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Spatial Spatial Analysis of Erosion Danger Level at Rambut Watershed Area Tegal District

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Abstrack

Erosion is a series of sedimentation processes associated with weathering, releasing, transporting, and settling grains of earth or earth's crust. As a watershed, watersheds are very vulnerable to erosion and sedimentation problems. This research was aimed to predict the erosion danger level at Rambut Watershed Area based on the Universal Soil Loss Equation Formula, by applying a Geographical Information System analysis. Based on the formula, we used four types of maps, i.e. rainfall, soil, slope, and land cover map. On each map, classification was done to get four to five classes based on a specific factor standard. To get the final result from the erosion danger levels which is categorized into five classes, they are very light, light, moderate, heavy, and very heavy, it is necessary to overlay the four types of maps. The results showed that the erosion danger levels at Rambut watershed area ranged from very light to very heavy, with the percentages of the affected areas are 46.91%; 35.13%; 12.47%; 3.67%; and 1.82% respectively. The very heavy and heavy danger areas covered 356.02 ha. And 717.99 ha. respectively. The results are used as a database to make a good planning watershed area management.

Keywords: Erosion, GIS, overlay, USLE, watershed management, weathering

Introduction

A The Rambut watershed is geographically located at 109°06'08"- 106°18' 55" East and 7°13'50"- 6°52'15" South, covering the administrative area of Tegal Regency with an area of 13,036.62 ha (66.60%) and Pemalang District 6,538.43 (33.40%). The total area of the Rambut Watershed ± 19,575.04 ha. has the Rambut River as the main river with a length of ± 79 km. Rambut River is the main river where small to medium rivers flow, such as the Ciawitali River, Tajem River, Ayer River, Pujang River, Dagul River, Handi River, Canei River, and Jambu River which stretches from the upper reaches of the river that comes from the foot of the mountain slope. Mount Slamet in the south flows north.

Rambut River is a dynamic river with a high level of erosion, both in the form of horizontal erosion and vertical erosion. Repeated erosion and sedimentation processes along the river channel cause the river channel to winding. Erosion is the removal of a layer of soil or sediment due to pressure caused by the movement of wind or water on the surface of the soil or the bottom of the water (Poerbandono et al., 2006). External factors that cause erosion are rainfall and water flow on the slopes of the watershed. High rainfall and sloping watershed slopes are the main factors that generate erosion.

The Erosion Danger Levels (TBE) is an estimate of the maximum amount of land loss that will occur on land, if crop management and soil conservation measures do not change.

Quantitative erosion danger levels analysis can use the formula formulated by Wischmeier and Smith (1978) in the form of the Universal Soil Loss Equation (USLE).

The purpose of this research is to identify The Erosion Danger Levels of Erosion in the Rambut watershed based on the USLE formula. And calculate the area of area with a high level of erosion hazard in the Rambut Watershed. The results of this study are expected to be used as a basis for making better watershed management plans.

Material and Methods

Research sites

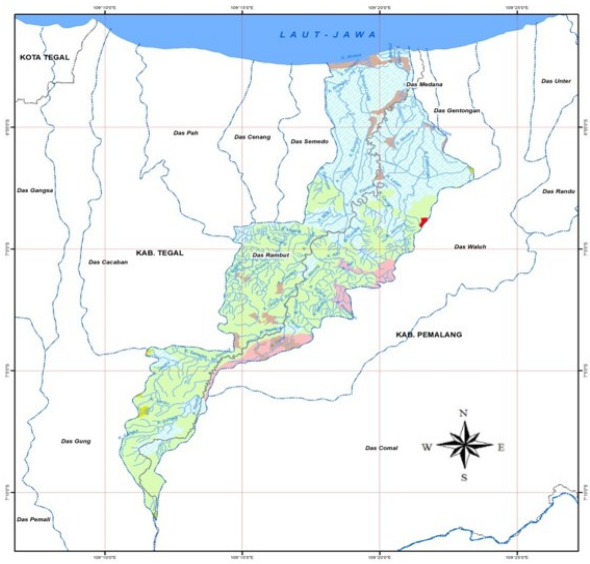

Figure 1. Map of Watershed area Rambut in Tegal District and Pemalang District.

Table 1. The extent of the watershed around the Rambut Watershed

Watershed	Large (ha)
Cacaban	17.083
Gung	18.691
Pah	3.501
Cenang	4.627
Brungut	3.207
Rambut	19.575
Gangsa	5.023
Pemali	135.065
Comal	64.039
Waluh	25.971
Srengseng	5.333
Medana	1.698
Total	303.813

Spatial analysis of TBE was carried out in the Rambut watershed, Tegal Regency and Pemalang Regency. The map of the Rambut watershed area included in Tegal Regency and Pemalang Regency can be seen in Figure 1, while Table 1 presents data on the area of each watershed around the Rambut Watershed located in Tegal Regency and Pemalang Regency.

Materials and Tools

The materials used in this study are administrative, watershed areas, rainfall, soil type, slope, and land cover maps. The analysis process uses analysis tools with *Geographic Information System* (GIS) software 3.2.

Method

The Erosion Danger Levels analysis using the USLE formula from Wischmeier and Smith (1978). The USLE formulation is as follows:

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

where:

A = Soil erosion rate (ton/ha/th)
R = Rain erosivity index
K = Soil erodibility index
L = Slope length index
S = Slope index
C = Vegetation cover index
P = Land management index and soil conservation measures

Based on the formula used, four types of maps are needed as the basis for calculating TBE, namely rainfall maps, soil type maps, slope, and land cover maps. The relationship between map types and the factors used in calculating soil erosion rates is presented in Table 2.

The process of calculating the index value of each map data is carried out with various formulations, namely:

1. Erosivity index (R). Rain erosivity index can be obtained by calculating the amount of rain kinetic energy (Ek) caused by the maximum rainfall intensity for 30 minutes (EI30). Rain erosivity factor can be calculated using the Asdak equation (2010), namely: R = 2.21 P 1.36 where R = erosivity of rain and P = monthly rainfall (cm).
2. Erodibility index (K). The soil erodibility index shows the level of soil susceptibility to erosion, namely the retention of particles to erosion and soil displacement by the kinetic energy of rainwater. A very fine soil texture will be more easily washed away compared to rough soil texture. High organic matter content will cause high erodibility value.
3. Length and slope index (LS). Slope factor and slope length (LS) consist of two com-

Table 2. The variables in the erosion danger level calculation

Erosion danger level factors	Symbols	Type of map
Erosivity index	R	Map of rainfall
Soil erodibility index	K	Soil map
Slope length-gradient index	LS	Map of slope classification
Crop vegetation and management index	CP	Land cover map

Table 3. The classification of erosion danger level

No.	Class of erosion danger level	Soil loss (ton/ha/th)	Remark
1.	I	< 15	Very ligth
2.	II	16-60	Ligth
3.	III	60-180	Moderate
4.	IV	180-480	Heavy
5.	V	> 480	Very heavy

ponents, namely, slope factor and slope length factor. The slope length factor is the horizontal distance from the upper surface that flows downward where the gradient of the slope decreases to the starting point or when runoff is focused on a particular channel (Renard et al., 1997).

4. Vegetation cover and land management index (CP). Land cover factors describe the impact of agricultural activities and their management on the level of soil erosion (Renard et al., 1997).
5. The Erosion Danger Levels. The results of the calculation of the erosion rate using the USLE formula are then classified into 5 classes, which are very light, light, moderate, heavy, and very heavy. Table 3 shows the classification of TBE.

Data processing

To get the rate of soil erosion, then the processing of four types of maps is carried out as a basis for calculating TBE, i.e. rainfall, soil, slope, and land cover map. After the four types of maps have been processed, the next process is to overlay the entire map into one combined map that results in the distribution of areas based on the respective TBE values (Figure 2). The overlay process is carried out with a conventional model (Jaya, 2002).

Results and Discussion

The results of rainfall overlay maps, soil type maps, slope class maps, and land cover maps, obtained results of TBE distribution maps in the Rambut Watershed. From the map of erosion danger levels, it can be seen that the Rambut watershed area is mostly included in TBE 1 class or the erosion danger levels are very light. Land area data for each class the level of erosion danger levels are presented in the diagram in Figure 3 and Table 4.

Based on Figure 2 and Figure 3, it can be seen that the Rambut watershed has an area with heavy erosion danger level (180-480 tons/ha/year) of 3.67% and very heavy erosion danger level (> 480 tons/ha/year) of 1,82%. The overall area of each Rambut watershed area in each grade the level of erosion danger is presented in Table 4. To find out the distribution of areas with heavy and very heavy erosion levels in each sub-district, an overlay map of the results of the TBE analysis was carried out with the map of the sub-district boundary as shown in Table 5.

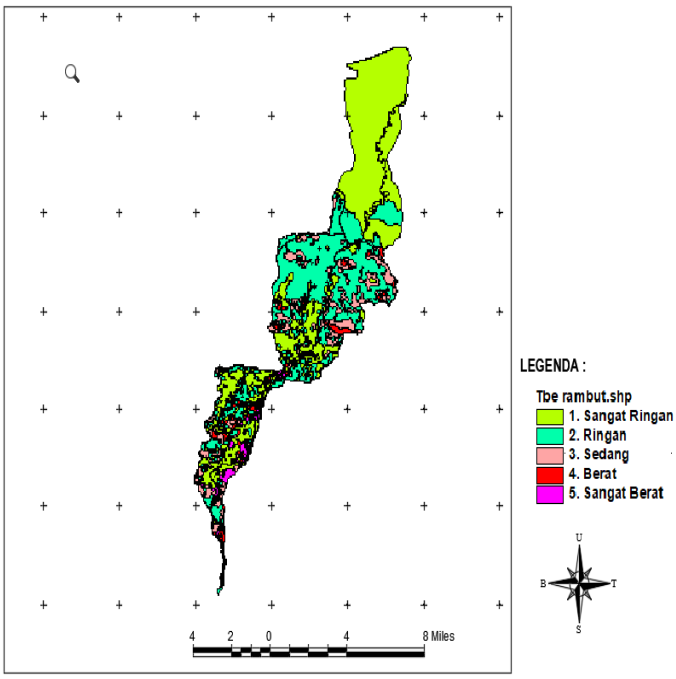

Figure 2. Map of Watershed area Rambut in Tegal District and Pemalang District.

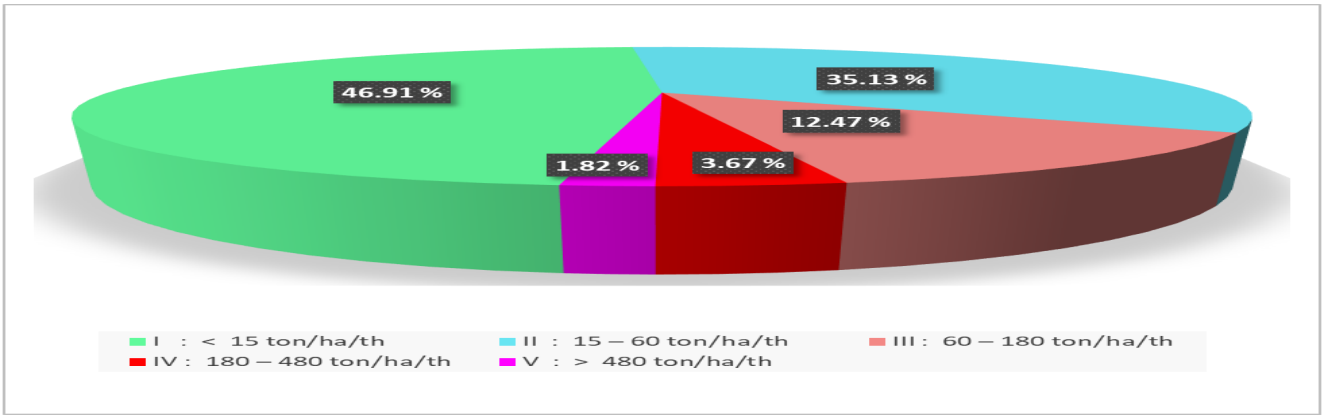

Figure 3. Area of watershed for each erosion danger level.

Table 4. Area of each class the erosion danger levels

Erosion danger level	Areas (Ha)	Percentage (%)
I : < 15 ton/ha/th	9.183,19	46,91
II : 15 – 60 ton/ha/th	6.875,94	35,13
III : 60 – 180 ton/ha/th	2.441,89	12,47
IV : 180 – 480 ton/ha/th	717,99	3,67
V : > 480 ton/ha/th	356,02	1,82
Amount	19.575,04	100,00

Table 5. The Erosion Danger Levels (TBE) for each district in the Rambut watershed

No.	District	Land Area of Each TBE Class					Amount (ha)	% Area
		1	2	3	4	5		
		< 15	15-60	60-180	180-480	> 480		
1.	Warureja*)	4.555,22	370	-	-	-	4.925,22	25,16
2.	Kedungbanteng*)	32,39	302,02	45,77	1,56	-	381,74	1,95
3.	Pemalang**)	1.224,69	453,13	33,37	24,59	-	1.735,77	8,87
4.	Randudongkal**)	263,34	1.823,96	1.031,37	163,10	-	3.281,77	16,77
5.	Bantarbolang**)	-	-	3,22	-	-	3,22	0,02
6.	Jatinegara*)	1.841,92	2.976,29	718,82	266,34	58,62	5.861,98	29,95
7.	Warungpring**)	379,29	367,86	59,57	35,68	30,23	872,63	4,46
8.	Bojong*)	710,32	413,66	406,20	169,01	150,50	1.867,69	9,54
9.	Moga**)	173,77	26,33	58,55	22,87	102,38	383,89	1,96
10.	Pulosari**)	2,27	124,71	85,03	34,85	14,29	261,15	1,33
							19.575,04	100,00

where:
*) Tegal district
**) Pemalang district

Based on the TBE class 5, the districts identified as having land area with very heavy erosion danger levels are Bojong (150.50 ha), Moga (102.38 ha), Jatinegara (58.62 ha), Warungpring (30.23) ha), and Pulosari (14.29 ha). Whereas the sub-districts that have TBE 4 or heavy land are Jatinegara (266.34 ha), Bojong (169.01 ha), Randudongkal (163.10 ha), Warungpring (35.68 ha), Pulosari (34, 85 ha), Pemalang (24.59 ha), Moga (22.87 ha), and Kedungbanteng (1.56 ha). From the results of the

class mapping, the erosion danger levels in each district in the Rambut watershed in Table 5 can be shown that the subdistrict is classified as the most vulnerable because it has land with very heavy TBE classes, especially Bojong and Moga.

Conclusion

The erosion danger levels (TBE) in the Rambut watershed area include TBE 1 (<15 tons/ha/yr) up to TBE 5 (> 480 tons/ha/yr) with a successive area percentage of 46.91%; 35.13%; 12.47%; 3.67%; and 1.82%. Land that is included in the level of heavy erosion hazard (180-480 tons/ha/yr) is 717.99 ha and the level of very heavy erosion hazard (> 480 tons/ha/yr) is 356.02 ha.

The district that has the most extensive area of heavy erosion hazard is Jatinegara (266.34 ha). Meanwhile, the land with the most very heavy erosion hazard was found in Bojong District (150.50 ha). Some districts that are classified as erosion-prone areas because they have areas with heavy and very heavy erosion hazards which are quite large are Bojong, Moga, Jatinegara, Warungpring, and Pulosari.

Suggestion

In subdistricts that are identified as areas with heavy and very heavy erosion danger levels, erosion prevention measures need to be taken in the form of soil conservation measures and improved land management. In other subdistricts that are classified as relatively safe, it is also necessary to pay attention to soil treatment and conservation activities, so that The erosion danger levels does not become heavier.

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