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Choosing Different Contour Interval on a Fully Raster-Based Erosion Modeling: Case Study at Merawu Watershed, Banjarnegara, Central Java

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ABSTRACT

The research was aimed to study the efect of choosing different contour interval to produce Digital Elevation Model on a fully raster-based erosion modeling of The Universal Soil Loss Equation using remote sensing data and a geographical information system technique. Methods were applied by analyzing all factors that affecting erosion in GIS environment such data were in the form of raster. Those data were R , K, LS, C and P factors. LS factor was derived from Digital Elevation Model by taking flow direction from each pixel into consideration. Research used 3 contour intervals to produce Digital Elevation Model, *i.e.* 12.5, 25 and 50 meter. C factor was derived from the formula after applying linearly regression analysis between Normalized Difference Vegetation index of remote sensing data and C factor measured directly on the field. Another analysis was the creation of map of Bulk Density used to convert erosion unit as from Mg $ha^{-1}mo^{-1}$ to mm mo^{-1}. To know the model accuracy, validation of the model was done by applying statistical analysis and by comparing the result of erosion model (E_{model}) with actual erosion (E_{actual}) which was measured regularly in Merawu watershed. A threshold value of $\geq$ 0.80 or $\geq$ 80% was chosen to justify whether the model was accurate or not. The results showed that all E_{model} using 3 countour intervals have correlation value of > 0.8. These results were strenghtened with the result of analysis of variance which showing there were no difference between E_{model} and E_{actual}. Among the 3 models, only E_{model} using 50 meter countour interval reached the accuracy of 81.13% while the other only had 50.87% (using countour interval 25 meter) and 32.92% (using countour interval 12.5 meter).

Keywords: Erosion modeling, fully raster-based, GIS, Landsat 7 ETM+

INTRODUCTION

Degraded land is one of the environmental problems that must be overcome (Sulistyo 2011). Indication the occurrence of degraded land can be shown by investigating the watershed condition. In Indonesia, the number of critical (*highly eroded*) watershed is increasing. In 1984 there are 22 watersheds in critical condition and increase to 29 in 1992; 39 in 1994; 42 in 1998; 58 in 2000; 60 in 2002; 65 in 2004 and 72 in 2007 (Kartodihardjo 2008). Planning to conserve degraded land requires good and accurate data, one of them is the availability of erosion map.

Generally, erosion data is predicted using a model because to gain actual erosion requires much resources (timely, costly and labour intensive). USLE is one of the existing erosion model applied worlwide, including Indonesia (Sulistyo 2011). Nevertheless, so far erosion analysis conducted is based on analysis using vector-based maps. This method involves simplification, either algorithms or procedures, and subject to subjectivity, so the result has high uncertainty (Eweg *et al.* 1998). For example, slope data when used to compute erosion was *margin error* of ± 70% (for *slope* < 9%) and ± 25% (for *slope* > 9%), while rainfall data was ± 52%.

With the the technological advance in Remote Sensing (RS) and Geographical Information System (GIS) these uncertainties can be minimized, that is by applying a fully raster-based erosion modeling (Sulistyo 2011). This is in a line with Fistikoglu and Harmancioglu (2002) who state that erosion modeling which is estimated using USLE will be more *reliable* when the analysis is conducted using small raster-based data because initially USLE is developed at small areas. Raster-based erosion modeling can be conducted objectively, using established algorithms and mathematical formulae, and no simplification is needed (Hadmoko 2007). Slope data can be analyzed more accurately and more faster by utilizing *Digital Elevation Model* (DEM) in a GIS environment, while C factor can be derived through the analysis of vegetation index of remote sensing data (Sulistyo 2011).

USLE is applied worldwide because this model is easily managed, relatively simple and the number of required parameters is relatively less as compared to other more complex erosion modeling (Sulistyo 2011). In Indonesia, its usage has been started since 1972 by Soil Research Agency in Bogor, meanwhile Ministry of Forestry also applies USLE to assess degraded land and has been adopted nationalwide (Indonesian Ministry of Forestry 2009). Morgan and Nearing has proven that USLE has higher accuracy compared to RUSLE (*Revised USLE*) and the more complex model of WEPP (*Water Erosion Prediction Project*) (Wainwright and Mulligan 2002). USLE erosion model is predicted using equation as follows (Wischmeier and Smith 1978):

$$A = R\,K\,L\,S\,C\,P \qquad [1]$$

where:

A = mean annual soil erosion rate (Mg ha^{-1} y^{-1})

R = rainfall erosivity factor (R factor) (MJ mm ha^{-1} h^{-1} yr^{-1})

K = soil erodibility factor (K factor) (Mg ha^{-1} MJ^{-1} mm^{-1})

LS = slope length and steepness factor (LS factor) (dimensionless)

C = cover and management factor (C factor) (dimensionless)

P = support practice factor (P factor) (dimensionless)

A fully raster-based erosion modeling is an erosion modeling using data input that are all in raster format, not in raster format as a result of *Vector to Raster Conversion* algorithm (Sulistyo, 2011). From 5 parameters, LS, C and P are factors that can be directly as data input using raster format, while R and K factors can have raster format through spatial interpolation available in almost all GIS software. Spatial interpolation is the process of using points with known values to estimate values at other points (Chang 2008).

The research was aimed to study the efect of choosing different contour interval to produce DEM (CI = 12.5 meter, CI = 25 meter and CI = 50 meter) on a fully raster-based erosion modeling (The case in Merawu watershed, Banjarnegara, Central Java).

MATERIALS AND METHODS

Data, hardware, software, research area and methods were almost similar to those research done by Sulistyo (2011). The difference was that the previous research focused on the efect of rain erosivity generated from different formulae on a raster-based erosion modeling, while this research focused on the efect of choosing different contour interval on a fully raster-based erosion modeling.

Data required for fully raster-based erosion modeling were: topographical map, landform map, monthly data/report on sediment yield in watershed outlet during 24 months (June 2004 to May 2006), remotely-sensed data of Landsat 7 ETM^+ recorded on 21 May 2003 and on 20 June 2006, rainfall data during 24 months (June 2004 to May 2006) recorded in Merawu watershed and surroundings, other data and reports which support the activity. To analyze and handle these data various GIS software were used: ILWIS (*Integrated Land and Water Information System*) version 3.4, Arc/Info version 3.5, Arc/View version 3.5. Meanwhile, some hardwares were also required consisting of drafting tablet, equipments used for field work such as: binoculars, compass, hagameter, soil munsell color, tape, ring sample, auger, *Global Positioning System* (GPS), and digital camera.

Research area was located in Merawu watershed lies between 109°41’24" – 109°50’24" E and 7°10’12" – 7°22’12" S and administratively located in Banjarnegara district, Central Java Province. Merawu watershed covers ± 22.734 hectares with 3 main rivers flowing through the area from north to south that are: Merawu, Urang and Penaraban rivers. Among the watersheds in the area, Merawu watershed resulted the most of sediment yield to Sudirman Reservoir (11 mm yr^{-1}) (PT. Indonesia Power 2009). Sudirman Reservoir is one source for electrical power in Central Java (Figure 1).

Methods were applied by analysing factors affecting erosion in GIS environment using fully raster-based format. The pixel size for the study was 30 m by 30 m to account for the spatial resolution of Landsat 7 ETM^+ which was 30 m by 30 m.

Diagrametrically, a fully raster-based erosion modeling is presented in Figure 2.

Monthly rainfall data which recorded between June 2004 and May 2006 (from 8 rainfall stations located within and surrounding of Merawu watershed) was computed to get R factor based on

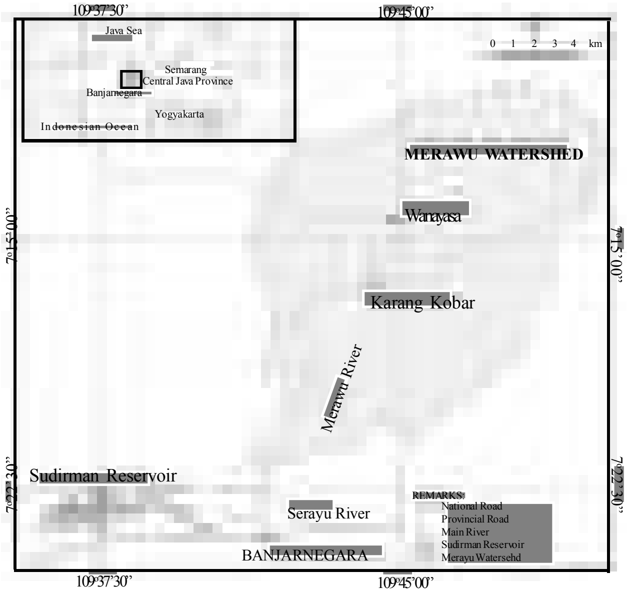


Figure 1. Location of the study.

formula developed by Abdurachman (2008) as follow:

$$R_m = (Q^{2.263} * Pm^{0.678})/(40.056*D^{0.349}) \quad [2]$$

where:

R_m = monthly average of rain erosivity index (EI_{30})
Q = monthly average of rainfall (cm mo^{-1})
Pm = maximum daily rainfall average (cm)
D = monthly average of the number of rainfall days

The result of R factor then was plotted on a map for each station according to its position, digitised, transformed and spatially interpolated using *Moving Average* technique to gain map of R factor of the study area.

Soil erodibility factor (K factor) was determined using formula as follow:

$$K = \{2.17 \times 10^{-4} \text{ x } (12\text{-OM}) \times M^{1.14} + 4.20 \times (s\text{-}2) + 3.23 \times (p\text{-}3)\}/100 \quad [3]$$

where K is soil erodibility (Mg ha^{-1} hr^{-1} (ha MJ^{-1} mm^{-1})), OM is percentage of organic matter, **s** is soil structure class, p is soil permeability class, and M is {(% silt + % very fine sand) × (100 - % clay)}.

Thirty soil samples, distributed evenly according to the landform, were taken in the field. The result of K computation for each sample then was plotted according to its position, digitised, transformed and spatially interpolated using *Kriging* technique to gain map of K factor of the study area. To apply spatial interpolation using *Kriging* technique it needs information about *sill*, *nugget* and *range* values that can be obtained by executing *spatial correlation* analysis. Selecting different *sill*, *nugget* and *range* values will result different maps. The best *sill*, *nugget* and *range* values only can be gained after some *trial and error* by investigating every resulted map.

Slope is derived directly from DEM (Digital Elevation Model) from which also can be derived L factor by taking *flow direction* from each pixel into consideration. Slope distance for each pixel is equal to 30 meters long for *flow direction* directed to the South, West, North and East, and is equal to 42.43 meters long for *flow direction* directed to Southeast, Southwest, Northwest and Northeast.

Slope length and steepness factor (LS factor) for slope ≤ 20% is computed using the formula of Schwab *et al.* (1981 *cited by* Asdak 2007):

$$LS = \sqrt{\{(L_a) \times (1.38 + 0.965\, s + 0.138\, s^2)/100\}} \quad [4]$$

while for slope > 20% LS factor is computed using the formula of Goldman *et al.* (1986 *cited by* Asdak 2007):

$$LS = [(65{,}41 \times s^2) / (s^2 + 10.000) + (4{,}56 \times s) / (s^2 + 10.000)^{0,5} + 0{,}065]\,[(L_a/2{,}21)^m] \quad [5]$$

where L_a is actual slope length (in meters), s is slope (in %) and m is a constant value which is depended on the slope, those are m = 0.1 if s ≤1%; m = 0.3 if s > 1% and if s ≤ 3%; m = 0.4 if s > 3% and if s < 5%; and m = 0.5 if s ≥ 5%.

In this study, 3 contour intervals (12.5, 25 and 50 meter) were used prior to DEM analysis.

Cover and management factor (C factor) was derived from the regression analysis using equation of Siregar (2005) as follow:

$$Y = a + b\,X \quad [6]$$

where Y is C factor measured directly on the field, X is NDVI derived from Landsat 7 ETM^+ (recorded on 20 June 2006). This technique has ever been done by other researcher such as Lin *et al.* (2002) and Karaburun (2010).

The C factor was estimated in the field (C_f) using prior land use (PLU), canopy cover assessed for different cover types (CC), surface cover (SC), and Surface Roughness (SR) following the method explained for RUSLE (Renard *et al.* 1997 *cited by* Suriyaprasit 2008) as follow:

$$C_f = PLU\ CC\ SC\ SR \quad [7]$$

Vegetation index is a mathematical combination of satellite bands, which have been found to be sensitive indicator of the presence and condition of green vegetation. It is based on the reflectance properties of vegetation in comparison with water on the one hand and bare soil on the other hand. Vegetated areas have high reflectance in the near infrared and low reflectance in the visible red (Lillesand *et al.* 2004).

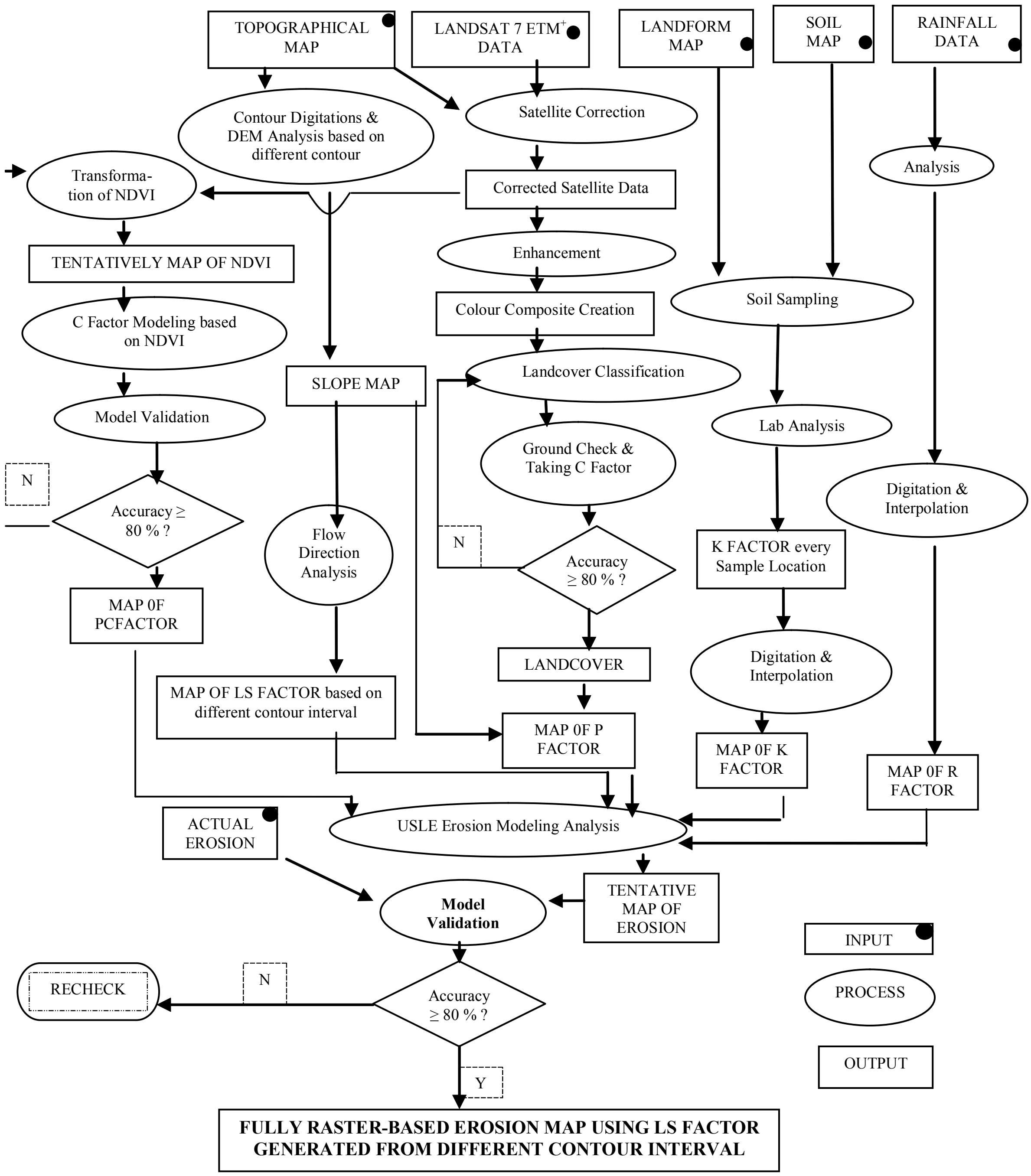


Figure 2. Diagram flow of the study

Normalized Difference Vegetation Index (NDVI) is formulated as follow:

$$NDVI = (NIR – R) / (NIR + R) \qquad [8]$$

where NIR and R indicate channel or band of Landsat 7 ETM$^+$ which are near infrared and visible red respectively.

The regression analysis resulted coefficient of correlation value. In this study, a threshold of the correlation coefficient value o (r) $\geq$ 0.80 was chosen as criteria for NDVI to be used further for final C factor.

Landcover change analysis was done using two satellite Landsat 7 ETM$^+$ (recorded on 20 June 2006 and 21 May 2003) to know the rate of changes to justify the correction factor used for computing monthly C factor for 24 months in a line with the months of rain erosivity.

Generally, for the shake of ease and practicality, support practice factor (P factor) is assigned value as 1 for the whole area under studied. In this research P factor is derived from the combination between slope data from Digital Elevation Model and landcover classification

Table 1. P factor value based on Abdurachman *et al.* (1995).

Landcover	P factor
Agricultural Area with Slope ≤ 8%	0.50
Agricultural Area with Slope between ≥ 8% and 20%	0.75
Agricultural Area with Slope ≥ 20%	0.90
Shrub, Secondary Forest and Forested Area	1.00

interpreted from Landsat 7 ETM+ using criteria developed by Abdurachman *et al.* (1985) as shown in Table 1.

Another analysis supporting the research activity was the creation of bulk density map which was generated through plotting bulk density data according to its position, digitised, transformed and spatially interpolated using *Kriging* technique. Map of bulk density was used to convert erosion unit as from a Mg ha^{-1} mo^{-1} to mm mo^{-1} (Arsyad 2000).

After whole data were analysed, then erosion can be calculated. The result of erosion using USLE is assumed only to gain *sheet* and *rill erosion*. In order to get total erosion in a watershed (*gross erosion*), other erosion such as *gully erosion* and *channel erosion* are determined according to the result of previous research done by Piest *et al.* and Seyhan (Santoso 2005) stated that *gully erosion* was one-fifth (1/5) of the total sediment occured, while *channel erosion* was about 10% of *sheet* and *rill erosion*.

Technically, estimated total soil loss (A) of Merawu watershed is the result of multiplication among USLE parameters previously described. Pixel value of map of erosion from USLE (A) is soil loss as a result of *rill erosion* and *sheet erosion* for the area of 30 m x 30 m, in Mg ha^{-1} mo^{-1}. By multiplying (and then summing them up for the whole Merawu watershed) pixel value of map of erosion from USLE (A) with pixel area (900 m^2 = 0.09 hectare) and divide it by bulk density, watershed area (22,734 ha = 227,340,000 m^2) and constant number of 10 will result real soil loss in a watershed ($A_{watershed}$) in mm mo^{-1}.

$$A_{watershed} = (A \times 0.09/\text{bulk density}/227,340,000/10)_{1-n} \quad [10]$$

However, USLE is assumed only to gain *sheet* and *rill erosion*. In order to get total erosion in a watershed (*gross erosion*), other erosion such as *gully erosion* and *channel erosion* are determined according to the result of previous research done by Piest *et al.* and Seyhan (Santoso 2005) who stated that *gully erosion* was one-fifth (1/5) of the total sediment occured, while *channel erosion* was about 10% of *sheet* and *rill erosion*.

$$E = (A + G + C) \quad [11]$$

where E is *gross erosion,* A is *sheet* and *rill erosion* resulted from USLE, G is *gully erosion* and C is *channel erosion*.

A fully raster-based erosion modeling is a new model in which it needs model validation. Comparison between erosion as a result of modeling (E_{model}) with actual erosion (E_{actual}) can be done using statistical analysis (ANOVA or Correlation Analysis) or direct comparison (substracted E_{model} from E_{actual}). A threshold value of ≥ 0.8 or ≥ 80% is chosen to determine whether or not a model is accepted or refused. Actual erosion data for this study was suplied by PT Indonesia Power which regularly monitor sediment yield in outlet of Merawu watershed.

RESULTS AND DISCUSSION

Map of R Factor

Eight rainfall stations located within and surrounding of Merawu watershed which were used for the study to compute R factor are presented in Table 2. Example of the pattern of some R factor as a result of spatial interpolation using *Moving Average* technique is presented in Figure 3.

Map of K Factor and Map of Bulk Density

To apply spatial interpolation using *Kriging* technique, to get map of K factor and map of Bulk Density, it needs information about *sill*, *nugget* and *range* values that can be obtained by executing *spatial correlation* analysis. After some *trial and error*, finally to map K factor the values of 0.000; 0.013; and 8.000 were chosen as *sill*, *nugget* and *range*. The result of map of K factor is shown in Figure 4. While to map the distribution of bulk density the values of 0.025; 0.150 and 8.500 were chosen as *sill*, *nugget* and *range*. The result of map of bulk density is shown in Figure 5.

Merawu watershed has soil erodibility in average of 0.29 (minimum: 0.08 and maximum: 0.54), while their bulk density average is 1.60 (minimum 1.03 and maximum 2.16).

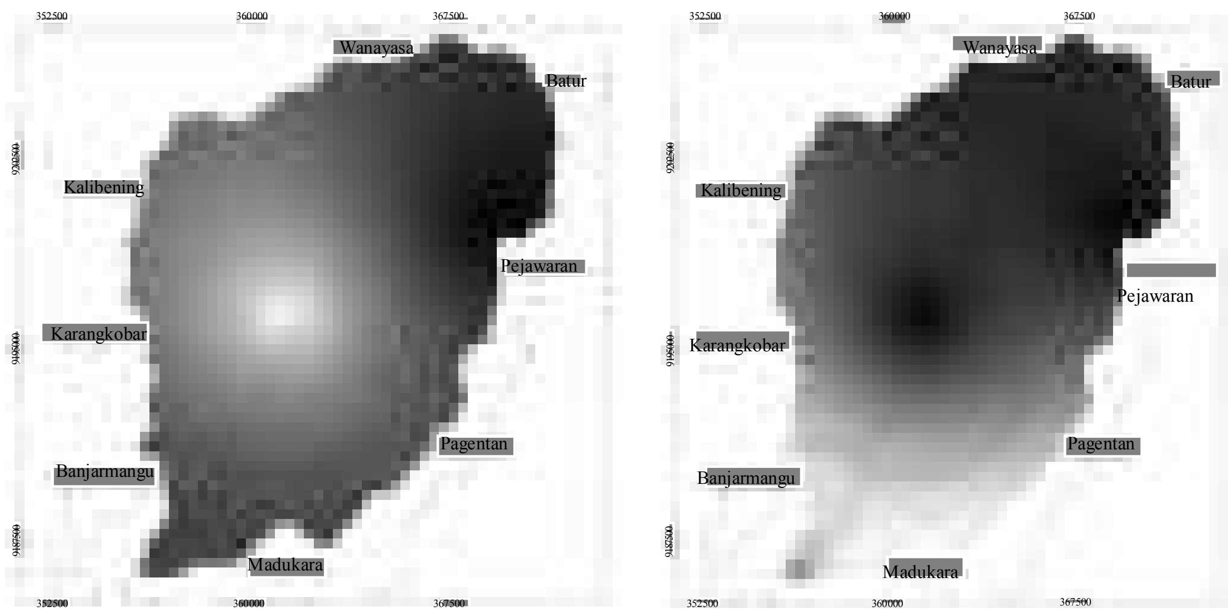
Map of LS Factor

The result of LS factor derived from different contour interval is presented in Table 3, while its distribution is shown in Figure 6. From Table 3 it can be inferred that Merawu watershed was dominated by LS factor < 20 with average covering

Table 2. Rain Erosivity in Merawu watershed.

No.	Month	Rainfall station							
		BN	CL	GA	KR	LI	PE	WA	PA
1	May-06	21	44	46	12	16	9	52	16
2	Apr-06	410	396	132	81	159	2	374	4
3	Mar-06	65	54	13	1	40	1	51	429
4	Feb-06	868	205	35	62	136	31	164	2,803
5	Jan-06	527	809	95	184	298	10	747	844
6	Dec-05	436	1,082	428	222	1,185	22	282	1,922
7	Nov-05	53	323	128	35	235	28	41	198
8	Oct-05	33	197	78	26	414	0	104	308
9	Sep-05	19	60	10	1	41	0	12	0
10	Aug-05	25	41	1	0	25	0	26	0
11	Jul-05	13	8	6	3	379	0	8	0
12	Jun-05	46	15	19	44	414	0	41	2
13	May-05	3	118	51	6	158	1	5	30
14	Apr-05	220	52	204	3	117	4	211	106
15	Mar-05	142	114	127	59	758	4	44	51
16	Feb-05	201	56	252	14	544	3	31	90
17	Jan-05	310	209	322	4	67	28	154	364
18	Dec-04	956	989	209	1,009	249	338	431	411
19	Nov-04	443	323	213	240	1,198	11	361	8
20	Oct-04	0	5	1	13	4	0	2	0
21	Sep-04	0	0	5	3	1	0	0	0
22	Aug-04	0	0	0	0	0	0	0	0
23	Jul-04	10	5	1	0	6	0	6	0
24	Jun-04	6	0	0	0	44	0	0	10

Source: Pusat Penelitian dan Pengembangan Sumberdaya Air Bandung (2006). BN = Banjarnegara; CL = Clangap; GA = Garung; KR = Karangkobar; LI = Limbangan; PE = Pejawaran; WA = Wanadadi and PA = Paninggaran.



a. Map of R factor, October 2004.

b. Map of R factor, April 2005.

Figure 3. The pattern of some R factors of Merawu watershed.

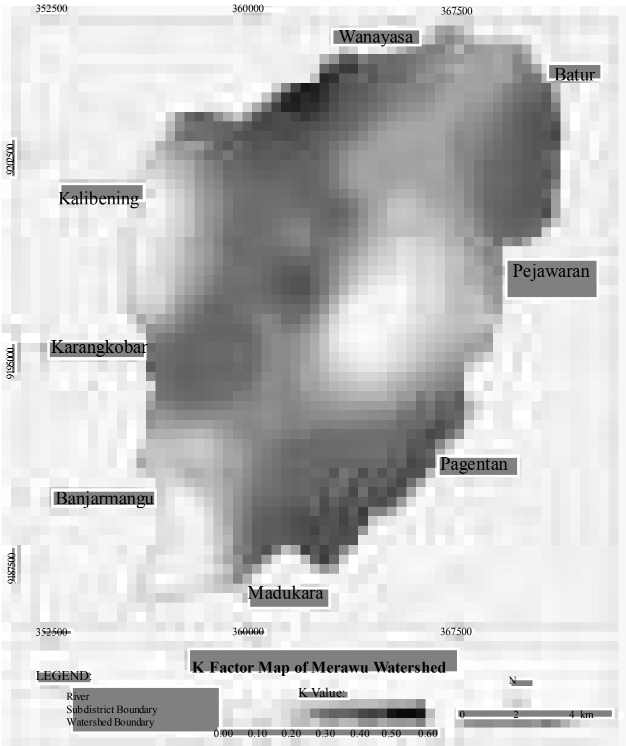


Figure 4. Map of K factor of Merawu watershed.

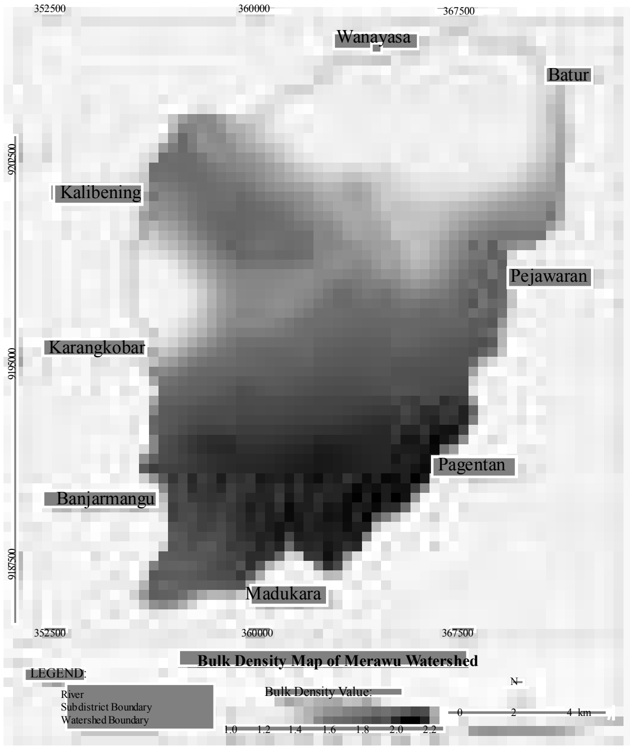


Figure 5. Map of bulk density of Merawu watershed.

area of 18,059 ha, while the rest area had LS factor ≥ 20.

Map of C Factor

Linierly regression to model C factor as a result of analysis was:

$C_{factor} = 0.60 - 0.77\ NDVI \qquad (r = 0.80) \qquad [12]$

The area of C factor is shown in Table 4, while its distribution is presented in Figure 7.

To interpolate C factor every month in accordance with the months used in computing R factor, analysis of landcover change was done. This analysis was used by overlaying NDVI recorded on 20 June 2006 on NDVI recorded on 21 May 2003. The result in the form of table is presented in Table 5.

From Table 5 it can be inferred that the total number of unchange pixel is 218,947 (86.69%). This means that the pixel changed is 13.31% during 36 months, or it can be concluded that the rate of change is 0.3698% mo^{-1}. This value is used for interpolating monthly C factor between May 2006 and June 2004.

Map of P Factor

The result of P factor is presented in Table 6, while its distribution is shown in Figure 8.

From Table 6 it can be inferred that Merawu watershed is dominated by agricultural area with P factor < 1 covering 15,186 ha (66.8%), while the rest is non agricultural area with P Factor = 1 covering 7,548 ha (33.2%).

Fully Raster-Based Erosion Modeling

The gross erosion estimated using USLE generated from 3 different contour interval (E_{model}), actual erosion (E_{actual}) and the result of validation is presented in Table 7.

Table 3. Area of Merawu watershed according to its LS factor.

No	LS factor	CI = 12.5 meter	CI = 25 meter	CI = 50 meter	Average Area
1	$0 < LS < 20$	18,769	18,944	16,465	18,059
2	$20 \leq LS < 40$	2,072	2,165	3,437	2,558
3	$40 \leq LS < 60$	1,107	934	1,680	1,240
4	$60 \leq LS \leq 80$	784	688	1,150	874
	T o t a l	22,731	22,731	22,731	22,731

Figure 6. Map of LS factor of Merawu watershed using CI = 50 meter.

Figure 7. Map of C factor derived from NDVI.

From Table 7 it can be inferred that all E_{model} using 3 countour intervals have high correlation with E_{actual} (r = 0.869 using CI = 12.5 meter, r = 0.870 using CI = 25 meter and r = 0.873 using CI = 50 meter). These results were strenghtened with the result of analysis of variance (F test) showing that there were no difference between E_{model} and E_{actual}, indicated by the $F_{computation}$ values (varies from 0.24 to 1.66) which were less then F_{table} (4.06) using degree of freedom 1 and 46 at α 5%. From the 3 models, only E_{model} using CI = 50 meter reached accuracy threshold value of 80%, that was 81.13%, meaning that this model can be used for further analysis (such as for planning purposes, research, or other analysis) while other models only had the accuracy of 50.87% (using CI = 25 meter) and 32.92% (using CI = 12.5 meter).

Table 4. The area of C factor in Merawu watershed.

Interval class of C factor	Area (ha)
0 - 0.1	12,986
0.1 - 0.2	5,804
0.2 - 0.3	2,291
0.3 - 0.4	1,116
0.4 - 1.0	535
Total	22,731,48

Table 5. Changed analysis between NDVI 2003 and NDVI 2006.

NDVI 2003	NDVI 2006							Σ_{Row}
	Water	0.06 - 0.15	≥ 0.15 - 0.25	≥ 0.25 - 0.35	≥ 0.35 - 0.45	≥ 0.45 - 0.55	≥ 0.55 - 1.00	
Water	**536**	27						563
0.06 - 0.15	81	**1,171**	3					1,255
≥ 0.15 - 0.25		614	**2,487**					3,101
≥ 0.25 - 0.35			1,903	**3,127**				5,030
≥ 0.35 - 0.45				4,176	**3,664**			7,840
≥ 0.45 - 0.55					8,003	**4,738**		12,741
≥ 0.55 - 1.00						18,818	**203,224**	222,042
Σ_{Column}	617	1,812	4,393	7,303	11,667	23,556	203,224	**252,572**

Table 6. Area width of P factor in Merawu watershed.

Landcover	Area (ha)	Area (%)
Agricultural Areas with P factor = 0.50	2,760	12.14
Agricultural Areas with P factor = 0.75	5,604	24.65
Agricultural Areas with P factor = 0.90	6,824	30.01
Non Agricultural Areas with P factor = 1	7,548	33.2
T o t a l	22,734	100,00

The shorter CI (meaning closer contour lines), the higher LS factor. It is because DEM analysis considers the distance among elevation data. The closer the distance the higher LS factor, so that the estimation of erosion was also higher.

CONCLUSIONS

All E_{model} using 3 countour intervals had a high correlation with E_{actual} (r = 0.869 using CI = 12.5 meter, r = 0.870 using CI = 25 meter and r = 0.873 using CI = 50 meter). These results were strenghtened with the result of analysis of variance (F test) showing that there were no difference

Table 7. Estimated USLE erosion, actual erosion and the result of validation.

No	Month	E_{actual} (mm mo^{-1})	E_{model} (mm mo^{1}) using different CI		
			CI = 12.5 meter	CI = 25 meter	CI = 50 meter
1	May-06	0.794	0.289	0.257	0.202
2	Apr-06	1.707	1.822	1.630	1.311
3	Mar-06	0.780	0.391	0.351	0.284
4	Feb-06	2.030	2.793	2.501	2.007
5	Jan-06	3.075	3.780	3.381	2.715
6	Dec-05	2.702	6.417	5.742	4.606
7	Nov-05	0.879	1.461	1.305	1.039
8	Oct-05	0.564	1.378	1.236	0.998
9	Sep-05	0.289	0.185	0.166	0.135
10	Aug-05	0.207	0.127	0.115	0.093
11	Jul-05	0.191	0.711	0.640	0.520
12	Jun-05	0.374	1.048	0.938	0.756
13	May-05	0.800	0.523	0.469	0.378
14	Apr-05	1.764	0.675	0.605	0.486
15	Mar-05	1.370	2.016	1.806	1.455
16	Feb-05	1.341	1.418	1.272	1.024
17	Jan-05	1.765	1.150	1.027	0.814
18	Dec-04	2.738	10.442	9.244	7.213
19	Nov-04	0.988	4.364	3.901	3.128
20	Oct-04	0.036	0.085	0.075	0.059
21	Sep-04	0.029	0.020	0.018	0.014
22	Aug-04	0.024	0.000	0.000	0.000
23	Jul-04	0.082	0.025	0.023	0.019
24	Jun-04	0.130	0.081	0.073	0.059
A.	Average	1.027	1.717	1.532	1.221
B.	Coefficient of Correlation		0.869	0.870	0.873
C.	ANOVA test:				
1.	$F_{computation}$		1.66	1.09	0.24
2.	F_{table}		4.06	4.06	4.06
D.	Accuracy (%)		32.92	50.87	81.13

Figure 8. Map of P factor of Merawu watershed.

between E_{model} and E_{actual}, indicated by the $F_{computation}$ values (varies from 0.24 to 1.66) which were less then F_{table} (4.06) using degree of freedom 1 and 46 at α 5%. From the 3 models, only E_{model} using CI = 50 meter reached accuracy threshold value of 80%, that was 81.13%, meaning that this model can be used for further analysis (such as for planning purposes, research or other analysis) while other models only had the accuracy of 50.87% (using CI = 25 meter) and 32.92% (using CI = 12.5 meter).

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