

Application Usle and Gis Tool to Predict Soil Erosion Potential and Proposal Land Cover Solutions to Reduce Soil Loss in Tay Nguyen

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Key words: Soil erosion, Universal Soil Loss Equation (USLE) model, GIS

SUMMARY

Soil erosion is the main reason of the soil degradation in the mountain and plateau areas in Vietnam. Soil in Tay Nguyen are losing productivity because erosion. This research was used the Universal Soil Loss Equation (USLE) was established by Wischmeier W.H and Smith D.D, together with Geographical Information System (GIS) tool and soil profile in the fields to establish soil erosion potential map and assess soil loss level in each part of Tay Nguyen. The soil erosion level I was occupied 79,1% of the total area; the soil erosion level II was hold 16,5% of the total area; the soil erosion level III was occupied 0,39% of the total area; and each or the level IV and V weren't over 1% of the total area. Tay Nguyen can be divided into three soil erosion zones according to the average soil unit erosion potential, that were the North, the Center and the South zones. In the North zone, the average soil unit erosion potential was predominating from 200-600 ton/ha/yr. In the Center zone, the average soil unit erosion potential was predominating from 0-100 ton/ha/yr. In the South zone, the average soil unit erosion potential was predominating from 200-400 ton/ha/yr. In Tay Nguyen can be applied four principles for protecting soil avoid erosion that are principle 1, using land cover (including vegetation and cultivate method) as a the protected cover for soil; principle 2, using terraced field in the slope land; principle 3, planting the suitable vegetation or crop for each soil unit; principle 4 is to ensure for slope land has dense vegetation cover during the rain reason.

Application Usle and Gis Tool to Predict Soil Erosion Potential and Proposal Land Cover Solutions to Reduce Soil Loss in Tay Nguyen

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1. INTRODUCTION

The Universal Soil Loss Equation (USLE) was established by Wischmeier W.H and Smith D.D since 1978, it is applied in many areas in the world. The main coefficients of this equation are including rainfall, soil erodibility, slope, vegetation, and cultivate method. However, the values of these coefficients are rather difference in each area, because they are presented for these conditions, their inter-characteristics and their interaction between them in each area.

Tay Nguyen lie down in the Central South of Vietnam, stretch out from $107^{\circ}17'30''\text{E}$ - $108^{\circ}59'14''$, and $11^{\circ}54'$ N to $15^{\circ}10'$ N. The total area is approximate 5.5×10^6 ha. It is a biggest regional plateau of Vietnam and contains Kontum, Gialai, Daklak, Daknong and Lamdong provinces. Tay Nguyen has three big plateaus (Playcu, Buon-me-thuot and Dilinh). The average of the altitude is from 500 m - 1500 m, the lowest of altitude is from 100 - 200m, and its has 2 highest mountains, that are Ngoc-linh (with the top of the mountain is 2598m height) and Chu-yang-sin (with the top of the mountain is 2405m height). The condition of the topology is rather complicate; the degree of topological partition is rather strong and in the East is stronger than in the North. The degree of slope can be divided into 5 levels, the degree of the slope from $0-3^{\circ}$ is occupied 59% of the total area; the degree of the slope from $3^{\circ}-8^{\circ}$ is occupied 15% of the total area; the degree of the slope from $8^{\circ}-15^{\circ}$ is about 12% of the area, and they are concentrated in Dak-nong; the degree of the slope from $15^{\circ}-25^{\circ}$ is approximate 11% of the total area, and they are distributed in the north of Da-lat City, Lac-duong, Sa-thay and Dak-glei districts; the degree of the slope higher 25° is is occupied only 2% of the total area and they are distributed around Da-lat City and in the high mountains. The topological condition is high affected to the potential soil loss in Tay Nguyen. Other soil loss coefficient is rainfall. This region has dried and rain reason. The average of rainfall is 1900 mm per year. The rain reason is from June to October, they are occupied from 85-90% of the total volume of rainfall in year, so the soil loss by rainfall and slop are big problem. In the dried reason, the water in soil is exhausted, particular in the bazan plateaus, so the soil loss by wind is happened.

Soil erodibility is one of the main coefficient affect to the soil loss in the area. In the study area has 6 main group soil types, that are Flovisols (FL); Acrisols (AC); Luvisols (LV); Ferralsols (FR); Alisols (AL), etc. they are include 17 main type soils. Some of them have K coefficients are rather high, such as, Calcic Luvisols, Chromic Luvisols, Rhodic Ferralsols, Xanthic Ferralsols and Gleysols. But the amount of the soil loss is much depends on the steep slope, the rainfall and cover. In fact, these soil types had the amount of the soil loss range from weak to strong in many place because the difference of the slope, rain and cover condition. The soil erosion in Tay Nguyen was also depending on the cultivated method, especial in the slope areas, because this region are concentrated the ethnic people, such as Bana, Xo-dang, Gia-rai, Co-ho, Ma and Mo-nong. They still keep the burnt over land for cropping, so the soil erosion was strong in this type of fields.

So that, Although the slope below 15° is hold 87% of the total area and the soil layer is thicker than 100 cm that is occupied 43,5% of the total area but 131,000 ha of land was loss of the productivity [5]

The assessment of the soil loss potential is required for land use planning. It is needed information for controlling soil erosion and degradation in Tay Nguyen. This article concentrated on perdition soil loss potential in Tay Nguyen based on three main affected factors that are R; K; and LS. The output of the soil loss potential, together with the cover factors (include vegetation and cultivate) were role to proposal solutions to control and reduce the soil loss in the study area.

2. METHODOLOGY AND METHODS

2.1 Universal Soil Loss Equation apply for Tay Nguyen plateau

2.1.1 The Universal Soil Loss Equation

The USLE was established by Wischmeier W.H and Smith D.D since 1978, it is applied in many areas in the world. It is described by factors, they are following:

$$A = R.K.L.S.C.P \quad (1)$$

- A represents the potential long term average annual soil loss in tons per acre per year.
- R is the rainfall and runoff factor by geographic location
- K is the soil erodibility factor
- LS is the slope length-gradient factor; L is the length of the slope steepness, its unit is m; and S is slop angle, LS unit is radian
- C is the crop/vegetation and management factor
- P is the support practice factor

2.1.2 The coefficient of the factors for assessing soil erosion in the Tay Nguyen Plateau in the USLE model

This research assesses and predicts the potential of the soil loss in the Tay Nguyen. Three of the coefficients of the USLE that are R, LS and K factors were integrated. The C and P factors are as the solutions to reduce the soil loss in the study area.

R factor is the coefficient of the average erosion by rain (J/m^2). Rain is a direct impact to the surface of soil; its kinetic energy is destroying the soil structure and brings the soil components together with runoff water.

According to Wischmeier and Smith (1978), the R coefficient is calculated based on maximum rain volume in 30 minute, the equation is following:

$$R = EI_{30}/1000 \quad (2)$$

- In which: E is kinetic energy of the rain (J/m^2)
- I is the maximum rain volume in 30 minute (mm/h)

Depend on aim of the research, the E factor can be calculated in whole year, month or each rain. The equation is following:

$$E_i = (11,89+8,73.\log I_i)N_i$$

- In which E_i is kinetic energy of the rain i

- li Intensity of the rain i
- Ni Volume of the rainfall i

However in Vietnam and also in many other countries, to record enough number of the Ei is difficult, so the equation (2) is hardly applied in many areas as Vietnam. Researchers give other solution for R factor. It was suggested calculating by the average rainfall year or month. Almost of the researchers given the correlate coefficient in this case is from 0.8 – 0.9 [2] According to Ha N.Tr (1996), the R coefficient can be calculated based on the average rainfall year, the equation is following:

$$R = 0,548257P - 59,9 \quad (3)$$

In which P is the average rainfall year (mm/year)

In Tay Nguyen, the rainfall characteristics were collected from 5 weather stations in Tay Nguyen and its vicinity (table 1). And the value of the R coefficient of Tay Nguyen region was calculated by equation (3).

K factor is the soil erodibility factor. It is the average soil loss in tons/acre per unit area for a particular soil in cultivated. K is a measure of the susceptibility of soil particles to detachment and transport by rainfall and runoff. Texture is the principal factor affecting K, but structure, organic matter and permeability also contribute. Wischmeier gave the equation for calculating K factor as following:

$$100K=2,1.10^{-4}M^{1,14}(12-OS) + 3,25(A-2) + 2,5(D-3) \quad (4)$$

In which,

K is the soil erodibility factor. Its unit is ton/acre.1000.foot.ton.inch.acre⁻¹.h⁻¹

M is weight of size of the grain (according to 2R of the grain).
(%) M = (%limon + % smooth sand)*(100% - %clay)

OS is the content of the organic master in soil, its units is %

D coefficient of the permeability of the soil

A coefficient of the soil structure (shape, arrange and kind of composition or structure)

LS is the slope length-gradient factor. L is the length of steep slope and S is the slope coefficient. They are reprehensive for the relationship between erosion and topological characteristics. L can be obtaining from equation as following:

$$L = (x/22,13)^m \quad (5)$$

In which:

L is the coefficient of the length of the steep slope.

x is the length in meter and m is the exponent. They are belonging to the steep slope, as following:

m	Slope
0,5	>= 5%
0,4	3% - 5%
0,3	1% - 3%
0,2	<1%

S coefficient were calculated by the following equation, and its unit is percent (%)

$$S = (0,43 + 0,30S + 0,043s^2)/6,613 \quad (6)$$

LS factors are presented for topographical condition relates to soil loss; they can be calculated by the topographical data, such as DEM and its derivation. These tools can be formed quickly and exactly in GIS software.

2.2 Application GIS tools

2.2.1 Establishing GIS database

The database of the soil erosion assessment are include data types, they are following

- Topological data
- Hydrological system
- Rainfall
- Soil map
- Auxiliary data: They are land-use/cover; administrative and catchments boundary, etc.

2.2.2 Spatial analysis tools and running USLE model in GIS software

The USLE can carry out in GIS. The coefficients of the module and their maps can be achieved by using GIS tools and input data from the database. Figure 1 showed the main steps from input data (include average rainfall, DEM, Soil type) to calculate R, LS, K coefficients, to created the outputs that are soil erosion potential and soil erosion zoning.

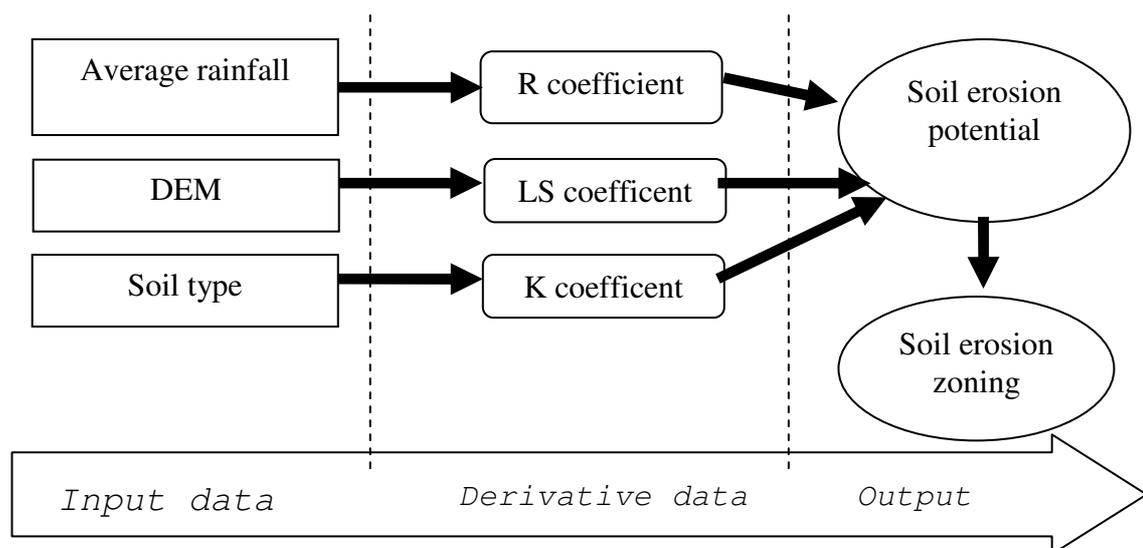


Figure 1: Processing carrying out of the USLE module in GIS

3. PREDICTING SOIL EROSION AND DISCUSSION

3.1. The coefficient of the R factor of the soil erosion by rain in Tay Nguyen

The rainfall of Tay Nguyen is seasonal. And the amount of rainfall wasn't equal distribution in the whole area. The average rainfall is around 2000 mm per year (table 1). However, the affecting of the R coefficient on the soil loss is depending on the number of heavy rainfall day per year and insensitive rain. The characteristic of rainfall are affected to R factor, also the soil loss in the study area. Table 2 showed the R coefficient in Tay Nguyen. The R value is from 300-2100, its can be divided into 4 levels: the first is below 700, that is occupied 60% of the total area, they were distributed in Lam-dong and Dak-nong, and lie down as a range from the South then thinner to the center and thinnest up to the North (figure 2); the second is from 700-1200, they are distributed in the Northwest; and the third is displayed R value is higher than 1200, they are distributed in Kon-plong, Ea-sup and Chu-se in the Northeastern.

Table 1: The characteristic of the rainfall in Tay Nguyen

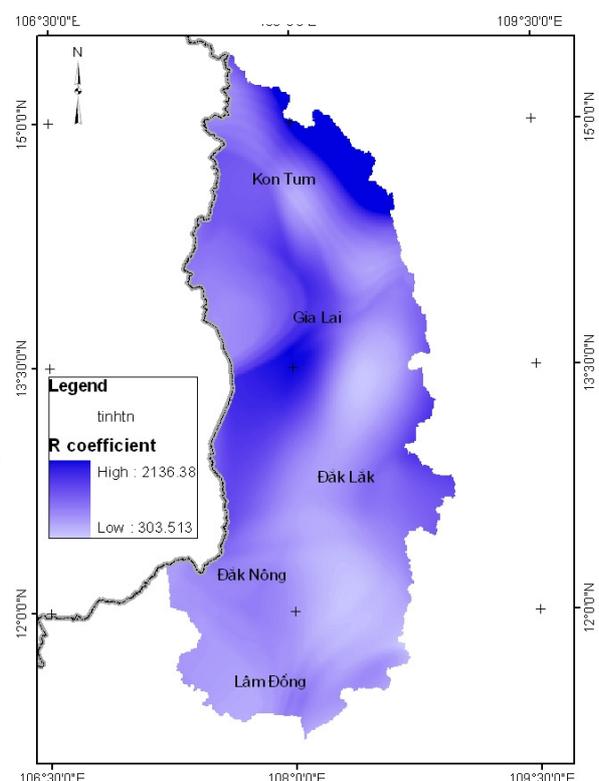
	Kon-tum	Play-cu	Buon-me-thuot	Da-lat	Bao-loc
Average rainfall (mm per year)	1852	2447	1936	1820	2878
The average of number rain days	132	133	138	165	199
The number of days have rain higher than 100 mm	0.4	1.7	0.4	0.0	0.0

Besides the affecting of the rainfall characteristics (as in table 1 showed) to create value of the R coefficients in the study area. Some of the physical conditions were also impact to the R factor. They are called auxiliary data, such as the elevation, direction of the mountain side, and wind direction, etc, because they are affected and make the difference of the distribution of the rainfall characteristics into many pieces. In fact, the relationship between R and soil loss were closely with the steep of the slope and cover, including vegetation and cultural method [3]. GIS tool had role to interpolate and integrate all of the relate data by the algorithms and their weights to create the R coefficient map for the study area.

Table 2: The coefficient of R factor in Tay Nguyen

Level	R value	Area (ha)	% the total area
1	300 – 500	1257840	23.04%
2	500 – 700	2194674	40.20%
3	700 – 1200	1827716	33.48%
4	> 1200	179283	3.28%
Total		5459513	100.00%

Figure 2: R coefficient map



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2.3 The coefficient of K factor of the soil erodibility

Tay Nguyen has 6 main groups of soil type as according to FAO-UNESCO classification, those are Fluvisols, Acrisols, Luvisols, Ferralsols, Leptosols, Gleysols, etc. They have total of 17 main kinds of soil type. In fact the soil erodibility (K) for each soil type is depend on characteristics of the soil that are the soil quality, organic matter, permeability, etc. and the other environmental conditions, such as, slope and land cover. All of these difference conditions are stored in the soil map and its database in the GIS database.

In this article, K coefficient was calculated based on the equation (4) and soil profiles in fields, and integrated with auxiliary data. Table 3 was showed the K coefficient obtained from the field trips and soil profile. K coefficient was grouped in the table 4. Figure 3 showed the distribution of the value of K coefficient in the geo-spatial. It displayed the high K value from 0.35-0.52, they were distributed in the South, then run to the center of the study area, they were occupied 25% of the total area (approximately 1.46 million ha). The lower and lowest of the K value was below 0.25 hold 68% of the total area (approximately. 3.72 million ha). They were distributed in almost of the North and some part of the center of the study area. The K value from 0.25-0.35 were only take of 7% of the total area (approximately 0.38 million ha). They are distributed very disperse.

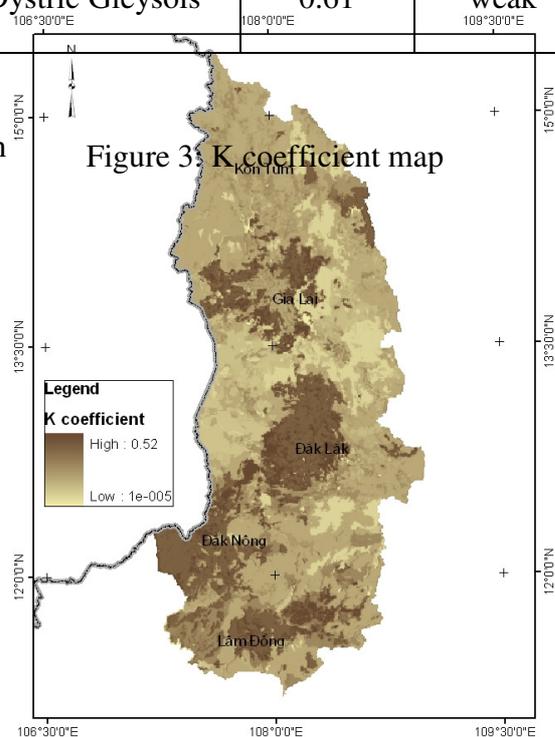
Infact, the Rhodic Ferralsols is largest occupied in Tay Nguyen, it hold 19,76% the total area. The K coefficient of this soil type was rather high, it is from 0.35 – 0.45. But its distribution didn't the same place with high rainfall and steep slope areas, so the amount of its soil loss wasn't high.

Table 3: The K coefficient of some main soil types in Tay Nguyen

Vietnamese soil symbol	Vietnamese soil type	FAO soil symbol	FAO-UNESCO soil type	K coefficient	Status soil erosion in the fields
P	Nhóm đất phù sa	FL	Fluvisols		
Pbc	Đất phù sa được bồi chua	FLd	Dystric Fluvisols	0.46	weak
Pc	Đất phù sa không được bồi chua	FLd	Eutric Fluvisols	0.3	weak
Pg	Đất phù sa Glay	FLg	Gleyic Fluvisols	0.56-0.48	weak
Pf	Đất phù sa có tầng loang lổ	FLb	Cambic Fluvisols	0.31	weak
Py	Đất phù sa ngòi suối	FLd	Dystric Fluvisols	0.44	weak
X	Nhóm đất xám		Acrisols		
X	Đất xám trên phù sa cổ	ACh	Haplic Acrisols	0.15-0.34	strong
Xa	Đất xám trên đá Macma acid và đá cát	ACh	Haplic Acrisols	0.14	strong

Xq	Đất xám trên đá cát kết	ACa	Areni Acrisols	0.28	strong
B	Nhóm đất bạc màu				
B	Đất xám bạc màu trên phù sa cổ	ACh	Haplic Acrisols	0.1	strong
Ba	Đất xám bạc màu trên đá Macma acid và đá Cát	ACh	Haplic Acrisols	0.1	strong
R	Nhóm đất đen	LV	Luvisols		
Rk	Đất đen trên sản phẩm bồi tụ của đá Bazan	LVk	Calcic Luvisols	0.26-0.48	weak
Ru	Đất nâu thẫm trên sản phẩm đá bột và đá Bazan	LVx	Chromic Luvisols	0.29-0.52	Medium
F	Nhóm đất đỏ vàng		Ferralsols		
Fk	Đất nâu đỏ trên đá Bazan	FRr	Rhodic Ferralsols	0.29-0.38	weak
Fu	Đất nâu vàng trên đá Bazan	FRx	Xanthic Ferralsols	0.4-0.38	weak
Fs	Đất đỏ vàng trên đá sét và biến chất	ACf	Ferralic Acrisols	0.32	medium
Fa	Đất vàng đỏ trên đá Macma acid và đá cát	ACf	Ferralic Acrisols	0.2-0,23	strong
Fq	Đất vàng nhạt trên đá cát	ACf	Ferralic Acrisols	0.16-0.14	strong
Fp	Đất nâu vàng trên phù sa cổ	ACf	Ferralic Acrisols	0.18	medium
H	Nhóm đất mùn đỏ vàng trên núi	ACu	Humic Acrisols	0.20	strong
D	Nhóm đất thung lũng dốc tụ	GL	Gleysols		
D	Đất thung lũng do sản phẩm dốc tụ	GLd	Dystric Gleysols	0.61	weak

Table 4: Classify K coefficient in Tay Nguyen



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No	K coefficient	Area	% the total area
1	< 0.15	1053943.3	19.30%
2	0.15 - 0.25	2673425.1	48.97%
3	0.25 - 0.35	386252.48	7.07%
4	0.35 - 0.52	1345892.1	24.65%
Tổng		5459513	100.00%

2.4 The coefficient of slope length-gradient factor (LS)

Topographical characteristics are main role in the soil erosion, and the most importance is slope. The slope supplies energy for the transport material down the foot. And it's

also increased the erosion process.

In fact, the topo-condition affected to the soil loss by its characteristics as following:

- If the steep slope increase two time, the soil loss were increased from 2-7,5 time, depending on the soil type and cover.
- The east, southeast, southwest and west mountain sides have the stronger weathered condition than other, so the soil loss in them was from 1.8 – 3.9 times than other.
- In the convex mountain side, the soil loss was higher from 2-3 times than straight mountain side. The volume of the soil loss in the deep-set mountain side and in the terraced fields was inappreciable.

Table 5: The coefficient of LS factor in Tay Nguyen

No	LS	Area (ha)	% of the total
1	0-5	4145977	75.94%
2	5-10	369906	6.78%
3	10-20	465208	8.52%
4	20-30	205532	3.76%
5	30-40	101264	1.85%
6	40-100	134773	2.47%
7	100-500	34678	0.64%
8	500-2000	2175	0.04%
Total		5459513	100.00%

Figure 4: SL coefficient map

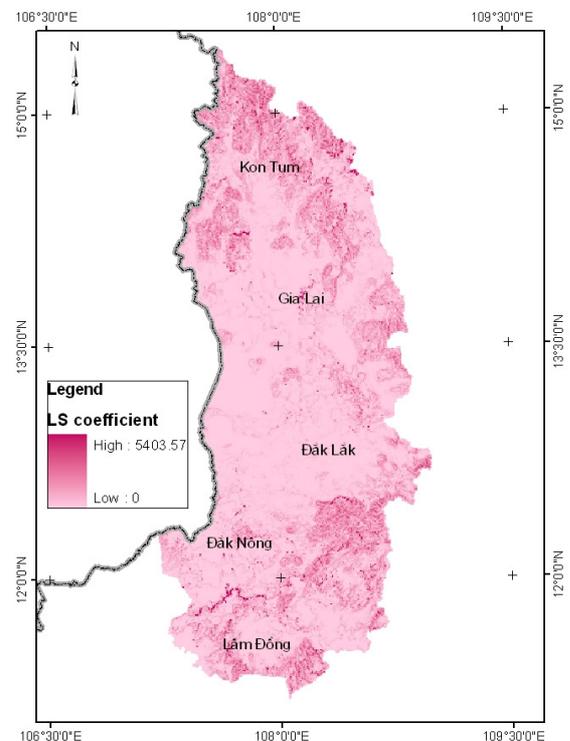


Table 5 showed the output of the LS coefficient in Tay Nguyen. LS value is from 0-2000, they can be divided into 8 levels. The LS value from 0-5 was occupied 76% of the total area (approximately 4.1 million ha), and it was distributed in almost of the West of Tay Nguyen (figure 4). The LS value higher than 100 was take below 1% of the total area (approximately 0.03 million ha). It was distributed in some places in the North and the South-east. The LS from 500- 2000 was occupied only 0.04%, it distributed scattered in DakGlei, Dak Ha, Kbang, Krongbong and Lacduong. These areas are the high sensitive with soil erosion. The rest occupied less than 9% of the total area.

2.5 The soil erosion potential in Tay Nguyen

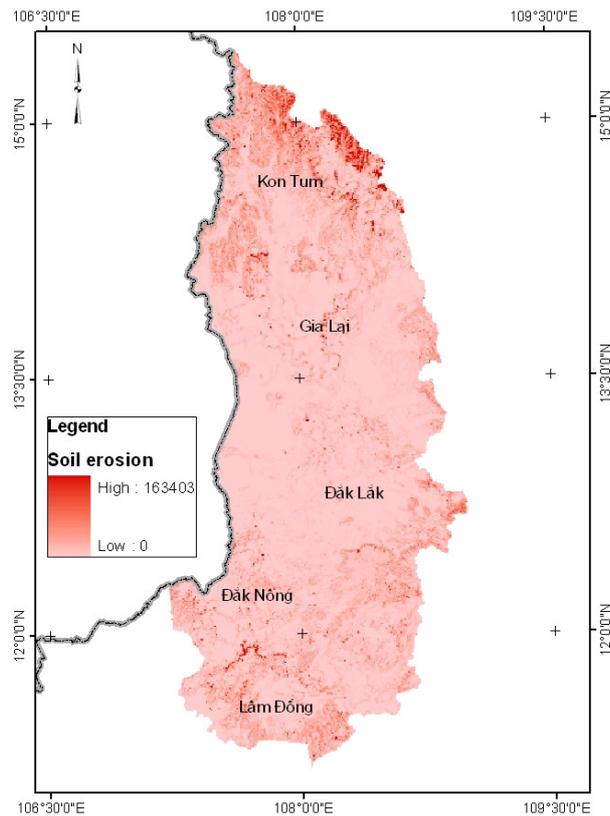
In this research, the soil erosion potential in Tay Nguyen was established by three main affected factors (R, K and LS). The cover includes vegetation and cultural method as a role to control and reduce the soil loss in the study area. So the equation was applied for calculating and mapping the soil erosion is following:

$$P = R.K.LS \quad (7)$$

GIS help to create the R, K and LS coefficients then integrated them as the equation (7). The soil erosion map (figure 4) showed the soil erosion potential in Tay Nguyen. Soil erosion here has 5 levels from the weak to the dangerous. The LS and R coefficients were high affected to the potential of soil loss in Tay Nguyen. The form of the soil erosion map was look rather like the LS and R maps. The soil map or K coefficient map didn't high affect to the soil erosion in this area. Table 6 listed the statistic of the soil loss potential in Tay Nguyen. It showed the weak level (with lower 100 ton/ha/year) occupied 79.1% of the total area (approximately 4.32 million ha). They were outstretched distributed whole in Gialai Daklak provinces and they went along rivers in Daknong and Lamdong provinces. In fact, the steep slope of these areas is from 0-3°. And the rainfall was lowest in the study area. The medium of soil erosion (with 100-500 ton/ha/year soil loss) took about 16.57% of the total area (approximately 0.9 million ha), it was distribute in almost hills and low mountains in all of the plateaus, particular concentrated in Gialai, Daklak and Lamdong provinces. The strong level has potential of 500-1000 ton/ha/year soil loss were occupied 0.39 million ha, it was distributed in Kontum province and Dilinh district (belong to Lamdong province). Each of the very strong and dangerous levels wasn't taking over 1% of the total area. They were distributed in the high steep slope and rainfall, concentrated in the high mountains in Kontum and Konplong Plantau in the Northeastern, and distributed scattered in Daklak and Lamdong provinces in the South-east of Tay Nguyen.

Table 6: The degree of the soil loss potential in Tay Nguyen

Degree of the soil loss potential	Amount of the soil loss potential (ton/ha/year)	The average of the amount of the soil loss potential (ton/ha/year)	Area (ha)	% total area
Weak	< 100	14.2	4318649.2	79.10%
Medium	100 – 500	179.2	904906.2	16.57%
Strong	500 – 1000	707.9	152026.6	2.78%
Very strong	1000 – 1500	1207.2	39539.9	0.72%
Dangerous	> 1500	3713.4	44391.0	0.81%
Total			5459513	100.00%



2.6 Potential soil er Figure 5: Soil erosion potential map in Tay Nguyen

The format of the potential soil erosion data is raster with pixel size is 100m x 100m (equivalent 1 ha). But each of the soil unit covers many of cells that had difference value. The average soil erosion of each soil unit was calculated based on the total of soil loss in its boundary divide to number of cells that it covered. The average soil unit erosion potential were from 0 – 597 ton/ha/yr. The degree of the average soil unit erosion potential was divided based on the average soil unit erosion potential and the statistic of the soil erosion potential (table 6). The average soil unit erosion potential had 5 levels that are from 0-100 ton/year/ha; 100-200 ton/year/ha; 200 - 300 ton/ha/yr; 300-400 ton/ha/yr and 400-600 ton/ha/yr. According to these levels, Tay Nguyen could be divided into 3 zones that were the North, Center and the South.

- The North zone covered whole of Kon-tum province and Chu-Pah, Lagrai, Dakdo and KBang belong to Gia-lai. Their average soil unit erosion potential was from 200-600 ton/ha/yr was predominating.
- The Center zone covered Gia-lai province and Ea-sup, Ea-Hleo, Krong-nang, Eakar, Krong-pawk, Buon-me-thuot belongs to Dak-lak, and Cu-jut, Dak-mil belong to Dak-nong. Their average soil unit erosion potential was from 0-100 ton/ha/yr was predominating.

- The South zone covered Lamdong province and Krong-bong, Lak, MD Rak belong to Dak-lak, and Dak R'lap, Dak-nong, Đak-song, Krong-no belong to Dak-nong. Their average soil unit erosion potential was from 200-400 ton/ha/yr was predominating.

4. PROPOSAL LAND COVER SOLUTION TO REDUCE SOIL LOSS IN TAY NGUYEN

4.1. Relationship between land cover and soil erosion in Tay Nguyen

In this research, land cover had three main indicators that are vegetation, Leaf area index (LAI), and cultivated method. The relationship between vegetation, LAI and soil loss in Tay Nguyen was researched by My N. Q. (2005). He built some of the experimental models for main crops in Tay Nguyen, that were coffee, grass, sweet potato, cassava, maize mix bean, dry rice, and peanut. The changing of amount of soil loss in each month, relationship between amount of soil erosion and the steep slopes according to the time periods of the plant grow were monitoring. He had three main considered that are following:

- The average soil erosion was decreased according to increasing of the % LAI.
- The amount of soil erosion was increasing together with the amount of rainfall, but it also depended on the plant grow periods.
- The soil erosion was increasing when steep slope was increasing, however the amount of the soil erosion were decreased when the % of the LAI was increased, this is depend on the crop or time of periods of the plant grow.

4.2. The strategic cultivate to reduce soil erosion in Tay Nguyen

The principles of reduce soil erosion in Tay Nguyen were built based on soil erosion potential, the average soil plot erosion potential, the physical condition and the cultivate methods in the slope land. They are following:

- *Principle 1: using land cover as the protected cover.*
- *Principle 2: using terraced field in the slope land.* If the slop is from 10 – 20⁰, apply the terraced field in every where, even the narrow fields. The path at edge of rice-field must be stable and control landslide. The runoff run through each of the steps should be run zigzag, and the derivations must be keep the lowest speed of the runoff, and its size is belongs to the topological condition and the surface. If the slop is higher than 25⁰, the land cover should be forest or plantation and limited work the soil.
- *Principle 3: planting the suitable vegetation or crop for each soil type.* The Fluvisols is suitable for planting rice, maize, potato, sugar and industrial crop trees; the Acrisols is suitable for planting soybeans, cashew trees; The Luvisols is suitable for planting rice, maize, sugar; The Rhodic Ferralsols should be plant rubber tree, sugar and coffee tree.
- *Principle 4: to ensure for slope land has dense vegetation cover during the rain reason.*

Almost of the area in the North and South zones were strong affected by LS coefficient or R coefficient. And other had the average soil unit erosion potential were high from 300-500, because they were affected by both LS and R coefficients. The method for areas had LS coefficient high is applied terraced field for cultivate. The area with the high average soil unit erosion potential should have the dense cover vegetation during the rain reason. The specific solutions for each level of the average soil unit erosion potential are following:

- The average soil unit erosion potential is below 100 ton/ha/yr was occupied 280 thousand ha in the North zone and 700 thousand ha in the South zone. The main group soils in these areas are including Fluvisols, Ferralsols, Luvisols, Acrisols and Humic Acrisols that can be used normal cultivate method with slope level I and II, and applied terraced field for the level of slope higher, together with plant drought trees and avoid turn over the soil.
- The average soil unit erosion potential from 100-200 ton/ha/yr was occupied 400 thousand ha in the North zone and 800 thousand ha in the South zone. The main soil groups in the slope level I, II and III are including Fluvisols, Ferralsols, Acrisols and Humic Acrisols. In the slope level I use suitable plant for soil type together with the suitable time for cultivating to ensure dense leaf cover during the rain reason; applied terraced field for areas had slope level II and III. The main group soil in the slope level IV and V area only Ferralsols and Humic Acrisols soils, these areas are only suitable for afforesting and protecting forests. And avoid turn over the soil.
- The average soil plot erosion potential from 200-300 ton/ha/yr was occupied 240 thousand ha in the North zone and 200 thousand ha in the South zone. The soil erosion was strong affected by R coefficient, so avoid turn over the soil and strengthen cover for land. The main soil groups in the slope level I are appear Fluvisols, Ferralsols, Humic Acrisols, Gleysols and Acrisols soil types. The main soil groups in the slope level II and II are appear Ferralsols, Humic Acrisols, and Acrisols that are strong affected by SL and R coefficients, so the terraced field must be applied in these soil types, particular for in the heavy rainfall areas. In the slope level IV and V areas must be afforested that is the best solution.
- The average soil unit erosion potential from 300-600 ton/ha/yr was occupied 300 thousand ha in the North zone and 35 thousand ha in the South zone. The main soil groups are Fluvisols, Ferralsols, and Humic Acrisols. These area should be plant long-time industrial crops and afforest. Application terraced field in the slope area and strengthen cover for land.

Almost of the area in the Center zone had the average soil unit erosion potential was from 0-100 ton/ha/yr. However some of the areas had the average soil unit erosion potential from 400-500 ton/ha/year because the K coefficient were high, such as, La-grai, Dak-doan, Mang-yang, Duc-co, Chu-se, Chu-prong belong to Gia Lai, and Eahleo, Krong-nang, Krong-buk, Cu-Mgar, Buon-me-thuot, Krong-rak belong to Dak-lak. In the strong soil erosion potential, particular in the areas had both K and R coefficients were high, should be care on the method for reducing soil loss by erosion. Some of the suggestions for protecting soil are following:

- The average soil unit erosion potential from 0-100 ton/ha/yr was occupied 2,134 thousand ha. The main soil groups are including Fluvisols, Ferralsols, Humic Acrisols, Luvisols and Acrisols, in addition Gleysols. The slope level I was

occupied 1,712 thousand ha and the total area of the slope level higher than level II were hold very small. In this area, the crop, plant and cultivate method are main belong to the soil type and plant grow.

- The average soil unit erosion potential from 100-200 ton/ha/yr was occupied 236 thousand ha. The mail soil groups are the same above. But the total area of the slope level III - V were occupied 50% the total area (approximately 160 thousand ha), these areas need terraced field for cultivate.
- The average soil unit erosion potential from 200-300 ton/ha/yr was occupied 30 thousand ha with the mail soil groups are Fluvisols, Ferralsols, Humic Acrisols, Haplic Acrisols and some area the soil were erode and expose stone. These uint soils were eroding by the K and R coefficients were high. So that they are suitable for cultivating terraced field. In the slope area should be afforested.
- The average soil unit erosion potential from 300-500 ton/ha/yr was occupied only 1.4 thousand ha. This area must be afforested and avoid turn over the soil.

5. CONCLUSIONS AND RECOMMENDATIONS

The soil loss potential map can be achieved by integrating the erosion factors (R, K and LS). The partitions of the soil loss are created by the difference of the rainfall, runoff and topological conditions. GIS is a power-full tool for building the coefficient maps and integrating them to establish the soil loss map.

The soil loss in Tay Nguyen was much depends on the steep slope and rainfall. The level strong and very strong soil loss were distributed almost fix with in the areas that had the high of rainfall and steep slope. The soil type wasn't strong impact to the soil loss here. All of the experience modules and soil profiles in field were also showed the close relationship between amount of soil loss with the steep slop and rainfall. The cover are include type of vegetation, % of the LAI, grow time period, and cultivate way, as the control method to find out the solutions to reduce the soil loss based on the soil potential map.

The average soil erosion potential for each of soil unit can get from the soil erosion potential. So that, Tay Nguyen can be divided into three zones, that are the North, the Center and the South zones. The average soil erosion potential was from 200-500 ton/ha/yr in the North zone, from 0-100 ton/ha/yr in the Center zone and from 200-400 ton/ha/yr in the South zone. The average soil erosion potential for each soil unit in each zone is more effect for solutions to reduce soil erosion in Tay Nguyen thought collect suitable crops, seasonal, and cultivate method.

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