WATER QUALITY AND EROSION RATE ASSOCIATED WITH PINE RESIN TAPPING IN GUNUNG CIREMAI NATIONAL PARK

NISA SYACHERA FEBRIYANTI[1], ENDANG HILMI[2], YAYAN HENDRAYANA[3], IRMA SURYAHANI[4], IMAM SANTOSA[5]

[1].Graduate School of Environmental Studies, Universitas Jenderal Sudirman. Jl. Dr. Soeparno, Purwokerto Utara, Banyumas 53122, Central Java, Indonesia.

[2] Program of Aquatic Resources Management, Faculty of Fisheries and Marine Science, Universitas Jenderal Sudirman. Jl. Dr. Soeparno, Purwokerto Utara, Banyumas 53122, Central Java, Indonesia. Tel./fax.: +62-281-6596700,

[3]Program of Forest, Faculty of Forest and Environment, Universitas Kuningan Jl. Cut Nyak Dhien No.36A, Cijoho,, Kuningan District, West Java 45513

[4] Faculty of Economics and Business, Universitas Jenderal Sudirman. Jl. Dr. Soeparno, Purwokerto Utara, Banyumas 53122, Central Java, Indonesia

[5] Faculty of Social and Political Sciences, Universitas Jenderal Sudirman. Jl. Dr. Soeparno, Purwokerto Utara, Banyumas 53122, Central Java, Indonesia

Corresponding email: dr.endanghilmi@gmail.com

Abstract

Gunung Ciremai National Park (GCNP) has experienced pine resin tapping without formal cooperation agreement since 2023, potentially affecting ecosystem conservation. This study aimed to develop conservation strategies for GCNP in response to the impacts of illegal pine resin tapping. A quantitative approach was used to assess erosion rates and water quality. The study was conducted from February to June 2026 at two location: Kopi Sereh site (without pine resin tapping) and Panandaan site (with pine resin tapping). At each location, three sampling points were established at the upstream, midstream, and downstream where samples were collected during the rainy, transitional, and dry seasons. The results showed that Kopi Sereh Site had TDS (27 mg/L), temperature (21.4°C), BOD (1.07 mg/L), COD (34,13 mg/L), DO (12,45 mg/L) and a plankton diversity index (2,44), while Panandaan Site had TDS (45 mg/L), temperature (23,04°C), BOD (1,14 mg/L), COD (46,54 mg/L), DO (10,54 mg/L) and a plankton diversity index (2.41). However, the estimated erosion rate at Kopi Sereh Site (417.56 tons/ha/year) and Panandaan Site (78.24 tons/ha/year). The study concludes that the site without pine resin tapping activities exhibited more favorable water quality conditions and high erosion rate.

Keywords: Erosion Rate, Gunung Ciremai National park, Pine Resin Tapping;

I. INTRODUCTION

Pine resin is one of the most economically important NTFPs harvested from natural and planted pine forests. Global demand for pine resin has increased considerably due to its extensive industrial applications, including adhesives, pharmaceuticals, cosmetics, and bio-based chemicals. Recent studies indicate that resin production is strongly influenced by climatic conditions, tree physiology, extraction techniques, and management practices (López-Álvarez et al. 2023).

Although resin tapping provides important socioeconomic benefits, intensive tapping may adversely affect tree growth and forest ecosystem health. Repeated resin tapping creates mechanical wounds that damage cambial tissues and stimulate anatomical changes in xylem development. Previous studies have demonstrated reductions in radial growth, alterations in resin canal formation, and increased susceptibility to mechanical failure following intensive tapping (Rodriguez Garcia et al. 2014). Furthermore, stimulant chemicals containing sulfuric acid are commonly applied to increase resin yield; however, excessive application may accelerate wood deterioration and negatively affect tree vitality (López-Álvarez et al. 2023).

Beyond tree-level impacts, resin tapping may influence soil and water conservation through increased human disturbance, reduced vegetation protection, soil exposure, and accelerated runoff and erosion. Forest degradation in mountainous watersheds has been widely associated with

declining soil stability, reduced infiltration, and deterioration of downstream ecosystem services. However, the ecological consequences of resin tapping on soil and water conservation remain insufficiently understood.

Gunung Ciremai National Park (GCNP) represents one of Indonesia's important mountain ecosystems that simultaneously functions as a biodiversity conservation area and a major water catchment and was designated in 2004. Access to pine resin as an NTFP under the conservation partnership scheme may be granted upon the establishment of a formal cooperation agreement between the Head of the National Park Office and the community group leader, through traditional practices that have been passed down through generations since before the area was designated as a national park. In GCNP, there is no formal cooperation agreement has been established but since 2023, pine resin tapping has been implemented. This activity will associated with ecology of GCNP. This study provides novel field based information on water quality and erosion rates in a previously unassessed area. Therefore, this study aims to assess water quality and erosion rates affected by pine resin tapping activities.

II. METHOD

Study area

The study was conducted in GCNP, West Java, Indonesia, from February to June 2026 in two location: Kopi Sereh site (without pine resin tapping) and Panandaan site (with pine resin tapping). Kopi Sereh Site (Grid 9N), located at approximately 1,400 masl and is characterized by natural forest vegetation. Panandaan Site (Grid 16O), located at approximately 700 masl. For water quality measurement, three sampling points were established at the upstream, midstream, and downstream where samples were collected during the rainy, transitional, and dry seasons.

Table 1. Research location

No	Location	Coordinate	
		Longitude	Latitude
1	Kopi Sereh Site	108.442995°E	6.901643°S
2	Panandaan Site	108.453052°E	6.845227°S

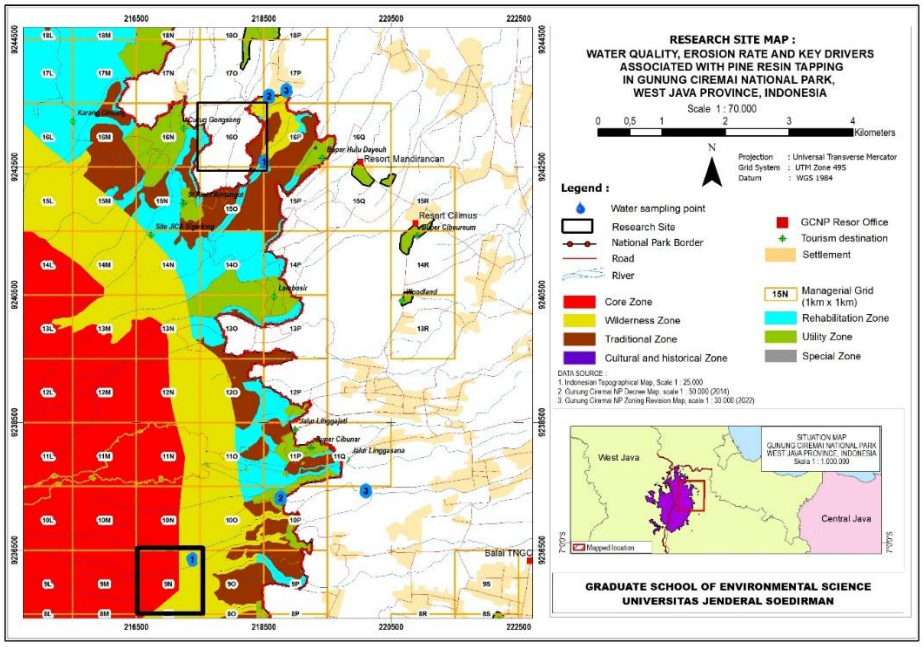

Figure 1. Location of research

Research design

This study employed an integrated ecological and participatory approach. Field measurements were conducted to evaluate water quality and erosion rate. The analytical framework consisted of three sequential stages: (1) field data collection, (2) estimation of water quality and erosion rate and (3) data analysis.

Water Quality Measurement

Water quality was evaluated using physical, chemical, and biological parameters. The physical parameters included water temperature, color, and TDS which were measured in situ using a portable TDS meter. Chemical parameters included pH, DO, BOD, and COD. Water samples (200 ml) were collected at a depth of 10–15 cm and using the grab sampling technique and analyzed in an accredited laboratory following the procedures specified in the Indonesian National Standard in Universitas Jenderal Soedirman Laboratory. Water quality was interpreted according to Government Regulation No. 22 of 2021.

Table 2. The Measurement of Water Quality

No	Parameters	Unit	Class 1	Class 2	Class 3	Class 4
1	pH		6-9	6-9	6-9	6-9
2	BOD	Mg/L	2	3	6	12
3	COD	Mg/L	10	25	40	80
4	DO	Mg/L	6	4	3	1

Source : Government Regulation No. 22 of 2021

Biological Parameters

Biological water quality was evaluated based on the diversity of plankton organisms collected using a plankton net 20 μm and preserved with final concentrate 1% before laboratory identification in Universitas Jenderal Soedirman. Formalin was used to preserve sample integrity and prevent organism decomposition or changes in community composition. To assess the ecological condition of the aquatic ecosystem, the Shannon–Wiener Diversity Index (H') was calculated using the following equation:

$$H' = -\sum_{i=0}^{n} pi \ln pi$$

$pi = \frac{ni}{N}$, where *ni is* amount of species individuals –i

N is the total number of individuals across all species. Based on the Shannon–Wiener Diversity Index, water quality can be classified as follows (Wu, Schmalz & Fohrer, 2014) :

1. **H' < 1.0**: heavily polluted water;
2. **1.0 ≤ H' < 3.0**: lightly polluted water
3. **H' ≥ 3.0**: unpolluted water.

Erosion Rate

Potential erosion rate was estimated using the RUSLE analysis with ArcGIS 10.6 (Wischmeier and Smith. 1978).:

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

A = Annual soil loss (tons ha^{-1} $year^{-1}$)
R = Rainfall erosivity factor
K = Soil erodibility factor
LS = Slope length and steepness factor
C = Cover-management factor
P = Conservation practice factor

Soil characteristics, slope, and land-cover information were obtained from GCNP spatial database in 2026.

a. Rainfall Erosivity (R)

Rainfall erosivity represents the potential of rainfall to cause soil erosion and is an important factor in understanding hydrological and geomorphological processes (Arsyad. 2010). The monthly rainfall erosivity factor was calculated using the following equation:

$$Rb=2.21(Rainb)1.36$$

where R_β is the monthly rainfall erosivity, and $(Rain)_\beta$ is the monthly rainfall amount (cm).

b. Soil Erodibility (K)

The soil erodibility factor (K) was determined for each land unit. The K factor was derived by analyzing the soil-type map and the corresponding erodibility values for each soil type. The results were then matched with the established K-factor values.

Table 3. K-Factor Values

K Value	DUDAL_SUPR Soil Type	USDA Soil Type
0.315	Alluvial	Inceptisol
0.193	Alluvial; Alluvial; Podzolic coklat	Inceptisol
0.315	Alluvial; Podzolic coklat	Inceptisol
0.193	Alluvial; Regosol; Regosol	Inceptisol
0.278	Andosol; Organosol	Andisol
0.271	Andosol; Podzolic coklat; Andosol	Andisol
0.271	Andosol; Podzolic merah kuning	Andisol
0.187	Grumosol; Podzolik	Entisol–Inceptisol
0.187	Grumosol; Podzolik Coklat	Entisol–Inceptisol
0.176	Grumosol; Renzina; Podzolik; Litosol; Rock outcrops	Entisol–Inceptisol
0.187	Latosol; Podzolik; Aluvial	Ultisol
0.323	Mediteran	Inceptisol
0.323	Mediteran; Aluvial	Inceptisol
0.273	Mediteran; Aluvial; Litosol	Inceptisol
0.188	Mediteran; Aluvial; Podzolik merah kuning	Inceptisol
0.273	Mediteran; Podzolik coklat; Aluvial	Inceptisol
0.158	Podzolik coklat; Aluvial; Grumosol	Ultisol
0.166	Podzolik merah kuning	Ultisol
0.107	Podzolik Aluvial	Ultisol
0.158	Podzolik; Latosol	Ultisol

Source : Arsyad (2010)

c. Slope Length and Steepness (LS)

The LS factor was determined by analyzing the slope-class map and matching the slope classes with the corresponding LS values presented in Table 5.

Table 4. LS Values

LS Value	Description	Slope Class
0.40	Flat	0–8%
1.40	Gentle	8–15%
3.10	Moderately steep	15–25%
6.80	Steep	25–40%
9.50	Very steep	>40%

d. Cover-Management Factor (C)

The C factor represents the effect of vegetation cover and land management on soil erosion. The C factor may vary dynamically depending on changes in land use and vegetation cover

e. Conservation Practice Factor (P)

The P factor represents soil conservation practices that reduce the rate of soil erosion. The P factor ranges from 0 to 1, where a value of 0 represents highly effective conservation practices that provide maximum resistance to erosion, whereas a value of 1 represents the absence of conservation practices and the lowest resistance to erosion.

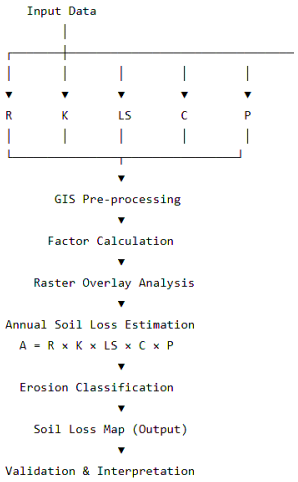

Figure 2. Soil Loss Equation Data Analysis

III. RESULTS AND DISCUSSIONS

A. Result

Water Quality

The results of the physical water quality assessment at the two locations showed that the average TDS concentration and water temperature at Kopi Sereh Site were lower than those at Panandaan Site.

Table 5. Water Physical Parameters

Location	Average TDS (mg/L)	Average Temp (^{0}C)
Kopi Sereh Site	27	21,4
Panandaan Site	45	23,04

Water temperature is another important water quality parameter because it affects the solubility of DO, microbial activity, and various chemical processes in aquatic environments. The results of the chemical water quality analysis at the two sampling stations showed differences in the average values of the measured chemical parameters.

Table 6. Water chemical Parameters

Location	Average DO (Mg/L)	Average BOD	Average COD
Kopi Sereh Site	12,45	1,07	34,13
Panandaan Site	10,54	1,14	46,54

Table 7. Measurement of Physical and Chemical Water Quality

Location	Replicate	Time	Point	Color	TDS Mg/L	Temp (^{0}C)	DO	BOD	COD	pH
Kopi Sereh Site	1	Feb 26	1	Clear	27	19,6	13	1,22	5,77	6,23
			2	Clear	24	20,4	13	1,53	23,11	6,45
			3	Clear	28	21,7	14	2,75	15,41	6,54
	2	Mar 26	1	Clear	27	18,9	9,21	0,88	16,37	6,76
			2	Clear	28	20,4	9,21	1,11	13,48	6,78
			3	Clear	29	24,8	8,61	0,42	9,63	6,83
	3	Apr 26	1	Clear	22	19,5	15	0,15	45,25	7,2
			2	Clear	29	21	15	0,08	63,55	6,4
			3	Clear	29	24,3	15	1,53	62,59	6,5
Panandaan Site	1	Feb 26	1	Clear	47	22,5	10	1,3	28,89	6,51
			2	Clear	47	22,4	10	1,61	21,18	6,62
			3	Clear	47	22,7	10	1,07	15,41	6,65
	2	Mar 26	1	Clear	44	22,9	7,72	1,38	8,67	6,67
			2	Clear	45	22,2	8,97	0,88	7,70	6,7
			3	Clear	45	22,9	9,21	0,08	19,26	6,71
	3	Apr 26	1	Clear	43	23,3	13	1,64	61,62	5,95
			2	Clear	43	23,3	13	0,23	53,92	6,11
			3	Clear	44	25,2	13	2,06	54,88	6,09

Source : Laboratory Test and Direct Measurement (2026)

Biological Parameters

Plankton are broadly classified into two major groups: phytoplankton, which are plant like organisms capable of photosynthesis and therefore function as primary producers in aquatic ecosystems, and zooplankton, which are animal like organisms possessing locomotory structures and serving as primary consumers within aquatic food webs.

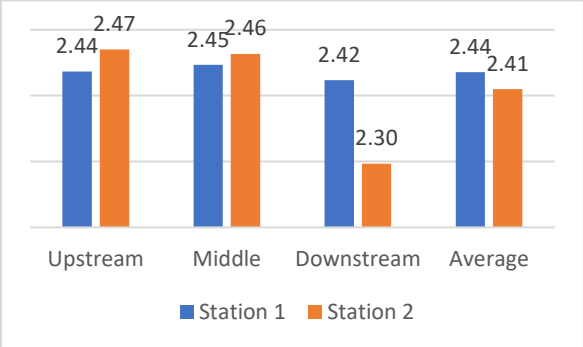

Figure 3. Diversity index of plankton

Based on the Shannon–Wiener diversity index analysis, values in the range of 2.3–2.47 indicate moderate diversity. This suggests that the plankton is relatively stable under moderately stable environmental conditions. Therefore, both Kopi Sereh Site and Panandaan Site are classified as moderately polluted. The biodiversity index was determined based on the number of individuals and species. The identification results for each sampling point at every site are presented as table 8.

Table 8. Number of Individual and Spesies

Variabel	Kopi Sereh Site			Panandaan Site		
	Point 1	Point 2	Point 3	Point 1	Point 2	Point 3
Plankton replicate 1						
Number of Spesies	12	11	10	13	15	9
Number of individuals	97	65	65	147	156	67
Plankton replicate 2						
Number of Spesies	19	22	20	12	21	20
Number of individuals	162	155	142	182	167	155
Plankton replicate 3						
Number of Spesies	14	14	14	15	14	14
Number of individuals	79	75	96	92	76	84

Source : Laboratory test (2026)

At Kopi Sereh Site for first replicate, three divisions of phytoplankton were identified: Cyanobacteria, represented by one family comprising four species; Chlorophyta, represented by one family comprising one species; and Heterocontophyta (Chrysophyta), represented by five families comprising eight species. In addition, one phylum of zooplankton, Rotifera, was identified, comprising one family with one species. The phytoplankton community was dominated by the family Fragilariaceae, accounting for 44.05% of the total composition, followed by Naviculaceae (28.63%) and Oscillatoriaceae (25.11%). Zooplankton accounted for 3.08% of the total plankton composition. At Panandaan Site, three phytoplankton divisions were also identified: Cyanobacteria, represented by one family comprising three species; Chlorophyta, represented by one family comprising one species; and Heterocontophyta (Chrysophyta), represented by five families comprising fifteen species. One zooplankton phylum, Rotifera, represented by one family and one species, was also recorded. The phytoplankton community at Station 2 was dominated by Fragilariaceae, which constituted 55.41% of the total composition, followed by Naviculaceae (28.93%) and Oscillatoriaceae (24.59%). No zooplankton individuals were observed during this sampling period; therefore, the zooplankton composition was 0%.

At Kopi Sereh for second replicate, three divisions of phytoplankton were identified: Cyanobacteria, represented by one family comprising four species; Chlorophyta, represented by two families comprising two species; and Heterocontophyta (Chrysophyta), represented by seven families comprising eighteen species. In addition, one zooplankton phylum, Rotifera, represented by a single family and a single species, was identified. The phytoplankton community was dominated by the family Pinnulariaceae, accounting for 40.96% of the total composition, followed by Naviculaceae (33.77%) and Fragilariaceae (23.97%). Zooplankton comprised 3.70% of the total plankton composition. At Panandaan Site, three phytoplankton divisions were also identified: Cyanobacteria, represented by one family comprising four species; Chlorophyta, represented by two families comprising two species; and Heterocontophyta (Chrysophyta), represented by seven families comprising nineteen species. One zooplankton phylum, Rotifera, represented by one family and one species, was also recorded. The phytoplankton community was dominated by Pinnulariaceae, which accounted for 40.96% of the total composition, followed by Fragilariaceae (33.73%) and Diatomaceae (18.25%). Zooplankton represented 7.94% of the total plankton composition.

The laboratory analysis from the third sampling event at the two monitoring stations showed that the highest Shannon–Wiener diversity index (H') was recorded at Station 1, Sampling Point 1, with a value of 2.34. This sampling point also had the highest species richness, with 15 species, and a total abundance of 92 individuals. The highest relative abundance was recorded for *Synedra* sp. (Family Fragilariaceae) at Kopi Sereh Site, Sampling Point 3. At Kopi Sereh Site, three phytoplankton divisions were identified: Cyanobacteria**,** represented by one family comprising two species**;** Chlorophyta, represented by two families comprising two species; and Heterocontophyta (Chrysophyta), represented by six families comprising thirteen species. In addition, one zooplankton phylum, Rotifera, represented by one family and one species, was recorded. The phytoplankton community was dominated by Fragilariaceae (48%), followed by Naviculaceae (28%) and Pinnulariaceae (15.06%). Zooplankton accounted for 3.6% of the total plankton composition. At Panandaan Site, three phytoplankton divisions were also identified: Cyanobacteria, represented by one family comprising four species; Chlorophyta, represented by two families comprising two species; and Heterocontophyta (Chrysophyta), represented by six families comprising thirteen species. One zooplankton phylum, Rotifera, represented by one family and one species, was also observed. The phytoplankton community was dominated by Fragilariaceae (51.59%), followed by Naviculaceae (22.22%) and Cymbellaceae (16.67%). Zooplankton accounted for 5.16% of the total plankton composition.

Table 9. Relative Abundance of Plankton

Spesies	Family	Blok Kopi Sereh									Blok Panandaan								
		Titik 1			Titik 2			Titik 3			Titik 1			Titik 2			Titik 3		
Ulangan		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Cyanobacteria																			
Oscillatoria limnosa	Oscillatoriaceae	5,15	0	0	7,69	3,87	0	9,23	0	0	0	2,2	0	2,56	4,79	0	0	2,58	0
Oscillatoria sp	Oscillatoriaceae	4,12	3,09	6,33	6,15	0	10,7	0	0	4,17	3,4	3,3	4,35	3,85	2,99	0	10,4	5,61	3,57
Phormidium sp	Oscillatoriaceae	0	4,32		4,62	3,23	0	6,15	4,23	3,13	10,2	1,65	0	7,05	0	7,89	11,5	3,23	8,33
Spirulina sp	Oscillatoriaceae	3,09	0	3,8	0	3,87	0	0	4,93		0	3,85	0	0	2,4	0	0	0	0
Chlorophyta																			
Geminella sp	Geminellaceae	6,19	0	6,33	6,15	2,58	8	4,62	4,23	7,29	2,72	3,3	5,43	1,92	4,19	10.5	0	2,58	0
Microspora sp	Microsporaceae	0	3,7	0	0	3,87	6,67	0	0	7,29	0	2,75	8	0	2,99	0	0	0	2,38
Heterocontophyta /chrypsophyta																			
Cymbella affinis	Cymbellaceae	0	4,94	0	0	0	0	0	3,52	0	0	3,85	0	0	0	0	0	3,87	0
Cymbella sp	Cymbellaceae	0	0	7,59	0	4,52	6,67	0	2,82	8,33	4,76	3,85	12	5,77	2,99	9,21	8,96	5,16	9,52
Cyclotella sp	Stephanodiscaceae	0	3,09	0	0	1,94	8	0	0		0	1,65	4,35	0	2,99	2,63	0	0	5,95
Diatoma linearis	Diatomaceae	5,15	0	0	0	3,87	0	0	2,11	0	0	6,04	0	0	3,59	0	0	4,52	0
Diatoma sp	Diatomaceae	0	8,02	3,8	9,23	5,81	0	6,15	4,23	5,21	3,4	2,75	0	0	6,59	5,26	5,97	7,74	0
Diatoma vulgaris	Diatomaceae	0	3,7	0	0	3,23	4	0	1,41	0	2,72	0	4,35	0	2,4	0	0	0	8,33
Navicula gracilis	Naviculaceae	0	3,7	0	0	4,52	0	0	6,34	0	0	3,3	0	0	0	0	0	3,23	0
Navicula sp	Naviculaceae	15,5	6,79	15,2	18,5	5,81	14,67	20	7,75	9,38	6,8	3,85	10,9	22,4	7,19	9,21	16,4	4,52	9,52
Navicula lanceolata	Naviculaceae	0	8,02	0	0	5,81	14,67	0	4,93	0	0	0	0	4,49	2,4	0	0	3,87	0

Spesies	Family	Blok Kopi Sereh									Blok Panandaan								
		Titik 1			Titik 2			Titik 3			Titik 1			Titik 2			Titik 3		
	Ulangan	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Navicula placentula	Naviculaceae	0	3,7	5,06	0	4,52	0	0	0	6,25	0	0	5,43	1,92	1,8	6,58	0	0	0
Nitzschia sp	Bacillariaceae	9,28	11,7	3,8	12,3	8,39	6,67	16,92	10,6	4,17	5,44	2,2	5,43	20,5	9,58	5,26	14,9	6,45	5,95
Nitzschia vermicularis	Bacillariaceae	0	3,09	0	0	0	5,33	0	2,11	0	4,08	2,75	3	0	0	0	0	2,58	3,57
Pinnularia gibba	Pinnulariaceae	0	5,56	7,59	6,15	17,4	0	4,62	15,5	5,21	0	19,8	0	3,21	16,8	5,26	4,48	20	0
Pinnularia nabilis	Pinnulariaceae	0	4,32	5,06	0	2,58	0	0	6,34	0	0	8,24	0	2,56	6,59	0	0	3,87	0
Pinnularia sp	Pinnulariaceae	5,15	3,7	8,86	4,62	2,58	5,33	6,15	4,93	4,17	0	6,04	4,35	5,13	4,79	5,26	5,97	3,23	4,76
Synedra acus	Fragilariaceae	10,3	6,79	15,2	0	3,23	4	0	2,82	6,25	7,48	3,3	5,43	0	0	6,58	0	4,52	7,14
Synedra sp	Fragilariaceae	24,7	3,09	0	20	9,03	14,7	16,9	6,34	19,8	30,6	6,59	19,6	13,5	5,39	18,4	20,9	9,03	20,2
Synedra tabulata	Fragilariaceae	0	0	0	0	3,87	0	0	4,93	0	8,16	0	0	1,92	1,8	0	0	0	0
Synedra ulna	Fragilariaceae	7,22	0	8,86	4,62	0	2,67	9,23	0	7,29	10,2	8,79	4,35	3,21	11,4	5,26	0	11,6	7,14
Rotivera																			
Brachionus sp	Brachionidae	4,12	0	2,53	0	2,58	2,67	0	4,23	2,08	0	7,14	3,26	0	4,19	2,63	0	3,23	3,57

Erosion Rate

Erosion rate in the GCNP area is dominated by the moderate class (53% or 7,910.33 ha) and the high class (26% or 3,846.52 ha). Areas with very high vulnerability (SB IV) account for only 5% of the total area (813.79 ha). This indicates that the national park is generally at a moderate vulnerability level, where potential degradation is driven by erosion processes affecting shallow to moderately developed volcanic slopes (Syaifarudin, 2026).

Based on spatial analysis of the erosion rate map, the Kopi Sereh Block (Grid 9N) exhibits extremely high erosion rates ranging from 13,94 to 857.3 tons/ha/year. The erosion rate at Station 1, Sampling Point 1 (Kopi Sereh spring) is 417.56 tons/ha/year, which classified as severe erosion class (PDASHL, 2017). The areas with the lowest erosion rates are located in primary forest land cover with dense canopy, characterized by a crop management (C factor) value of 0.050–0.161. The dominant soil type is a Regosol association, which is highly porous, light, loose, and unstable under rainfall impact. This area is also characterized by high rainfall erosivity of 2,894.45 MJ·mm/(ha·hr·year). The slope length and steepness (LS factor) vary significantly between 0.4 and 9.5 (0 to >40% slope). The area is classified as a protected zone without mechanical conservation practices (P = 1.00).

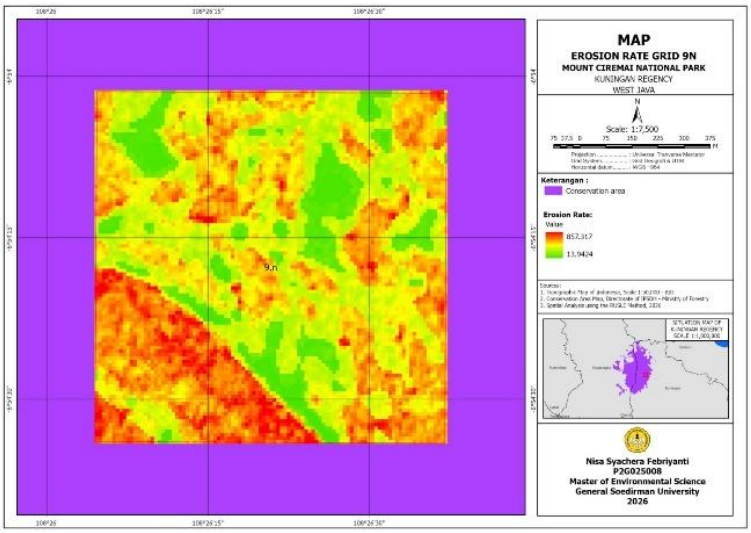

Figure 4. Erosion Rate in Grid 9N
Source : Processed Data (2026)

Meanwhile, in the Panandaan Block (Grid 16O), the estimated erosion rate ranges from 7,98 tons/ha/year to 517,9 tons/ha/year. The erosion rate at Station 2, Point 1 (Cigorowong Spring) is 78.24 tons/ha/year. This erosion rate is classified as moderate erosion class (PDASHL, 2017). The area with the lowest erosion rate in this block is found in densely vegetated forest land use with a crop management factor (C factor) of 0.0449–0.2194. The dominant soil type in this area is Latosol (K = 0.186), which has a structure that is susceptible to erosion when its topsoil layer is exposed. This block is located in an area with rainfall erosivity intensity slightly lower than Grid 9N, ranging from 2,063.29 to 2,257.74 MJ·mm/(ha·hour·year). Similar to Grid 9N, this area has slope length and steepness values ranging from 0.4 to 9.5, and no artificial conservation measures are applied (P = 1.00).

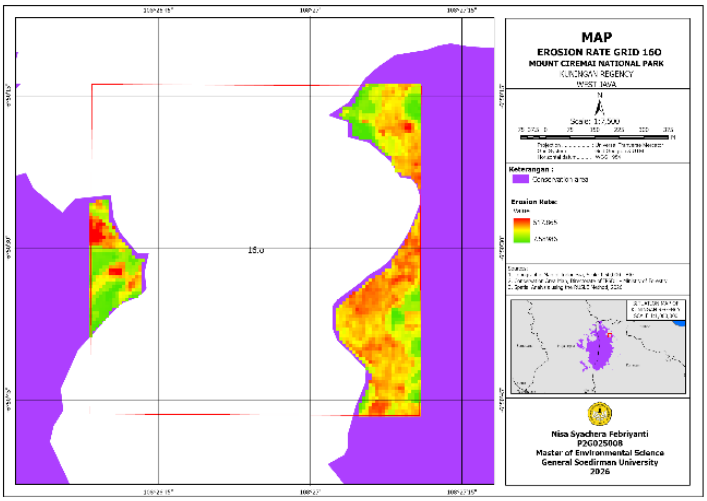

Figure 5. Erosion Rate in Grid 16O
Source : Processed Data (2026)

Discussion

TDS reflects the level of dissolved minerals and the potential for contamination, whereas temperature influences the physical and biological dynamics of aquatic ecosystems (Nafisya et al. 2025). According to Salim (2019), TDS values range from 0–300 mg/L fall within Category A, indicating raw water that can be used without treatment. Water with TDS values below 50 mg/L is generally considered very pure, such as rainwater or water treated using a Reverse Osmosis (RO) filtration system.

High DO levels indicate that the water body is rich in oxygen, which is essential for sustaining aquatic life. Adequate dissolved oxygen ensures sufficient oxygen availability for various aquatic organisms. Therefore, adequate DO concentrations support the growth and development of aquatic biota (Ali et al. 2025). According to Government Regulation (PP) No. 22 of 2021, the minimum acceptable DO concentration is 6 mg/L. DO concentrations below this threshold indicate water pollution or environmental degradation. A substantial decline in DO may adversely affect aquatic organisms and reduce biodiversity (Masruroh & Purnomo. 2024).

BOD is defined as the amount of dissolved oxygen required by microorganisms, primarily bacteria, to decompose organic matter under aerobic conditions. These relatively low BOD values indicate that the concentration of biodegradable organic matter at both stations was low. Consequently, the oxygen demand for microbial decomposition was minimal, leaving sufficient dissolved oxygen to support aquatic life. The difference in BOD between Kopi Sereh Site and Panandaan Site was relatively small (0,07 mg/L). Nevertheless, the slightly higher BOD at Panandaan Site would be suggests a greater input of organic matter like domestic activities, surface runoff, decomposing vegetation, and pine resin tapping activities.

COD represents the amount of oxygen required to oxidize all organic substances present in the water chemically. The higher COD observed at Panandaan Site indicates a greater concentration of organic matter and other oxidizable compounds. Elevated COD values may result from organic inputs associated with pine resin harvesting, soil erosion transporting organic materials, and the decomposition of surrounding vegetation (Fathrizky, Mulyandari, & Novadli. 2025). COD values exceeding 40 mg/L indicate the presence of organic compounds that are resistant to biological degradation. This suggests that a considerable proportion of the organic matter in the water consists of relatively recalcitrant compounds that microorganisms cannot readily decompose. A substantial increase in COD was observed during the third replicate in the dry season, when reduced stream discharge decreased the water body's capacity to dilute pollutants, thereby increasing the concentrations of organic matter and oxidizable compounds and resulting in higher COD values (Effendi. 2013). The third replicate was taken in April 2026, when the average monthly rainfall was 69.9 mm.

The average pH was 6,63 at Kopi Sereh Site and 6,45 at Panandaan Site. The lower pH observed at Panandaan Site replicate 1 was 5,95 suggests the input of acidic organic or inorganic substances, such as natural and anthropogenic sources and H_2SO_4 stimulants used during pine resin tapping. Water with a pH approaching the lower limit of neutrality tends to be less chemically stable and more susceptible to changes in water quality. If the pH continues to decline, it may induce physiological stress in aquatic organisms, particularly species that are sensitive to pH fluctuations (Nafisya et al. 2025).

High diversity values may be influenced by nutrient availability, such as nitrate and phosphate, as well as low environmental stress. Adequate variation in nutrient availability allows different phytoplankton species to grow and interact in a balanced manner, thereby optimizing overall biodiversity (Ulpa, Ihsan & Suprayogi. 2025). This finding is consistent with the ecological conditions at the study site, which indicate that Panandaan Site has pine resin tapping activity.

Plankton are aquatic organisms, including both plants and animals, that drift or float passively in the water column, with their movement and distribution primarily influenced by water currents, even when currents are weak. Plankton are microscopic organisms that inhabit aquatic environments (Hertika, Arsad, & Baghaz. 2021). Phytoplankton identification revealed that the class Bacillariophyceae had the highest number of families compared to other classes, with seven families, where the highest relative abundance was observed in *Pinnularia gibba* and *Synedra* sp. Members of Bacillariophyceae are capable of more efficient reproduction than other phytoplankton groups, doubling their population through cell division every 18–36 hours (Leidonald et al. 2022).

Bacillariophyceae are cosmopolitan and tolerant to extreme conditions, making them useful indicators of polluted waters (Tamama & Asadi. 2024). Plankton taxa associated with polluted conditions include *Chaetoceros* sp., *Coscinodiscus* sp., *Navicula*, *Nitzschia* sp., *Oscillatoria*, *Melosira* sp., *Pinnularia* sp., *Closterium* sp., *Ceratium* sp., and *Euglena viridis* (Evita, Hariyati & Hidayat. 2021).

The zooplankton recorded at both stations consisted of a single taxon, Brachionus sp., which is widely used as a bioindicator of water quality because its abundance is strongly influenced by environmental conditions such as nutrients, temperature, pH, and organic matter content (Sachlan. 1982).

Panandaan site, where pine resin tapping occurs, exhibited a lower erosion rate than the Kopi Sereh Site. The higher erosion rate in Kopi Sereh was primarily associated with high rainfall erosivity, highly erodible regosol soils, greater slope length and steepness at an elevation of approximately 1,400 masl. In contrast, field observations indicated greater surface runoff in Panandaan, characterized by fallen bamboo and several landslide points as qualitative observations. The results instead show that site-specific biophysical factors strongly influence modeled erosion risk.



Figure 4. Runoff, fallen bamboo and several landslide points in Panandaan Site

IV. CONCLUSION

The study concludes the site without pine resin tapping activities (Kopi Sereh Site) exhibited more favorable water quality conditions and high erosion rate with the ecological characteristic. As field observations indicated greater surface runoff in Panandaan Site, characterized by fallen bamboo and several landslide points as qualitative observations. The results instead show that site-specific biophysical factors strongly influence modeled erosion risk.

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