Available Online at http://www.journalajst.com

ISSN: 0976-3376

ASIAN JOURNAL OF SCIENCE AND TECHNOLOGY

Asian Journal of Science and Technology
Vol. 08, Issue, 03, pp.4543-4549, March, 2017

RESEARCH ARTICLE

LAND COVER AND SOIL EROSION ESTIMATION OF PRODUCTION FOREST DURING LOGGING MORATORIUM IN MOUNT SEULAWAH, ACEH INDONESIA

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ARTICLE INFO

Article History:
Received 17th December, 2016
Received in revised form
24th January, 2017
Accepted 18th February, 2017
Published online 31st March, 2017

Key words:

Landcover,
Moratorium,
Soil erosion hazard.

ABSTRACT

Increase of deforestation in Aceh has been growing concern, despite logging moratorium has been imposed since 2007. Deforestation has caused land cover changes, and led to uncontrolled erosion and flooding. This study aimed to find out land cover change during legal moratorium of production forest of Mount Seulawah, Aceh, and the level of soil erosion caused due to land cover changes. Descriptive method was implemented for this study. Qualitative and quantitative analysis were applied. Data collection was carried out in Forest Production Management, Region I, Banda Aceh, while field data was carried out in Production Forest, Lembah Seulawah Sub-district, Aceh Besar during May till July 2016. Landsat 8 OLI Path 131 Row 56 of January 18, 2015 was utilized in this study. Soil erosion calculation was done using Wischmeier Method (USLE). Overlying maps of class of erosion and a map of soil depth was carried out to produce map of erosion hazard. Rate of erosion hazard was classified based on the Minister of Forestry of Republic Indonesia Number P.32/Menhut-II/2009 guidelines. The findings show legal moratorium not significantly affects the continuing of erosion hazard due to Illegal logging, deforestation and land cover change. Secondary forest (57.71%) and bush (40.95%) are dominant vegetation in the area. Soil erosion level in the area was from light to severe with dominant of light erosion (59.13%).

INTRODUCTION

Forest is an important role in socio-economic life. Forest provides a lot of benefits for life and environment directly or indirectly. The immediate benefits of the forest includetimber forest products (TFP), non-timber forest products (NTFPs), oxygen, medicines, and others. Indirectly, among others, are as a regulator of a water system, climate control and ecotourism. Such benefits could be lost and turned into disaster if forest management is not taken into consideration seriously for its sustainability. The need for land and utilization of the forest products continues to increase along with the growth of population and development activities. Data from Forest Watch Indonesia (2014) indicates that the total area of deforestation of natural forests in Aceh Province in 2009-2013 was 31,802 hectares. Even the Governor of Aceh on his speech on the day of Indonesia planting trees on December 6, 2014 has stated that average of deforestation 23,000 ha per year (almost 2,000 ha per year) but deforestation in Aceh is still continuing.

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This situation is very alarming for Aceh Forest even though logging moratorium has been imposed since 2007. Forestland conversion indicators can be seen from several aspects such as land cover change and the rate of eroded soil in the forest area. By definition, all physical and biological appearance of vegetation cover such as vegetation or man-made elements (CFS, 2003) and the physical material in the earth's surface, including grass, asphalt, trees, open land, water, and others (Comber *et al*., 2005) can be considered as a land cover. To obtain land cover information, a field survey and remote sensing data can be utilized. Forest cover is rapidly changing and very dynamic, thus, it is very important that information of land cover change is regularly monitored. Land cover change is mostly due to illegal logging or land clearing for cultivation and forest fires. The change of land cover as a result of above activities could lead to the forest's function as prevention to erosion is weakened. Erosion could cause loss of soil layer, reducing the soil's ability to absorb and to hold rainfall water. The influence of the presence of forest against erosion is by protecting the collision rainwater, reducing rate and volume of runoff, holding soil particles in place through the root system and generating littering as well as maintaining the stability of the soil's capacity to absorb water. Conversely, if land cover condition is not good, erosion rate will also be higher. Water from rainfall cannot be absorbed by the soil; the flow rate of the surface (runoff) becomes larger. Precipitation is directly into the sea, carrying a variety of sediments and particles resulted from the erosion. Therefore, erosion monitoring and maintaining the rateare very important aspect in forest management. Therefore, regularly monitoring and periodically evaluation of land cover in the production forest is important aspect for forest management practices. The purpose of this study is to analyze the land cover condition in production forests and to calculate the erosion level in the production forest area of Aceh Besar district.

MATERIALS AND METHODS

Data collection was conducted in the Forest Production Management Board, Region 1, and Banda Aceh. Field data collection was conducted in Production forest of Lembah Seulawah Sub-district of Aceh Besar (Figure 1). Soil samples were analyzed at Research Laboratory of Soil and Crops, Faculty of Agriculture, Syiah Kuala University. This research was carried out from May to July 2016.

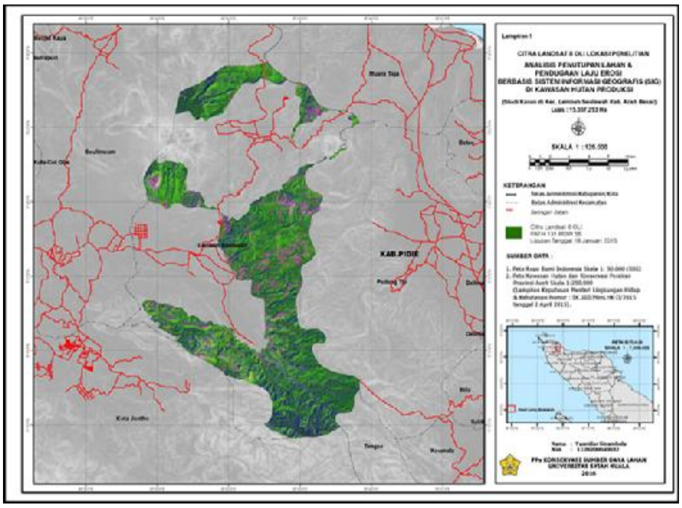

Figure 1. Landsat image of study area

This research used a descriptive method. Qualitative and quantitative analysis were applied to obtain the variables observed. Qualitative descriptive variables such as the size and level of erosion as well as the distribution of land cover werealso carried out. Meanwhile, quantitative analysis such as grading, scoring and weighting criteria wasestablished. Landsat 8 OLI Path 131 Row 56 Released January 18, 2015 wasusedin this study. ArGIS version 10.2 was used for overlaying of selected thematic maps of land mapping unit (LMU). LMU was generated based on the soil and land cover maps with equal consideration. Land cover maps were generated from the interpretation of Landsat 8 data. To determine the sampling points a stratified random sampling was implemented. The land use and soil types of the location were stratified sampled. Erosion index, length and slopes were not stratified sampled because we focused on the vegetation. To determine the erosion level spatially, an overlaying process of the thematic maps was conducted in order to calculate the total score of all parameters used to obtain the level of erosion spatially for each land mapping unit mapped. Weighting score for each parameter, such as rainfall, eroded index, slope and crop management or land use was carried out. The thematic maps consisting the variables needed to calculate the erosion level, the Equation USLE (Wischmeier and Smith, 1978) was adopted for this research. Mapping of Erosion Hazard level (TBE) was done by overlaying class erosion map (USLE) with soil depth (solumn) map. The level of erosion hazard was classified according to the decree of Minister of Forestry of the Republic of Indonesia Number: P.32 / Menhut -II / 2009. Image interpretation to produce land cover map of 2015was performed using software Arc Map 10.2 (ESRI, 2014). Landsat 8 satellite image was obtained from URL http://earthexplorer.usgs.gov/. Landsat-8 used in this study was Path 131 Row 56 of January 18, 2015. This image was selected because the image has a good quality because its cloud cover is less than 20% (Heni and Wijanarto, 2008).Cropping image, geometrical correction and land sat composite were carried to the image. Universal Soil Loss Equation (Wischmeier and Smith, 1978) combined with erosion index, eroded index, topography, land cover and soil conservation practices were calculated to estimate the soil erosion. Each USLE parameters was calculated individually for each element and entered to GIS database. Each parameter of USLE was then described in thematic maps. The erosion level map was produced by overlaying the four thematic maps of USLE parameters for each land mapping unit. Erosion index was calculated according to Levain formula as follows:

$$Rm = 2.21 \times (Rain_m)^{1.36} \quad \text{……………………………..} \ (1)$$

Where Rm = monthly erosion index, $Rain_m$ = monthly precipitation (cm), and R = total Rm for 12 months. While eroded index was calculated using the clay ratio as a criterion of susceptibility of soil to erosion (Bouyoucos, 1935).

To obtain an erosion map (erosion class, spatial extent), spatial data processing in ArcMap within GIS Software was carried out. The indexing process was then continued to produce the themes related to the parameters observed. Estimation of the erosion level in this study was conducted on each LMU. A LMU is defined as an area that has homogeneous land properties such as rainfall, soil type, slopes and land cover. In this study, the LMU was generated by overlaying between soil type and land cover maps.

RESULTS AND DISCUSSION

Land Cover

Figure 1 indicates that land cover in the research area can be classified into 3 types (Table 1.). Production forest land cover map is shown in Figure 2.

Table 1. Land Cover Type in Production Forest of Lembah Seulawah Sub District

Land cover types	Area (Ha)	Percentage (%)
Secondary Dry land Forest	8.862,696	57,710
Shrubs	6.289,050	40,952
Bare Soil / Bare land	205,508	1,338
	15.357,254	100,000

The entire production forest in research area concessions was given to IUPHHK-HTI PT Aceh Nusa Indrapuri. The image shows that only a small part has been replanted and maintained therefore this area is still dominant with secondary dry land forest in which many shrubs and tree vegetation were shown

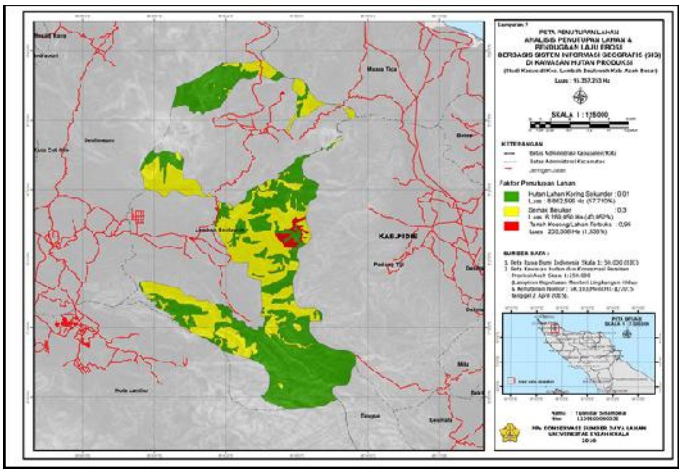

Figure 2. Land Cover Type Map

Land Mapping Unit (LMU)

The division of LMU was given in Figure 3 and description on each LMU can be seen in Table 2:

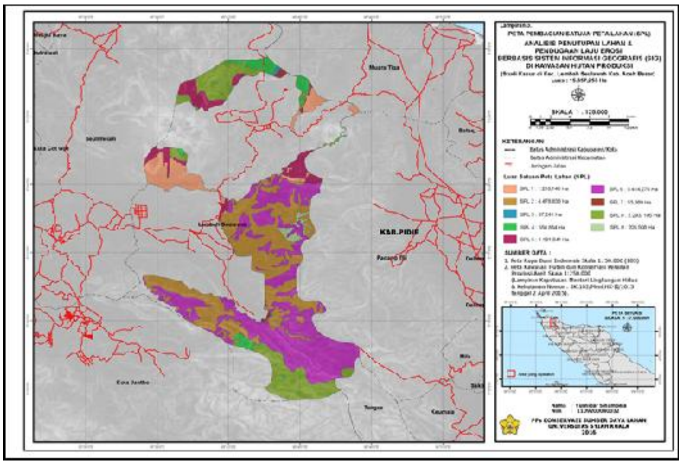

Figure 3. Land Mapping Unit (LMU) of Study Area

Table 2. Description of Research Sites in Each LMU

LMU	Land Cover	Land Type	Area (ha)	Percentage (%)
1	Shrubs	Andisol	1.216,140	7,919
2	Shrubs	Entisol - Inceptisol	4.478,836	29,164
3	Shrubs	Inceptisol	37,241	0,242
4	Shrubs	Ultisol	556,834	3,626
5	Secondary Dryland Forests	Andisol	1.101,341	7,171
6	Secondary Dryland Forests	Entisol - Inceptisol	5.414,270	35,255
7	Secondary Dryland Forests	Inceptisol	53,889	0,351
8	Secondary Dryland Forests	Ultisol	2.293,195	14,932
9	Bare soil/Bare land	Entisol - Inceptisol	205,508	1,338
	Total		15.357,253	100,000

Analysis of Contributing Factors to the erosion

Erosion index

The results of the erosivity value index (R) are 108 with the rainfall calculated 17 months, annual rainfall between 1500-2000 mm and the total 15,357.25 Ha. The map of the area is presented in Figure5. Since the amount of rainfall per year during a 10 year study is in range of 1500 – 2000 mm/year.

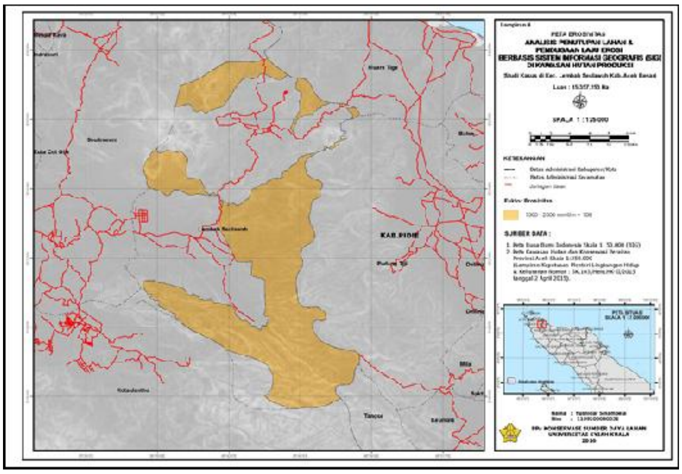

Figure 4. Erosivity map of study area

Erodibility Index

Erodibility value for each land mapping unit (LMU) of soil samples is presented in Table 4. The spatial distribution of erobility value is shown in Figure 5. The distribution of erodibility value of study area base on erodibility class is presented in table 4.

Table 3. Erodibility Value Index (K) calculation based on mapping unit

LMU	Sand (%)	Silt (%)	Clay (%)	Texture	Erodibility (K)	Level of Erodibility
1	23	66	11	Silt-clay	0.08	Very Low
2	35	59	6	Silt clay	0.16	Low
3	48	47	5	Sandy loam	0.19	Low
4	21	73	6	Silt clay	0.16	Low
5	7	82	11	Silt	0.81	Very Low
6	58	36	6	Sandy loam	0.16	Low
7	20	75	5	Silt clay	0.19	Low
8	28	66	6	Silt clay	0.16	Low
9	34	61	5	Silt clay	0.19	Low

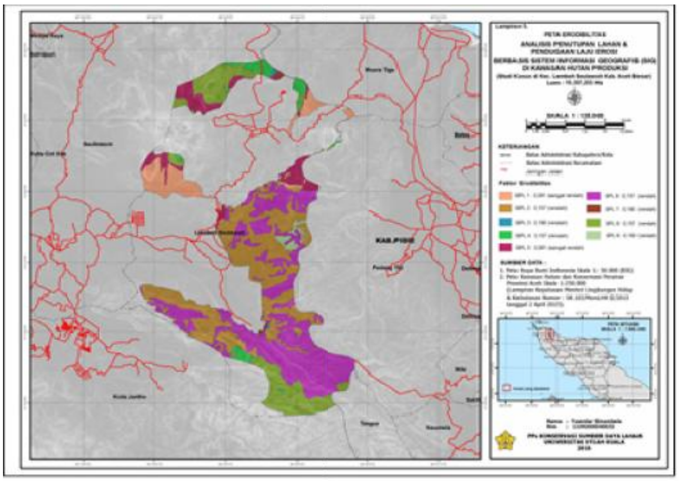

Figure 5. Erodibility (K) of Study area based on the LMU

Table 4. Area based on Erodibility (K)

Erodibility	Class	Area (Ha)	Percentage (%)
0,00 - 0,10	Very Low	2.317,481	15,090
0,11 - 0,21	Low	13.039,772	84,910
Total		15.357,253	100,000

Table 3 shows the value of erobility (K) for each LMU investigated vary from low to very low, but dominant is low category. The largest of K values are at LMU 3, 7 and 9, reaching of 0.190 and categorized as low. This category is found on entisol, inceptisol and ultisol soil order. While the lowest of K value occupied at LMU 1 and 5, with the total value 0.081, and they are categorized as very low, spreading on Andisol soil order in the study area. Figure 1dshow map of Kvalue in research area. The amount area of the value of K at each soil erodibility value is shown in Table 4. Erodibility index could demonstrate the ease of soil to be eroded; the higher the value the more easily soil to be eroded. The different value of soil erodibility areas is affected by the condition of soil texture; e.g clay percentage, very fine sand and silt. Morgan (1986) indicates that texture is role play in soil erodibility, e.g large-sized particles are resistant to haulage because of its size, while the fine particles are resistant to destructive power because power of its cohesive. Particles that are less resistant to both silt and sand is very fine textured soil. Zhang *et al.*, (2002) stated that soil which has higher silt loam is more resistant to erosion.

Length and Slopes

The length and slope factor (LS) on each of the LMU was determined by level of slope and LS factors. The length and slope factor (LS) on each of the LMU are presented in Table 5.

Table 5. The length and slope (LS) value of study area

LMU Area (Ha)	Slope (%)	Topography	LS	Area (Ha)
1	16-25%	somewhat steep	3.10	50.99
	8-15%	Sloping	1.40	436.45
	<8%	Flat	0.40	728.71
2	16-25%	somewhat steep	3.10	28,89
	8-15%	Sloping	1.40	1,274.94
	<8%	Flat	0.40	3,175.00
3	8-15%	Sloping	1.40	8.91
	<8%	Flat	0.40	28.33
4	>40%	very steep	9.50	8.60
	16-25%	somewhat steep	3.10	139.39
	8-15%	Sloping	1.40	308.39
	<8%	Flat	0.40	100,454
5	16-25%	somewhat Steep	3.10	271.88
	8-15%	Sloping	1,.40	623.77
	<8%	Flat	0.40	205.69
6	26-40%	Steep	6.80	31.90
	16-25%	somewhat steep	3.10	534.40
	8-15%	sloping	1.40	2,305.15
	<8%	Flat	0.40	2,542.83
7	8-15%	Sloping	1.40	20.87
	<8%	Flat	0.40	33.03
8	>40%	very steep	9.50	755.58
	26-40%	steep	6.80	221.82
	16-25%	somewhat steep	3.10	681.02
	8-15%	Sloping	1.40	605.09
	<8%	Flat	0.40	29.69
9	8-15%	Sloping	1.40	43.53
	<8%	Flat	0.40	161.98
	Total			15,357.25

The index value of length and slope near to 0, it indicates the value of length and slope index does not significantly affect the area. While the value of length and slope index near to 1, it influences the contribution to soil erosion. Variation of LS values from flat to very steep topography is at LMU 8, while LMU 3, 7 and 9 there are only flat and sloping topography. The extent of each factor LS research sites are presented in Table 6.

Table 6. Area of the research based on slopes and LS factor

Slope	Topography	LS	Area (ha)	Percentage (%)
<8%	Flat	0,400	7,005.69	45.62
8-15%	Ramps	1,400	5,627.10	36.64
16-25%	Somewhat Steep	3,100	1,706.57	11.11
26-40%	Steep	6,800	253.72	1.65
>40%	Very Steep	9,500	764.18	4.98
	Amount		15.357,26	100.00

Table 6showsmost of area investigated, from flat area covering an area of 7005.69 hectares (45.62%), till undulating counted for ± 5627.10 hectares (36.64%), with a total of12,632.79 (82.26%) all research area. Spatial distribution of steep to very steep topography is the smallest area with total of 253.72 ha (1.652%) and 764.18 ha (4.98%) respectively. Low percentage of slope contributea small contribution towards erosion. The value of LS determines the level of erosion, from small to severe impact on erosion process. The length and slope map in the research area is presented in Figure 6.

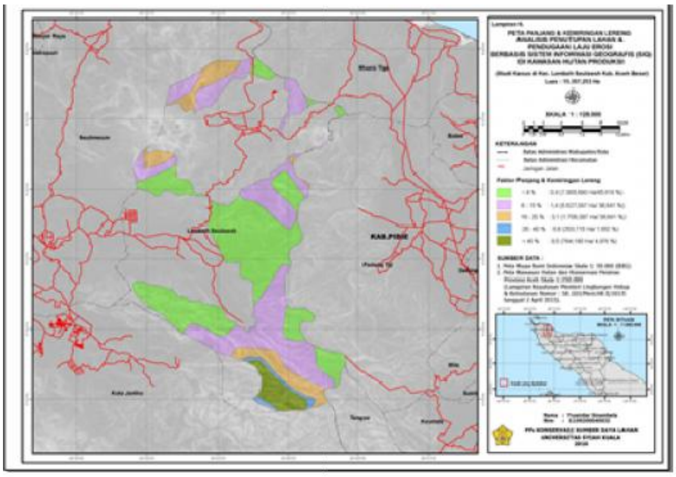

Figure 6. Length and Slope (LS) map of study area

Land Cover Land and Soil Conservation Index

Results show that the interpretation of Landsat imagery in 2015 for the Production Forest in the area can be grouped into three categories; 1) secondary dry forest, 2) scrub and, 3) bare land/wasteland. Classification of land cover (C) image interpretation results tested with the field observation for each LMU, and for soil conservation practices observed and to be valued to 1 indicate that this area has not been any conservation activities since.

The value of C for each land cover is presented in Table 8. The land cover types from field visit for each LMU have the same class from image interpretation of the area investigated. This happen because the interpretation is not based on the spectral analysis of the image rather visual analysis of the image through digitization on a screen. The extents of land cover (Table 1) is on the secondary dry forest ± 8.862,696Ha (57.710%), followed by scrub, counting for ± 6289.050 hectares (40.952%) and the smallest of bare soil with the total of ± 205.508 ha (1.338%). The land cover map of the location investigated is presented on Figure 2. As land cover class has a different index value, depending on the vegetation canopy, this value is used as a factor considered to classify the land cover and to estimate erosion level.

Table 7 Land Cover Types and Crop Practice (CP) of study area

LMU	Land Cover Type		CP Value	Area (ha)	Percentage (%)
	Image Results	Field test			
1	Shrubs	Shrubs	0,300	1.216,140	7,919
2	Shrubs	Shrubs	0,300	4.478,836	29,164
3	Shrubs	Shrubs	0,300	37,241	0,242
4	Shrubs	Shrubs	0,300	556,834	3,626
5	ScondaryDryland Forests	ScondaryDryland Forests	0,010	1.101,341	7,171
6	ScondaryDryland Forests	ScondaryDryland Forests	0,010	5.414,270	35,255
7	ScondaryDryland Forests	ScondaryDryland Forests	0,010	53,889	0,351
8	ScondaryDryland Forests	ScondaryDryland Forests	0,010	2.293,195	14,932
9	Bare land	Bare land	0,950	205,508	1,338
	Total			15.357,253	100,000

Table 8. The Values of erosivity(R), soil erodibility (K), land cover and land conservation practice (CP), and slope (LS)and Erosion Class

LMU	R	K	LS	CP	A = RKLSCP (tones / ha / yr)	class Erosion
1	108,000	0,081	3,100	0,300	8,127	
	108,000	0,081	1,400	0,300	3,670	
	108,000	0,081	0,400	0,300	1,049	
		LMU 1			12,845	I (very low)
2	108,000	0,157	3,100	0,300	15,736	
	108,000	0,157	1,400	0,300	7,106	
	108,000	0,157	0,400	0,300	2,030	
		LMU 2			24,872	II (low)
3	108,000	0,190	1,400	0,300	8,618	
	108,000	0,190	0,400	0,300	2,462	
		LMU 3			11,081	I (very low)
4	108,000	0,157	9,500	0,300	48,222	
	108,000	0,157	3,100	0,300	15,736	
	108,000	0,157	0,400	0,300	2,030	
		LMU 4			73,094	III (average)
5	108,000	0,081	3,100	0,010	0,271	
	108,000	0,081	1,400	0,010	0,122	
	108,000	0,081	0,400	0,010	0,035	
		LMU 5			0,428	I (very low)
6	108,000	0,157	3,100	0,010	0,525	
	108,000	0,157	1,400	0,010	0,237	
	108,000	0,157	6,800	0,010	1,151	
	108,000	0,157	0,40	0,010	0,068	
		LMU 6			1,980	I (very low)
7	108,000	0,190	1,400	0,010	0,287	
	108,000	0,190	0,400	0,010	0,082	
		LMU 7			0,369	I (very low)
8	108,000	0,157	9,500	0,010	1,607	
	108,000	0,157	3,100	0,010	0,525	
	108,000	0,157	1,400	0,010	0,237	
	108,000	0,157	6,800	0,010	1,151	
	108,000	0,157	0,400	0,010	0,068	
		LMU 8			3,587	I (very low)
9	108,000	0,190	1,400	0,950	27,292	
	108,000	0,190	0,400	0,950	7,798	
		LMU 9			35,089	II (low)

Estimation of erosion velocity

All factors affecting erosion such as rainfall erosivity(R), soil erodibility (K), land cover and land conservation practice (CP), and slope (LS) were utilized to predict the erosion-USLE method has indicated the variation of erosion velocity for each LMU. The overlaid maps using GIS tool indicates the different value the value of each class of erosion for each LMU is shown at Table 9.

1. Erosion Class I

This class is classified into class with an incidence of erosion is very low erosion rates, less than 15 tones / ha / year. This erosion class is cross over 6 LMU. The smallest erosion rate isLMU 1 (12.845 ton / ha / year), LMU 3 (11.081 ton / ha / year), LMU 8 (3,587 ton / ha / year), LMU 6 (1,980 tones / ha / year), LMU 5 (0.428 tones / ha / year) and LMU 7 (0.369 tones / ha / year). It can be seen that the land cover is very influent factor to the erosion process. The LMU 5, 6, 7 and 8 are areas with secondary dry- land forest. The effectiveness of vegetation in controlling the erosion rate is determined by its characteristics, such as type, density, low height canopy and litter. The vegetation is very effective to control the velocity of the erosion through massive modifications caused by the erosion (Chang, 2006). At LMU 1 and 5 that affecting the very low rate of erosion is the lowest value of erodibility. While in LMU 3, it can be seen that the influence of flat topography to gently sloping has contributed the erosion class of LMU is very low, besides also having a closure shrub land. Rain erosivity factors for all locations of the study are the same, thus they does not affect the erosion level between LMU1 to another LMU.

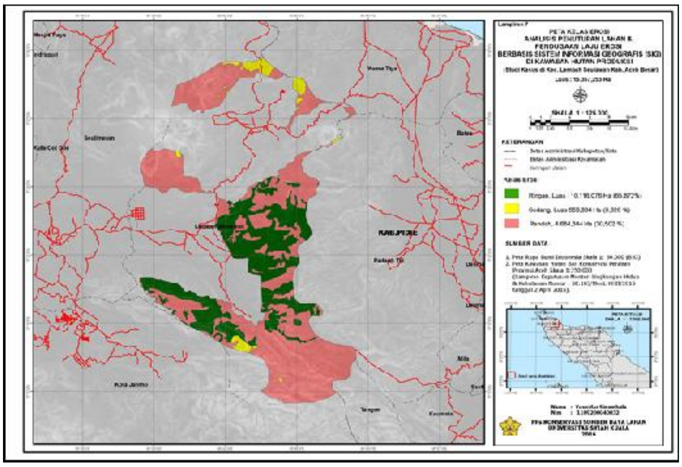

Figure7. Erosion Class Map of study area

2. Erosion Class II

This class is classified into class with a low erosion rate of erosion 15-60 tones / ha / year, erosion class is spread on LMU 2 (24.872 ton / ha / year) and LMU 9 (35.089 ton / ha / year). Both these LMU, their erosion levels are not the highest or the lowest, this is because of LMU 2 have shrub land cover, from flat to moderately steep topography and low erodibility value. While the LMU 9 despite its land cover is bare land, but its topography is flat to gently with low erodibility value.

3. Erosion Class III

This class is classified into class with the erosion velocity rate is 60-180 tonnes / ha / year, erosion class is only found only one LMU, LMU4 (73.094 ton /ha/year). The main factor causing this LMU is the highest erosion rate value, greatly varied topography ranging flat to very steep. The topography contributes a very high amount of erosion, where the long and increasingly steep slope, the erosion will be greater. This is caused by the speed and volume of flowing water on the increasingly steep slopes (Asdak, 2010. If the slope of the ground surface becomes twice as steep, then the amount of erosion per unit area becomes 2.0-2.5 times. Another factor is the closure of the land at this LMU is a shrub that has a class crown cover smaller / less than secondary dry forest. Each class of erosion, as shown in Table 9 below:

Table 9. Erosion class, total area and percentage of each erosion class of study area

Erosion Class	Area (Ha)	Area Percentage (%)
I (very Low)	10,116.08	65.87
II (Low)	4,684.34	30.50
III (average)	556.83	3,63
Total	15,357.25	100.00

Class erosion of the study area is dominated by a class I (very low) covering an area of 10116.076 ha (65.87%), followed by erosion class II (low), covering an area of 30.50 hectares (30.50%) and the smallest erosion area is class III (moderate), covering an area of 556.83 ha (3.63%). Table 10show the average erosion rate for each LMU of Study area. Table 10shows the average of erosion for the Production Forest Area, counting for 12.68 tonnes / ha / year. The erosion rate classification (Table 10), the total erosion rate of the Production Forest of Lembah Seulawah sub-district with the erosion class category very lowis categorized as the criteria of 0-15 tonnes/ha/year.

Table 10. Estimation of average erosion rate for each LMU of study area

LMU	Total Area (Ha)	Percentage of area (%)	A = The rate of erosion	Erosion average
			(Ton / ha / year)	(Ton / ha / year)
1	1,216.14	7.92	12.85	1.02
2	4,478.84	29.16	24.87	7.25
3	37.24	0.24	11.08	0.03
4	556.83	3.63	73.09	2.65
5	1,101.34	7.17	0.43	0.03
6	5,414.27	35.26	1.98	0.70
7	53.89	0.35	0.37	0.00
8	2,293.20	14.93	3.59	0.54
9	205.51	1.34	35.09	0.47
Total	15.357,26	100.00	163.35	12.68

The factors affecting the erosion rate estimated in each region is dominated by Topography factor. The erosion of the very low class is greatly influenced by topography. The flatter the topography the smaller of land runoff occurs, thus the strength of transportation process of the granules of soil is getting smaller, compared to the level of land with steep slopes, contributing higher runoff. This can be seen in Table 6, slope predominantly flat topography (<8%) of 45.62% up to undulating (8-15%) of 36.64% with a total of 85.26%. When it is compared to the steepness of topography (26-40%) of 1.65% to very steep (> 40%) of 4.98% with a total of only 6.63%, there is different effect on the erosion rate to the area investigated. This is consistent with the function that the Production Forest is intended to produce the results of timber and non-timber (exploitable), so as to topography potentially damage is not designated as production forest. Land cover factor also affects the total of erosion. Forest land cover data of Lembah Seulawah Production Forest is dominated by secondary dry forest (57.71%) and shrubs (40.95%), and only a small portion of bare land, accounting for 1.34% (Table 7). A good secondary dry forest or scrubland an area covered by a variety of vegetation. Secondary dry land forests mostly grow in the habitats of dry land to forested plains, hills and mountains or tropical highland forests. Human intervention or had appeared logged (the appearance of curved and patches of logged-over) and shrubs are dry land area covered by a variety of heterogeneous and homogeneous natural vegetation densities. This region is usually dominated by low vegetation (natural vegetation) (BSN, 2010).

Land with poor vegetation conditions is not well protected, and the soil surface of the land is intended to be dispersed as a result of rain water. Land with poor vegetation has a small infiltration rate. Consequently, most of the rain that falls is not absorbed into the ground but still flowing above ground, and it becomes runoff. Thus, soil with good vegetation conditions can reduce the amount of surface runoff; resulting erosion rate will be lower.

Erosion Hazard Level Analysis (TBE)

The class erosion map, soil solum (effective depth of soil) can be obtained from the data of TBE (Tabe12). The erosion potential calculation in the production forest of Lembah Seulawah sub-district consists of four classes of erosion level; very light, light, medium and severe.

Table 11. Erosion Hazard Level for each LMU of study area

LMU	SOLUM	Erosion Class	TBE	area (Ha)	Percentage (%)
1	Deep	I	SR	1.035.77	6.74
	Average	I	R	180.37	1.17
2	Deep	II	R	4,039.92	26.31
	Average	II	S	438.91	2.86
3	Deep	I	SR	37.24	0.24
4	Deep	III	S	548.41	3.57
	Average	III	B	8.42	0.06
5	Deep	I	SR	811.15	5.28
	Average	I	R	290.20	1.89
6	Deep	I	SR	4,926.73	32.08
	Average	I	R	487.54	3.18
7	Deep	I	SR	53.89	0.35
8	Deep	I	SR	2,216.46	14.43
	Average	I	R	76,735	0,500
9	Deep	II	R	205,508	1,338
		amount		15.357,253	100,000

- Erosion Hazard Level, Very Light TBE result of very light was at LMU 3, 7 and partly on LMU 1, 5, 6 and 8. These are TBE very light in most areas that have very low erosion rates (0-15 tonnes /ha/year). However because some of the LMU, there are two classes solum, then a minority of areas outside the TBE very light. If we considered factors such erosion of the influence of land cover and topography, there are the dominant factor for this level.
- Level of Erosion Hazard, Light TBE distribution for light is found in the LMU 9 and partly in LMU 1, 2, 5, 6, and this light LMU 8.Alalthough LMU 9 have the worst land cover, bare land but has a flat topography class (<8%) to ramps (8-15%) with soil solum> 90 (inside). While LMU 1, 2, 5, 6 and 8 are found only in a small portion of their area just to the flat topography (<8%), ramps (8-15%), rather steep (16-25%) and only a little steep (26-40%).
- Erosion Hazard Level, Medium TBE with this category is only in some of LMU 4 and LMU 2 and they are categorized as low and medium erosion level, but because they have land solum 60-90 (medium), then there are categorized as TBE medium.
- Erosion Hazard Level, severe TBE with severe category is found only in a small portion LMU 4 with the percentage of 0.06% (8.42 Ha). The topography class is highly variable in the LMU to a very steep (>40%), in addition to the LMU also include erodibility with low value land cover thickness, Finally the soil depth 60-90 cm then TBE is included in the severe.

To determine the amount and the ratio of the TBE obtained from TBE class is taking into account for each LMU. The distribution of TBE is seen in Figure 10 and total area on each TBE is shown in Table 12.

Table 12. Erosion Hazard Level, total area and Percentage of the Study Area

TBE		Total Area	Percentage (%)
I	(very Light)	9,081.29	59.13
II	(Light)	5,280.27	34.38
III	(average)	987.33	6.43
IV	(heavy)	8.42	0.06
	Amount	15,357.31	100.00

The study area is dominated by very light TBE, occupying an area of 9,081.27 hectares (59.13%), followed by mild TBE area of 5,280.27 hectares (34.38%), and then average TBE 987,33 (6.43%) and the smallest severe TBE, counting for only 8.42 hectares (0.06%).

Conclusion

The proportion of land cover types of the area investigated consists of secondary dry forest occupied area of 8,862.70 Ha or 57.710%)and bush/shrub6,289.05 ha (40.952%), and then the bare land,205.508 Ha (1.34%).Three classes of erosion consists of class I (very low) covering an area of 10,116.08Ha (65.87%), followed by erosion class II (low) covering an area of 30.50 hectares (30.50%) and class III (moderate) covering an area of 556.83 ha (3.63%). Total of erosion rate in Production Forest in Lembah Seulawah Sub-district, Aceh Besar is 163.346 tons/ ha/year and the average erosion rate of 12.68 ton / ha / year.We found four level of Erosion Hazard Level (TBE); very light 9,081.24 ha (59.13%), light 5, 280.27 (34.38%), medium 987.33 ha (6.42%) and the severe 8.42 ha (0.06%). There is no significant effect on moratorium logging in the area on continuing erosion hazard occurrence.

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