http://journal.uir.ac.id/index.php/JGEET
E-ISSN : 2541-5794
P-ISSN : 2503-216X

Journal of Geoscience,
Engineering, Environment, and Technology
Vol 10 No 1 2025

RESEARCH ARTICLE

Potential Hazards of Erosion and Conservation Strategis in the Sail Sub-Watershed, Pekanbaru City, Riau Province, Indonesia

Rani Amalia Ramsof [1]*, Zufialdi Zakaria[1], Irvan Sophian[1], Arie Afriadi[2]

[1] *Department of Geological Engineering, Padjadjaran University, Indonesia*
[1] *Department of Geological Engineering, Padjadjaran University, Indonesia*
[1] *Department of Geological Engineering, Padjadjaran University, Indonesia*
[2] *Faculty of Engineering and Maritime Technology, Maritime Raja Ali Haji University, Indonesia*

* Corresponding author : rani20006@mail.unpad.ac.id
Tel.: +628-52-710-911-84
Received: Jan 09, 2025; Accepted: Feb 10, 2025.
DOI: 10.25299/jgeet.2025.10.1.20795

Abstract

Erosion in watershed area can be triggered by changes in land use, human activities, and cause increased sedimentation, flood risk, and environmental degradation, effective conservation measures are necessary to ensure its impact is reduced. To determine potential erosion hazards in Sail Sub-Watershed the method used is Revised Universal Soil Loss Equation (RUSLE), parameters include rainfall, soil erodibility, slope length and slope, and land cover and soil conservation. In addition, an analysis of permissible erosion and an erosion hazard index were carried out. The research results show that the level of erosion hazard is influenced by the value of the rain erosivity factor (R) of 2678.98 m with the wet rainfall classification. The soil erodibility factor (K) is dominated by cambisol soil types with a K value of 0.28 and podzolic with a K value of 0.20. The length and slope (LS) factors are dominated by flat topography with an LS value of 0.4. Meanwhile, the land cover and soil conservation (CP) factors mostly consist of open land, shrubs and plantations that have not received any conservation efforts. The erosion hazard level (TBE) in ranges from moderate to very severe, indicating that the areas affected by erosion are predominantly due to the use of open land, such as at station 16. The erosion hazard index (EHI) varies from moderate to very high. As a land conservation effort, vegetative methods in the form of reforestation are recommended for open land, while terrace walls or wet masonry are recommended for agricultural land and plantations. In addition, conservation structures such as retaining walls, bench terraces, or stairs can be implemented on plantation land to reduce the danger of erosion.

Keywords: *Sail Sub - Watershed, Erosion, RUSLE, Land Cover, Conservation*

1. Introduction

Erosion is a common issue in watershed area and can be accelerated by human activities. This process is influenced by factors such as climate, soil, topography, human activities, and vegetation (Arsyad, 2012). Erosion upstream produces fine particles that are carried by water flows and settle on the river bed as sediment. This sediment accumulation can cause shallowing downstream and increase the risk of flooding (Sujatmoko et al., 2022). The study by Sanchez et al., 2024 also emphasized that rainfall and changes in land cover have a significant effect on erosion levels.

The Sail sub-watershed, which is located in Pekanbaru City and a small part in Pelalawan and Kampar Regencies, has experienced significant land cover changes. Urban development causes an increase in built-up land and palm plantations, while swamps, bushes, agriculture and dry land decrease. These changes affect hydrological conditions and increase the risk of floods and drought (Nugraha et al., 2018). Changes in land use also cause increased surface flow, erosion and sedimentation (Utami et al., 2019).

Changes in land use without good vegetation management can increase the rate of erosion, especially on steep slopes (Andriana et al., 2021). As a result, sedimentation worsens river flow conditions and increases the potential for flooding. In March 2021, the Sail Sub DAS recorded 25 flood points, which is the largest compared to other sub watershed area (BPBD Pekanbaru City, 2021). Conversion of agricultural land into residential areas also reduces groundwater infiltration, reduces flow discharge, and damages water quality (Lele, 2009; Wibowo et al., 2015).

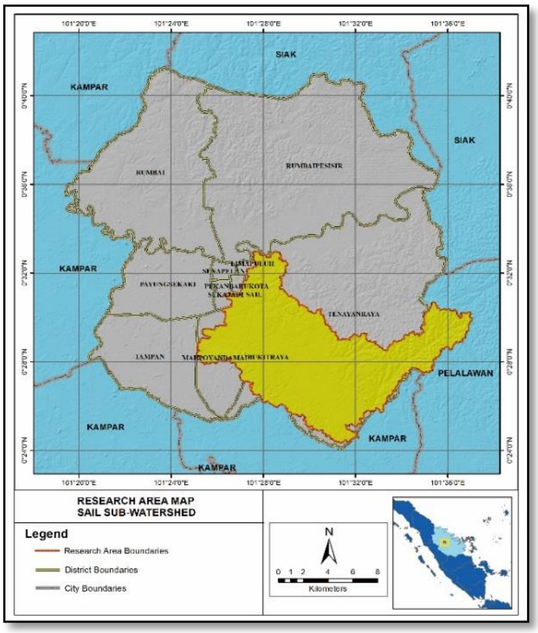

Fig 1 Research Area Map Sail Sub-Watershed

Soil erodibility is an important factor in determining the level of erosion. According to Wang (2011) soil erodibility helps estimate soil loss, design conservation, and assess environmental impacts on water bodies.

Therefore, analysis of the factors that cause erosion and the potential for erosion is very necessary to minimize the impacts. This research aims to analyze the erosion hazard level (TBE) and erosion hazard index (EHI) in the Sail Sub-watershed, especially in high potential areas. It is expected that the results will be able to identify factors that cause erosion and design appropriate land conservation directions, thereby contributing to the management and improvement of environmental quality in this area.

2. Data and Method

This study, the RUSLE (Revised Universal Soil Loss Equation) method is used, which is a model employed to estimate the rate of soil erosion in an area. RUSLE is an improvement of the USLE (Universal Soil Loss Equation) method and is widely used in environmental studies and soil conservation (Renard, K.G et al., 1997). The diagram of the conceptual framework for this research can be seen in the figure 2.

2.1 Rain Erosivity Factor

Rain erosivity factor (R) uses rainfall data from rain observation stations at the research location for the last five years (2016-2021) using CHIRPS data (*Climate Hazards Group Infrared Precipitation with Station Data*). The average rainfall in the month, year and maximum rainfall was calculated to determine the value of rain erosivity using the equation by (Arsyad, 2010). The data is then analyzed using the method *Inverse Distance Weighted* (IDW) and from IDW interpolation the distribution of rain erosivity can be determined using the classification in (Karondia et al., 2022)

2.2 Soil Erodibility Factor (K)

The soil erodibility factor using 2020 soil types is sourced from the Bappeda of Riau Province. Determining the erodibility value (K) is based on soil type data which is matched with the classification of soil erodibility values by (Sadewo et al., 2023) then analyzing the K distribution.

2.3 Length and Slope Factor (LS)

The slope's length and slope factors are calculated using the equation by Renard et al., (1997), namely the ratio between the slope's length and slope. Slope steepness can be determined based on classification (Puslittanak 2004; Setiawan 2024). The data used are DEM data for Riau Province, resolution 20 × 20 m (ASTER-GDEM, 2011) and administrative base maps. DEM data is used to obtain slope and flow accumulation, which are calculated using the Raster Calculator. The length of the slope and the slope of the slope are calculated by the formula:

$$L = (l / 22 , 1)^{m} \quad (1)$$
$$S = (10.8 \sin \alpha + 0.03) \text{ for } s < 9\% \quad (2)$$
$$S = (16.8 \sin \alpha - 0.5) \text{ for } s \geq 9\%.$$

Information :
L : Slope length
S : Slope

2.4 Vegetation Cover and Land Cultivation (CP) Factors

The classification of factors C and P uses land use data at the research location, namely Pekanbaru City in 2020, sourced from Bappeda, Riau Province. This data is used to analyze the influence of land use types on erosion levels in the research area. The value of this factor is obtained through overlay analysis between the slope map and land use map. The following are CP values, which are different for each type of land use based on their classification (Isma et al., 2017).

2.5 Erosion Rate of the Sail Sub-Watershed

Calculation of erosion rate using the RUSLE method with the following equation:

$$A = R \times K \times L \times S \times C \times P \quad (3)$$

Information :
A : the amount of eroded soil (erosion rate)
R : rain erosivity factor
K : soil erodibility factor
LS : factor of length and slope of the slope
C : plant management factors
P : factors of conservation actions

The calculation will produce an erosion rate value for each land unit and certain area. This value is then classified based on the Erosion Hazard Level, Erosien Rate can be determined based on classification (Ministry of Forestry, 1998)

2.6 Allowable Erosion (T)

The calculation of tolerable erosion (T) is calculated using the method by Hammer, (1980) with an equation that considers the value of the soil depth factor, effective soil depth, resource life and bulk density value with the following equation:

$$T = \frac{EDC}{RL} \times BD \quad (4)$$

Information:
T : Tolerable erosion rate (mm/ha/year)
EDC : Soil depth factor x effective soil depth (cm)
RL : Resource Life (years)
BD : Bulk density (gr/cm3)

The soil's effective depth value is measured by drilling in the field to a depth that plant roots can penetrate using soil auger. Meanwhile, the bulk density value is carried out by purposive sampling using the ring method, the ring replaced with a PVC pipe and then tested in the laboratory to analyze the bulk density value.

2.7 Erosion Hazard Index

Analysis of the Erosion Hazard Index (EHI) was carried out using the Geographic Information System (GIS) with the interpolation method, using the Arsyad, (1989) equation:

$$EHI = \frac{A}{T} \quad (5)$$

Information :

EHI : Erosion hazard index
A : Number of estimated erosion rates (tons/ha/year)
T : Tolerable erosion rate (tones/ha/year)

The results of the EHI calculation produce values which are then classified based on the Erosion Hazard Level. Although erosion cannot be completely avoided, the steps taken aim to keep erosion below the maximum permissible limits. The erosion hazard classification, which shows the erosion rate in tones/ha/year, can be seen in (Arsyad, 2010).

2.8 Land Conservation Directions

Soil conservation is an effort to protect and control erosion. In this research, we discuss land use and management that should be carried out to reduce the rate of erosion to reach or be lower than the permitted erosion rate limit. Soil conservation

(P) direction which aims to maintain or increase supporting data and land productivity.

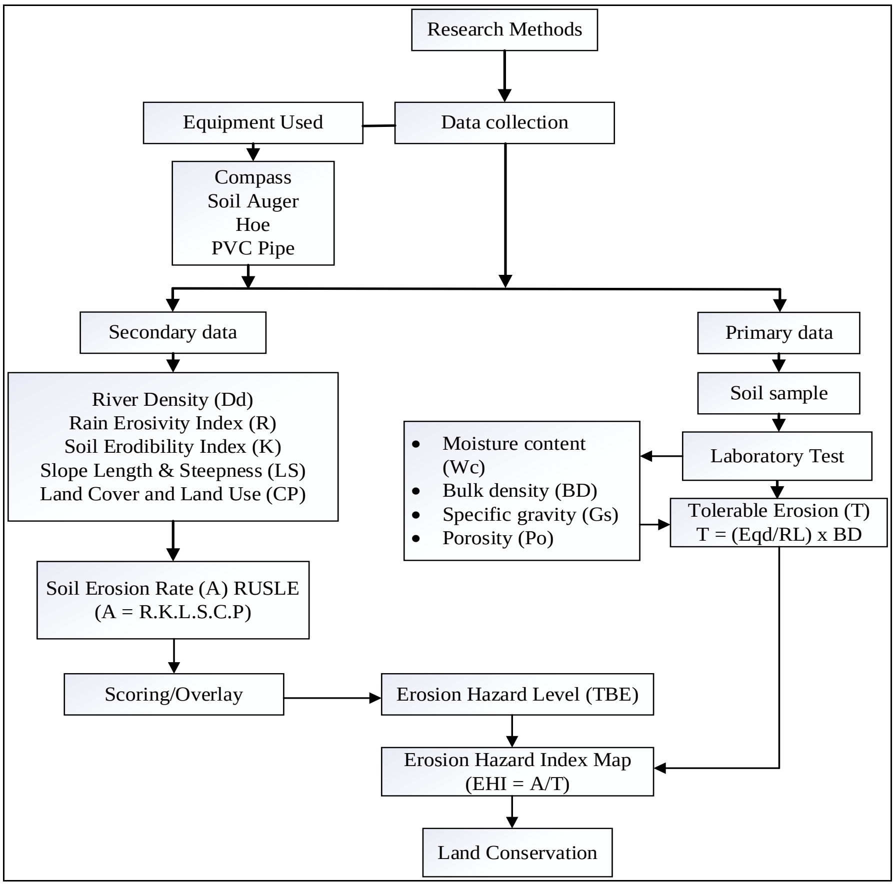

Fig 2 Framework diagram

3. Result

3.1 Rain Erosivity Factor Analysis (R)

Based on the rainfall distribution map at the research location, the calculated rain erosivity value falls into the wet classification (2,500-3,000mm) with a value of 2678.79mm from the average rainfall in the period 2017 to 2021.

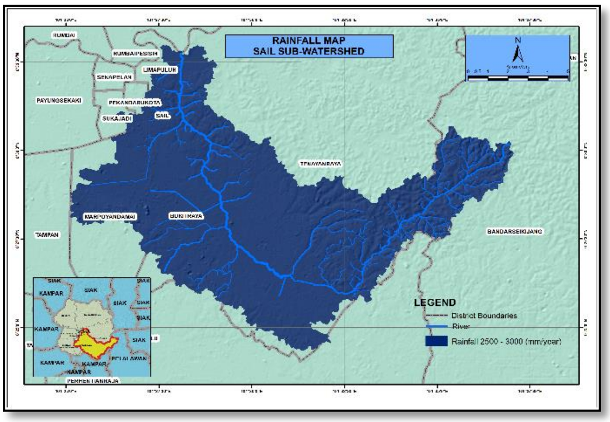

Fig 3. Rainfall map in the Sail sub-watershed

3.2 Analysis of Soil Erodibility Factors (K)

Regarding the Soil Erodibility factor, there are two types of soil used at the research location, namely cambisol and podzolic soil. The cambisol soil type has a soil erodibility factor (K) value of 0.28 and podzolic 0.20, referring to research by Sadewo, (2023). From the calculation of soil erodibility values, there is a cambisol soil area of 10705.9 Ha and a podzolic soil area of 3531.8 Ha.

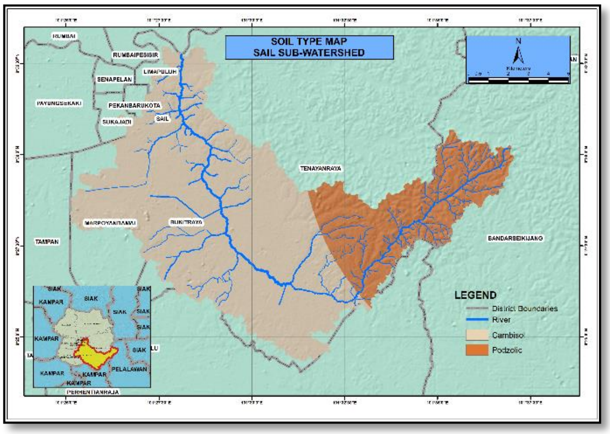

Fig 4. Soil Type Map in the Sail Sub-DAS

3.3 Analysis of Slope Length and Slope (LS)

In the Length and Slope factors, the research area is dominated by a slope of 0-8% with an area of 105.49 Km^2 where the classification of LS values using the (Puslittanak 2004; Setiawan 2024) approach is included in the Flat category. Apart from that, the distribution of slopes in the research area is also included in the gentle category with a LS value of 1.40 with an area of 24.97 $km.^{2.}$, Slightly Steep category with a LS value of 3.10 with an area of 10.97 Km^2, and steep category with an LS value of 6.80 with an area of 0.94 km^2.

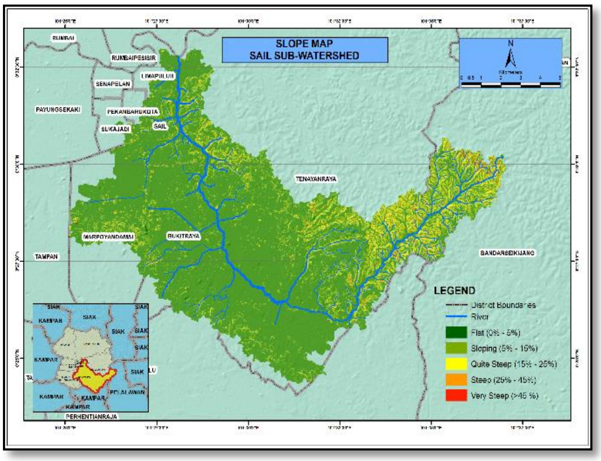

Fig 5. Slope Map in the Sail Sub-Watershed

3.4 Analysis of Vegetation Cover and Land Cultivation (CP)

The Sail Sub-Watershed has 6 types of land cover including plantations, settlements, bushes, ponds, open land, and agriculture. Most of the Sail Sub-Watershed is dominated by residential land covered with an area of 52.90 km^2 and plantations covering an area of 52.25 km^2. Based on the results of the analysis of land cover factors (CP), it shows that open land and settlements are the main factors that influence the potential contributors to erosion and then related to the second potential contributor to erosion is the land cover of plantations, shrubs, and agriculture.

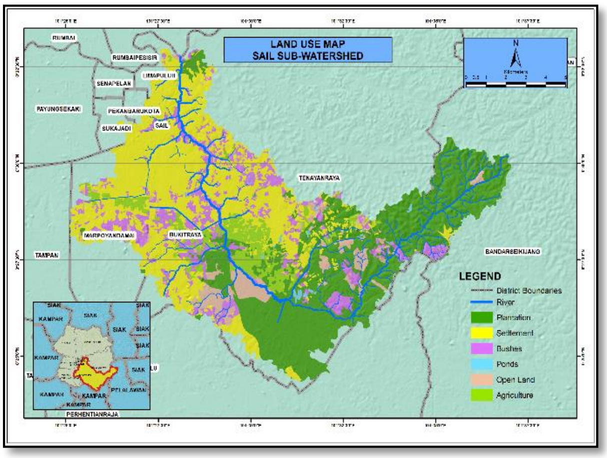

Fig 6. Land Use Map in the Sail Sub-Watershed

3.5 Erosion Rate (A) in the Sail Sub-watershed

The rate of erosion in the research area consists of the erosivity factor, rainfall factor (R), soil erodibility factor (K), slope length and slope factor (LS), and land cover & soil conservation factor (CP). Based on the results of RUSLE analysis at 18 station points, the erosion rate values that occur are as follows.

From the calculation results of all influencing factors, there are several stations that have high actual erosion values (A), reaching thousands of tons/ha/year, such as stations 1, 5, 7, 8, 12, 16 and station 4 which have actual erosion values A reaching 2550.21 tones/ha/yr. Based on the erosion rate value or the results of calculations using RUSLE, it will produce an erosion rate class for each land unit and area area with an Erosion Hazard Level Classification.

Table 1. Erosion Rate Values in the Sail Sub-Watershed

STA	R	K	LS	C	P	A (tones/ ha /yr)
1	2678.79	0.28	1.4	1	1	1050.09
2	2678.79	0.20	0.4	0.3	1	64.29
3	2678.79	0.28	1.4	0.3	1	315.03
4	2678.79	0.28	3.1	1	1	2550.21
5	2678.79	0.28	1.4	1	1	1050.09
6	2678.79	0.28	0.4	1	1	300.02
7	2678.79	0.28	1.4	1	1	1050.09
8	2678.79	0.20	3.1	1	1	1821.58
9	2678.79	0.20	3.1	1	1	1821.58
10	2678.79	0.20	3.1	0.1	1	182.16
11	2678.79	0.20	3.1	0.1	1	182.16
12	2678.79	0.20	3.1	1	1	1821.58
13	2678.79	0.28	0.4	1	1	300.02
14	2678.79	0.28	0.4	1	1	300.02
15	2678.79	0.20	1.4	0.1	1	75.01
16	2678.79	0.20	3.1	1	1	1821.58
17	2678.79	0.28	1.4	0.1	1	105.01
18	2678.79	0.28	1.4	0.1	1	105.01

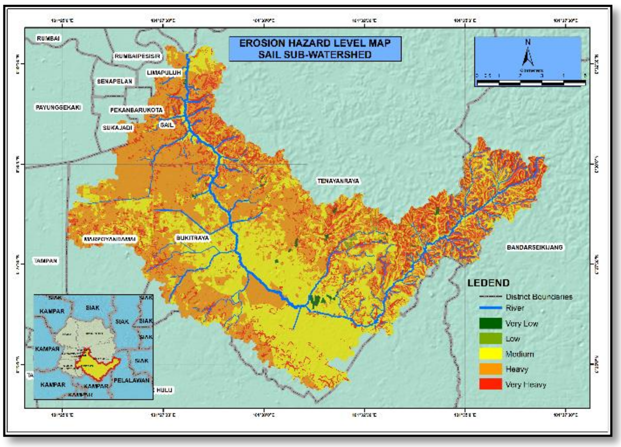

Fig 7. Map of Erosion Hazard Level in the Sail Sub-Watershed

In the analysis of the Erosion Hazard Level Classification, it is known that areas with a very heavy erosion hazard level (more than 480 tons per hectare per year) cover an area of 2,246.37 hectares, or the equivalent of 25.30% of the total area analyzed. This area mostly consists of land cover such as plantations, settlements, agriculture, bushes, and open land. Meanwhile, at the level of erosion hazard in the heavy category (between 180 and 480 tons per hectare per year), the area reaches 6,520.99 hectares, or 73.44% of the total area, with similar types of land cover, namely plantations, settlements, agriculture, bushland, and open land.

Table 9. Classification of Erosion Hazard Levels in the Sail Sub-Watershed

Erosion Rate (Tons/ha/year)	Area (Ha)	Wide (%)
Very Heavy (>480)	2246.37	25.30%
Weight (180-480)	6520.99	73.44%
Medium (60-180)	21.57	0.24%
Low (15-60)	21.75	0.24%
Very Low (<15)	68.67	0.77%

Furthermore, at the moderate category of erosion hazard level (between 60 to 180 tons per hectare per year), the area included in this category is 21.57 hectares, or 0.24% of the total area. This area is dominated by land cover in the form of plantations, agriculture, and shrubs. Then, at the low category erosion hazard level (between 15 and 60 tones per hectare per year), an area of 21.75 hectares, or 0.24% of the total area, was recorded, the majority of which consisted of agricultural land cover. Finally, at a very low level of erosion hazard (less than 15 tons per hectare per year), there is an area of 68.67 hectares, or 0.77% of the total area analyzed, where the type of land cover is ponds.

3.6 Tolerable Erosion Level Analysis (T)

The results of calculating tolerable erosion (T) at each point of the Sail Sub-Watershed location vary in each land unit, this is due to differences in equivalent soil depth, soil depth factors, soil useful life, and bulk density values.
Sampling was done using a grid model measuring 3000 x 3000 meters, with 18 stations as observation points. This grid model was chosen to ensure a representative sample distribution in the study area.

The soil depth factor value for the Kambisol soil type with the Inceptisol order and the Aquept sub-order is 0.95. Meanwhile, for the Podzolic soil type with the Ultisol order and the Aquults sub-order, the depth factor value is 0.8 which uses the USDA Soil Taxonomy system soil classification as a reference. The effective depth of soil measured directly ranges from 42cm to 100cm, and the resource life for conservation purposes is 400 years. Bulk density values start from 1.125 - 1.922 g/ cm^3. Based on the equation, the tolerable erosion value is 5,896 - 37,264 tones/ha/yr.

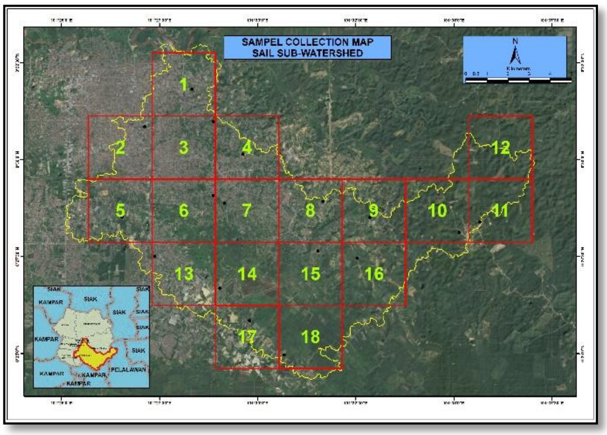

Fig 8. Map of research location station points

Table 10. Tolerated Erosion Value (T)

STA	Soil Depth Factor (Eq)	Effective Depth Land (D) mm	*Resource Life* (RL) *th*	*Bulk density* (BD) *g/cm3*	Tolerable Erosion (T) tones/ha/yr
1	0.95	650	400	1.437	22.184
2	0.8	200	400	1.474	5.896
3	0.95	800	400	1.566	29.754
4	0.95	700	400	1.436	23.874
5	0.95	780	400	1.916	35.494
6	0.95	1000	400	1.569	37.264
7	0.95	1000	400	1.125	26.719
8	0.8	500	400	1.615	16.150
9	0.8	650	400	1.758	22.854
10	0.8	500	400	1.581	15.810
11	0.8	620	400	1.311	16.256
12	0.8	600	400	1.669	20.028
13	0.95	500	400	1.702	20.211
14	0.95	880	400	1.698	35.488
15	0.8	950	400	1.922	36.518
16	0.8	420	400	1.591	13.364
17	0.95	600	400	1.618	23.057
18	0.95	500	400	1.626	19.309

Table 11. Sail Sub-Water Erosion Hazard Index

STA	Land Use	A	T	EHI	Honor
1	Open Land	1050.09	22.184	47.34	Very high
2	Check the Bushes	64.29	5.896	10.90	Very high
3	Check the Bushes	315.03	29.754	10.59	Very high
4	Open Land	2550.21	23.874	106.82	Very high
5	Open Land	1050.09	35.494	29.58	Very high
6	Open Land	300.02	37.264	8.05	High
7	Open Land	1050.09	26.719	39.30	Very high
8	Open Land	1821.58	16.150	112.79	Very high
9	Open Land	1821.58	22.854	79.70	Very high
10	Plantation	182.16	15.810	11.52	Very high
11	Plantation	182.16	16.256	11.21	Very high
12	Open Land	1821.58	20.028	90.95	Very high
13	Open Land	300.02	20.211	148.44	Very high
14	Open Land	300.02	35.488	8.45	High
15	Plantation	75.01	35.518	2.05	Moderate
16	Open Land	1821.58	13.364	136.30	Very high
17	Plantation	105.01	23.057	4.55	High
18	Plantation	105.01	19.309	5.44	High

3.7 Erosion Hazard Index Analysis Results

The erosion hazard index is determined by comparing the actual erosion rate (A) with the tolerable erosion rate (T). Actual erosion is the amount of soil erosion that occurs on land in real or actual conditions. Meanwhile, tolerance erosion is the maximum amount of erosion that can be accepted without causing permanent damage to soil fertility or land productivity. Hazard Index Analysis The results of the EHI analysis at the research location are dominant with very high marks. Station 15 is included in the medium value category of 2.05, stations 6, 14, 17, 18 with a high value of 4.55 - 8.45, and stations 1-5, 7-

13, and 16 with a very high value of 10.59 – 136.30 which can be seen in the following table.

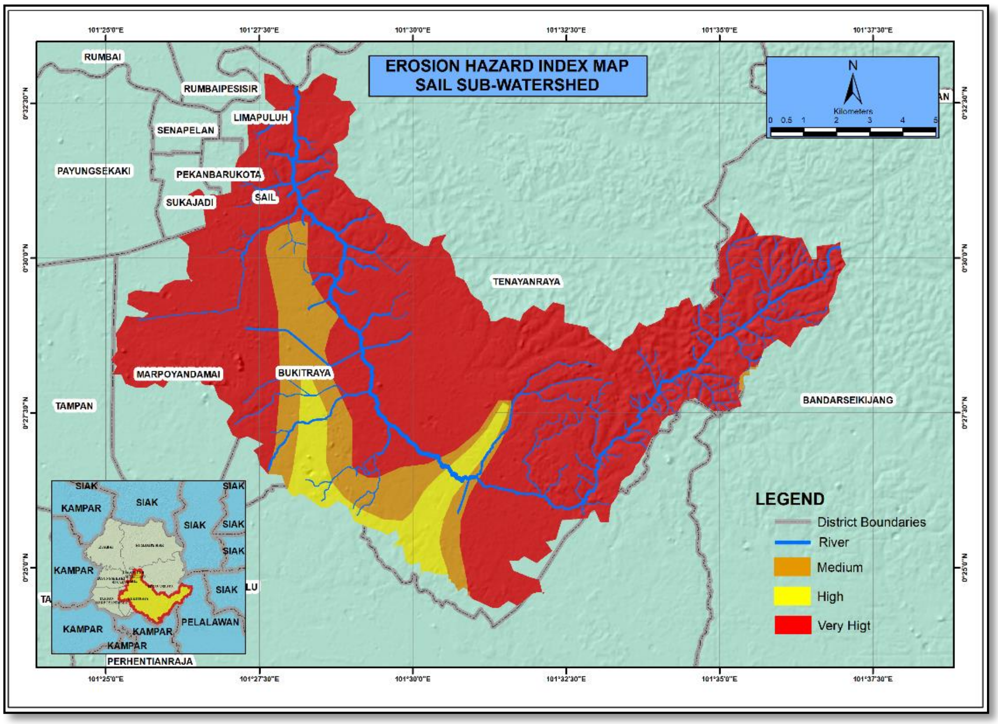

Fig 9. Erosion Hazard Index Map in the Sail Sub-Watershed

3.8 Land Conservation

The results of the erosion hazard level analysis in the Sail Sub-watershed area show variations in the erosion hazard levels, ranging from moderate to very heavy categories. The very heavy category dominates, with 8 stations using open land. The heavy category consists of 6 stations with land use types including open land, plantations, and shrub areas. Meanwhile, 4 stations are in the medium category, mostly using plantation and shrub areas, with the majority of the plantation land being palm plantations. Based on this data, conservation efforts are needed to reduce the risk of erosion and prevent an increase in erosion intensity. Erosion control efforts can be implemented with three approaches to soil conservation, namely vegetative, mechanical and chemical (Kironoto et al., 2020). One method used is a vegetative approach, which involves the use of cover crops and effective land management (Nikkami et al., 2002; Iskandar et al., 2023). Apart from that, erosion control can also be carried out using vegetative and mechanical approaches which aim to reduce surface runoff, repair damaged soil, and increase soil productivity (Sarminah et al., 2022). These two methods can be applied simultaneously or separately, tailored to specific land conditions and management needs, so that both make an important contribution to controlling erosion and improving soil quality. In the research area, several conservation measures are proposed that take into account the type of land use at the research location, to ensure effectiveness in reducing the risk of erosion and improving soil quality.

3.8.1 Land Conservation in Open Land Use

Land conservation on open land in the Sail watershed can be done through reforestation or reforestation. Reforestation aims to improve the ecological and hydrological conditions of the area by planting trees. This process also increases the levels of soil organic matter from the litter, supports fertility, and restores water management functions, such as storing water when it rains and providing water during the dry season (sponge effect). Reforestation is effective on land with a soil depth of more than 3 meters. In shallow soil (<3 m), surface flow is high because water storage capacity is limited. The process of restoring forest function takes 20–50 years until the canopy is fully formed. The recommended types of plants are those that are easy to adapt, grow quickly, have strong roots and a shady canopy (Subagyono et al, 2003).

3.8.2 Land Conservation in the Use of Bush Land

Land conservation in bush areas in the Sail Sub-watershed is similar with handling open land, but additional methods need to be added to reduce damage due to erosion. One way is to build wet masonry using concrete construction (Figure 10). This structure functions to block water flow and prevent erosion. The water channel is equipped with a waterway to direct the flow, which is combined with vegetative conservation measures such as planting grass and shrubs. This method is very suitable for bushland.

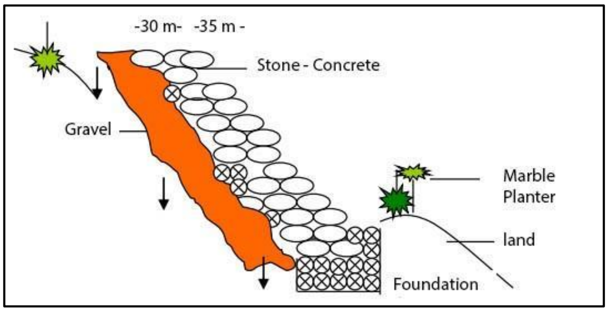

Fig 10. Wet Masonry Schematic Illustration (Wahyudi, 2014)

3.8.3 Land Conservation in Plantation Land Use

Land conservation on plantations can be done using various methods, one of which is a mechanical approach. This includes physical treatment and building construction to reduce surface runoff, suppress erosion, and increase the soil's ability to support sustainable agriculture. Mechanical conservation must be followed by vegetative methods, such as the use of plants, plant residues (mulch, green manure), as well as the application of planting patterns that cover the soil surface throughout the year (Arsyad, 2000). Conservation methods used include wet masonry or building retaining wall terraces, which are equipped with planting grass, bamboo, or perennial plants to maintain soil stability. Bench terraces or stair terraces are made by cutting a slope and leveling the ground beneath it to form a row like stairs. The main functions of bench terraces on dry land are: (1) slowing down surface flow, (2) collecting and channeling flow without damaging it, (3) increasing infiltration, and (4) making it easier to cultivate the land. Individual terraces, which are similar to bench terraces, are more suitable for annual crops and are often used on oil palm plantations (Idjudin, 2011).

4. Discussion

The results of this study indicate that the erosion rate in the research area, particularly in the Sail Sub-Watershed, has reached an alarming level. The rainfall erosivity (R) value, which falls into the wet category (2,500-3,000 mm) with an average of 2,678.79 mm, shows that high rainfall is the primary factor triggering erosion. Additionally, the cambisol soil type, which has a higher erodibility (K) value (0.28) compared to podzolic soil (0.20), also contributes to the high erosion rate. The varying slope steepness (LS), especially in areas with steep slopes (LS 6.80), further exacerbates the erosion potential. Land cover dominated by settlements and open land is also a significant factor influencing the high erosion rate, followed by plantations, shrubs, and agricultural land.

The erosion rate (A) calculated using the RUSLE method shows values ranging from 64.29 to 2,550.21 tons/ha/year. Several stations, particularly in open land and plantations, show extremely high erosion values, even exceeding the tolerable limit (T). The Erosion Hazard Index (EHI), predominantly in the very high category (10.59–136.30), indicates that the actual erosion has far exceeded the permissible limit. This poses a serious risk of soil degradation and reduced land productivity, which could ultimately affect the sustainability of agriculture and plantations in the area.

To address this issue, appropriate and sustainable conservation measures are needed. Recommended conservation actions include reforestation in open land to increase vegetation cover and reduce erosion, constructing terraces in plantation areas to reduce surface runoff, and using ground cover vegetation such as grass or cover crops in shrub and plantation areas. Additionally, building conservation structures like bench terraces or masonry weirs can help retain water flow and reduce erosion in steeper areas.

The high erosion rate not only impacts soil degradation but also affects water quality and surrounding ecosystems. Uncontrolled erosion can lead to sedimentation in rivers and lakes, ultimately threatening clean water availability and the sustainability of aquatic ecosystems. Beyond environmental impacts, erosion also has socio-economic implications, especially for communities relying on agriculture and plantations as their livelihood. Therefore, soil conservation efforts must consider the socio-economic aspects of local communities.

In the research location, several areas experience severe erosion (Figure 8), particularly at STA 16. In this area, soil erosion occurs due to surface water flow (sheet erosion), which erodes the topsoil layer. This is exacerbated by increased river discharge during rainfall, further eroding the soil in the area. The topography of this region is categorized as moderately steep, which also influences the speed of water flow. STA 16 has land use consisting of open land, palm plantations and shrubs. Open land that is not protected by vegetation is very susceptible to erosion, because it is directly exposed to rain and surface flows, while vegetation functions to protect the soil surface from erosion. According to (Lestari et al, 2022) vegetation can slow down the flow of rainwater to the surface of the soil, thereby reducing the potential for erosion. With a covering layer of leaves and twigs, the soil is better protected from direct friction with raindrops which can damage the soil surface. This litter decomposition process gradually improves soil quality, improves water absorption capacity, and improves the condition of the soil structure. Therefore, open land is more easily eroded due to the lack of vegetation that functions to protect the soil surface. In contrast, palm plantations and bush areas tend to be better protected, although the level of erosion in these two areas is not completely avoided. However, palm plantations and bushes still contribute to erosion, although not as fast as on open land.

Fig 11. Erosion that occurred in the Sail Sub-watershed at STA 16.

5. Conclusion

Factors that influence the level of erosion hazard include rainfall erosivity (R) with an average rainfall of 2678.98 mm (wet classification), soil erodibility (K) on cambisol soils (0.28) and podzolic soils (0.20), length and The slope slope (LS) is dominated by lowlands (S 0.4), and the land use is dominated by open land, bushes and plantations with soil conservation that has not been carried out. The erosion hazard level in the Sail Sub-watershed is dominated by the very heavy category at 8 stations, the heavy category at 6 stations, and the moderate category at 4 stations.

The results of the Erosion Hazard Index (EHI) analysis show a category from moderate to very high, with severe erosion occurring at station 16 on open land which is included in the very high erosion hazard index. Therefore, land conservation is very important to reduce the impact of further erosion. For open land, one solution that can be implemented is reforestation to increase vegetation cover and prevent soil erosion. Meanwhile, for land overgrown with bushes, a combination of vegetative and mechanical methods such as wall terraces can be used to reduce surface water flow. On the other hand, in plantations, conservation can be carried out by using wet masonry and retaining structures such as retaining walls or terrace benches, which can maintain soil stability and reduce the risk of erosion in areas with high slopes.

Acknowledgements

The author thanks all parties who supported during research regarding the potential for erosion in the Sail Sub-watershed. Especially to the lecturers at the Faculty of Geological

Engineering, Padjadjaran University for their very meaningful support, guidance, and direction. Apart from that, the author would also like to thank the parties who have provided data, information, and technical assistance during this research. Hopefully, this research can provide benefits for land management and conservation in the Sail Sub-watershed.

References

Andriana, M., Badaruddin, Nisa, K. (2021). 'Analisis Erosi dan Tingkat Bahaya Erosi Pada Berbagai Tipe Tutupan Lahan yang Berbeda di Sub DAS Banyuirang DAS Maluka', Jurnal Sylva Scienteae Vol. 04 No. 4. Available at : https://doi.org/10.20527/jss.v4i4.3932

Arsyad S. 2010. *Konservasi Tanah dan Air*. Bogor : IPB Press. Edisi Kedua

Departemen Kehutanan. (1986). *Petunjuk Pelaksanaan Penyusunan RTL-RLKT*. Departemen Kehutanan RI. Jakarta.

Departemen Kehutanan RI. (1998). *Pedoman Penyusunan Rencana Teknik Rehabilitasi dan Konservasi Tanah DAS*. Kementerian Kehutanan. Jakarta.

Desriani, S., Adrianty, Y. (2003). 'Pengaruh Debit Limpasan Terhadap Debit Banjir pada Daerah Aliran Sungai (DAS) Sail Kota Pekanbaru', Pekanbaru: Universitas Islam Riau.

Hammer, WI. (1980), *Soil Conservation Consultant Report Center for Soil Research.* LPT Bogor. Indonesia.

Idjudin, A. (2011). 'Peranan Konservasi Lahan Dalam Pengelolaan Perkebunan', Jurnal Sumbardaya Lahan Vol. 5 No.2.

Iskandar, B., Zannah, F., Anshari, R. (2023). 'Impact ofLand Use Change on Land Capability in Katingan Regency, Central Kalimantan, Indonesia', Journal of Geoscience, Engineering, Environment, and TechnologyVol 8No 3.

Isma, F., Irwansyah, Neneng, I. (2017). 'Analisa Potensi Erosi Pada DAS Deli Sumatera Utara Menggunakan Sistem Informasi Geografis (GIS)', Jurnal Ilmiah Jurutera Vol.04 No.01.

Lestari L.M, Ichsan A.C, Aji I.M.L. 2022. 'Analisis Tingkat Bahaya Erosi Pada Lahan Garapan Kelompok Tani Hutan Makmur Desa Mekar Sari', Jurnal Tengkawang Vol. 12 (2): 129 – 146

Karondia, L.A., Fitrian, R., Hizkia. (2022). 'Pemetaan Zonasi Kerawanan Banjir berbasis Sistem Informasi Geografis (Studi Kasus: Kabupaten Berau, Kalimantan Timur)', Geoid Vol. 18, No. 1 (57-68).

Keputusan Menteri Kehutanan Republik Indonesia Nomor: SK. 328/ Menhut-II/2009 *Tentang Penetapan DAS Prioritas Dalam Rangka Rencana Pembangunan Jangka Menengah (RPJM) Tahun 2010-2014.*

Nikkami, D., Elektorowicz, M. and Mehuys, G.R. (2002) 'Optimizing the management of soil erosion', Water Quality Research Journal, 37(3), pp. 577–586.

Nugraha, I., Astuti, P., Manan, M., Asteriani, F., Hisyam, M.I. (2018). 'Kajian Perubahan Penggunaan Lahan Tahun 2000-2015 Sub DAS Sail Menggunakan Data Citra Satelit', Pekanbaru : Universitas Islam Riau.

Novita, D., Wijaya, K., Sasongko, P.E., 2024. 'Directions for Land Conservation Based on Determining the Erosion Hazard Index (EHI) Using the RUSLE Method in Sub-Watersheds Gunting, Jombang', Jurnal Agrinika : Jurnal Agroteknologi dan Agribisnis Vol. 08

Renard, K. G, Foster, G. R., Weisses, G. A., McCool, D. K., dan Yoder, D.C., (1997). *Predicting Soil Erosion by Water: A Guide to Conservation Planning with the Revised Universal Soil Equation (RUSLE)*, U.S. Department of Agriculture. Agriculture Handbook No. 703, 404pp.

Sadewo, W., Subagiada, K., Djayus. (2023). 'Analisis Klasifikasi Laju Erosi Menggunakan Metode Universal Soil Loss Equation (Usle) Dengan Sistem Informasi Geografi Kota Samarinda', Jurnal Geosains Kutai Basin Volume 6 No 1.

Sanchez, M.A., Castro, C.P., Lizana, C.R., Espezua, R.M.H., Ganoza, D.A., Acosta, R.S. (2024). Impact of Land Use on Soil Erosion : RUSLE Analysis in a Sub-Basin of the Peruvian Amazon (2016-2022)'. Geosciences. Available at: https://doi.org/10.3390/geosciences 15010015.

Sarminah, S., Timo, P.N., Aipassa, M.I. (2022). 'Design of Soil and Water Conservation Techniques to Minimize Soil Erosion on Degraded Land in Samarinda Tenggarong Axis Road', IOP Conference Series: Earth and Environmental Science https://doi:10.1088/1755-1315/1282/1/012022.

Setiawan A.R. (20204). 'Pendugaan Daerah Rawan Bencana Longsor Berbantuan Sistem Informasi Geografis di Kecamatan Pujon Kabupaten Malang', Geodika: Jurnal Kajian Ilmu dan Pendidikan Geografi Vol. 8 No.1. https://doi:10.29408/geodika.v8i1.17187

Soil Survey Staff. (1999). *Soil Taxonomy: A Basic System of Soil Classification for. Making and Interpreting Soil Surveys.* Washington DC: USDA-Natural Resources Conservation Service.

Subagyono, K., Marwanto, S., Kurnia, U. (2003). 'Teknik Konservasi Tanah Secara Vegetatif', Balai Penelitian Tanah.

Sujatmoko, B., Hirvan, Z., Fauzi, M. (2022). 'Analisis Laju Erosi dan Sedimentasi Lahan pada DAS Batang Kuranji Kota Padang', Jurnal Teknik, Vol. 16, No.1.

Utami, A.K., Sujatmoko, B., Fauzi, M. (2019). 'Kajian Sedimentasi pada DAS Sail Pekanbaru Dengan Menggunakan SIG dan Metode USLE', Pekanbaru : Universitas Riau.

Wahyudi. (2014). 'Teknik Konservasi Tanag Serta Implementasinya pada Lahan Terdegradasi Dalam Kawasan Hutan', Journal Sains dan Teknologi Lingkungan Vol.6 No.2 Hal (71-85).

Wang, B., Zheng, F., Romkens, M. J. M., Darboux, F. (2013). 'Soil erodibility for water erosion: A perspective and Chinese experiences. Geomorphology187(April). https://doi.org/10.1016/j.geomorph.2013.01.018

Wibowo, A., Soeprobowati, T, R., Sudarno. (2015). 'Laju Erosi dan Sedimentasi Daerah Aliran Sungai Rawa Jombor Dengan Model USLE dan SDR Untuk Pengelolaan Danau Berkelanjutan', Indonesian Journal of Conservation Vol. 04, No.1.