الممكنة للتخفيف من انخفاض إنتاجية البن هو تقدير معامل قابلية التربة للتعرية في ناحية سيلاين. يهدف هذا البحث إلى تقدير معامل قابلية التربة للتعرية وتحديد علاقته بإنتاجية البن المعتمد على نظام الزراعة الحرجية (الأغروفورستري) في ناحية سيلاين، قضاء توبا. تم تحديد حدود الأراضي باستخدام وحدات خريطة الأراضي (SPL) التي تشمل نوع استخدام الأرض، ونوع التربة، ودرجة الانحدار. وشملت المعلمات المستخدمة: نسيج التربة(M) ، المادة العضوية(a) ، البنية(b) ، النفاذية(c) ، وإنتاج حبوب البن. وشمل التحليل الإحصائي اختبار الارتباط واختبار الانحدار. أظهرت نتائج التحليل أن أعلى وزن رطب لثمار البن سُجّل في SPL 8 ضمن الأراضي المزروعة، ذات تربة Typic Hapludands وانحدار أرضي يتراوح بين 8–15%. وبلغ الوزن الرطب لثمار البن في SPL 8 قيمة 2.19 طن/هكتار مع قيمة قابلية تآكل بلغت 0.39. أما أدنى وزن رطب لحبوب البن فكان في SPL 2 ضمن الأراضي البور، ذات تربة Andic Eutrudepts وانحدار أرضي بين 8–15%. وكان متوسط الوزن الرطب لحبوب البن في SPL 2 يساوي 0.15 طن/هكتار بقابلية تآكل قدرها 0.28، بينما بلغت قيمة معامل التحديد في اختبار الانحدار $R^2 = 0.11$ ، مما يشير إلى أنّ قابلية التربة للتعرية تؤثر في الوزن الرطب لثمار البن بنسبة11% . تشير النتائج إلى أن تطبيق تقنيات المحافظة على التربة—مثل إنشاء المصاطب، والملش العضوي، ونظام الأغروفورستري—يمكن أن يساهم خلال مدة تتراوح بين 5–10 سنوات في خفض قابلية التعرية وتحسين الإنتاجية الزراعية.

الكلمات المفتاحية: إنتاجه البن، معامل قابلية التربة للتعرية، نوع التربة، التربة الرملية، قضاء توبا.