THE ESTIMATION OF AMOUNT EROSION IN THE CANDIDATE AREA IUPHHK-HA PT CAKRA SEJATI SEMPURNA ENTERPRISE, PROVINCE OF CENTER KALIMANTAN

Zainal Muttaqin[1*], **Abdul Rahman Rusli**[2]

[1,2] *Faculty of Forestry, Nusa Bangsa University, Bogor, Indonesia*

muttaqinznl@gmail.com; rusli.abdulrahman.69@gmail.com
**Corresponding author: muttaqinznl@gmail.com*

Abstract. *The aim of this research is to estimate of amount erosion and erosion hazard level (ehl) in the candidate area IUPHHK-HA (timber forest product utilization business license-Natural forest) PT Cakra Sejati Sempurna enterprise, area of 45.000 ha. Calculating of amount erosion is determined using USLE (Universal Soil Loss Equation) method and combined by spasial analysis through overlay on maps consists of maps of land system unit, soil type, slope, land cover type. The results show erosion (ton/ha/year) on every land system such as: TWH (Teweh) amount 10,973 - 15,845 and (ehl) very low - low, LWW (Lawanguang) amount 7,317 - 18,109 and (ehl) very low - low, MPT (Maput) amount 4,116 - 19,241 and (ehl) very low - low, MTL (Mantalat) amount 10,061 - 24,900 and (ehl) very low - low, PDH (Pandreh) amount 11,318 - 53,879 and (ehl) very low - low, BRW (Beriwit) amount 26,340 - 163,576 and (ehl) low - moderate. Conclusion that erosion hazard level on covered of secondary dry forest classified from very low until moderate and on slope of 25-24% have (ehl) which is increasing. Erosion hazard level on covered of young grove and bush classified from very low until low.*

Keywords: *erosion, land system, the erosion hazard level, land coverage, USLE*

1. INTRODUCTION

Forest exploitation in the form of a Business Permit for Utilization of Timber Forest Products - Natural Forest (IUPHHK-HA) should follow the principles of soil and water conservation and management of watersheds (DAS) as well as product preservation to prevent or reduce direct and indirect impacts on environmental damage such as soil erosion and sedimentation and increased surface runoff, especially in open areas without ground cover (vegetation).

PT Cakra Sejati Sempurna (PT CSS) has a ± 45,000 ha IUPHHK-HA reserve area located in the district of Laung Tuhup and Barito Tuhup Raya, Murung Raya Regency, Central Kalimantan Province. The licensing process stage definitively requires the preparation of an environmental document in the form of an Environmental Impact Analysis (AMDAL). The ANDAL of PT CSS document has reviewed the environmental impact analysis of the physical components, including the assessments on erosion and sedimentation. Since the analysis of erosion and sedimentation estimates in this ANDAL is semi-detailed, it is necessary to describe it in detail in this study.

Based on the forest function map and in reference to the Map of Forest Areas and Marine Conservation and Certain Areas Designated as Forest Areas in Central Kalimantan with the Scale of 1: 250,000 (Attachment to the Decree of the Minister of Forestry No. SK.529/Menhut-II/2012 dated 25 September 2012), the forest area being requested is included in the function of Limited Production Forest (HPT) covering 39,719 Ha (88.26%) and Permanent Production Forest (HP) covering an area of 5,281 Ha (11.74%). The study of land cover types included secondary forest (79.70%), young bushes and shrubs (20.21%), and open land (0.09%).

The research on flow and surface erosion in the proposed PT CSS area is necessary and important as input and comparison for IUPHHK-HA companies/managers in environmental management and monitoring efforts, especially in controlling erosion, sedimentation and surface runoff. The goal is to increase the performance of environmental management when the company operates. The purpose of this study was to estimate the amounts of erosion and surface runoff, floods/puddles of the prospective land-based PT CSS area.

2. LITERATURE REVIEW

2.1 Erosion

Erosion is the event of moving or transporting parts of the soil from one place to another by a natural medium. Based on the cause or the transportation media, there are two types of erosion: wind erosion and water erosion. Basically, it can be concluded that erosion occurs due to work interactions among climate, topography, vegetation and human soil factors (Arsyad 2010).

There are three types of erosion: geological erosion, normal erosion, and accelerated erosion. Geological erosion occurs since the earth's surface was formed, and this causes the erosion of rocks resulting in the formation of the morphology of the earth's surface as it is today. Two other types of erosion are caused by nature and by human activities. Natural erosion or normal erosion occurs due to the occurrence of soil erosion processes and soil formation to maintain natural soil balance but still provides adequate plant growth media. Erosion due to human activities is called accelerated erosion where there are activities that do not heed the principles of soil and water conservation, resulting in peeling of the top soil layer including top soil. These activities include land preparation and land processing, a series of natural forest exploitation activities, and mining businesses (Arsyad 2010; Asdak 2010). However, this research will focus more on the accelerated erosion, and the term erosion will be used in further discussions.

Forest exploitation activity has a great potential to open up land, which can lead to erosion, including wood production activity, and this activity includes the construction of a base camp, transportation roads, skid trails, TPn and TPK. In addition to reducing land cover, this activity also results in the compaction of the top soil so that the soil pores shrink/are ccovered so that the soil loses its function in controlling flow and surface erosion. As for mining, there are opportunities for erosion and increased surface runoff i.e. the stripping of the topsoil and overburden when extracting mining materials such as coal, nickel, and tin and when constructing mining roads.

a. Erosion measurement method

The measurement of the rate of soil erosion that occurs can be qualitative and quantitative. Qualitative measurement method is used by interpreting aerial portraits and satellite images, and quantitative measurement method includes the measurement of land subsidence, quick measurement method, measuring stick method and small plot method.

1. Subsidence Method

This method is used to determine the amount of soil mass that has been eroded from the furrow/runoff on a plot of land. The determination of the thickness of the soil layer in this erroded area is based on the differences in height between the observation points at the base of the eroded area. In other conditions, this determination can be based on the differences in height between the observation points in the same direction of the tree roots and several observation points on the currently exposed ground surface (Poerwowidodo 1999; Ispriyanto 2001).

2. Quick measuring method

This method is effective for determining the mass of the eroded soil of the alur on a plot of land that has been eroded such as the base camp area, TPK, TPn, and forest roads. The determination of the calculation of erosion parameters included length, number of channel, depth of each channel, wide area of the channel, total area of the channel reservoir, width of the channel reservoir and total volume of the channels (Poerwowidodo 1999).

3. The measuring stick method

A stick marked with a measuring stick is used to measure changes in the depth of eroded or buried soil. This measuring stick is immersed in the ground until the zero mark is precisely on the ground. Monitoring the rate of soil erosion requires placing several measuring stick points that represent land conditions. In the event of rain, there will be a change in the height of the soil surface at the observation points. The rate of soil erosion is calculated by multiplying the soil density (m^3/gr) (Poerwowidodo 1999; Ispriyanto 2001). Using a stick is relatively much cheaper, but the final measurement results need to be corrected against the measurement results using the measuring plot.

4. Small Plot Method

The construction of soil erosion plots according to USLE guidelines has constraints in time and cost. De. Meester et al. (1977) referred to in Poerwowidodo (1999) show a fixed measuring plot of 200 m^2 in order to allow measurement of soil erosion rate over a long period of time, placed at observation points with various types of land cover.

5. USLE Method

Universal Soil Loss Equation (USLE) is a parametric model which has been frequently used despite its strengths and weaknesses. An improvement has been made on this formula known as RUSLE (Revised Universal Soil Loss Equation).

The standard size of the erosion plot in the USLE method is 22 m long, while the width can be modified based on the field conditions (Wischmeier & Scmith 1978). According to Hardjowigeno and Sukmana (1995), an estimate of the amount of erosion that will occur in a land if land cultivation does not change is carried out using the following USLE formula (Wischmeier & Scmith 1978):

$$A = R \times K \times LS \times C \times P \qquad \text{...............} \quad (i)$$

Remarks:
A: Amount of erosion (tons/ha/year); R: Rain erosivity factor
K: Soil erodibility factor; LS: Length and slope factor
C: Plant factor (land use); P: Soil conservation technique factor

6. The SLEMSA method

Soil Loss Estimation Model for South Africa (SLEMSA) is a simplification of the USLE model based on differences in the quantitative limits of soil erodibility. This model is designed to reduce the cost and time required for field survey in determining the independent value/score for each soil erosion control factor. In the SLEMSA model, the determination of soil erosion control parameters is still based on the study of measuring plots: (Poerwowidodo 1999)

$$Z = K \times C \times X \qquad \text{...........} \quad (ii)$$

Remarks:
Z: mean annual soil erosion rate forecast (tons/ha/year)
K: mean annual soil erosion rate (tons/ha/year) of the 30 m x 10 m sample plots on a slope of 4.5%, open and known for their erodibility
C: ratio value of soil erosion rate between the planted measuring plot and the measuring plot laid without cover
X: comparison of the rate of soil erosion between fields with a certain length and slope with the rate of erosion of the measuring plot

7. The RUSLE method

According to Poerwowidodo (1999), this method was developed to correct weaknesses in the USLE method by updating new data and approaches, correcting the USLE weaknesses, and using new technology based on computers. The RUSLE method was released in December 1992. Since it was first published, the RUSLE program has undergone various changes to its software.

2.2 Surface Flow

Surface run-off is part of rainwater that falls directly above the ground and flows into rivers, lakes and oceans. The water flow underneath is called the sub-surface run-off in which part of the rainfall is infiltrated into the ground, flows and joins the stormflow. Stormflow is the most important hydrograph component in flood analysis related to watershed characteristics. Subsurface water flows are a significant contributor to discharge in forested areas. Anything far from below the surface is called the base flow. Base flow is the flow rate that flows during the dry season. Furthermore, the three components are united in an area called a river (Asdak 2010).

The factors that affect the amount and rate of surface runoff are divided into two components: climate including the type, intensity, duration, distribution of the rain, rainfall, temperature, wind and humidity, and the nature of the watershed including the initial groundwater content, size and shape of the watershed, elevation and topography, growing vegetation, geology and soil (Haridjaja 1991 referred to in Londongsalu 2007).

a. SDR method

In case the data on the size of the components of the USLE formula in the watershed or water catchment are not available, it is necessary to seek a simpler prediction method so that valid results using the SDR method erosion prediction can be obtained. This SDR method requires data on the discharge, sediment load, soil density in the study area, and sediment delivery ratio (SDR).

Initial data collection of erosion estimates is in the form of sediment discharge and load at the point of observation (outlet) of a watershed. The data are valid for a fairly long period of time (annual). This is conducted by making a sediment-discharge rating curve from the sediment discharge and charge data, so that the sediment load data for the following years can be calculated using only the discharge (Asdak 2010).

b. Sedimentation

Sediment is soil and part of land transported from an eroded place. The sediment resulting from the erosion process and carried by a flow will be deposited in a place where the water velocity slows down or stops, and this is called sedimentation (Arsyad 2010). Sediment yield is the amount of sediment originating from erosion that occurs in the water catchment area measured at a certain time and place. The measurement result of the sediment is obtained from the dissolved sediment measurement in rivers or by direct measurement in reservoirs (Asdak 2010).

The factors that influence sedimentation include the amount and intensity of rain, geological formation and soil type, land use, topography, erosion in the upstream, runoff, sediment characteristics and channel hydraulics (Strand and Pemberton 1982, referred to in Setiawan 1999). According to Breussers (1974) referred to in Setiawan (1999), sediments are divided into two groups based on their movement mechanism: i) Suspended load, a moving sediment particle suspended in a water flow, and ii) Bed load, a sediment particle moving by rolling and jumping.

2.3 Results of Research on Surface Flow and Soil Surface Erosion

Research on surface runoff and surface erosion in forest concession areas has been widely carried out (Siddik 1994; Winderiaty 2000; Ramadhon 2009), and the results show differences due to differences in activity intensity, soil type, topography and rain characteristics.

3. RESEARCH METHOD

3.1 Research Location and Time

This research was conducted in the prospective areal of IUPHHK-HA PT CSS as wide as ± 45,000 ha in the Laung Tuhup and Barito Tuhup Raya Districts, Murung Raya Regency, Central Kalimantan Province (Figure 1). The field research was carried out from May to early June 2020.

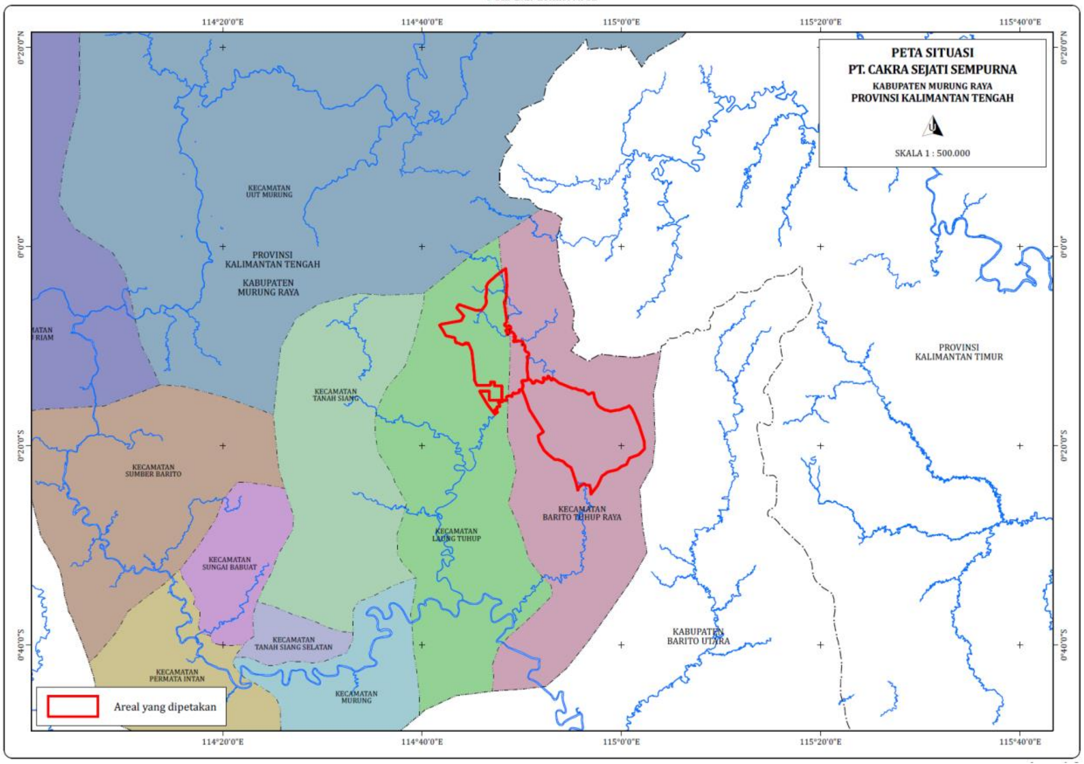

Figure 1. Research Location

3.2 Tools and Materials

The tools and materials used in this study consisted of a soil drill, a kapi knife, a bamboo stick with a scale, a clinometer, a stopwatch, a meter, a computer, an ArcGIS 10.8 software, MS Excel 2016, sample bottles, millimeter measuring cups, digital scales, ovens, tools-stationary.

The materials used in this study consisted of filter paper, sample bags (plastic), label paper, and water containers.

3.3 Data Collection

3.3.1 Data/Map Types

The map and review map collected had a scale of 1: 200,000 including soil type map, land system map, slope map, and land cover map. The data collected included daily and monthly rainfalls, chemical properties and soil texture, slopes, vegetation cover, soil and water conservation techniques, soil erosion, and surface runoff.

3.3.2 Data Collection Method

a. Rainfall

Rainfall data including daily and monthly rainfalls at the study location were interpreted using recorded data for the last 16 years (2004-2019) kept at the Beringin Meteorological Station (Muara Teweh, Central Kalimantan).

b. Soil properties

Soil properties data included chemical properties and soil texture. The chemical properties consisted of pH (H2O), pH (KCl), C-organic, N-total, C/N, P-available, Ca, Mg, K, Na, total base-exchangeable, CEC, KB, Al 3+, H+; and the oil texture included the percentage of sand, dust, clay, and the texture class was determined according to the soil texture triangle.

Soil samples in the form of composite samples (soil aggregates) were collected using a soil drill at a depth class of 0-30 cm and 30-60 cm. Each soil sample was put in a plastic bag and labeled. The locations of the soil sampling points are presented in Table

1.

Table 1. Composite soil sampling locations (soil aggregates)

No	Sampel Code	Sampel Type	Latitute	longitude	Soil Type
1	T-1	Chemical and texture	114° 56' 27.30" BT	0° 23' 22.35" LS	Tropudults Plinthudults Paleudults
2	T-2	Chemical and texture	114° 58' 25.07" BT	0° 19' 51.77" LS	Paleudults Tropudults Tropaquents
3	T-3	Chemical and texture	114° 58' 55.17" BT	0° 17' 18.44" LS	Paleudults Tropudults Tropaquents
4	T-4	Chemical and texture	114° 54' 29.78" BT	0° 19' 55.45" LS	Paleudults Tropudults Tropaquents
5	T-5	Chemical and texture	114° 53' 25.18" BT	0° 13' 42.22" LS	Tropudults Dystropepts
6	T-6	Chemical and texture	114° 53' 5.82" BT	0° 13' 45.25" LS	Tropudults Dystropepts
7	T-7	Chemical and texture	114° 49' 29.10" BT	0° 13' 22.51" LS	Tropudults Dystropepts Troporthods
8	T-8	Chemical and texture	114° 49' 36.29" BT	0° 12' 37.28" LS	Tropudults Dystropepts Troporthods
9	T-9	Chemical and texture	114° 49' 10.94" BT	0° 12' 24.48" LS	Tropudults Dystropepts
10	T-10	Chemical and texture	114° 45' 33.53" BT	0° 9' 16.84" LS	Dystropepts Tropudults Troporthods
11	T-11	Chemical and texture	114° 45' 23.59" BT	0° 8' 58.55" LS	Dystropepts Tropudults Troporthods
12	T-12	Chemical and texture	114° 47' 18.68" BT	0° 3' 8.67" LS	Tropudults Dystropepts

c. Establishment of land map unit (SPT)

Land Map Unit (LMU) is prepared based on landscape morphology as a basic framework through the land unit approach. In this study, the Land Map Unit (LMU) was determined with the uniform characteristics of soil type, land system, slope class and land cover type. This is carried out by overlay including the maps of soil type, land system, sulfur class, and land cover at a scale of 1: 200,000. From the results of the overlay of these maps, 12 Soil Map Units (LMU) obtained are presented in Table 2. At each LMU obtained, one composite (aggregate) soil sample point was taken in two depth classes: 0 - 30 cm and 30 - 60 cm.

Table 2. Types of land map unit (SPT)

SPT	Soil Type	Land System	Slope (%)	Land cover	Area	
					Ha	%
1	Tropudults, Plnthudults, Paleudults	TWH (Teweh)	0 - 8	Young grove and bush	2.789	6,20
2	Paleudults, Tropudults, Tropaquents	LWW (Lawanguang)	0 - 8	Secondary dryland forest	7.811	17,36
3	Paleudults, Tropudults, Tropaquents	LWW	8 - 15	Secondary dryland forest	3.164	7,03
4	Tropudults, Plnthudults, Paleudults	TWH	8 - 15	Secondary dryland forest	4.198	9,33
5	Tropudults, Dystropepts	MPT (Maput)	0 - 8	Secondary dryland forest	2.978	6,62
6	Tropudults, Dystropepts	MPT	8 - 15	Secondary dryland forest	7.194	15,99

7	Tropudults, Dystropepts, Troporthods	MTL (Mantalak)	0 - 8	Young grove and bush	627	1,39
8	Tropudults, Dystropepts, Troporthods	MTL	8 - 15	Young grove and bush	3.154	7,01
9	Tropudults, Dystropepts	PDH (Pendreh)	8 - 15	Secondary dryland forest	3.333	7,41
10	Tropudults, Dystropepts, Troporthods	BRW (Beriwit)	8 - 25	Secondary dryland forest	5.711	12,69
11	Tropudults, Dystropepts, Troporthods	BRW	25 - 45	Secondary dryland forest	2.578	5,73
12	Tropudults, Dystropepts	PDH	15 - 45	Secondary dryland forest	1.463	3,25
	Total				45.000	100,00

d. The amount of erosion

To predict the amount of erosion that will happen on every Soil mapping unit use formula of Universal Soil Loss Equation (USLE) (Wischmeier and Smith 1978), i.e.

A = R x K x LS x C x P ....iii)

Remarks:
A = The amount of erosion (ton/ha/year)
R = Factor of rain erosivity
K = Factor of soil erodibility
LS= Factor the lenght and slope
C = Factor of plant (use soil)
P = Factor technic of soil conservation

Factor of rain erosivity (R) is determined using data of the month rain of Lenvain formula (1975, in Bols 1978). That formula is simple but more closer to reality. Value f R a year is given with the sum of RM a year, i.e.

RM = 2,21 (Rain)m 1,36 ....iv)

Remarks:
RM = The month rain of erosivity
(Rain)m = The month rain (cm)

Factor of soil erodibility (K) is determined using formula (Hammer 1978), i.e.

$$K = \frac{2{,}713M^{1{,}14}\ (10^{-4})(12 - a) + 3{,}25\ (b - 2) + 2{,}5\ (c - 3)}{100} \quad \text{....................v)}$$

Remarks:
M = (% silt + % sand very fine)(100 - % clay), % sand very fine can be considered of one third of sand percentage
a = % of organic material (% C x 1,724)
b = code (value) soil structure, i.e. granular very fine (1), granular halus (2), granular moderate and coarse (3), blocky, platy, solid (4) (Hammer 1978)
c = code (value) permeability, i.e. rapid (>25,4 cm/hour)(1), moderate until rapid (12,7 - 25,4 cm/h)(2), moderate (6,3 - 12,7 cm/h), moderate until slowly (2,0 - 6,3 cm/h), slowly (0,5 - 2,0 cm/h), very slowly (<0,5 cm/h) (Hammer 1978).

Factor of the lenght and slope is determined by ignore the slope lenght and take effect only the slope amounted three times to erosion so that LS refers to: S (0 - 8%) (LS=0,25), S (8 - 15%) (LS=1,20), S (15 - 25%) (LS=4,25), S (25-45%) (LS=9,50), S >45% (LS=12,00).

Factor of plant (use soil) refers to value of factor C with planting single and value of factor C with some planting management (Abdulrachman et al. 1981; Hammer 1981). While factor of soil conservation technic refers to value of P factor (Hardjowigeno and Widiatmaka 2001).

e. Erosion allowed (Edp) and Erosion hazard index (IBE)

Hammer (1981) present that counter of Edp based on the depth of equivalent soil that got with soil depth (mm) multiple of soil depth factor. The soil depth factor base on the large and speed reduction of soil deterioration quality that caused by reduction of soil physical and chemical. Equation formulation, ie.

$$\text{Edp} = \frac{\text{The effective soil depth (cm)} \times \text{soil depth factor (cm)}}{\text{The soil sustainable age (year)}} \times \text{BD (gr/cm3)} \times 10 \quad \text{......vi)}$$

Erosion hhazard index (IBE) is determined base on equation (Wood dan Dent 1983), i.e.

$$\text{Edp} = \frac{\text{The amount soil erosion (ton/ha/year)}}{\text{The soil sustainable age (year)}} \quad \text{...........vii)}$$

f. Run-Off

To estimate the amount of runoff, the rational method mathematical equation developed by the U.S. Soil Conservation Service (1973) in Asdak (2010) was used as follows:

$$Q = 0{,}0028\ C.i.A \quad \text{.................viii)}$$

Remarks:
Q = Peak of runoff (discharge) (m3/s)
C = Runoff coefficient
i = Maximum rain intensity (mm / hour)
A = Area of the watershed (Ha)

The assessment of the impact on the peak of runoff was conducted using the runoff water coefficient (C) by the U.S. Forest Service (1980) in Asdak (2010) as a measure in the study area.

4. RESULTS AND DISCUSSION

4.1 Soil Erosion Rate

The amount of soil erosion rate (A) was determined by several factors including rain erosivity (R), soil erosion sensitivity (K), length and slope factor (LS), land cover type (C), and land management patterns (P). By using the USLE (Universal Soil Loss Equation) formula: A = R.K.LS.C.P. The amounts of soil erosion in the study area are presented in Table 3.

Table 3. Soil erosion rates in the study area

SPT	Soil Type	Land System	Slope (%)	Land cover	R	K	LS	CP	A (ton/ ha/year)	TBE*
1	Tropudults, Plnthudults,	TWH	0 - 8	Young grove and bush	2.286,5	0,12	0,40	0,10	10,975	SR
4	Paleudults	TWH	8 - 15	Secondary Dryland Forest	2.286,5	0,14	0,99	0,05	15,845	R
2	Paleudults, Tropudults,	LWW	0 - 8	Secondary Dryland Forest	2.286,5	0,16	0,40	0,05	7,317	SR
3	Tropaquents	LWW	8 - 15	Secondary Dryland Forest	2.286,5	0,16	0,99	0,05	18,109	R
5	Tropudults, Dystropepts	MPT	0 - 8	Secondary Dryland Forest	2.286,5	0,09	0,40	0,05	4,116	SR
6		MPT	8 - 15	Secondary Dryland Forest	2.286,5	0,17	0,99	0,05	19,241	R
7	Tropudults, Dystropepts,	MTL	0 - 8	Young grove and bush	2.286,5	0,11	0,40	0,10	10,061	SR
8	Troporthods	MTL	8 - 15	Young grove and bush	2.286,5	0,11	0,99	0,10	24,900	R
9	Tropudults, Dystropepts	PDH	8 - 15	Secondary Dryland Forest	2.286,5	0,10	0,99	0,05	11,318	SR
12		PDH	15 - 45	Secondary Dryland Forest	2.286,5	0,08	5,89	0,05	53,879	R
10	Tropudults, Dystropepts,	BRW	8 - 25	Secondary Dryland Forest	2.286,5	0,09	2,56	0,05	26,340	R
11	Troporthods	BRW	25 - 45	Secondary Dryland Forest	2.286,5	0,14	10,22	0,05	163,576	S

Remarks: TBE = Erosion hazard level, SR = very low, R = low, S = moderate, B = heavy, and SB= very heavy

* Ministry of Forestry (1986)

Based on Table 3, it appears that the level of erosion hazard in the initial baseline with secondary dry land forest cover was classified from very low to moderate, especially on the slopes of 25-45% having an increasing TBE. However, the level of erosion hazard in young bushes and shrub cover types was classified as very low to low. As for, the calculation yield of Edp (erosion allowed) and IBE (Erosion hazard index) is presented in Table 4.

Table 4. Value of Edp and IBE in study area

SPT	Edp (mm/year)	IBE	IBE Class	Identification the main problem*
1	2,70	4,06	High	Erosion
4	2,70	5,87	High	Erosion
3	2,70	2,71	Moderate	Erosion
3	2,70	6,71	High	Erosion
5	2,70	1,52	Moderate	Erosion
6	2,70	7,13	High	Erosion
7	2,70	3,73	Moderate	Erosion
8	2,70	9,22	High	Erosion
9	2,70	4,19	High	Erosion
12	2,70	19,96	Very High	Erosion
10	2,70	9,76	High	Erosion
11	2,70	60,58	Very High	Erosion

*Based on erosion class and soil depth (Ministry of Forestry 1986)

In Table 4, that indicate that the amount of erosion allowed (Edp) is 2,70; Erosion Hazard Level (IBE) ranges 1,52 - 60,58 or moderate until very high, and identificaton the main problem is increasing of erosion from year to year.

4.2 Sedimentation Rate

Sedimentation is a consequence of soil erosion. The sediment that is carried into water bodies is only part of the soil that has eroded from its place. The sediment load that occurs can be studied with the SDR (Sediment Delivery Ratio) approach. The parameters used were the SDR value (Arsyad, 2010) and the calculated erosion rate value in the study area as described above, so the sedimentation rate in the study area was 16.40 - 843.40 tons/year as presented in Table 5. The smallest sedimentation rate was in the Maruwei sub-watershed which had an MTL land system, and the largest sedimentation rate was in the Mandalinan sub-watershed.

Table 5. Sedimentation rates in the sub-watersheds in the study area

No.	Watershed	Sub-Watershed	Land System	SPT	Area (ha)	The amount of erosion (ton/ha/year)	SDR (%)*	sedimentation rate (10^3 ton/ year)
1.	BARITO	S. Musak	TWH	1	2.789	10,975	20,0	6,122
2.		S. Obuh	LWW	2	3.164	15,845	18,0	9,024
3.		S. Ngoleng	LWW	3	7.811	18,109	14,0	19,803
4.		S. Bunut	TWH	4	4.198	15,845	16,0	10,643
5.		S. Bunut	MPT	5	7.194	19,241	14,0	19,379
6.		S. Maruwei	MPT	6	2.978	4,116	20,0	2,451
7.		S. Maruwei	MTL	7	627	10,061	27,0	1,703
8.		S. Maruwei	MTL	8	3.154	24,900	18,0	14,136
9.		S. Maruwei	PDH	9	3.333	11,318	18,0	6,790
10.		S. Tuhup	BRW	10	5.711	26,340	15,0	22,564
11.		S.Mandalinan	BRW	11	2.578	163,576	20,0	84,340
12.		S. Maruwei	PDH	12	1.463	53,879	23,0	18,130

* Arsyad (2010)

4.3 Run Off

The results of the calculation of the surface runoff from the sub-watersheds in the study area using the rational method mathematical equation are presented in Table 6.

Table 6. Surface runoff discharge in the study area

No.	Watershed	Sub-Watershed	Land cover	Area (Ha)	C Value	Rain Intensity (mm/hour)*	Run-off Discharge (m^3/second)
1.	BARITO	S. Musak	Young grove and bush	2.789	0,10	30	23,428
2.		S. Obuh	Secondary Dryland Forest	3.164	0,05	30	13,289
3.		S. Ngoleng	Secondary Dryland Forest	7.811	0,05	30	32,806
4.		S. Bunut	Young grove and bush	4.198	0,10	30	35,263
5.		S. Bunut	Secondary Dryland Forest	7.194	0,05	30	30,215
6.		S. Maruwei	Secondary Dryland Forest	2.978	0,05	30	12,508
7.		S. Maruwei	Young grove and bush	627	0,10	30	5,267
8.		S. Maruwei	Young grove and bush	3.154	0,10	30	26,494
9.		S. Maruwei	Secondary Dryland Forest	3.333	0,05	30	13,999
10.		S. Tuhup	Secondary Dryland Forest	5.711	0,05	30	23,986

No.	Watershed	Sub-Watershed	Land cover		Area (Ha)	C Value	Rain Intensity (mm/hour)*	Run-off Discharge (m^3/second)
11.		S. Mandalinan	Secondary Forest	Dryland	2.578	0,05	30	10,828
12.		S. Maruwei	Secondary Forest	Dryland	1.463	0,05	30	6,145

* T_c = 1 hour, the largest I used was 1-hour rainfall

In Table 6, the results of the calculation of the surface runoff discharge in the sub-watersheds in the study area with land cover in the form of secondary dry forest ranged from 6.145 to 32.806 m3/second, while the surface flow discharge at land cover in the form of young bushes and shrubs ranged from 5.267 – 35.263 m3/second, indicating that the values did not differ between the two land coverings.

4.4 Instruction of soil and water conservation technique

Base on evaluation the value every erosion factor (R, K, LS, C, P) (Table 3) and notice to identify main isuue (Table 4), so that instruction of soil and water conservation technique can be determined (Ministry of Forestry 1986). Application of soil and water conservation technique would strive value of erosion factor minimum possible so that the amount erosion will happen also minimum. Detemination of soil and water conservation technique must not single but can combination of some treatment of vegetatif, engineering technique and chemical. It is simultaneus can make impact the best soil and water conservation technique to minimize. While, the best that also can reduce run-off in the flooding and puddle in swampland and valley area. Finally, aplication soil and conservation right can keep productivity of land and soil sustainable.

Choice of soil and water conservation technique also consider land capability and suitability class. In this study, alternative instruction of soil and water conservation technique that adjusted alternative determination of function i.e. protected, annual plant cultivation, annual crops cultivation, as presented in Table 7.

Table 7. Construction of soil and water conservation technique corresponding alternative of forest area function (protected, production) in study area

SPT	Depth soil (cm)	The amount erosion (ton/ha/year)	TBE	Soil and water conservation technical base on land function*	
				Protected	Annual plant cultivation
1	> 90	10,975	SR	-	-
4	> 90	15,845	R	- channel terrace, mounds terrace, credit terrace, individual terrace, bench broke up, waterfall - natural succession, vegetation permanetly (reforestation/ plantation - water springs protected/ river border	- channel terrace, mounds terrace, credit terrace, bench terrace, flat terrace - Planting according to contours, strip cropping), (agroforestry, farming forest), community forest
2	> 90	7,317	SR	-	-
3	> 90	18,109	R	The same as SPT 4 above	The same as SPT 4 above
5	> 90	4,116	SR	-	-
6	> 90	19,241	R	The same as SPT 4 above	The same as SPT 4 above
7	> 90	10,061	SR	-	-
8	> 90	24,900	R	The same as SPT 4 above	The same as SPT 4 above
9	> 90	11,318	SR	-	-
12	> 90	53,879	R	The same as SPT 4 above	The same as SPT 4 above

10	> 90	26,340	R	The same as SPT 4 above	The same as SPT 4 above
11	> 90	163,576	S	- channel terrace, mounds terrace, credit terrace, flat terrace, idividual terrace, Gully control (gully plug, gully drop, drop structure) - natural succession, vegetation permanetly (reforestation/ plantation) - water springs protected/ river border	- channel terrace, mounds terrace, credit terrace, flat terrace, individual terrace, check dam - intercropping planting, Planting according to contours, strip cropping, cover crop, (agroforestry, farming forest)

* Ministry of Forestry (1986)

Table 7. (continue) Construction of soil and water conservation technique corresponding alternative of forest area function (protected, production) in study area

SPT	Depth soil (cm)	The amount erosion (ton/ha/year)	TBE	
				Annual crop cultivation
1	> 90	10,975	SR	-
4	> 90	15,845	R	- channel terrace, mounds terrace, credit terrace, flat terrace, Hill side ditches - land management, intercropping planting, planting according to contours, strip cropping, cover crop
2	> 90	7,317	SR	-
3	> 90	18,109	R	The same as SPT 4 above
5	> 90	4,116	SR	-
6	> 90	19,241	R	The same as SPT 4 above
7	> 90	10,061	SR	-
8	> 90	24,900	R	The same as SPT 4 above
9	> 90	11,318	SR	-
12	> 90	53,879	R	The same as SPT 4 above
10	> 90	26,340	R	The same as SPT 4 above
11	> 90	163,576	S	- channel terrace, mounds terrace, credit terrace, flat terrace, Hill side ditches - land management, intercropping planting, planting according to contours, strip cropping), cover crop

* Ministry of Forestry (1986)

CONCLUSION

A land system of BRW has the amount erosion higher than others of TWH, LWW, MPT, MTL, PDH. All land system have IBE range moderate until very high and have the main problem is erosion. Continuity of erosion data is sedimentation rate of 1,703 x 10^3 - 84,340 x 10^3 ton/year and run-off discharge of 5,267 - 35,263 m^3/second.

REFERENCES

Abdulrachman A, Sofiah A, and U. Kurnia. (1981). Land management and agricultural management in effort of soil conservation dalam usaha konservasi tanah. Paper in Congress HITI 16-19 Maret 1981 di Malang. Soil Research Institution, Bogor.

Arsyad S. (2010). *Soil and water conservation*. Second edition. Bogor (ID): IPB Press.

Asdak C. (2010). *Hidrology and Watershed Management.* Yogyakarta (ID): Gadjah Mada University Press.

Baver LD, Charles E, Wiley, Inc S. (1972). *Soil Physics*. Third Edition. New York (US): Tuttle Company. Modern Asia Edition.

Bols PL. (1978). *The Isoerodent Map of Jawa and Madura*. Belgium Technical Assistance Project ATA 105. Soil Research Institute, Bogor.

The Ministry of Forestry, Ditjen RRL. (1986). *Guidance Implementation Making Field Technical Plan of land rehabilitation and soil conservation.* Jakarta (ID): Ministry of Forestry.

Hammer WI. (1978). *Soil Conservatioan Report INS/78/006*. Technical Note No. 7. Soil Research Institute, Bogor.

Hammer WI. (1981). *Final Soil Conservation Report*. Center For Soil Research, Bogor.

Hardjowigeno S, Sukmana S. (1995). *Determination of Erosion Hazard Level*. Bogor (ID): Center for Soil and Agroclimate Research.

Hardjowigeno S, Widiatmaka. (2001). *Land suitability and Land Use Planning.* Soil Departement, Faculty of Agriculture, Bogor Agricultural University.

Ispriyanto R. (2001). Erosion in intercropping plantation of Pinus merkusii Jungh. et de Vriese stand of 1 year (Case study in KPH Tasikmalaya, Perum Perhutani Unit III Jawa Barat) [Skripsi]. Bogor (ID): Faculty of Forestry, Bogor Agricultral University.

Lodongsalu DT. (2007). Analyze of erosion prediction, sedimentation, and run-off using AGNPS model base on geographis information system in Sub Watershed of Jeneberan, Province of South Sulawesi [Skripsi]. Bogor (ID): Faculty of Forestry, Bogor Agricultural University.

Purwowidodo. (1999). *The subject matter of Soil Conservation in Forest Area*. Bogor (ID): Forest Influence Laboratorium, Departemen of Forest Management, Faculty of Forestry IPB.

Ramadhon M. (2009). The rate of erosion in area of former forest harvest (case study in UIPHHK-HA PT. Austral Byna, Province of Central Kalimantan). [skripsi]. Bogor: Faculty of Forestry. Bogor Agricultural University.

Setiawan BI. (1999). Land Use Planning For Cigulung Maribaya Sub Watershed Using ANSWERS Model. Bogor: In Proceeding of International Workshop on Sustainable Resource Management for Cidanau Watershed. Bogor (ID): RUBRD- UT/IPB.

Siddik IS. (1994). Run-off and erosion in natural forest and timber estate in PT Wirakarya Sakti Province of Jambi [Skripsi]. Bogor (ID): Faculty of Forestry, Bogor Agricultural University.

Winderiaty. (2000). Study of effectiveness using cross-drain in reduction erosion and run-off in skid trail: case study in HPH PT Kulim Company Province Riau [Skripsi]. Bogor (ID): Faculty of Forestry, Bogor Agricultural University.

Wischmeier WH, Smith DD. (1978). *Predicting Rainfall Erosion Losses*. Agric Handb. 573. Washington DC (US): Agriculture Research Service.