

Identification of Erosion and Infiltration Measurement in the Bengo-Bengo Educational Forest, Hasanuddin University

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Abstract- Soil erosion is one of the most common forms of land degradation in tropical and subtropical regions. At the same time, infiltration is the process of water entering the soil, which affects the hydrological cycle and soil productivity. This study was conducted in the Bengo-Bengo Educational Forest, Hasanuddin University, to identify forms of erosion and measure soil infiltration rates based on topographical variations. This area has the characteristics of a tropical rainforest ecosystem with land cover consisting of *Arenga pinnata* and *Flacourtia sp.* trees, as well as flat, moderate, and steep topography. The methods used included direct observation to identify erosion types and measurement of infiltration rates using metal pipes on various types of topography. The study's results revealed two main types of erosion: rill erosion and gully erosion. Rill erosion had an average length of 38.12 meters, width of 0.55 meters, and depth of 0.15 meters, while gully erosion exhibited a deeper and more progressive pattern. Infiltration measurements showed that the highest infiltration rate occurred on flat topography (13.2 cm/hour), followed by moderate topography (4.8 cm/hour) and steep topography (3.6 cm/hour). The study highlights the importance of vegetation cover in soil conservation to reduce erosion risk and enhance infiltration capacity. This study provides a scientific basis for designing sustainable soil and water conservation strategies and managing educational forest areas. These findings also serve as an essential reference for environmental education and land-use policy development.

Keywords- Bengo-Bengo, Erosion, Infiltration, Conservation, Slope

I. INTRODUCTION

Erosion is the process of soil particles moving from one place to another, caused by natural agents such as water, wind, and others (Muhana et al., 2024). Soil erosion is one of the most common forms of land degradation in sub-tropical to tropical regions (Ghosh & Maiti, 2021; Wuepper et al., 2020). This process occurs due to the movement of soil particles by rainwater or surface runoff, which, if not controlled, can lead to the loss of fertile topsoil (Inhazama et al., 2023). Based on Isra et al (2023) findings, the most influential factor triggering erosion is slope; steep slopes increase the speed of surface flow, and the energy-carrying soil particles and erosion cause the loss of nutrient-rich topsoil, adversely affecting soil fertility. The impact is not only limited to decreased soil productivity but also to the disruption of ecosystem balance, increased sedimentation in rivers, and potential disasters such as floods and landslides (Dali et al., 2023; Jainuddin, 2023; Nandra Eko Nugrogo & Dicko Rizky Febriansanu, 2022). Furthermore, human activities such as deforestation, agricultural land clearing without adequate conservation techniques, and infrastructure development without environmentally-based planning exacerbate the rate of erosion. This process not only accelerates the loss of fertile topsoil but can also cause permanent damage to soil structure, making long-term ecosystem recovery more difficult (Nugroho & Handayani, 2021; Dunggio & Ichsan, 2022)

Meanwhile, infiltration is the process of water movement (mainly from precipitation) into soil pores until it reaches the groundwater table (Novianto et al., 2021). Infiltration is the water entering the soil, which is very important in the hydrological cycle and is influenced by soil texture, slope, and land use (Arianto et al., 2021). Good infiltration can reduce surface runoff, increase groundwater availability, and support vegetation growth (Hidayat et al., 2022). However, land use change, loss of vegetation cover, and soil compaction can reduce infiltration capacity, thus accelerating erosion and worsening environmental conditions (Tamod et al., 2020).

Erosion and infiltration are interrelated processes in water management and land use systems. When erosion rates increase, soil infiltration capacity decreases, leading to an imbalance in the hydrological cycle that can exacerbate land degradation (Pasaribu, 2023). Therefore, understanding the relationship between these two processes is crucial in sustainable natural resource management. Inappropriate land use, such as land clearing without considering soil and water conservation, can cause increased surface runoff and decreased infiltration, ultimately leading to extreme erosion (Ayu et al., 2024; Lorenz et al., 2019). Information about erosion and infiltration is key to designing effective and adaptive conservation strategies for specific biophysical land conditions. Meanwhile, identifying factors influencing erosion and infiltration, such as soil type, land cover, slope gradient, and human activities (Apriani et al., 2021; Fajeriana & Darmawan Risal, 2023; Lasaiba et al., 2023), is essential. Various studies indicate that changes in land cover from natural vegetation to agricultural or residential land use often result in decreased soil quality and increased risk of degradation (Asrul et al., 2025; Juarti, 2016). Therefore, integrating biophysical data with spatial approaches such as geospatial mapping and hydrological modelling becomes important for understanding land vulnerability patterns to erosion and declining infiltration capacity more comprehensively (Suprayogo et al., 2017).

The complexity of interactions between soil characteristics, vegetation, and climate conditions makes it necessary to conduct site-specific assessments when evaluating erosion and infiltration. Each landscape has unique properties that influence how water moves through and over the soil, meaning generalizations are often inadequate for designing local conservation strategies (Safira et al., 2023). Therefore, local empirical studies are essential to complement broader theoretical knowledge and to ensure that conservation measures are both effective and contextually appropriate.

Bengo-Bengo Educational Forest, under Hasanuddin University's management, has a strategic role as a conservation area and field learning site for students and researchers. This area reflects the characteristics of tropical rainforest ecosystems with varied topography, making it vulnerable to erosion processes and changes in infiltration rates (Ballabio et al., 2017; Delgado-Baquerizo et al., 2020). Unfortunately, scientific information on the physical condition of the land,

especially related to erosion and infiltration, is still minimal. In fact, the potential of this area as an open natural laboratory is immense for supporting experiential learning and applied research in the fields of forestry and environmental sciences.

In addition, given the important role of Bengo-Bengo as a forest for education at Hasanuddin University, understanding erosion and infiltration is crucial in climate change mitigation. Increasingly erratic rainfall patterns due to global climate change can increase the risk of extreme erosion and reduce the ability of soil to absorb water (Mendrofa & Hulu, 2024). Therefore, data-driven information on land conditions in this area will also be highly valuable in developing effective ecosystem-based adaptation (EbA) strategies to better adapt to climate change (Siregar Siagian et al., 2021).

Therefore, a study is needed to identify the types of erosion in the area and measure soil infiltration rates based on slope variations. The results of this study are expected to serve as a scientific basis for designing appropriate and sustainable soil and water conservation efforts in the Bengo-Bengo University Forest. In addition, the findings can also be used as a reference in the management of educational forest areas, the development of land use policies, and as a source of practical learning for students in the field of forestry and the environment. In addition, the results of this study are expected to strengthen Bengo-Bengo's role as a model area for implementing sustainable forest management principles. By understanding the relationship between topographical characteristics and hydrological processes such as erosion and infiltration, conservation strategies can be more accurately targeted and based on scientific evidence. For instance, in steep slope areas prone to erosion, planting ground cover vegetation, constructing terraces, or applying other site-specific soil and water conservation techniques may be effective. This approach not only helps preserve the ecological functions of the area but also enhances its social and economic benefits for surrounding communities and the managing educational institution.

II. METHODS

This research was conducted in the Bengo-bengo educational forest of Hasanuddin University, Cenrana District, Maros Regency, South Sulawesi. Identifying erosion types and measuring infiltration was carried out through several systematic stages. First, the coordinates of the observation location were entered into the GPS. Next, a square-shaped observation plot was made by determining the starting point (P1) and recording its coordinates. From point P1, a roll meter was pulled 50 meters west to determine point P2. Then, from P2, a roll meter was pulled at a 90° angle for 50 meters to get point P3. This process was repeated from P3 to P4 at a 90° angle to form a square plot, and all sides of the plot were marked using rope.

Within the designated plots, erosion types were monitored through direct observation in the field to identify erosion forms on the soil surface. The process

begins with determining the observation location using a GPS device to ensure precise coordinates. Locations that showed indications of erosion, such as water flow marks, soil cracks, or sediment accumulation at the bottom of the slope, were prioritized for observation. At these locations, visual identification of various forms of erosion, including splash, sheet, rill, and gully erosion, characterized by specific features such as uniform loss of soil layers or the formation of rills and gullies along the slope, was conducted.

After initial identification, measurements of erosion characteristics were taken to obtain quantitative data. Parameters measured included the length, width, and depth of the rill or ditch using a tape measure. In addition, the sedimentation direction and the sediment's shape were also recorded to illustrate more complete erosion patterns. These observations were complemented by visual documentation in the form of photographs and recordings of the coordinates of erosion locations. This data was then processed in tabular form to provide a systematic overview of the types of erosion found at the research site.

The final step is data verification, where direct observations are compared with literature references to ensure the accuracy of erosion type identification. This process is important for categorizing erosion types according to their characteristics and provides a strong scientific basis for understanding erosion processes at the study site. The resulting data is a reference for designing effective and sustainable soil conservation strategies. In addition, an inventory of the trees in the plot was conducted, including counting the number of individuals of each species. Observations also included recording the types of saplings, poles, and seedlings found in the plot (Apriani et al., 2021).

Each point was determined using a GPS device to ensure the accuracy of the location. At each location, a metal pipe with a specific diameter was stuck into the ground to a depth of 5 cm to limit the measurement area and minimize the influence of surface runoff. To obtain representative data, site selection considers soil conditions, land cover, and slope variations (Utomo et al., 2020).

After the metal pipe was installed, water was poured into the pipe until it reached a height of 10 cm, and the change in water height was measured using a ruler. Measurements were taken for ten minutes at one-minute intervals using a stopwatch. At each interval, the decrease in water level was recorded to calculate the infiltration rate, expressed in centimetres per hour. This process was repeated three times on each topography type to ensure consistency and accuracy of the data. Visual documentation was also conducted to record the condition of the soil and the surrounding environment during the measurements.

The data obtained was analyzed to see the difference in infiltration rates among flat, moderate, and steep topographies. In flat topography, infiltration rates tend to be higher than in moderate and steep topography because water has more time to infiltrate without significant

gravity (Kala et al., 2025). In addition, the influence of soil aggregates and vegetation cover was analyzed to explain the differences in infiltration rates. This information provides a better understanding of the relationship between slope, soil conditions, and infiltration capacity, which helps design soil and water conservation strategies.

III. RESULTS AND DISCUSSION

The erosion forms were identified by making a 50 x 50 m plot in the Bingo educational forest of Hasanuddin University. The plot's shape and its coordinate points are presented in Figure 1. The identification of erosion on the plot obtained five erosions, two gully erosions, and three rill erosions, which are available in Table 1.

The results of erosion identification found two main types of erosion at the research site: rill erosion and ditch erosion. Rill erosion is characterized by long rills with average dimensions of 38.12 meters in length, 0.55 meters in width, and 0.15 meters in depth. Ditch erosion, which was found in a newly formed condition, has average dimensions of 14.80 meters in length, 0.53 meters in width, and 0.46 meters in depth. This gully erosion results from the development of a continuous process of gully erosion based on the characteristics described by (Pasaribu et al., 2018). This pattern indicates strong erosion dynamics, especially in areas with significant slopes.

The gullies were 14.80 meters long, the average width was 0.53 meters, and the average depth was 0.46 meters. The rill erosion and ditch erosion found in Plot 9 are continuous because ditch erosion is formed by continuing the erosion/transportation of soil particles in the already-formed rills. The newly formed ditch erosion was found; as stated by (Pasaribu et al., 2018), the newly formed ditch erosion is about 40 cm wide with a depth of about 30 cm.

The conservation method is carried out by using plant remains or parts in the form of mulch. The erosion location is a forest overgrown with trees, so the application is relatively easy. Plant remains, or plants cut into pieces, only need to be spread evenly over the soil surface (Isra et al., 2023).

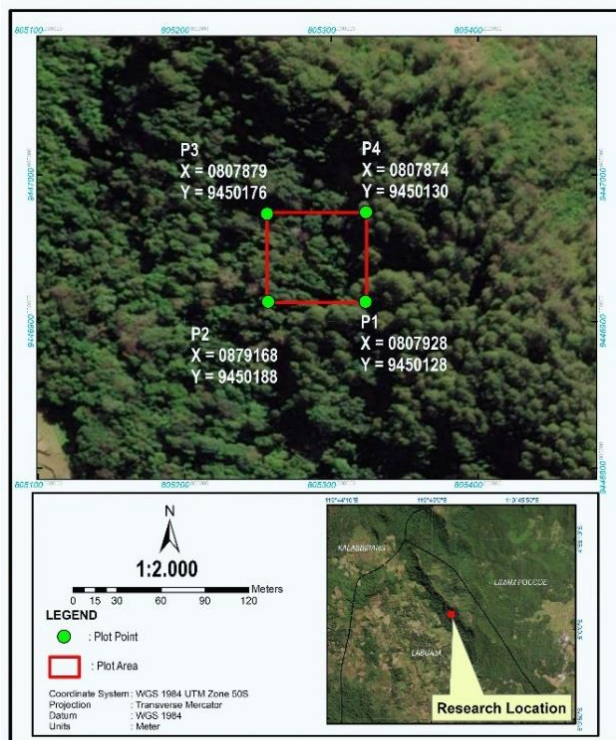


Figure 1. Research location

Table 1. Coordinates, land cover, slope, and erosion shape characteristics of the

Shape Erosion	Coordinates	Land Cover	Slope (%)	Erosion Characteristics				
				Erosion Dimension			Directions Erosion	Sediment Texture
				Long (m)	Width (m)	Depth (m)		
Rill erosion	X: 0807923 Y : 9450115	Aren (<i>Arenga pinnata</i>) and Lobe-lobe (<i>Flacourtia</i> Sp.)	20	15.4	0.56	0.15	Southwest	Sandy loam
Gully erosion	X: 0807907 Y: 9450143	Aren (<i>Arenga pinnata</i>) and Lobe-lobe (<i>Flacourtia</i> Sp.)	0	1.2	0.45	0.32	Southwest	Sandy loam
Rill erosion	X: 0807917 Y: 9450154	Aren (<i>Arenga pinnata</i>) and Lobe-lobe (<i>Flacourtia</i> Sp.)	39	22	0.7	0.1	Southwest	Sandy loam
Gully erosion	X: 0807928 Y: 9450141	Aren (<i>Arenga pinnata</i>) and Lobe-lobe (<i>Flacourtia</i> Sp.)	27	0.72	0.38	0.2	Southwest	Sandy loam
Rill erosion	X: 0807916 Y: 9450152	Aren (<i>Arenga pinnata</i>) and Lobe-lobe (<i>Flacourtia</i> Sp.)	27	13.6	0.61	0.6	Southwest	Sandy loam

The land cover of the plot consists of Aren (*Arenga pinnata*) and Lobe-lobe (*Flacourtia* Sp) trees, providing natural protection against erosion. This vegetation reduces the intensity of surface flow by slowing down water velocity and increasing infiltration. However, the erosion risk remains high in areas with less dense vegetation cover, underscoring the importance of maintaining vegetation cover density for soil conservation. In line with Riley et al. (2023) and Nuraeni et al. (2020), *Arengan pinata* and *Flacourtia* Sp. grew in the Bengo-Bengo University, Hasanuddin University Forest. The land cover in this plot is high density, as seen from the dense vegetation and diverse species, indicating

that this plot is in a natural forest (Maharani & Febrina, 2024; Vijay et al., 2024).

Infiltration measurements were conducted three times in different areas, namely in flat, medium, and steep areas (Table 2). Wahyuni et al. (2017) suggested that the slope affects the infiltration rate. The infiltration rate is faster on flat slopes than on moderate and steep slopes. On flat slopes, the infiltration rate is 13.2 cm/hour. On moderate slopes, the infiltration rate is 4.8 cm/hour, while on steep slopes, the infiltration rate is 3.6 cm/hour. This aligns with what Fadhillah & Setiawan (2024) reported, that the infiltration rate on flat slopes is faster than on slopes.

Table 2. Infiltration rate on flat, moderate, and steep slopes

Minute-	Flat Slope		Moderate Slope		Steep Slope	
	Water Height (cm)	Infiltration (cm)	Water Height (cm)	Infiltration (cm)	Water Height (cm)	Infiltration (cm)
1	9.2	0.8	9.7	0.3	9.4	0.6
2	9	0.2	9.6	0.1	9.2	0.2

3	8.8	0.2	9.6	0	9.2	0
4	8.6	0.2	9.5	0.1	9.2	0
5	8.5	0.1	9.5	0	9.2	0
6	8.4	0.1	9.5	0	9.2	0
7	8.2	0.2	9.5	0	9.2	0
8	8.1	0.1	9.5	0	9.2	0
9	7.9	0.2	9.5	0	9.2	0
10	7.7	0.1	9.5	0	9.2	0

The slope affects the infiltration rate. The infiltration rate is faster on flat slopes than on gentle slopes and steep slopes. On flat slopes, the infiltration rate is 13.2 cm/hour. On moderate slopes, the infiltration rate is 4.8 cm/hour, while on steep slopes, the infiltration rate is 3.6 cm/hour.

The infiltration rate measurements taken in the plot on the flat land slope can be seen in Figure 2. On flat land slopes infiltration occurs every minute with an average infiltration of 0.22 cm. Although infiltration occurs every minute, within 10 minutes, the water in the pipe only decreases by 2.2 cm; this can also indicate that the state of the soil at that time also began to touch the saturation point, so the absorption that occurred was small within 10 minutes.

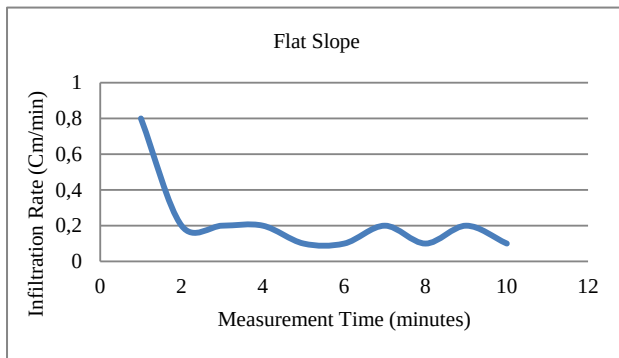


Figure 2. Graph of Infiltration Rate Measurement on Flat Slope

Based on the results of measurements taken, it can be seen that infiltration on land slopes classified as flat has the greatest infiltration rate of 0.22 cm/min, and the smallest is the infiltration rate on land slopes classified as steep at 0.05 cm/min.

The infiltration rate measurements taken in the plots on medium slopes can be seen in Figure 3.

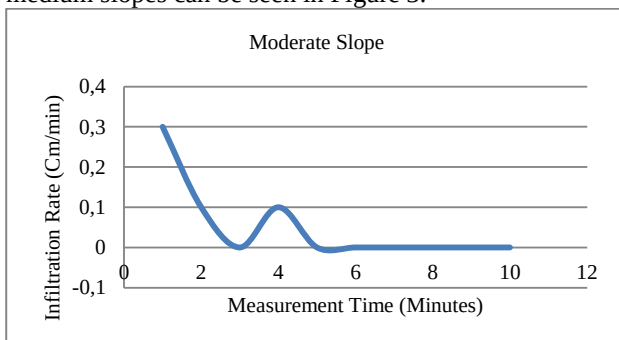


Figure 3. Graph of Infiltration Rate Measurement at Medium Slope

On moderate slopes, infiltration only occurs in minutes 1, 2 and 3. The infiltration that occurs is very small. This is almost the same as the measurements taken on steep slopes. So it can also be said that the soil at this slope has also reached its saturation point so that it can no longer absorb the water on its surface. The infiltration rate measurements taken in the plots on steep slopes can be seen in the figure 4:

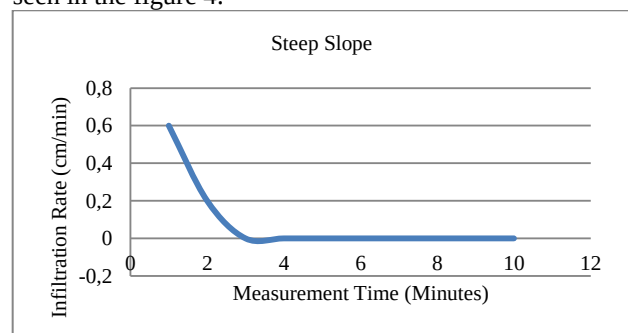


Figure 4. Graph of Infiltration Rate Measurement on Steep Slope

On steep slopes, infiltration only occurs in the first minute at 0.6 cm/minute, and in the next minute until the tenth minute, no infiltration occurs. This can occur when the soil has reached the water saturation point, which is the condition of the soil that can no longer absorb the existing water, so that the water on the surface of the soil becomes stagnant.

After the first minute, the infiltration rate decreased dramatically for all slope conditions. This decrease indicates that the soil became increasingly saturated with water over time. The infiltration rate pattern from the second to the tenth minute was relatively stable, with minor fluctuations around a low value (below 0.2 cm/minute). This indicates that the soil's ability to absorb water decreased significantly after the initial infiltration phase.

The low infiltration rate on steep slopes compared to flat slopes and moderate slopes is because gravity causes water to flow vertically into the soil through the soil profile (Qur'ani et al., 2022). The slope also affects soil aggregates, with the formation of aggregates indicating soil looseness. The more aggregates formed, the looser the soil and the easier it is to pass water. The percentage

of soil aggregates on flat slopes is higher than on moderate and steep slopes (Chen et al., 2024).

Differences between slopes indicate that steep slopes have slightly lower infiltration rates than flat and moderate slopes most of the time shown on Figure 5. This may be due to higher water runoff rates on steep slopes, which reduce water's opportunity to infiltrate the soil (Iskandar & Salman, 2025).

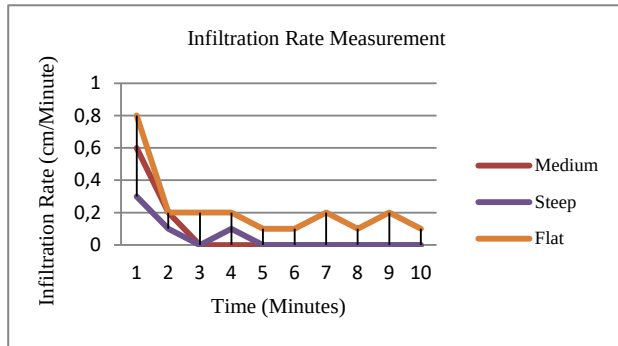


Figure 5. Infiltration rate

Erosion identified at the study site can remove the fertile topsoil rich in organic matter and nutrients. This loss of topsoil can adversely affect land productivity, especially if left without conservation measures. In addition, sediment accumulation in downstream areas can disrupt water flow and cause sedimentation of water bodies (Ayu et al., 2024).

Mulch from vegetation remnants at the study site is recommended to reduce erosion risk. Mulch can absorb the energy of raindrops and reduce the speed of surface flow, thus helping to protect the soil from erosion (Sidik et al., 2025). In addition, management of vegetation cover through reforestation with local plant species such as Aren and Lobe-lobe can also strengthen conservation efforts (Kore et al., 2024).

Field measurements are a crucial step in soil erosion and infiltration research. Although simulation models can explain potential damage or water flow, the results can be far from real conditions without accurate field calibration. Local calibration is an important process to ensure that the model reflects the actual environmental conditions, such as soil type, vegetation, and topographic variations in the research location. This process involves collecting direct data through detailed field observations and measurements, which are then used to adjust the parameters in the simulation model, so that the results are more representative and valid (Nofitasari, Muhammad Ruslan, 2020). Without adequate field calibration, models developed based on global or regional data can produce inaccurate predictions. For example, in erosion and infiltration research, models that have not been properly calibrated may not be able to capture the differences in soil characteristics found in each topography. Soil with high moisture content or rougher surfaces will have different infiltration rates than drier or smoother soils. Therefore, it is important to conduct field measurements that can accurately reflect local conditions (Lumbantoruan et al., 2021).

In addition, local calibration also allows for consideration of specific factors that cannot always be included in global models, such as changes in land cover or microclimate influences that may not be detected at larger scales. For example, the vegetation cover in the Bengo-Bengo Educational Forest research area can significantly affect erosion and infiltration rates. In this case, model calibration using field data allows researchers to understand how these factors affect surface water flow and the soil's capacity to absorb water (Pasaribu et al., 2018).

The field calibration process can also help identify additional factors that may affect erosion and infiltration, such as changes in land use or human activities that may not be captured in the broader model. Therefore, to obtain more valid results, researchers need to conduct direct measurements in the field and compare the results with the predictions generated by the model (Saputra et al., 2024).

By conducting careful field calibration, this study produces more accurate data and provides a strong basis for developing more effective soil conservation strategies. Therefore, field measurements and local calibration are critical components in ensuring the reliability of research results and their application in natural resource management policies, especially in facing the challenges of climate change and increasing land degradation (Nofitasari, Muhammad Ruslan, 2020).

The importance of these field measurements is also reflected in the relevance of research results to policies that will be implemented in the future. With more accurate data, the recommended conservation strategies can be more appropriate to local conditions and provide greater benefits for ecosystem sustainability (Apriani et al., 2021).

Soil erosion and infiltration are critical processes affecting soil quality and water availability in the Bengo-Bengo Educational Forest. Soil erosion, which occurs due to rainwater runoff, can remove the topsoil layer rich in nutrients, reducing soil fertility and the soil's ability to support vegetation growth. Meanwhile, infiltration is the process of water seeping into the soil, which affects groundwater storage and water availability for plants. If infiltration is disrupted, rainwater will not seep properly, which can lead to increased groundwater levels and flood risk (Zahura et al., 2024).

Erosion and infiltration process occurring in the Bengo-Bengo Educational Forest are also influenced by external factors, such as climate change, which causes more extreme rainfall and unpredictable weather patterns. Climate change can increase rainfall intensity, worsen soil erosion, and reduce the soil's ability to absorb water. Therefore, this study emphasizes the need for continuous monitoring of both processes as a mitigation measure against the impacts of climate change (Goeller et al., 2019).

This study also underlines the importance of strengthening soil and water conservation efforts in this forest area. One of the proposed measures is the promotion of sustainable land use practices. These

practices include reforestation with native tree species that have strong roots and can help improve soil structure and minimize the impact of erosion. In addition, reforestation can increase biodiversity, which is essential for a healthy ecosystem (Teku & Derbib, 2024).

Besides reforestation, the use of vegetation mulch is also recommended as a method to reduce soil erosion. Vegetation mulch, which consists of organic materials such as dry leaves and grass, protects the soil surface from erosion caused by heavy rain. Additionally, mulch improves water infiltration by helping to maintain soil moisture and reduce evaporation. Using vegetation mulch is one of the natural solutions that can reduce the adverse effects of erosion and improve overall soil quality (Zahura et al., 2024).

This study aims to provide deeper insights into soil dynamics in the Bengo-Bengo Educational Forest by collecting and analyzing data obtained from erosion and infiltration monitoring. This data is crucial for developing more effective and sustainable conservation strategies. This monitoring will also enable the identification of patterns of change in soil and water and provide a clearer picture of possible mitigation measures.

Through research based on accurate data and a deep understanding of erosion and infiltration processes, more adaptive conservation strategies can be developed in response to climate change. This is essential to ensure the sustainability of the Bengo-Bengo Educational Forest ecosystem, which serves as a place for learning and research and is an important area for nature conservation and biodiversity. Maintaining ecological balance in this area ensures that future generations will preserve and use natural resources wisely.

IV. CONCLUSION

This study identified the erosion forms and measured the soil infiltration rate on various topographies, with the results showing two main types of erosion, rill erosion and furrow erosion, where furrow erosion is more profound and more progressive. Rill erosion has an average length of 38.12 meters, a width of 0.55 meters, and a depth of 0.15 meters. In comparison, furrow erosion was found to be at a length of 14.80 meters, a width of 0.53 meters, and a depth of 0.46 meters, indicating that furrow erosion is more intensive. The highest infiltration rate was found on flat topography (13.2 cm/hour), followed by moderate topography (4.8 cm/hour) and steep topography (3.6 cm/hour), indicating that slope gradient affects the ability of the soil to absorb water. This study also emphasizes the importance of natural vegetation cover, such as *Arenga pinnata* and *Flacourtia* sp., in reducing erosion risk and increasing soil infiltration capacity. These findings provide a strong scientific basis for designing more effective soil and water conservation strategies, support sustainable land management policies, and can be used as a reference for designing more adaptive land use policies to climate change and mitigating erosion impacts in the future,

empowering land managers and policymakers to implement effective strategies.

REFERENCES

- Apriani, N., Arsyad, U., & Mapangaja, B. (2021). Prediksi Erosi Berdasarkan Metode Universal Soil Loss Equation (USLE) Untuk Arah Penggunaan Lahan Di Daerah Aliran Sungai Lawo. *Jurnal Hutan dan Masyarakat*, 13(1), 49–63. <https://doi.org/10.24259/jhm.v13i1.10979>
- Arianto, W., Suryadi, E., & Perwitasari, S. D. N. (2021). Analisis Laju Infiltrasi dengan Metode Horton Pada Sub DAS Cikeruh. *Jurnal Keteknik Pertanian Tropis dan Biosistem*, 9(1), 8–19. <https://doi.org/10.21776/ub.jkptb.2021.009.01.02>
- Asrul, Eraku, S., Agu, R. R., Maini, A. A., Lasamu, M., Massi, S., Selatan, K. L., & Timur, K. K. (2025). Di Kelurahan Leato Selatan Kecamatan Kota Timur. *Geodika: Jurnal Kajian Ilmu dan Pendidikan Geografi*, 9, 52–61. <https://doi.org/10.29408/geodika.v9i1.29256>
- Ayu, I. W., Kusumawardani, W., Lestari, N. D., Kartini, A., Jamelela, D., Zikra, F., Apriliani, R., Sumbawa, K., Hulu, K. M., Tanah, I., Tanaman, B., & Tanah, K. (2024). Identifikasi Erosi Lahan Di Lahan Kering Kabupaten Sumbawa, NTB. *Jurnal Agroteknologi Universitas Samawa*, 4(2), 38–46.
- Ballabio, C., Borrelli, P., Spinoni, J., Meusburger, K., Michaelides, S., Beguería, S., Klik, A., Petan, S., Janeček, M., Olsen, P., Aalto, J., Lakatos, M., Rymaszewicz, A., Dumitrescu, A., Tadić, M. P., Diodato, N., Kostalova, J., Rousseva, S., Banasik, K., ... Panagos, P. (2017). Mapping monthly rainfall erosivity in Europe. *Science of the Total Environment*, 579(November 2016), 1298–1315. <https://doi.org/10.1016/j.scitotenv.2016.11.123>
- Chen, M., Ai, S., Yang, Y., Yang, Q., Huang, B., Liu, Z., Ai, X., & Ai, Y. (2024). Effects of slope aspect on soil aggregates humus on cut slopes in alpine areas of Southwest China. *CATENA*, 238, 107833. <https://doi.org/https://doi.org/10.1016/j.catena.2024.107833>
- Dali, A. S. A., Pendang, A., & Musa, R. (2023). Uji Tingkat Erosi Tanah dengan Variasi Intensitas Curah Hujan Menggunakan Alat Rainfall Simulator. *Jurnal Teknik Sumber Daya Air*, 3(1), 55–66. <https://doi.org/10.56860/jtsda.v3i1.14>
- Delgado-Baquerizo, M., Reich, P. B., Trivedi, C., Eldridge, D. J., Abades, S., Alfaro, F. D., Bastida, F., Berhe, A. A., Cutler, N. A., Gallardo, A., García-Velázquez, L., Hart, S. C., Hayes, P. E., He, J.-Z., Hseu, Z.-Y., Hu, H.-W., Kirchmair, M., Neuhauser, S., Pérez, C. A., ... Singh, B. K. (2020). Multiple elements of soil biodiversity drive ecosystem functions across biomes. *Nature Ecology & Evolution*, 4(2), 210–220. <https://doi.org/10.1038/s41559-019-1084-y>
- Dunggio, I., & Ichsan, A. C. (2022). Efektifitas Pembuatan Tanaman Vegetatif dalam

- Menanggulangi Erosi dan Sedimentasi (Studi Kasus di Daerah Aliran Sungai Limboto Provinsi Gorontalo). *Jurnal Belantara*, 5(1), 45-58. <https://doi.org/10.29303/jbl.v5i1.882>
- Fadhilah, I. N., & Setiawan, B. (2024). Pengaruh Kemiringan Lereng Terhadap Infiltrasi Air Hujan Menggunakan Model Green-Ampt. 20(3), 111-118.
- Fajeriana, N., & Darmawan Risal. (2023). Peningkatan Pemahaman Tentang Potensi Erosi: Erosivitas dan Erodibilitas Dengan Simulasi Hujan Pada Topografi dan Tutupan Lahan yang Berbeda. *Abdimas: Papua Journal of Community Service*, 5(1), 64-74. <https://doi.org/10.33506/pjcs.v5i1.1687>
- Ghosh, D., & Maiti, S. K. (2021). Biochar-assisted eco-restoration of coal mine degraded land to meet United Nation Sustainable Development Goals. *Land Degradation & Development*, 32(16), 4494-4508. <https://doi.org/https://doi.org/10.1002/ldr.4055>
- Goeller, B. C., Burbery, L. F., Febria, C. M., Collins, K. E., Burrows, N. J., Simon, K. S., Harding, J. S., & McIntosh, A. R. (2019). Capacity for bioreactors and riparian rehabilitation to enhance nitrate attenuation in agricultural streams. *Ecological Engineering*, 134, 65-77. <https://doi.org/https://doi.org/10.1016/j.ecoleng.2019.03.014>
- Hidayat, N., Ramli, M., & Purwanto, P. (2022). Tyre Drop Structure Design for Erosion Handling in Mine Rehabilitation Area: Desain Tyre Drop Structure untuk Penanganan Erosi pada Area Rehabilitasi Tambang. *JURNAL GEOCELEBES*. <https://doi.org/10.20956/geocelebes.v6i2.21106>
- Inhazama, T. A., Mustofa, A., & Syafi'i Ali, A. (2023). Analisis erosi menggunakan USLE pada area disposal dan sekatan Sump Angsana Pit Tutupan PT Adaro Indonesia Erosion analysis using USLE in disposal area and Angsana Sump barrier at Pit Tutupan PT Adaro Indonesia. *Jurnal HIMASAPTA*, 8(3), 201-208.
- Iskandar, A., & Salman, N. (2025). Prediction Of Rate And Hazard Erosion Zone in the Weathering of Volcanic Rock in Cililin Subdistrict , West Bandung District ., *Jurnal Sains, Teknologi Dan Rekayasa (JSTR)*, 1(1), 1-9.
- Isra, N., Arsyad, U., & Chairuddin, Z. (2023). Sedimentation analysis using SWAT model (soil and water assessment tool) in Mamasa Sub-Watershed. *IOP Conference Series: Earth and Environmental Science*, 1230(1). <https://doi.org/10.1088/1755-1315/1230/1/012027>
- Jainuddin, N. (2023). Dampak Deforestasi Terhadap Keanekaragaman Hayati Dan Ekosistem. *Jurnal Humaniora, Sosial Dan Bisnis*, 1(2), 131-140.
- Juarti. (2016). Analisis Indeks Kualitas Tanah Andisol Pada Berbagai Penggunaan Lahan Di Desa Sumber Brantas Kota Batu. *Jurnal pendidikan geografi*, 58-71. <http://journal.um.ac.id/index.php/pendidikan-geografi/index>
- Kala, R., District, D., & Tenggara, W. N. (2025). *Jurnal Biologi Tropis Analysis of Infiltration Rate in Community Forest Land (HKm) Wombo*.
- Kore, M. J. T., Nastiti, H. P., & Osa, D. B. (2024). Pengaruh Ketebalan Mulsa Organik Kirinyuh (*Chromolaena odorata*) terhadap Pertumbuhan Rumput Mulato (*Brachiaria hybrid cv. Mulato*). *Animal Agricultura*, 2(1), 340-347. <https://doi.org/10.59891/animacultura.v2i1.46>
- Lasaiba, M., Leuwol, F. S., Pinoa, W. S., Lasaiba, I., Riry, R. B., & Sandia, S. (2023). Integrasi Sig Dengan Usle Dalam Penilaian Erosi Di Das Wairutung. *Jurnal Tanah dan Sumberdaya Lahan*, 10(2), 191-201. <https://doi.org/10.21776/ub.jtsl.2023.010.2.2>
- Lorenz, K., Lal, R., & Ehlers, K. (2019). Soil organic carbon stock as an indicator for monitoring land and soil degradation in relation to United Nations' Sustainable Development Goals. *Land Degradation & Development*, 30(7), 824-838. <https://doi.org/https://doi.org/10.1002/ldr.3270>
- Lumbantoruan, S. U., Kadir, S., & Nisa, K. (2021). Analisis Tingkat Bahaya Erosi Pada Vegetasi Kebun Karet Pada Berbagai Kelerengan Di Sub Das Bati-Bati Das Maluka Provinsi Kalimantan Selatan. *Jurnal Sylva Scientiae*, 4(3), 525. <https://doi.org/10.20527/jss.v4i3.3754>
- Maharani, M., & Febrina, L. (2024). POTENSI BIOMASSA TANAMAN ARENGA-PINNATA SEBAGAI ALTERNATIF BAHAN BAKU ENERGI TERBARUKAN (KAWASAN AGRO-FORESTRY EKO WISATA CISOLOK, SUKABUMI, JAWA BARAT). *Seminar Nasional Pariwisata dan Kewirausahaan (SNPK)*, 3, 759-767. <https://doi.org/10.36441/snpk.vol3.2024.297>
- Mendrofa, P. Z., & Hulu, Y. (2024). Pengaruh Rata-Rata Curah Hujan Terhadap Kapasitas Infiltrasi Dan Stabilitas Tanah Di Wilayah Pertanian. *Jurnal Ilmu Pertanian dan Perikanan*, 01, 205-210.
- Muhana, N. H. N., Al Ghifari, M. S., Putri, A. N., Saputri, M. M. A., & Haji, A. T. S. (2024). Pemetaan Tingkat Bahaya Erosi dan Rekomendasi Mitigasi di Kawasan UB Forest, Desa Tawangargo, Kabupaten Malang. *Jurnal Sumberdaya Alam dan Lingkungan*, 11(1), 42-53. <https://doi.org/10.21776/ub.jsal.2024.011.01.5>
- Nandra Eko Nugrogo, & Dicko Rizky Febriansanu. (2022). *Kajian Dampak Degradasi Sungai Progo (Studi Kasus: Penggalan Sungai Progo di Daerah Wiyu, PundakWetan dan Jomboran Yogyakarta)*. *Jurnal Ilmiah Lingkungan Kebumihan*, IV(No.2)(2), 34-41.
- Nofitasari, Muhammad Ruslan, S. K. (2020). Study Infiltration in Dua Laut Watersheds of Tanah Bumbu District. *Jurnal Sylva Scientiae*, 03(5), 919-927.
- Novianto, N., Chandra, A. A., & Bahtiar, B. (2021). Pengaruh Sistem Biopori Untuk Menangani Genangan Pada Tanah Lanau. *CRANE: Civil Engineering Research Journal*, 2(1), 18-24.

- <https://doi.org/10.34010/crane.v2i1.5008>
- Nuraeni, S., Fortuna Wahab, D., Latif, N., Armidha Laboratorium Perlindungan dan Serangga Hutan, N., & Kehutanan Universitas Hasanuddin, F. (2020). Eksplorasi Pewarna Dan Motif Alami Pada Kain Sutra Dari Vegetasi Hutan Exploration of Natural Colours and Motives from Forest Vegetation on Silk Fabric. *Perennial*, 16(1), 53–58. <http://dx.doi.org/10.24259/perennial.v16i2.11504>
- Nugroho, D. A., & Handayani, W. (2021). Kajian faktor penyebab banjir dalam perspektif wilayah sungai: pembelajaran dari sub sistem drainase Sungai Beringin. *Jurnal Pembangunan Wilayah & Kota*, 17(2), 119–136. <https://doi.org/10.14710/pwk.v17i2.33912>
- Pasaribu, P. H. P. (2023). Analisis Faktor Erodibilitas Tanah Penyebab Erosi di Desa Merdeka Kecamatan Merdeka Kabupaten Karo. *Prosiding Seminar Nasional Biologi*, 3, 36–40. <https://jurnal.fmipa.unmul.ac.id/index.php/pbio/article/view/1248>
- Pasaribu, P. H. P., Rauf, A., & Slamet, B. (2018). Kajian Tingkat Bahaya Erosi Pada Berbagai Tipe Penggunaan Lahan di Kecamatan Merdeka Kabupaten Karo. *Jurnal Serambi Engineering*, 3(1), 279–284. <https://doi.org/10.32672/jse.v3i1.357>
- Qur'ani, N. P. G., Harisuseno, D., & Fidari, J. S. (2022). Studi Pengaruh Kemiringan Lereng Terhadap Laju Infiltrasi. *Jurnal Teknologi dan Rekayasa Sumber Daya Air*, 2(1), 242–254. <https://doi.org/10.21776/ub.jtresda.2022.002.01.20>
- Riley, E. P., Albani, A., Zak, A. A., Germani, L., Rothman, J. M., Carosi, M., & Ngakan, P. O. (2023). The potential conservation value of anthropogenically modified habitat for the Endangered moor macaque *Macaca maura* in Sulawesi, Indonesia. *Oryx*, 61(May). <https://doi.org/10.1017/S003060532200151X>
- Safira, A. D., Azmeri, A., Fatimah, E., Syahrial, A., & Rahmawati, T. (2023). The Hazard of Soil Erosion and Sediment Yield Prediction for Krueng Mane Watershed in Indonesia. *Bulgarian Journal of Agricultural Science*, 29(4), 615–622.
- Saputra, J., Sukarna, R. M., Junaedi, A., & Rizal, M. (2024). Kajian Tingkat Kerawanan Erosi Tanah Berbasis Spasial dan Survei Lapangan di Kecamatan Tewah Kabupaten Gunung Mas Provinsi Kalimantan Tengah. *Angewandte Chemie International Edition*, 6(11), 951–952., 7(November), 14–25.
- Sidik, A. A., Haafizh, M., & Kurniawan, N. (2025). Dampak kepadatan tanah pada berbagai penggunaan lahan terhadap erosi dan implikasinya bagi pertanian berkelanjutan di Sub DAS Brantas Hulu. 1(1).
- Siregar Siagian, R. C. H., Regina Princessa, Kogoya, R., Angkouw, R. E., & Tambunan, R. M. (2021). Analisis Kerjasama Sekretariat of the Pacific Regional Environment Programme (Sprep) Terkait Perubahan Iklim. *Jurnal Asia Pacific Studies*, 4(2), 144–153. <https://doi.org/10.33541/japs.v4i2.2559>
- Suprayogo, D., Hairiah, K., & Nita, I. (2017). *Manajemen Daerah Aliran Sungai (DAS): tinjauan hidrologi akibat perubahan tutupan lahan dalam pembangunan*. Universitas Brawijaya Press.
- Tamod, C. J. K. T., Aryanto, R., & Purwiyono, T. T. (2020). Analisis Laju Infiltrasi Berbagai Penggunaan Lahan di Desa Kaligending, Karangsambung, Jawa Tengah Analysis of The Infiltration Rate of Various Land Uses in Kaligending Village, Karangsambung, Jawa Tengah. *Indonesian Mining and Energy Journal*, 3(2), 76–88.
- Teku, D., & Derbib, T. (2024). Uncovering the drivers, impacts, and urgent solutions to soil erosion in the Ethiopian Highlands: a global perspective on local challenges. *Frontiers in Environmental Science*, 12(January), 1–19. <https://doi.org/10.3389/fenvs.2024.1521611>
- Utomo, A. P., Geologi, T., & Prisma, U. (2020). Laju Infiltrasi Dan Runoff Kelurahan Rangga Mekar, Kecamatan Bogor Selatan, Kota Bogor Infiltration. *Journal of Geoscience Engineering & Energy (JOGEE)*, 1, 96–107.
- Vijay, M. K., Tiwari, S., Kahar, L., Malviya, D., Aharwar, M., & Singh, N. (2024). Impact of seed size on germination parameters in *Flacourtia indica* (Burm.f.) Merr. *International Journal of Research in Agronomy*, 7(9), 23–29. <https://doi.org/10.33545/2618060x.2024.v7.i9a.1432>
- Wahyuni, W., Arsyad, U., Bachtiar, B., & Irfan, M. (2017). Identifikasi Daerah Resapan Air di Sub Daerah Aliran Sungai Malino Hulu Daerah Aliran Sungai Jeneberang Kabupaten Gowa. *Jurnal Hutan dan Masyarakat*, 9(2), 93. <https://doi.org/10.24259/jhm.v9i2.2891>
- Wuepper, D., Borrelli, P., & Finger, R. (2020). Countries and the global rate of soil erosion. *Nature Sustainability*, 3(1), 51–55. <https://doi.org/10.1038/s41893-019-0438-4>
- Zahura, F. T., Bisht, G., Li, Z., McKnight, S., & Chen, X. (2024). Impact of topography and climate on post-fire vegetation recovery across different burn severity and land cover types through random forest. *Ecological Informatics*, 82. <https://doi.org/10.1016/j.ecoinf.2024.102757>