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MAPPING OF EROSION HAZARD VULNERABILITY BASED ON GIS AND USLE IN WAIRUTUNG WATERSHED, SALAHUTU DISTRICT, CENTRAL MALUKU REGENCY

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Abstrak: Penelitian ini bertujuan untuk mengkaji tingkat bahaya erosi di Daerah Aliran Sungai Wairutung. Satuan lahan merupakan satuan analisis dalam penelitian ini yang dihasilkan dari hasil overlay peta penggunaan lahan, peta kemiringan lereng dan peta jenis tanah yang selanjutnya ditentukan kelas kerawanannya berdasarkan penjumlahan hasil pengharkatan dari parameter dengan menggunakan Sistem Informasi Geografi (SIG) berbasis komputer dengan program ArcGis yang diintegrasikan dengan model Universal Soil Loss Equation (USLE). Hasil yang diperoleh dari penelitian ini menunjukan pembagian dari 4 kelas kearawanan bahaya longsor lahan yang terdiri kelas sangat ringan dengan luas sebesar 2900.865 ha yang tersebar pada satuan lahan dengan jenis tanah alluvial. Untuk tipe sedang dengan total luas keseluruhan 3683.285 ha dan keseluruhan tersebar pada satuan lahan dengan jenis tanah podsolik, Tipe berat dengan total luas keseluruhan 1458.367 ha dan keseluruhan tersebar pada satuan lahan dengan jenis tanah podsolik dan litosol. Tingkat bahaya erosi pada tipe sangat berat dengan total luas keseluruhan 421.97 ha dan tersebar pada satuan lahan dengan jenis tanah podsolik dan litosol
Kata kunci: Erosi, Kerawanan, dan USLE

Abstract: This study aims to assess the erosion hazard level in the Wairutung Watershed. This study uses the results of overlaying land use maps, slope maps, and soil types maps to generate the Land unit, which is the unit of analysis. Done using a computer-based Geographic Information System (GIS) with the ArcGIS program integrated with the Universal Soil Loss Equation (USLE) model. The sum of the results of the rating of the parameters then determines the class of vulnerability. The results obtained from this study indicate the division of 4 categories of landslide hazards consisting of a very light course with an area of 2900,865 ha spread over land units with alluvial soil types. The medium type, with a total area of 3683.285 ha, is distributed over land units with podzolic soil types. Heavy type with a total area of 1458.367 ha and the whole place is spread over land units with podzolic and cytosol soil types. The erosion hazard level is hefty, with a total area of 421.97 ha, and is spread over land units with podzolic and cytosol soil types.
Keywords: Erosion, Vulnerability, and USLE

A. INTRODUCTION

Soil loss due to erosion is a global problem and has significantly increased land degradation (Sartori et al., 2019). Reduced crop production, decreased surface water quality, and changes in drainage canals can result from soil loss from agricultural land (Kumarasinghe, 2021). According to estimates, soil erosion occurs at an average of 12 to 15 hectares per year, translating to annual soil loss at the soil surface of 0.90 to 0.95 mm (FAO, 2015; Pham et al., 2018). This soil loss intensifies due to different climatic conditions and land use (García et al., 2021), reducing productivity. (Benavtdez et al. 2018: Singh & Panda. 2017), and degradation of ecosystems in

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the highlands and mountains. (Dinh et al., 2021). The ever-increasing erosion has created a problem impacting livelihoods and food production (Danasekara, 2022).

Erosion is losing or eroding soil or parts of land from a place transported by water or wind to another place (Arsyad, 2010; Sitepu et al., 2017). Human activity results in intensive and extensive agricultural activities that cause erosion (Labrière et al., 2015). Erosion is also a result of poor land management (Hariati et al., 2022), the absence of cover crops (Andriyani et al., 2019), and land use activities that are inappropriate based on the land's capability and carrying capacity (Eisenberg & Muvundja, 2020). Erosion also occurs due to changes in forest areas converted to agriculture and damage to the biophysical environment. Has an impact on the shallowing of rivers, resulting in more frequent floods during the rainy season and droughts during the dry season (Arsyad, 2010; Sitepu et al., 2017). In general, erosion means the topsoil's displacement, which causes topsoil loss by activity agent dynamics erosion such as water, ice, snow, air, plants, animals, and others (Nasir Ahmad et al., 2020). Complex and dynamic processes involving the retention, transport, and deposition of soil materials can be used to describe erosion. Natural erosion and accelerated erosion are two categories of erosion (Labrière et al., 2015).

Rain, wind, surface runoff, soil type, slope, land cover, and conservation efforts influence erosion. These elements, which affect erosion and cannot be separated, work simultaneously. (Morgan & Rickson, 2005; Putra et al., 2018). Climate factors, soil type, soil structure, vegetation, plant surface, and land management are other elements that impact erosion. Geomorphology, geology, hydroclimatic conditions, and human activities are further factors (Keesstra et al., 2016). Accurately describing the earth's surface is essential for modelling soil erosion. Analysis of erosion hazard levels is vital for determining and predicting the loss of soil aggregates (Efthimiou et al., 2017). as well as for classifying erosion hazards and the level of risk caused by erosion, both at global, national, and local scales (Terranova *et al* ., 2009; da Silva et al., 2011; Efthimiou et al., 2017). Various models have been developed to study erosion from field measurements and statistical analysis. One such model is the *Universal Soil Loss Equation* (USLE) (Wischmeier & Smith, 1978; Feiner et al., 2020). Among the USLE factors, the management cover factor (C-factor) is the most crucial factor regarding the sensitivity of calculated soil loss and a critical factor in soil erosion control. Erosion of vitality of precipitation (R), erodibility (K), slope factor, and slope length (L.S.) (Prasuhn, 2022).

Integrating remote sensing with Geographic Information Systems (GIS) and USLE has been widely discussed by researchers who can characterize soil erosion in large areas. (El Jazouli et al., 2017) Calculating aggregate soil loss (Devatha et al., 2015) classifies the erosion hazard level. (Prayitno et al., 2015), As well as mapping information to estimate soil loss. (Jl et al., 2010). The USLE model integrated with GIS can present the results using thematic maps in different formats and scales (Životić et al., 2012). The watershed is a water catchment area that has the power to control the water management process. One of the factors causing watershed damage is the increasing use of natural resources and population growth. There are approximately 62 DAS in critical and very severe situations out of 458 DAS in Indonesia, which are of concern. This condition is caused by human activities and worsening terrain erosion (Paimin & Pramono, 2009; Utama, 2022). In the eastern part of Ambon Island, which is geographically part of the Central Maluku Regency, there is the Wairutung Watershed. The Wairutung watershed is located on a 5–15% slope, with mixed gardens and dry agricultural land constituting most of the land cover. The Wairutung watershed has undergone many environmental changes, especially in the upstream areas where land use has changed, which has caused significant erosion and has hurt the river's capacity to handle water flow, especially during the rainy season. In addition, the Wairutung Watershed experiences very high rainfall, 187.77 mm, which can cause erosion and sedimentation in the river's lower reaches.

B. METHOD

Astronomically the Wairutung Watershed is located at coordinates 3° 34' 32.6" South Latitude – 128° 16' 0.2.9" East Longitude, with a length of 7.43 kilometres from upstream to downstream. The research location is a watershed east of Ambon Island and the Salahutu District and includes two villages, namely Tulehu Village and Wai Village. The boundaries are in the North and West with Leihitu District, South with Ambon City, and East with the Seram Sea (Figure 1).

The technique used in this research is the USLE method which Wischmeier and Smith developed in 1978 by Pham et al. (2018). This technique is used to measure the long-term level of erosion vulnerability in an area using a Geographic Information System (GIS) approach. Then predict the level of erosion vulnerability spatially obtained from the results of overlaying feature data in shapefile (SHP) format soil type maps, slope maps, and land use maps. This study's materials and tools consist of

Landsat 2022 imagery; rainfall data (2013-2022); Digital Elevation Model (DEM) for extracting Slope Maps, Soil maps; Land use maps, administrative maps, and RBI maps. While a geological compass, digital camera, Garmin handheld GPS, field stationery, and software, such as Ms Excel, ArcGIS 9.3, Er *Mapper*, and Global Mapper, were used to gather pertinent data for the analysis of flood danger and risk, carried out by field observation and document review.

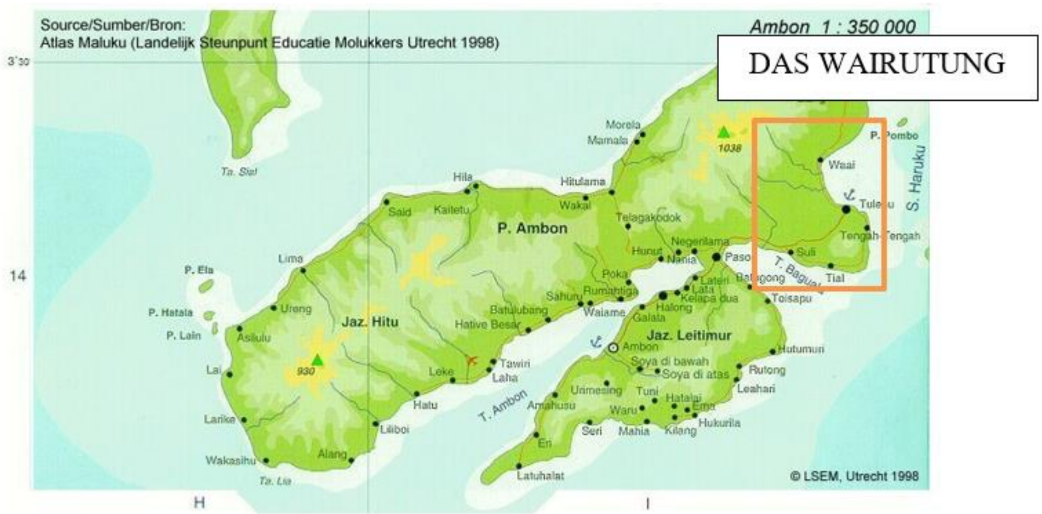

Figure 1. Map of Research Locations

Data was collected from the City Bappeda, the Public Works Agency, the Meteorology and Climatology Agency, the Ambon City Government, City BPS, Citra Landsat from the website of <u>*www.glovis*</u>. *USGS.gov*. and DEM data from the website *www. Tanahair. Indonesia.go.id/demnas*. Furthermore, the data that has been obtained is analyzed by weighting, scoring, and overlapping. Data collection is done using observation and documentation. Observation is a data collection technique that directly observes the object of research, especially those related to the studied variables. Documentation archives various visual appearances in the field to be presented in the research. Data analysis was carried out to examine the parameters used in this study which included; the regional average rainfall factor from the Central Maluku BMKG station in Central Maluku Regency from 2013 to 2022. The erosivity value is then determined by analyzing rainfall data in the erosivity equation (R). The Bols equation is used to calculate the R factor (The *et al.*, 2011):

$$\frac{2.5p^2}{100\,(0{,}073p+0{,}73)} \ldots\ldots\ldots\ldots..(1)$$

Information:

R: Average annual erosivity index

Q: Average annual rainfall

The K value factor is calculated by interpreting the soil type map (*Soil Erodibility Index*). For each soil type, the K factor value is calculated using the K value. The K layer K factor value is then entered as an attribute table. In addition, using GIS software, the map or K layer factors are extended to a range to determine the L.S. value. Slope and Length were collected from digital elevation model data (Pham et al., 2018).

$$LS = \frac{(FA\ x\ Cellsize^{0.4})}{22.12}\,x\,\frac{\sin slope^{1.3}}{0.0296} \ ..(2)$$

Information:

L.S.: Slope length and slope gradient

F.A.: accumulation of streams

Cell size: the size of the pixels

Slope: the slope of the slope (o)

The technique used in this research is the USLE method developed by Wischmeier & Smith (1978) for erosion rates. Determine land use factors; digital RBI maps are used. In addition, the criteria for each type of land use are used to determine the C.P. value. This value is converted to a raster, and the C.P. value is entered as an attribute table. Plant factors and their management are determined based on observations. The results then calculated the erosion rate using the Wischmeier & Smith (1978) in Pham et al. (2018) as follows:

$$A = R\ x\ K\ x\ L\ x\ S\ x\ C.P. \ \ldots\ldots(3)$$

Information:

A = Amount of lost land

R = Erosivity

K = Erodibility

LS = Length and slope of the slope

C.P. = Plant management vegetation / land cover.

C. RESULTS AND DISCUSSION

C.1. RESULTS

a. Erosivity Factor

The erosivity of the Wairutung watershed, including rainfall, rainy days, and maximum rainfall of 24 hours, was obtained from the nearest rain measuring station, namely the Central Maluku BMKG rainfall station. Rainfall is the climate component that has the most significant influence on erosion. Erosion is a climatic phenomenon that is strongly influenced by rainfall. The amount of rainfall, intensity, and distribution affect how much rain will spread over the land, how much surface runoff will occur, and how much erosion will cause damage. In measuring the erosivity value in this study, it was calculated using the Bols formula, which combines rainfall data for the previous ten years (2013–2022). (Bols, 1978; Luliro et al., 2013). Monthly rainfall data from 10 years is 508.9 mm/month, and the calculation results show that the erosivity value at the study site for a year is 2358.84 mm/month. When combined with the topography in the Wairutung watershed with steep slopes, these conditions can cause more significant erosion.

b. Erodibility Factor of Soil (K)

Soil susceptibility to erosion is indicated by soil erodibility (K). The soil's ability to absorb water and its resistance to external damage affect how easily it can erode. The clay ratio method was applied for the erodibility value in this study. (Wang et al., 2013). Based on the 1:50,000 Scale Soil Map, the conditions of the soil types in the study area show three different types of soil units in the study area. This soil unit is a classification of the physical and chemical properties of the soil based on the components contained therein. The soil types are alluvial, podzolic, and tool, as seen in Table 1. In addition, based on the GIS analysis, it was revealed that podzolic soil types cover an area of 7957.83 ha, followed by Litosol soil types, which cover an area of 1196.68 hectares. The soil type with the highest soil erodibility value is found in podzolic soil type, with a K value of 0.692, a reasonably high standard.

Table 1. Soil Erodibility Value (K)

No	Type of soil	Symbol	K value	Area (ha)	%
1.	Alluvial	Al	0.269	1237.97	11.91
2.	Litosol	Lt	0.034	1196.68	11.51
3.	Podzolic	Pd	0.692	7957.83	76.57

Source: Results of Data Analysis and Field Survey

c. Slope Factor (L.S.)

The soil lost during erosion depends on topographical factors, including slope and slope length. Erosion is affected by slope, where erosion increases the steepness of the slope and the amount of material carried by runoff increases with the Length of the slope. The magnitude of soil erosion will be greater where flow accumulation occurs because the L.S. Value occurs intensively in areas where flow congregates. The speed of surface runoff is significantly affected by the slope, which significantly impacts the erosion that occurs. The slope value, increased volume of surface runoff, and the risk of erosion will hamper the possibility of water seepage into the soil (infiltration). Digital Elevation Model (DEM) data analysis extracts slope maps. It calculates slope length and slope (L.S.) parameters, and the results show five slope classes at the study location. Slope dominated by slopes > 25% (high), area of 3113.70 hectares, 15 - 25% (steep), an area of 2537.71 hectares, a range of 8 - 15% with an area of 1606.50 hectares, flat slopes (0-8%) an area of 2878.37 hectares, according to the results of the GIS study (Table 2).

Table 2. Slope Factor (L.S.)

No.	Slope	Symbol	L.S. value	Area (ha)	%
1	0 -8	I	0.49	2878.37	28.40
2	8- 15	II	1.74	2537.71	25.04
3	15 - 25	III	3.86	1606.50	15.85
4	>25	IV	8.48	3113.70	30.72

Source: Results of Data Analysis and Field Survey

d. Land Use Factor (C.P.)

Land use is the next element affecting erosion in maintaining the soil surface from damage. The conservation direction (C.P.) is determined depending on the type of land use and the characteristics of the vegetation covering the soil. GIS analysis is used to determine the distribution of land use type to calculate the C.P. factor values. As a result, the research location has five different forms of land use: forests, mixed gardens, settlements, shrubs, and fields (Table 6).

Table 3. Factor Value of Slope Length and Slope (C.P.)

No.	Land Use	Symbol	C	P	CP value	Area (ha)	%
1.	Forest	ht	0.001	0.01	0.00001	1924.09	19.24
2.	Mixed Garden	Kc	0.1	0.04	0.004	4625.62	46.26
3.	Settlement	Pm	1.00	1.00	1.00	564.35	5.64
4.	Shrubs	sb	0.001	0.20	0.0002	2329.58	23.30
5.	Moor	Q	0.01	0.04	0.0004	950.66	9.51

Source: Results of Data Analysis and Field Survey

Table 6 shows that the C.P. value for residential land use is very high, while shrubs, mixed gardens, and dry fields have a high C.P. value because the plants planted do not have sound and robust roots in holding rainfall. Damage the soil's surface layer, especially with steep slope conditions. However, it differs from using forest land with a low C.P. value because the forest at the study site has a high canopy, density, and strong roots, so the ability to hold rainfall is tremendous.

e. Land Management Factor (P)

The Wairutung watershed has no land conservation activities, so the land management factor or conservation land (P) is 1.00. The leading causes of erosion in the study area are problems related to crop management and conservation efforts. In line with Asdak's statement (2001), a watershed or sub-watershed must know the erosion hazard for a soil conservation program to be successful. Soil restoration priorities can be determined once the risk of watershed erosion is identified.

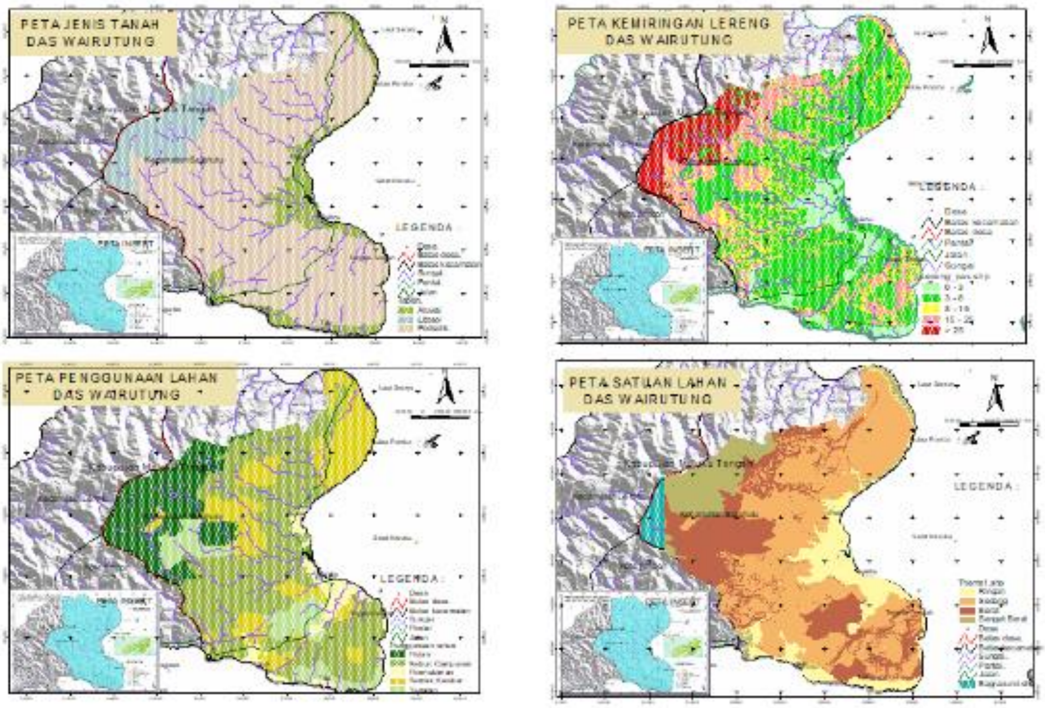

Figure 2. Land Type Map, Slope, Land Use, and Wairutung Watershed Land Unit

f. Erosion Calculation with USLE Model

The erosion hazard at the study site is very light, covering an area of 2900,865 hectares, found in alluvial soil types with land units, namely A lI Kc, Ali Pm, Al I Sb, Al I Lt, Pd I Kc, and Pd I Pm, on podzolic soil types available in land units, namely Pd I Sb, Pd I Lt, and Pd I Pk. The results of the calculation. Medium types with a total area of 3683,285 ha are spread over land units with podzolic soil types, namely Pd III H, Pd III Kc, Pd II Pk, Pd II Kc, and Pd II Pm. Erosion risk on heavy types with a total area of 421.97 hectares and spread over land units with podzolic and litosol soil types, including Lt III Sb, Lt IV H, Pd III Sb, and Pd III Lt. The heavy type has a total area of 1458,367 ha. It is distributed over land units with podzolic and litosol soil types, specifically Lt III H, Pd II Sb, and Pd II Lt. Planning land conservation programs requires erosion rate estimation.

Appropriate land use strategies and conservation measures can be devised to prevent further damage if erosion rates can be identified. So that land can be used sustainably and productively. High-intensity rainfall will increase the likelihood of natural disasters, including erosion and landslides, besides increasing the hazard level.

Table 4 Actual Erosion Hazard and Slope Erosion Hazard in Wairutung Watershed

No	Satlan	K	R	LS	CP	P	A	Class	Danger
1	Al I Kc	0.269	2358.84	0.49	0.004	1.00	87,961	I	Light
2	Al I Pm	0.269	2358.84	0.49	1.00	1.00	315,156	I	Light
3	Al, I Sb	0.269	2358.84	0.49	0.0002	1.00	176,994	I	Light
4	Al I Tg	0.269	2358.84	0.49	0.0004	1.00	13,904	I	Light
5	Lt III H	0.034	2358.84	3.86	0.00001	1.00	677,007	III	Heavy
6	Lt III Sb	0.034	2358.84	3.86	0.0002	1.00	13,916	IV	Very heavy
7	lt IV H	0.034	2358.84	8.48	0.001	1.00	283,709	IV	Very heavy
8	Pd III H	0.692	2358.84	3.86	0.00001	1.00	662.59	II	Currently
9	Pd III Kc	0.692	2358.84	3.86	0.004	1.00	19,294	II	Currently
10	Pd III Sb	0.692	2358.84	3.86	0.0002	1.00	20,565	IV	Very heavy
11	Pd III Tg	0.692	2358.84	3.86	0.0004	1.00	103.78	IV	Very heavy
12	Pd II H	0.692	2358.84	1.74	0.00001	1.00	461,054	II	Currently
13	Pd II Kc	0.692	2358.84	1.74	0.004	1.00	2445.103	II	Currently
14	Pd II Pm	0.692	2358.84	1.74	1.00	1.00	95,244	II	Currently
15	WWII Sb	0.692	2358.84	1.74	0.0002	1.00	613,194	III	Heavy
16	Pd II Tg	0.692	2358.84	1.74	0.0004	1.00	168,166	III	Heavy
18	Pd I Kc	0.692	2358.84	0.49	0.004	1.00	1276735	I	Light
19	Pd I Pm	0.692	2358.84	0.49	1.00	1.00	83,533	I	Light
20	Pd I Sb	0.692	2358.84	0.49	0.0002	1.00	820,882	I	Light
21	Pd I Tg	0.692	2358.84	0.49	0.0004	1.00	0.017	I	Light

Source: Results of Data Analysis and Field Survey

C.2. DISCUSSION

The erosivity value from the research results was calculated using the Bols formula, which combines the previous 30 years of rainfall data, and shows that the erosivity value for a year in the Wairutung Watershed is 2358.81 mm/month. When combined with the topography in the Wairutung watershed, which is 89% hilly and mountainous and has steep slopes, it has the potential to cause more significant erosion, in line with the findings of Putra et al. (2018), who examined the cold water watershed of the upstream part of Padang City, which is also a hilly area with steep slopes with a high level of erosivity. In line with Hermon's research (2012), erosion will increase with longer slopes at high rain intensities, while at lower intensities, it will decrease. If a ground cover does not protect the soil under these circumstances, runoff and erosion will further increase.

Significant rainfall is considered the root cause of erosion, disproportionate to surface runoff. Heavy rainfall will result in significant runoff and erosion because the soil's ability to absorb water is limited. The level of soil damage due to erosion is influenced by climate, topography, soil, vegetation, and human factors. High rainfall, which has kinetic energy, impacts the amount of erosion (Arsyad, 2010; Putra et al., 2018). Rainfall that is greater than the quantity of rainfall causes increased erosion. Erosion may not be caused by large volumes of rainfall, either low or high intensity, but occurs rapidly (Sitepu et al., (2017). But significant erosion can also be caused by frequent heavy rains (Wati et al., 2014),

This study's soil erodibility value (K) applied the *clay ratio method*. The soil type with the highest soil erodibility value at the study site was found in podzolic soil types, which had a K value of 0.692, with a reasonably high standard. According to the research of Morgan & Rickson (2005; Putra et al., 2018), a high soil erodibility value will lead to a higher soil erosion capacity. Soil erodibility and susceptibility of various types of soil to erosion vary. The chances of erosion are reduced if the soil can withstand heavy rains and vice versa. In contrast to soils with low erodibility and good erosion resistance, soils with high erodibility are sensitive to erosion (Arsyad, 2010; Putra et al., 2018).

Topographic factors, including slope and slope length, affect the amount of erosion. The slope at the research site mainly was steep slopes > 25% (with an area of 3113.70 hectares) and steep slopes 15 - 25% (with an area of 2537.71 hectares), with an area of 1606.50 hectares, according to the findings of the GIS analysis. Slopes and slope length are the topographic features that influence runoff and erosion (Arsyad, 2010). Therefore, the slope's Length and steepness dictate how much soil is carried by surface runoff and how quickly the runoff moves the soil. According to Hardjowigeno's research (2003) in Sinaga (2014), erosion will increase if the slope is longer or steeper.

A land surface with a steeper slope can increase runoff velocity and water-carrying energy, both of which cause an increase in soil exposure to rain impacts. Cause the land surface to become steeper and the erosion to be twice as significant (Hardjowigeno, 2003; Sinaga, 2014). The same thing was stated by Martono (2004) in Sitepu et al. (2017) in their analysis that increasing slope levels can increase the erosion rate. Because the high slope level causes runoff to occur faster than usual, resulting in reduced water entering the soil. Decreased infiltration capacity, increased surface runoff and runoff velocity, increased surface transport energy of the flow, and increased erosion are caused by topographical conditions with a low level of conservation (Dewi et al., 2012).

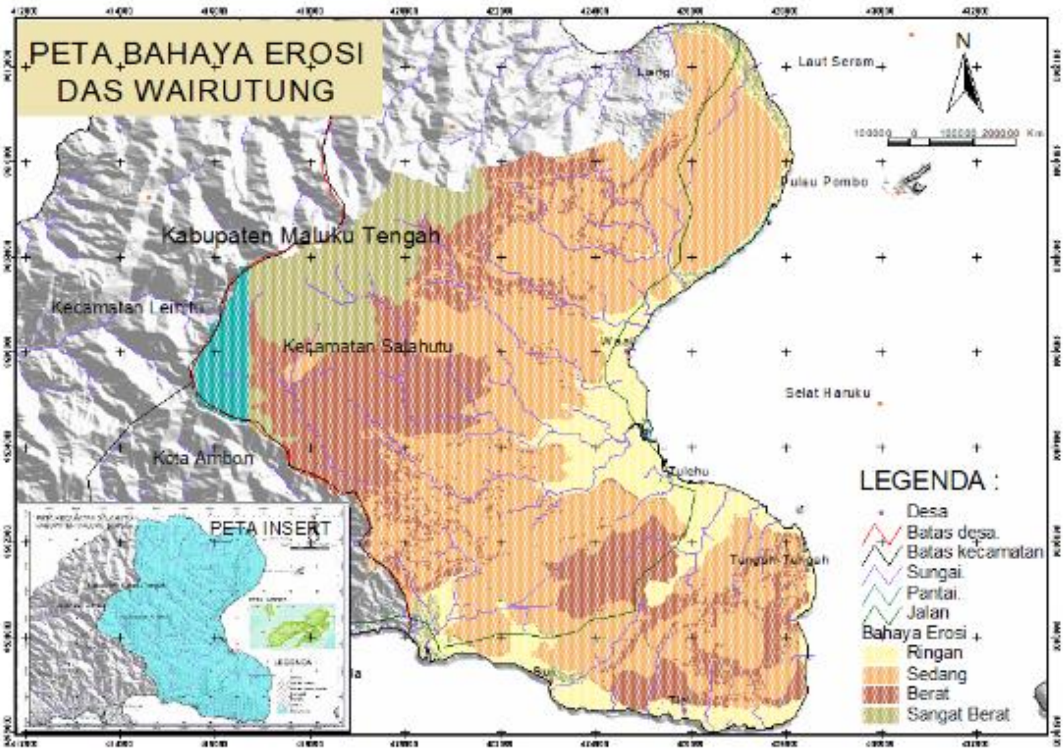

Figure 3. Erosion Hazard Map of the Wairutung Watershed

According to research by Labrière et al. (2015), vegetation significantly impacts erosion by preventing rainfall from falling directly onto the soil surface, reducing the force required to erode the soil. Canopy height and crown density, which affect raindrops falling on the ground surface, must also be considered when assessing how vegetation affects land cover. Plant roots also significantly contribute to aggregate stabilization and expansion of soil porosity. In addition, Prayitno et al. (2015) noted that using open land and garden land together significantly impacts accelerating soil erosion.

Erosion rates can be significantly reduced by vegetation. While the roots and stems of vegetation can help bind soil and water to slow erosion, the vegetation canopy is very effective at limiting rain's destructive power (Dinh et al., 2021). The vegetation cover factor (C), according to Efthimiou et al. (2017), slightly changes the vegetation factor by increasing the ability of plants to cover and protect the soil from erosion due to rainfall impacts. According to (Životić et al., 2012), vegetation is one of the factors that can change the amount of erosion in a location. Due to the vegetation's role in obstructing the intercept process and the soil's part in protecting against undergrowth and debris.

Djoukbala et al. (2019) argued that vegetation protects the soil and is in direct contact with rainfall, which can dissolve soil aggregates and cause compaction. The surface runoff will rise due to the breakdown of soil particles, which will clog macro soil pores and prevent groundwater infiltration. Plants can intercept raindrops, absorbing their kinetic energy so they do not directly impact the soil. According to Fiener et al. (2020), crown height and continuity, land cover density, and root density affect plant erosion resistance. The amount of water stored on the crown stems and vegetation branches are called intercept capacity. The amount is determined by the vegetation's density, shape, and texture, according to Eisenberg & Muvundja (2020). In addition, if the plant canopy growth is at most 30%, the runoff is still relatively large. Crops must be well protected from surface runoff of at least 70% (Kumarasinghe, 2021)

D. CONCLUSION

An erosion and erosion risk analysis has been carried out for each area in the study location. The primary input is erosion, which consists of slope length and slope (L.S.), crop management and conservation measures, soil erodibility, and rainfall erosivity (R, K, CP, and K). The raster tool calculator is also used to determine the degree of erosion. With an available land unit of 2,900,865 hectares with alluvial soil types, the study findings show that the average erosion rate at the study site is meagre. For the medium type with a total area of 3683,285 ha and all spread over land units with podzolic soil types, the heavy type with a total area of 1458,367 ha and all spread over land units with podzolic and litosol soil types. The erosion hazard level is very severe, with a total area of 421.97 ha spread over land units with podzolic and litosol soil.

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