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Analysis Of Erosion Hazard Index In Konaweha Sub-Watershed In Laosu Village, Bondoala Sub-District, Konawe District

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A B S T R A C T

The Erosion Hazard Index (EHI) is the ratio between potential erosion rate and allowable erosion rate, influenced mainly by climate (rainfall) and soil factors such as slope, slope length, land use, conservation practices, and soil physical-chemical properties. This study aims to determine the EHI in the Konaweha Sub Watershed, Laosu Village, Bondoala District, Konawe Regency, using the Universal Soil Loss Equation (USLE): A = R·K·L·S·C·P, compared to allowable erosion (ETol). Analysis shows variation in EHI across different land units, classified into low, moderate, and high hazard levels. The lowest EHI (0.02) occurs in dry/former agricultural land (U-06), moderate EHI (1.43) in swamp areas (U-04), and the highest EHI (6.71) in settlements (U-02). These differences arise due to varying potential erosion and tolerance levels, with major erosion drivers being rainfall erosivity, soil erodibility, slope steepness, and slope length. In general, residential lands (U-02 and U-03) have high erosion hazards (EHI 6.15–6.71), while dry/waste agricultural lands (U-08) and swamps (U-04) fall under moderate hazard. Other land uses such as mixed gardens (U-05) and built-up lands (U-01) show low erosion hazards (EHI <1.0). To mitigate erosion risks, the study recommends conservation practices such as contour planting and maintaining vegetation cover, especially in high-risk areas, to ensure sustainable land use and reduce soil degradation.

INTRODUCTION

Watershed (DAS) is land area that is a unity of rivers and their tributaries, which serves to accommodate, store, and drain water derived from rainfall to the lake or to the sea naturally, whose boundaries on land are topographical separators and boundaries in the sea up to the water area that is still affected by land activities. Watershed characteristics are a specific description of the watershed characterized by parameters related to morphometry, topography, soil, geology, vegetation, land use, hydrology, and people (Paimin et al., 2010).

Southeast Sulawesi is a province in Indonesia located in the southeastern part of the island of Sulawesi with the capital city Kendari, Sulawesi Island is geographically located in the southern part of the equator between 02°45' - 06° South latitude and 120°45' - 124°30' East longitude and has land area 3,814,000 ha and water sea area 11,000,000 ha.

Konaweha River or Sampara River is a river in Southeast Sulawesi Province, Indonesia, and is one of the longest and largest rivers in Sulawesi with a length of about 341.55 Km. The river has its headwaters at Bulu Brama Mountain, Uluiwoi District, East Kolaka Regency and empties into the Banda Sea near Kapoiala District, Konawe Regency, across 3 districts. Konaweha watershed is elongated with an area of ± 697,841 ha. The upper reaches of the river are mountains with steep slopes, while the middle reaches are low-lying marshy areas where the river flow is meandering and changing (BP DAS Sampara, 2009).

Watersheds are generally divided into upstream and downstream areas, where activities in the upstream region significantly influence the conditions in the downstream area. Soil, as a vital resource widely utilized by humans, is susceptible to erosion due to natural agents such as rainfall and wind. Erosion can be defined as the process of soil loss or displacement from one location to another, caused by the movement of water, wind, or ice (Rahim, 2018). Given these considerations, it is essential to conduct a study on the Erosion Hazard Index (EHI) and its relationship with land use, soil type, slope length and gradient, and rainfall in the Konaweha Sub-watershed. The objective of this research is to assess the Erosion Hazard Index in the upstream region of the Konaweha Sub-watershed and to analyze its spatial direction and distribution. The findings are expected to inform appropriate land use planning based on conservation principles to reduce the risk and extent of erosion.

METHODS

Location and Time

This research was conducted in Konaweha Sub Watershed, Laosu Village, Bondoala District, Konawe Regency, which is located between longitude 121°20'00" - 122°40'00" East Longitude and latitude 02°42'00" - 04°08'00". South latitude this research was conducted from May to June 2023.

Method of Colloecting Data

The data collection in this study involved a combination of fieldwork, laboratory analysis, and literature review. Direct observation was conducted at the study site to obtain primary data, particularly erosion indices derived from erosion predictions using the Universal Soil Loss Equation (USLE). Soil samples collected during field visits were analyzed in the laboratory to determine critical physical and chemical properties such as soil texture, organic matter content, and permeability, all of which significantly influence erosion processes. Additionally, a thorough literature review was performed to examine relevant theories and previous research findings, providing essential theoretical support and contextual background for the study. This integrated approach ensured comprehensive data acquisition and a robust foundation for analyzing erosion hazards within the study area..

Data Analysis

Data analysis in this study by utilizing the capabilities of GIS applications which include the creation of maps and tables (Data Base) with the digitization method; determination, distribution, area and classification of each biophysical component as well as, overlapping process to produce land units that will be used in each analysis of this study. Then this map is analyzed and compiled by selecting attributes in the calculation of the USLE method in equation one, namely the erosivity factor (R) from the rainfall map, the erodibility factor (K) from the soil type map, the length and slope factor (LS) from the slope map, the crop processing factor and soil conservation (CP) from the land use map. From the land unit map, calculations were carried out with the help of Field calculator to obtain the erosion rate value of each land unit. The use of erosion is done using the USLE method developed by Wischmeier and Smith (1958) in Arsyad (2006), namely:

The use of erosion is done using the USLE method developed by Wischmeier and Smith (1958) in Arsyad (2006), namely:

A = R.K.L.S.C.P

Description:

A= Estimated amount of erosion (Ton/Ha/Year) R = Rainfall erosivity factor

K= Land erodibility factor

LS= Length factor, slope inclination

C= Cover crop or management factor

P = Land conservation measures factor

data, used to determine the rainfall erosivity factor (R) through the Bols equation (1978) in Alwi (2004).

R= ∑ EI30= 6.12 (RAIN)1.21 (DAYS)-0.47 (MAXP)0.5

Description:

R = Erosivity of annual average rainfall (cm)

EI30 = Monthly average rainfall erosion index

(cm) RAIN = Monthly average rainfall (mm)

DAYS = Average number of rainy days per month (Days)

MAXP = Maximum rainfall for 24 hours in the month (cm).

According to Hammer (1978) in Asdak (2002), the calculation of the K value is calculated by the equation:

K= {2.71 × 104 (12-OM) M1.14 + 3.25 (S-2) + 2.5 (P-3)/100} (3)

By:

K = Erodibility

OM = Percent organic element

S = Soil structure classification code

P = Soil permeability

M = Particle size percentage (% dust + very fine sand) × (100-% clay).

Slope length (L) and slope slope (S)

The calculation of length and slope (LS) of Schwab et al., 1982 in Asdak (2002) is : LS = L1/2 (0.00138 S2 + 0.00965 S + 0.0138)

Description:

LS= Slope factor

L = Slope length (m)

S = Slope slope (%).

The C and P factor values (vegetation factor or crop management and soil conservation measures) were obtained from the C and P table of various land use types, Hammer (1981) in Arsyad (2000).

Erosion allowed (E Tol), determined by the Hammer (1981) equation in Mey (2003) as follows:

E Toll=$\frac{DE-DMIN}{\mathrm{MPT}}$+ LTP

Description:

E Tol = Erosion allowed (tons ha-1year(-) (1))

DE = Effective soil depth (mm) × depth factor value DMIN

= Minimum soil depth (mm) MPT = Land lifetime (250 years)

LTP = Soil formation rate (assumption: 1.2 mm th$^{(-)(1)}$.

IBE = A (Ton/Ha/Year)

E Toll (Ton/Ha/Year)

IBE = $\frac{\mathrm{A\ (Ton/Ha/Year)}}{\mathrm{E\ Toll\ (Ton/Ha/Year)}}$

Description:

IBE = Erosion Hazard Index

A = The amount of erosion that occurs (potential erosion) E Tol = Tolerable erosion rate.

The erosion hazard is expressed in the erosion hazard index, which is defined as follows (Hammer, 1981 in Arsyad, 2000).

RESULTS AND DISCUSSIONS

Land Unit

Land characteristics in the Laosu Sub Watershed Konaweha Village area are divided into 8 (Eight) land units, each land unit is distinguished based on the nature and characteristics of land use and slope, for details can be seen in Table 1.

Land use is the use of land in which there is human intervention with the aim of meeting needs. Land use is divided into agricultural and non-agricultural land use, which includes in agricultural land use, namely dry land agriculture, paddy fields, grasslands, protected forests and so on while non-agricultural land use is villages (settlements), industry, mining, and so on (Arsyad, 2010)

Table 1. Description of land unit characteristics of Laosu Village in Konaweha Watershed

No.	Land Unit	Land Use		Slope (%)
1	U-01	Built-up land		8-15% (Ramps)
2	U-02	Settlement		0-8% (Flat)
3	U-03	Settlement		8-15% (Ramps)
4	U-04	Swamp		0-8% (Flat)
5	U-05	Mixed garden		8-15% (Ramps)
6	U-06	Dry land/waste farming		0-8% (Flat)
7	U-07	Swamp		0-8% (Flat)
8	U-08	Dry land / waste farming		0-8% (Flat)

Source: Field survey and secondary data analysis, 2023

Rain Erosivity

Erosivity of rain is the driving force that causes chipping and transport of soil particles to lower places. The rainfall erosivity factor was calculated using the equation of Bols (1987) in Alwi (2004). The results of the rainfall erosivity analysis can be seen in Table 2.

Table 2. Data on average monthly rainfall, maximum rainfall and rainy days in 2018-2022

Month	Monthly Rainfall (cm)	Rainfall Maximum (cm)	Rainy Day	EI(30) (cm)
January	15,586	4,128	9,2	126,9
February	10,96	3,794	7,8	85,62
March	12,74	4,028	8,4	102,4
April	17,83	5,516	10,8	161,43
May	31,09	6,182	16,8	273,04
June	30,18	4,692	14	247,9
July	24,29	3,328	13,4	162,2
August	16,496	3,892	10,2	125,5
September	13,85	1,724	9,4	68,53
October	5,064	3,838	5,4	40,23
November	13,32	2,782	8,2	89,83
December	8,394	3,99	6,8	67,92
Total	**199,80**	**47,894**	**120,4**	**1551,50**
Average	**16,65**	**3,991**	**10,033**	**129,29**

Source: Kendari River Basin IV (BWS), 2023

Based on Table 2. shows that the amount of annual rainfall obtained from the Kendari River Basin IV (BWS), namely the highest rainfall occurred in May at 273.04 cm th-1, June 247.9 cm th-1, and July 162.2 cm th-1, this is because in these months the monthly rainfall is very high, daily, and maximum rainfall is very high, while the lowest rainfall occurs in October at 40.23 cm th-1, December 67.92 cm th-1, and February 85.62 cm th-1, this is because these months monthly, daily and maximum rainfall very low. The larger level of erosivity, then, will increase erosion. The value of rain erosivity (R) is calculated using data on average monthly rainfall, maximum rainfall, and rainy days in 2018-2022 from the Kendari River Basin IV (BWS). The results of the calculation of average rainfall, monthly rainfall, maximum rainfall and rainy days obtained rainfall erosivity value (R) of 1551.50 cm, can be seen in Table 2.

Rainfall that falls on the surface of the land will affect the amount of soil that will be eroded, this can happen because when it rains if there are no trees or ground cover that holds water directly to the ground it will slowly erode the surface of the soil in a certain time will cause damage soil or causing soil damage or erosion. The higher the value of rainfall erosivity, the higher the surface runoff that occurs (Sucipto, 2007).

Soil Erodibility

The results of the analysis for soil erodibility were obtained by entering the values of soil factors, namely soil texture, organic matter elements, soil structure and soil permeability obtained from laboratory analysis and directly observed in the field on each land unit in Laosu Village, Bondoala District, as presented in Table 3.

Table 3. Soil erodibility values (K) in Laosu Village, Konaweha Subwatershed

					Texture					
No.	**Land Unit**	**OM (%)**	**P (Cm/H)**	**Sand (%)**	**Dust (%)**	**Clay (%)**	**M**	**S**	**KP**	**K**
1	U-01	0,78	4,71	53,01	40,86	6,13	5335,73	3	4	0,59
2	U-02	1,6	9,29	50,37	44,44	5,19	5076,25	1	3	0,49
3	U-03	1,3	4,11	41,87	22,27	35,86	4173,41	1	4	0,39
4	U-04	1,53	06,83	29,26	57,29	13,44	2969,85	3	5	0,35
5	U-05	1,54	7,09	24,19	37,79	38,03	2418,76	3	4	0,27
6	U-06	1,44	9,3	23,15	26,60	50,14	2291,46	2	3	0,20
7	U-07	1,25	4,86	17,90	32,67	49,40	1773,27	2	4	0,18
8	U-08	1,60	8,20	22,45	28,70	40,88	2232,82	2	3	0,20

Source: Primary data, 2023

Based on Table 3, that the highest soil erodibility value is found in land unit (U-01) namely, 0.59, (U-02) 0.49 and (U-03) 0.39 this is due to soil erodibility factors such as less organic matter, high permeability, particle size and high soil structure while the lowest value is land unit (U-07) namely 0.18, (U-08) 0.20 and (U-05) 0.27, this is due to its erodibility factors such as high organic matter, low permeability, low particle size and high soil structure values. The analysis of soil erodibility levels in Laosu Village, Konaweha Sub Watershed, indicates that the highest value occurs in built-up land use (U-01) at 0.59. This is attributed to relatively large particle size (M), rapid permeability (P), low organic matter content (OM), high sand fraction, moderate silt content, low clay content, and well-developed soil structure across the land units. Conversely, the lowest soil erodibility value is found in swamp areas (U-07) at 0.18, which corresponds to smaller particle size (M), high organic matter content (OM), slow permeability (P), low sand and silt fractions, higher clay content, and strong soil structure.

Soil erodibility is influenced by several key factors, including texture, organic matter, permeability, and aggregate stability. Higher silt content tends to increase erodibility, whereas sand and clay often reduce it (Gyamfi et al., 2016). Variations in soil texture, such as sandy clay loam, affect erosion susceptibility across different regions (Tesfaye & Ameyu, 2021). Organic matter enhances soil structure and stability, thereby lowering erodibility, while permeability also plays a role—soils with slow to moderate permeability are more prone to erosion due to surface crusting and drainage issues (Tesfaye & Ameyu, 2021). Well-aggregated soils are more resistant to erosive forces (Soniari et al., 2024), and the arrangement of soil particles, particularly in medium to fine-grained soils, can increase erosion risk, especially on slopes (Tesfaye & Ameyu, 2021).

Slope length (L) and slope inclination (S)

Slope and slope length are two factors that determine the topographic characteristics of a watershed. The length and slope factors were calculated using the equation of Schwab et al. (1982) in Asdak (2002). The results of slope length and slope can be seen in Table 4.

Table 4. Length and Slope

Land Unit	Slope Length (m)	Slope (%)	m	L	S	LS
U-01	13,0	7	0,5	0,77	0,70	0,54
U-02	18,5	8	0,5	0,92	0,84	0,77
U-03	11	11	0,5	0,71	1,35	0,96
U-04	49,7	6	0,5	1,50	0,57	0,86
U-05	72,2	8	0,5	1,81	0,84	1,53
U-06	30,3	4	0,4	1,14	0,35	0,40
U-07	29,6	8	0,5	1,16	0,84	0,98
U-08	186	5	0,4	2,35	0,45	1,07

Source: Secondary data analysis, 2023

Based on Table 4, it shows that the highest values of length and slope are located in land unit (U-05) which is 1.53, (U-08) 1.07 and (U-07). 0.98, this is because the length and slope values are very high, while the lowest in the land unit (U-06) is 0.40, (U-01) .54, and (U- 02) 077. Due to values length and low slope values. The results of the analysis carried out in Laosu Village show that the highest value of length and slope (LS) is in mixed garden land use (U-05) which is 1.53 with a slope of 8-15% (Sloping or undulating) and the lowest in dry land / former agriculture (U- 06) which is 0.40 with a slope of 8-15% (sloping / undulating). Based on the results of the research conducted that in Laosu Village has a distribution of slopes ranging from 0-8% (flat) 8-15% (sloping), 15-15% (undulating), 15-15% (undulating), and 15-15% (undulating). 25% (moderately steep), 25-45% (steep).

Crop Management Value (C) and Soil Conservation Value (P)

The results of crop management and soil conservation can be seen in the following table:

Table 5. Crop Management and Soil Conservation Values

Land Unit	Crop Management	Action		
		C		**P**
U-01	Trees without shrubs	0,32	Uninterrupted	0,01
U-02	Partial settlement in vegetation	0,9	Ground cover is not Perfect	0,07
U-03	Partial settlement in vegetation	0,9	Ground cover is not Perfect	0,07
U-04	shrubs	0,95	Partial ground cover overgrown with reeds	0,02
U-05	Mixed garden density	0,2	Ground cover is Perfect	0,01
U-06	Fallow land without crops processed	0,1	Partial ground cover overgrown with reeds	0,02
U-07	Reeds burned one times	0,02	Partial ground cover overgrown with reeds	0,02
U-08	Fallow land without crops processed	0,1	Partially planted shrubs grass	0,10

Source: Primary data analysis 2023 and secondary data Alwi, 2012

The value of crop management and land conservation can be determined directly in the field on each land unit that has been determined. The highest C factor value is found in the land unit (U-04) is 0.95, and the lowest is (U-08) 0.1, while the highest P value in land unit (U-08) is 0.10 and the lowest is (U-05) 0.01.

The results of research conducted in the field the value of crop management and land conservation (CP) is one of the variables to calculate the value of the amount of erosion using the USLE formula, in CP research in the field is done directly by observing the types of plants located in each land unit and seeing if there is a change in land use. In the management of plants and soil conservation contained in each land unit varies, namely in the land unit (U-01) management of tree crops without shrubs undisturbed conservation measures, land units (U-02 and U-03) management of residential plants partially overgrown with vegetation imperfect soil cover conservation measures, land unit (U-04) management plants. land unit (U-05) medium density mixed orchard crop management perfect soil cover conservation measures, land unit (U-06) fallow land cultivation without crops cultivated soil cover conservation measures partially overgrown with reeds, land unit (U- 07) reed crop management burned once soil cover conservation measures partially overgrown with reeds, land unit (U-08) fallow land cultivation without crops conservation measures shrubs planted with grass.

The crop management factor (C-factor) plays a crucial role in soil erosion estimation, representing the combined effects of vegetation cover and land management practices in reducing soil loss. Lower C-factor values indicate stronger protection against erosion (Xiong et al., 2023). Changes in the C-factor can effectively capture the impact of conservation interventions over time, as shown in long-term studies of arable land (Prasuhn, 2022). A variety of methods are available for estimating the C-factor, ranging from empirical approaches to advanced techniques involving remote sensing, which facilitate broader spatial applications (Xiong et al., 2023; Tsai et al., 2021). The incorporation of geospatial data and machine learning has further improved the precision and temporal relevance of C-factor assessments (Tsai et al., 2021). Beyond technical considerations, understanding the C-factor also helps identify erosion-prone areas and supports the development of targeted soil conservation strategies, contributing to sustainable land management (Milekić, 2024). Moreover, the C-factor is influenced by socioeconomic conditions, highlighting the importance of integrating both biophysical and human dimensions in soil erosion control (Erol et al., 2015).

Predicted Erosion and Tolerable Erosion

Predicted total erosion that occurred in the Subwatershed Konaweha Kelurahan Laosu Table 6. Predicted Erosion using equation USLE equation, Wischmeier and Smith (1978) in (Arsyad, 2000).The results of the analysis at the research site can be seen in Table 6.

Table 6. Predicted Erosion.

			Value factor			
Land Unit	**R**	**K**	**LS**	**C**	**P**	**A**
						(tons ha^{-1}year$^{(-)}$ $^{(1))}$
U-01	1551,50	0,59	0,54	0,32	0,01	1,582
U-02	1551,50	0,49	0,77	0,9	0,07	36,879
U-03	1551,50	0,39	0,96	0,9	0,07	36,596
U-04	1551,50	0,35	0,86	0,95	0,02	8,873
U-05	1551,50	0,27	1,53	0,2	0,01	1,282
U-06	1551,50	0,20	0,40	0,1	0,02	0,248
U-07	1551,50	0,18	0,98	0,02	0,02	0,109
U-08	1551,50	0,20	1,07	0,1	0,10	3,320
Total						**88,889**
Average						**11,111**

Source: Primary data analysis, 2023

Based on Table 6, shows the highest erosion prediction value is in the settlement (U-02) with a total of 36,879 (tons ha-1thn-1) this is due to the erodibility value of (0.49) LS value (0.77) C value (0,9) and P (0.07), while the lowest erosion prediction value is in the swamp (U-07) of (0.109) (tons ha-1thn-1) this is because the erodibility value gets a value of (0.18) LS value (0.98) C value and P (0.02).

Based on Table 7, it shows that the highest tolerable erosion value is in dryland / former agriculture (U-06) which is 14.44 (tons ha-1 year-1) and the lowest is in swamp (U-07) which is 1.7 (tons ha-1 year-1).

Table 7. Calculation results of tolerable erosion (E Tol)

Land unit	D (mm)	NFK	DE (mm)	Dmin (mm)	MPT (mm)	LPT (mm)	E Toll (tons $ha^{-1}year^{(-)}$ (1)
U-01	560	0,9	504	250	250	1,2	2,216
U-02	1360	0,9	1224	150	250	1,2	5,496
U-03	1430	0,9	1287	100	250	1,2	5,948
U-04	1500	0,9	1350	100	250	1,2	6,2
U-05	1050	0,9	945	300	250	1,2	3,78
U-06	900	0,9	810	200	250	1,2	14,44
U-07	250	0,9	225	100	250	1,2	1,7
U-08	500	0,9	450	100	250	1,2	2,6

Source: Primary data analysis, 2023

Based on the results of the analysis of erosion prediction research using the USLE formula with various parameters including rain erosivity (R), soil erodibility (K), slope length (L) slope (S), crop management (C), and land conservation measures (P), obtained erosion prediction with a very high amount on Settlement land (U-02) with a total of 36,879 (tons ha-1thn-1) this is due to high erosivity factors, rather high erodibility, the length and slope of the slope are high, the management of residential crops is partially overgrown with vegetation imperfect soil cover conservation measures, while the lowest value is in the swamp (U- 07) of 0.109 (tons ha-1 year-1) this is due to factors of high erosivity, high erodibility, length and slope are rather high, the management of fallow land crops without being processed undisturbed conservation measures for the next time. Erosion prediction results can be seen in Table 6. For the highest tolerated erosion value is on dry land / former agricultural land use (U-06) which is 14.44 (tons ha- 1thn-1) this is due to the rather high effective soil depth value factor, the minimum soil depth is moderate, while the lowest tolerated erosion value is on the swamp (U-07) which is 1.7 (tons ha-1thn-1) this is due to the low effective depth factor and the minimum depth is also low. The tolerated erosion results can be seen in Table 7. Tolerable soil loss (T value) varies depending on soil properties, erosion susceptibility, and long-term productivity. Studies have shown that default T values often require adjustment based on factors such as soil thickness, humus content, and fertility. Methods for determining T values commonly consider the rate at which productivity can decline without compromising sustainable use. Approaches that integrate soil profile characteristics, erosion depth, and productivity loss are increasingly emphasized, highlighting the importance of site-specific assessments to support effective and sustainable land management (Duan et al., 2012; Chornyy & Poliashenko, 2017; Du et al., 2013; Pretorius & Cooks, 2017).

Erosion Hazard Index

The value of the erosion hazard index in Laosu Village of Konaweha Sub Watershed can be known by entering the values of the potential erosion rate (A) and the tolerable erosion value (E Tol), as presented in Table 8.

Based on Table 8, it shows that the land unit that has an erosion hazard index based on the IBE Classification, which is categorized as high, is located in settlements (U-02 and U-03) at 6.71 and 6.15, while the moderate erosion hazard index is located in swamps (U-04) at 1.43, dry land / former U-08) with a value of 1.28 and low is located in swamps (U-07) at 0.06 and built- up land (U-01) at 0.71.

Table 8. Erosion hazard index values in Laosu Village, Konaweha Subwatershed

Land Unit	A (tons $ha^{-1}yr^{-1}$)	E Toll (tons $ha^{-1}yr^{-1}$)	IBE	Description
U-01	1,582	2,216	0,71	Low
U-02	36,879	5,496	6,71	High
U-03	36,596	5,948	6,15	High
U-04	8,873	6,2	1,43	Medium
U-05	1,282	3,78	0,34	Low
U-06	0,248	14,44	0,02	Low
U-07	0,109	1,7	0,06	Low
U-08	3,32	2,6	1,28	Medium

Source: Primary data analysis, 2023

The results of the research analysis conducted in Laosu Village that the Erosion Hazard Index (IBE) has differences based on the IBE classification ranging from low, medium, high and very high. The lowest erosion hazard index is located on dry / waste land agriculture (U-06) of 0.02, while the moderate erosion hazard index is located in the swamp (U-04) of 1.43, and the highest erosion hazard index is located in the swamp (U-04) of 1.43. The high erosion hazard index is located in the settlement (U-02) of 6.71 this is due to the low erosion potential and rather high erosion tolerated as well as the main cause of erosion is the erosivity factor, the higher the value of rain erosivity, the higher the surface runoff that occurs the calculation of the rain erosivity index obtained is 1551.50. The soil erodibility factor, that is easy or not to experience erosion is determined by various soil properties including soil texture, soil structure, organic matter, and permeability, and also the slope factor length and slope factors can affect the high or low erosion and can refer to surface flow. While the main cause of tolerable erosion is the rate of erosion that can still be tolerated, especially lands that have slopes, the rate of erosion must be balanced with the rate of soil formation, as can be seen in Table 8. Alewell et al. (2015) indicated that the imbalance between soil formation and erosion rates may reflect unsustainable land management practices. Tolerable soil erosion is determined by various factors such as soil characteristics, topography, and land use practices. Accurate estimation of erosion thresholds is essential to maintain soil productivity and fertility (Karkee et al., 2012; Lisetsky et al., 2024).

CONCLUSIONS

Based on the analysis conducted, several conclusions can be drawn. One of them is the Erosion Hazard Index (EHI) values observed in each land unit. High EHI values (4.01–10.00) were found in residential areas (U-03 and U-02), with values of 6.15 and 6.71, respectively. Moderate values (1.01–4.00) were found in dryland agriculture/former agricultural land (U-08) with a value of 1.28, and in swamp areas (U-04) with a value of 1.43. Meanwhile, low EHI values (<1.0) were found in dryland agriculture/former agricultural land (U-06) with a value of 0.02, in swamps (U-07) with 0.06, in mixed gardens (U-05) with 0.34, and in built-up areas (U-01) with 0.71. Therefore, conservation measures are necessary in land use practices, such as contour planting and the use of vegetative cover.

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