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ASSESSMENT OF SPATIAL DISTRIBUTION OF LAND BASED ON ANALYSIS OF SLOPE AND WATER CONSERVATION PROGRAMS

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Abstract

Central Lematang is one of the Lematang sub-watersheds with a height of approximately 1,750 m above the average sea level located in Lahat Regency, South Sumatra Province. The difference in regional topography will affect the amount of rainfall to be distributed in the Central Lematang watershed. Mining activities around the area can also affect watersheds that cause runoff and erosivity to the process of spreading of sedimentation. On this basis, how the pattern and distribution of spatial sedimentation in the Central Lematang sub-watershed area occur due to the influence of rainfall intensity in the area.
From the results of rainfall analysis, obtained an equation for the distribution of rainfall intensity in the return period of 2 years, y = 24,470-0,011X with a correlation coefficient of 0.617. As for the equation of distribution of average annual rainfall, y = 3,069,493-0,743X with a correlation coefficient of 0.571. From the results of the analysis of the distribution of sedimentation in the Middle Lematang River Basin, it can be seen that the spread of sediment deposited in the Lematang 1, Lematang 4, Lematang 8 and Lematang 10 sub-watersheds is caused by rainfall intensity which is then flowed by soil types with a lot of clay texture and the presence of plantation and forest land. so that sediment in the area is carried away because of the slope so that it is retained in irrigated or irrigated land.

Kewords : *Erosion, spatial, sedimentation, rainfall intensity*

1. Introduction

Rainfall in an area has varying intensities in each region. The influence of topography on highland areas such as mountains or hills or lowlands such as rivers and seas will affect the amount of rainfall that varies. The distribution of rainfall is one of the factors that will affect the amount of erosivity and sedimentation of an area. Together with data on land use, slope and slope length, and soil type, rainfall intensity will affect the amount of spatial distribution due to erosivity and sedimentation in an area. The amount of erosivity and sedimentation in an area can be calculated using various approaches, one of which is the calculation using the Morgan, Morgan and Finney (MMF) method. In calculating the amount of erosivity and sedimentation based on the MMF method, the rainfall factor can be done using several approaches such as the Thiessen polygon method or using a distribution based on the height of the region. Thus, it can be predicted that the spatial representation of the distribution of erosivity and sedimentation will result in differences if the calculations are carried out using different methods.

This paper discusses ways to obtain quantitative estimates of soil erosion to better understand the relationship between the slopes and river systems that are the source of irrigation for agricultural activities. The focus is on the relationship between the sediment supply that flows into the river, and is analyzed using soil erosion modeling and sediment transport that is implemented using GIS (Geographic Information Systems). By analyzing the degree of slope erosion, and predicting the sediment supply pattern to the river, the model can predict parts of the landscape that indicate larger amounts of sediment contribute to the channel network and in which areas, a large number of such sediments will tend to be deposited on the channel. This prediction was tested by taking a fine sediment sampling of the river bed at selected sites along the channel network and comparing the observed patterns with those predicted using soil erosion models. Thus, the model is focused on the interaction between topography, soil and land use in influencing the potential of soil erosion and how the spatial distribution of these factors causes variations in the distribution of erosion and deposition in the watershed.

2. Material and Methods

The Study Areas was conducted on the territory of Central Lematang sub watershed, which is part of the watershed Lematang, and part of the Regional Unit of the Musi River Basin. In administration, location of the region lies in district of West Merapi, Lahat, South Sumatra Province. Geographically, the study area located at coordinates 103° 29 '27.24 "- 103° 43' 55.03" E and between 3° 56 '23.64 "- 3° 42' 9.47" S.

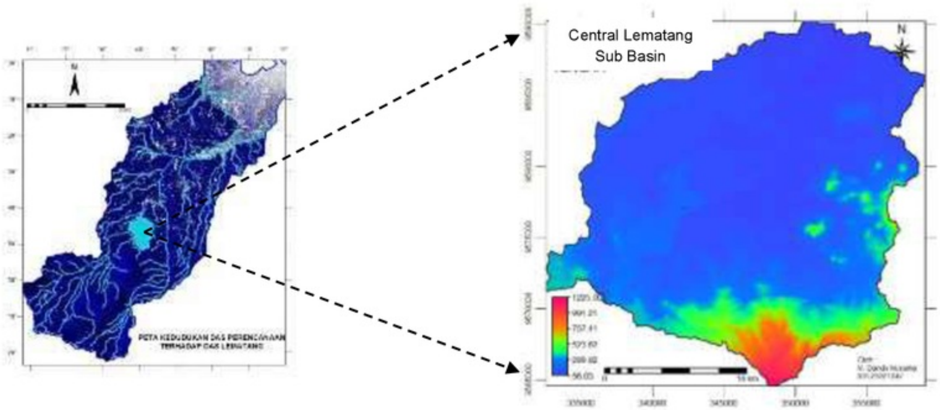


Figure 1. Location of Research area

Lematang Tengah is an area with an altitude of approximately 1.750 m above the average sea level located in Lahat Regency, South Sumatra Province. The difference in the topography of the area will affect the amount of rainfall to be distributed in the Lematang Tengah watershed. The existence of mining activities around the area can also affect watersheds that cause runoff and erosivity until the process of spreading of sedimentation

Model Formulation. The basis for the development of models of soil erosion that is used in the research area is model MMF (Morgan, Morgan, dan Finney) separating the soil erosion process into two phases: the water phase and the sediment phase, as in the equation in making a raster map.

SOILLOSS=MIN(G,F) (1)

This model compares the predicted level of soil particle sparking (F) and surface flow carrying capacity (G), with the minimum value taken as the rate of erosion (soil loss) in units of kg / m2 / year or tons / ha / year. Calculation of quantitative erosion using the MMF method (Morgan, Morgan, and Finney, 1984) applies to short-term planning, so it is necessary to show exact numbers

The model has proven to be sensitive to changes in annual rainfall and soil types. So good information in the context of rainfall and land is needed for predictions (Morgan, Morgan and Finney 1984)

$$F = K(E.\exp(-0.05.INT)).1,0.10^{-3} \quad (2)$$

Where :
F = average release of soil particles (kg / m2), K = soil erodibility index, and
INT = Percentage of rainwater interception by plants.

Surface flow carrying capacity (G) depends on surface flow volume (Q), land cover, management factor (C), which is a combination of C and P values in the USLE equation, and topographic slope factor (S) which can be calculated using the following equation:

$$G = C.Q^{2}.\mathrm{Sin}\ (S.10^{3}) \qquad (3)$$

The large volume of sediment depends mainly on changes in flow velocity, due to changes in the rainy and dry seasons, and changes in velocity that are affected by human activity. (Kusnan in Pangestu, 2013)

Erosion is three sequential processes, namely detachment, transportation, and deposition of soil materials caused by erosion (Asdak, 1995). The main factors of soil erosion that remove soil particles due to rain water are two main processes, namely the release caused by rain falling on the ground and runoff. This erosion is also exacerbated by pressures on land, especially agriculture (Boardman, 2001 in Fahliza, U., et al, 2013).

The surface flow value (Q) relates to the water storage capacity (Ms) of surface soil which can be derived from a broad capacity. It also depends on bulk density (Bd). It also depends on the root depth (Rd) of various land covers, the actual ratio to the potential for evapotranspiration (Et / Eo), the amount of annual rainfall (R) and the number of rainy days (Rn). This is explained by following the equation:

$$Q = Re\ (-Rc / Ro)\ (mm) \qquad (4)$$

Where,

$$Rc = 1000.Rd.Ms.Bd.\ (ETa / ETo)\ .0.5\ (mm) \qquad (5)$$

Where,

R	= Average annual rainfall (mm).
Rd	= root zone depth (m).
Rc	= Storing capacity of soil moisture in the state of actual vegetation (mm)
Ms	= Moisture capacity (w / w).
Bd	= Bulk density of topsoil (g / cm3).
ETa / ETo	= ratio of actual potential evapotranspiration.

$$Ro = R / Rn\ (mm) \qquad (6)$$

Where,
Rn = Number of rainy days

Model Implementation. Elevation, soil, land cover, and hydrographic data for the central Lematang sub basin were acquired from a number of sources. These spatial data were used to derive the parameters needed for the soil loss equation, on which the entire modeling approach was based. The soil loss equation parameters have been derived as follows :

Erosivity factor (R) - The erosivity index is related to rain kinetic energy (E) relative to the mean annual depth of rainfall (R), and the intensity of rainfall and soil type for the study area. The largest R Value in central Lematang sub Basin was 27,003 kg /m2. While the value of the smallest level of R release is 0.559 kg / m2

Erodibility factor (K) - Most of the soil types in the sub area of central Lematang sub Basin are derived from Andosol, Alluvial, Regosol, Podsolic and Latosol species with wave surface shape up to hilly was obtained from the Agriculture Department South Sumatera Province, in both tabular and spatial formats.

Topographic index ($A^m sin^n$ b) – The topographic index was calculated using the 10 m Digital Elevation Model (DEM, TM+8) obtained from the Balai DAS Musi Seamless Data Distribution database. The use of 10 m DEM has been documented by Putranto, *et al*. (2000) to be the most reliable elevation data when higher resolution data is unavailable because it allows for lower levels of systematic errors and artifacts of analysis compared to the lower resolution DEMs that are available (10 m resolution DEM was also tested). Contributing area per contour width (A) was obtained through the D-Infinity flow algorithm available in TAS (Terrain Analysis System, Creed et al., 1996 and Creed et al., 2003).

Land cover and management factor (C) – The distribution of C factor values was based on Balai DAS Musi (2012) land cover map for the entire South Sumatera Area obtained from the TM+8 Satelite Image. The data were reclassified based on values for the C factor determined by Wischmeier and Smith (1978) and Renard *et al*. (1996). Each type of Balai DAS Musi present in the central Lematang basin was assigned a C value based on the degree of protection offered by various canopy covers. Since the lowest degree of soil protection is provided by mined and barren lands, and croplands, these land uses get assigned the highest C values, in accordance with literature. Pastures and areas covered by shrubby vegetation, depending on the degree of coverage, are assigned C values lower than 0.1, whereas forested areas, which provide the highest degree of protection, are assigned the lowest C values (lower than 0.01).

Support practice factor (P) – The P factor was held constant (equal to 1) in the analysis due to the lack of reliable data sources necessary to document the various conservation practices applied in the basin through Balai DAS Musi. Thus, the resulting analysis does not account for differences in erosion and soil loss due to differing cropping and land use practices

3. Results and Discussion

Analysis of Sediment Transport and deposition. The decrease in rainfall that occurs on land cover affects an runoff resulting in the carrying of sediment that flows due to the level of soil release in watersheds to cause erosivity in the central Lematang watershed. The level of soil release that causes erosivity can be analyzed using equation 2. The following map is the result of the calculation of the level of soil release in the central Lematang watershed.

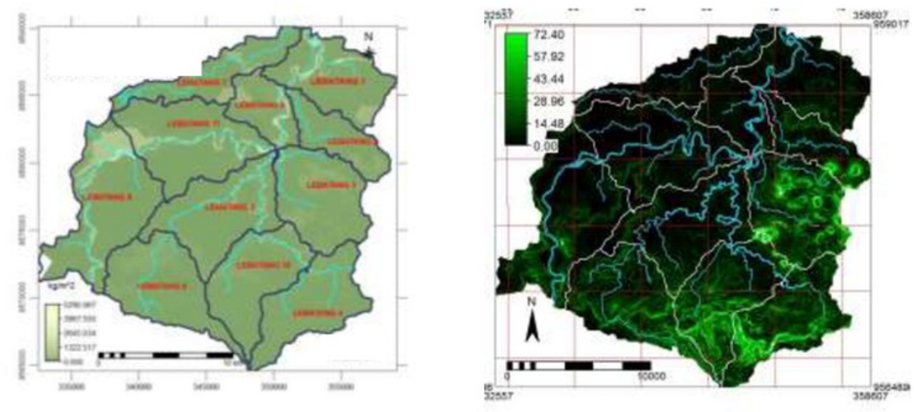
From the map at Fig.2, it can be seen that the value of the highest level of soil release in the central Lematang watershed is 7.579 kg / m2. While the value of the smallest level of soil release in the central Lematang watershed is 4,531 kg / m2. Following is the average value of soil release level for each of the Central Lematang sub-watersheds tabulated in table 1.

Table 1. Value of Sediment Transport each sub watershed

Name of Sub Basin	Square (Km2)	Sediment Transport (Kg/m2)	Average of Soil release (Kg/m2)
Sub Basin 1	38,083	9.137	5.669
Sub Basin 2	22.414	23.656	7.149
Sub Basin 3	42.286	13.933	4.865
Sub Basin 4	39.489	21.930	7.579
Sub Basin 5	47.738	6.967	4.531
Sub Basin 6	44.231	22.355	6.953
Sub Basin 7	29.757	18.926	5.141
Sub Basin 8	59.140	35.184	6.349
Sub Basin 9	20.140	11.517	6.712
Sub Basin 10	41.330	12.101	6.106
Sub Basin 11	52.662	16.522	6.616

Based on the above analysis found that the sub-basins 8 has a high degree of transport sediment of 35.184 Kg/m2. While the sub-basin 5 is a region of sediment transport minimum of

6.967 Kg/m2. If the spread of sedimentation analyzed based on various factors such as land use and land slope, the results can be seen on the following figure.



(a) (b)

Figure 2. Central Lematang watershed sediment transport rate with (a) and soil release rate resulting from various combinations of factors in the MMF method (b).

From the table above it can be seen that the highest average soil release rate is 7,579 kg / m2 located on Sub Basin 4. While the smallest value of soil release rate is 4.531 kg / m2 located on sub Basin 5. The runoff value and effect of land cover and slope which have been analyzed previously, the surface flow carrying capacity occurring in the central Lematang watershed can be analyzed using equation 3. The results of the analysis of surface flow carrying capacity produce a map of sediment transport in the central Lematang watershed as shown in Figure 2 (a)

The results of the analysis of the level of soil release and surface flow carrying capacity are then analyzed so that they can predict soil loss to predict the spread of sedimentation in the Middle Lematang River Basin. The minimum value of the second raster map analysis results the level of soil release and surface flow carrying capacity is processed using equation 3. The following is a map of the results of soil loss analysis in the central Lematang watershed.

Table 2. Average soil loss value for each Central Lematang watershed

Land Use	Area (Km2)	Average Value of ED (Kg/m2/year)
Sub Basin 1	38,083	2.868
Sub Basin 2	22.414	4.116
Sub Basin 3	42.286	3.047
Sub Basin 4	39.489	5.968
Sub Basin 5	47.738	1.642
Sub Basin 6	44.231	3.844
Sub Basin 7	29.757	3.673
Sub Basin 8	59.140	5.454
Sub Basin 9	20.140	5.550
Sub Basin 10	41.330	2.333
Sub Basin 11	52.662	4.914

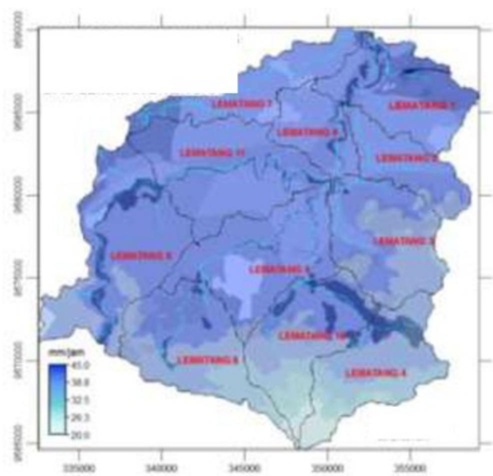


FIGURE 3. Map of Results of Analysis of Soil Loss in Central Lematang sub watershet

From the map above it can be seen that the most sedimentation is distributed in the sub Basin 4, sub Basin 10 and Lematang sub-watersheds. The greatest loss value in the Middle Lematang watershed is 27,003 kg / m2 / year, which is located in the sub Basin 1. Whereas the average value average soil loss in the central Lematang watershed is 7.198 kg / m2 / year. The results of the analysis are then divided into each sub-basin. Table. 2. is the recap of the results of the calculation of the value of soil loss for each of the Central Lematang sub-watersheds,

The distribution of sedimentation is then linked based on various types of soil and the parameters of the average soil loss value and the shape of the slope. The following is a map of sedimentation analysis of the soil types of the central Lematang Watershed, which can be seen in Figure 4 (a). From the picture, in the Alluvial Podsolik Brown and Litosol areas, there are many places with sloping slopes. Podsolic Alluvial Brown and Litosol types with an area of around 14,390 Ha have a clay loam texture so that it is possible to spread a lot of sediment on the soil. In addition to the type of soil, land use is also very influential on the spread of sedimentation which is then linked to the parameters of the average soil loss value and the shape of the slope. At the figure 4 (b), sedimentation analysis of the central Lematang watershed with land use. From the map, can be seen that from the form of slope and land use, the average value of sedimentation deposits is mostly located on plantation and forest land. Seen in the steeper slope which results in erosion of the surface land. As a result of the erosion of plantation and forest land, sediment deposition can occur until carried away by irrigation or irrigation land due to locations close to steep slopes

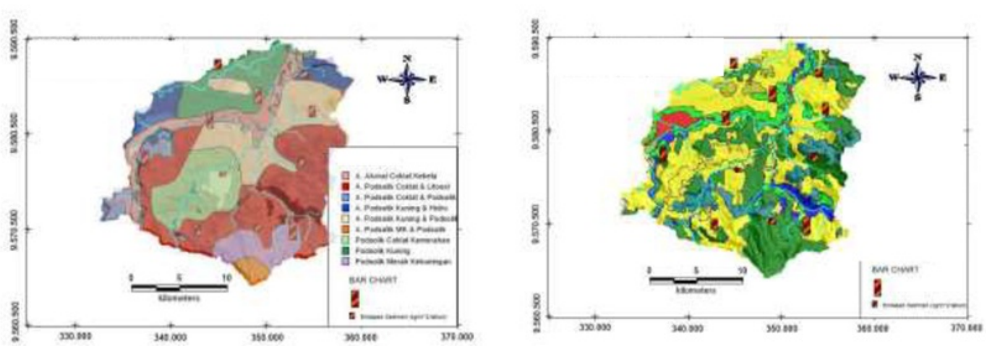


Figure 4. Central Lematang watershed sediment transport rate with (a) the type of soil and (b) sedimentation analysis of land use

4. Conclusions and Suggestion

Based on the results of the research and discussion above, it can be concluded several things as follows:

1) From the results of rainfall analysis, the equation for the distribution of rainfall intensity in the return period of 2 years is obtained, which is y = 24,470-0,011x with a correlation coefficient of 0.617. As for the distribution of the average annual rainfall distribution, y = 3,069,493-0,743x with a correlation coefficient of 0.571.
2) From the results of the analysis of the distribution of sedimentation in the Lematang Tengah Watershed, it can be seen that the spread of sediment deposited in the Lematang 1, Lematang 4, Lematang 8 and Lematang 10 sub-watersheds is caused by rainfall intensity which is then drained by soil types with a lot of clay texture and the presence of plantation land. and forests so that sediment in the area is carried away because of the slope so that it is retained on irrigation or irrigation.

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