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INTEGRATION OF OF GEOGRAPHIC INFORMATION SYSTEMS AND UNIVERSAL SOIL LOSS EQUATION FOR SOIL EROSION ASSESSMENT IN DONG PHU DISTRICT, BINH PHUOC PROVINCE, VIETNAM

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INTRODUCTION

In earth science, erosion is defined as incorporation and transportation of material by a mobile agent, such as water, wind, or ice (Lutgens, 2016). Thus, soil erosion is a natural process that occurs regularly and continuously, affecting the characteristics and properties of the soil. Erosion can occur in all different types of terrain. Agricultural scientists believe that soil erosion is the process in which topsoil is removed due to physical factors such as water and wind or factors related to farming activities. Thus, erosion is considered one of the causes of soil degradation, especially in sloping areas. Factors affecting soil erosion are mainly terrain slope, soil characteristics, rainfall, vegetation cover characteristics and farming techniques. In recent years, climate change is becoming more evident in Vietnam such as the increase in temperature, changes in rainfall and sea level rise. All of which can be potential causes for exacerbation of soil erosion.

Dong Phu is a district located in the southern major economic zone of Binh Phuoc province. It offers a lot of advantages in terms of territory, natural resources, people, and economic potential. Dong Phu district is an important location in Binh Phuoc province, with the National Highway 14 serving as an arterial artery connecting Dong Phu to the Central Highlands, Ho Chi Minh city and Cambodia. Soil deterioration is becoming more likely as a result of socioeconomic development, population growth, and changing farming circumstances. As a result, research to assess soil erosion is critical.

RESEARCH METHOD

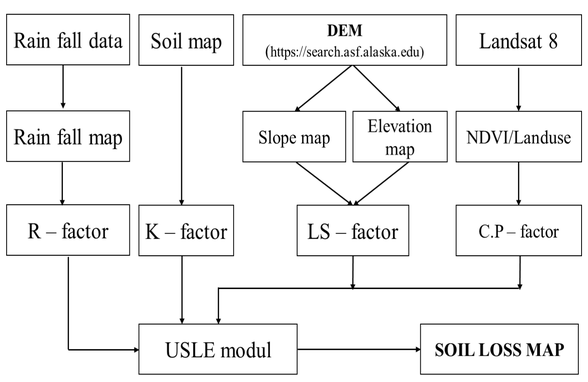

Figure 1. Flowchart of the methodology

To prepare a soil erosion map, the study used USLE and GIS models. Factors affecting soil erosion are performed according to USLE developed by Wischmeier and Smith in 1978 (equation 1):

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

In which:
A: Average annual soil loss (ton/ha/year)
R: Rainfall erosivity factor
K: Soil erodibility factor
L x S: Slope length-gradient factor (m)
C: Cropping management factor
P: Conservation practices factor

RESULT AND DISCUSSION

a. Rainfall erosivity factor

$$R = 0.548257 \times M_{TB} - 59.9 \quad (3)$$

In which: (R) rainfall erosivity (J/m2); (P) annual average rainfall (mm/year); From equation (1), a map of R was developed for the district, showing value in range of 872.13 – 1091.43.

b. Soil erodibility (K)

Table 1. K factor of different soil types in Dong Phu District

N_o	Type	WRB (World Reference Base for Soil Resources)	K – factor	Area (ha)	Ratio (%)
1	D	Umbric Gleysols	0.32	1,000.90	1.07
2	Fk	Acric Ferralsols	0.20	22,356.54	23.9
3	Fp	Haplic Acrisols	0.23	8,315.88	8.89
4	Fs	Haplic Acrisols	0.27	39,783.41	42.53
5	Fu	Acric Ferralsols	0.21	8,549.74	9.14
6	X	Haplic Acrisols	0.22	13,535.53	14.47
	Total			93,542.00	100.00

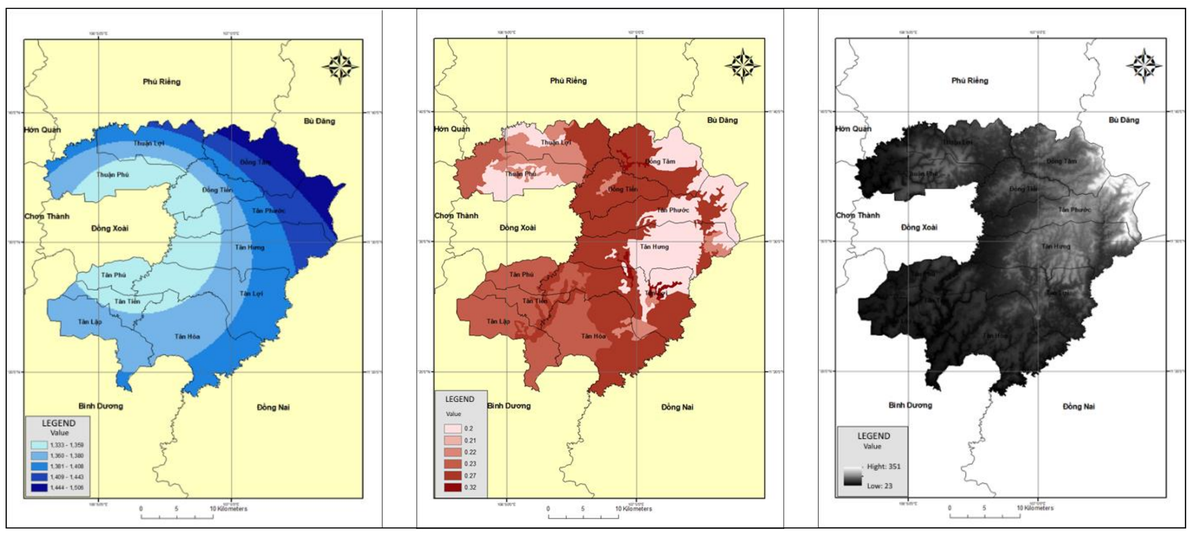

Figure 2. R factor

Figure 3. K factor

Figure 4. DEM

c. Slope-length and steepness

LS factor distribution map is developed from digital elevation model (DEM) and Wischmeier and Smith (1978) equation. DEM (Figure 4) is acquired from https://search.asf.alaska.edu/ (equation 4).

$$LS = \left(\frac{X}{22.13}\right)^n * (0.065 + 0.045 * S + 0.0065 * S^2) \quad (4)$$

In which: (X) slope length in m, (S) steepness in %; (n) experiment coefficient, n = 0.5 if S > 5%; n = 0.4 if 3.5% < S < 4.5%; n = 0.3 if 1% < S < 3.5%; n = 0.2 if S < 1%.

Table 2. LS distribution

N_o	LS factor	Area (ha)	Ratio (%)
1	0 – 0.2	56,134.55	60.01
2	0.2 – 0.5	9,840.62	10.52
3	0.5 - 1	16,762.73	17.92
4	1 – 1.5	7,240.15	7.74
5	>1.5	3,563.95	3.81
Total		93,542.00	100.00

d. Crop management factor

Map of crop management factor (C) is developed from normalized difference vegetation index (NDVI – Figure 7) based on equation of Durigon (2014) as follow (equation 5):

$$C = \frac{-NDVI + 1}{2} \quad (5) \quad \textit{in which} \quad NDVI = \frac{NIR - RED}{NIR + RED}$$

In which:
NIR and RED: reflection on near-infrared and red channels
In this study, data was collected from Landsat 8 image downloaded from: https://earthexplorer.usgs.gov/.

Table 3. Crop management factor (C)

No	C factor	Type	Area (ha)	Ratio (%)
1	0.0	Water (lake)	1,159.92	1.24
2	0.08	Forest, perennial plant	19,662.52	21.02
3	0.2	Rubber plant	59,081.13	63.16
4	0.3	Fruit plant	5,893.15	6.30
5	1.0	Other land	7,745.28	8.28
		Total	93,542.00	100.00

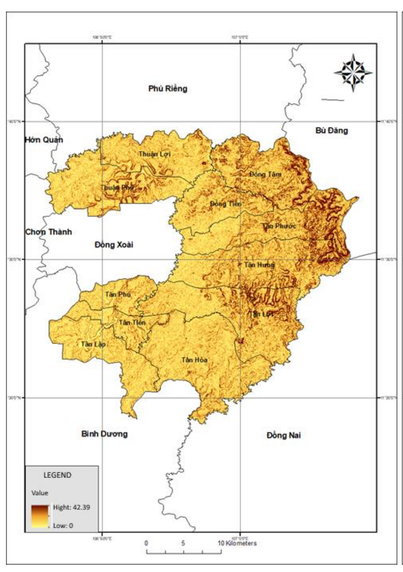

Figure 5. Slope

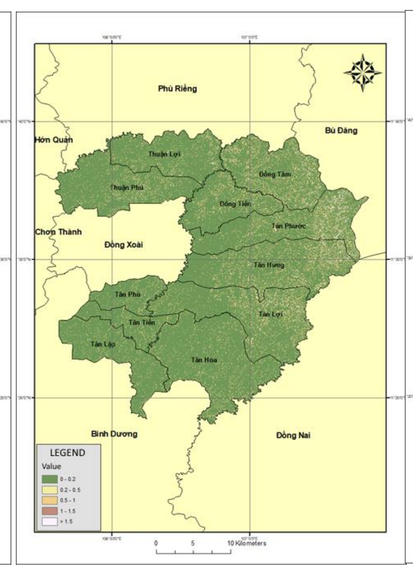

Figure 6. LS factor

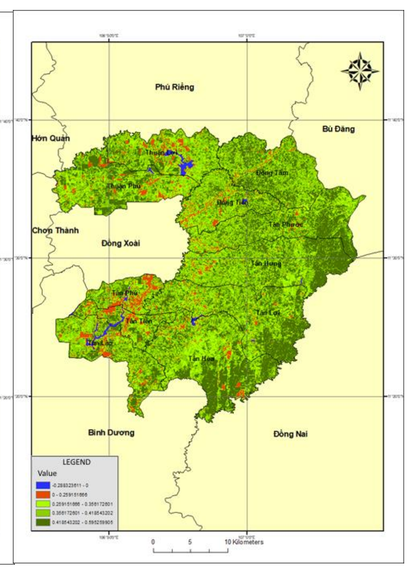

Figure 7. NDVI

e. Farming conservation practice (P)

Table 4. P by steepness

No	P factor	Slope	Area (ha)	Ratio (%)
1	0.5	< 8	60,699.40	64.89
2	0.6	9-12	26,799.78	28.65
3	0.7	13-16	4,031.66	4.31
4	0.8	17-20	1,328.30	1.42
5	0.9	> 20	682.86	0.73
	Total		93,542.00	100.00

g. Assessment of soil erosion status

It can be seen that the current erosion status in Dong Phu District is divided to the following levels (Table 5 and Figure 10):
- Level I (no or negligible erosion): accounting for 63,645.98 ha (68.04% of the entire area), distributed throughout the area, and with low terrain factors (LS).
- Level II (mild erosion): accounting for 20,878.57 ha (22.32%), sandwiched between Level I, Level III and Level IV land.
- Level III (medium erosion): most concentrated in the North, the central region and the South with an area of 6,791.15ha (7.26%).
- Level IV (high erosion): distributed in the entire district, accounting for 1,917.61ha (2.05%).
- Level V (extreme erosion): accounting for 308.86ha (0.33%).

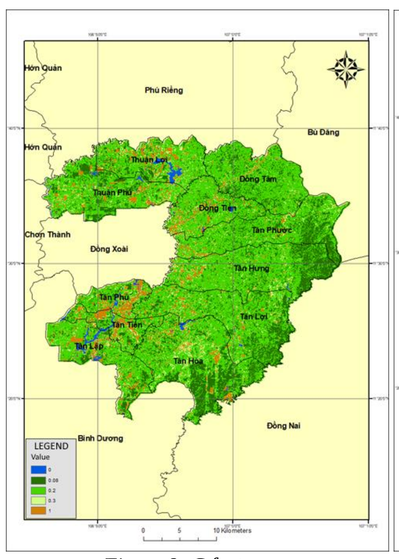

Figure 8: C factor

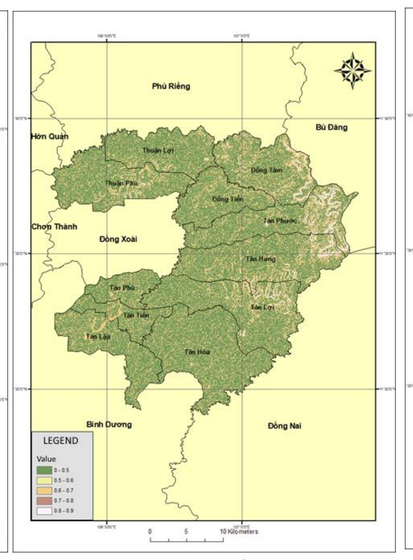

Figure 9. P factor

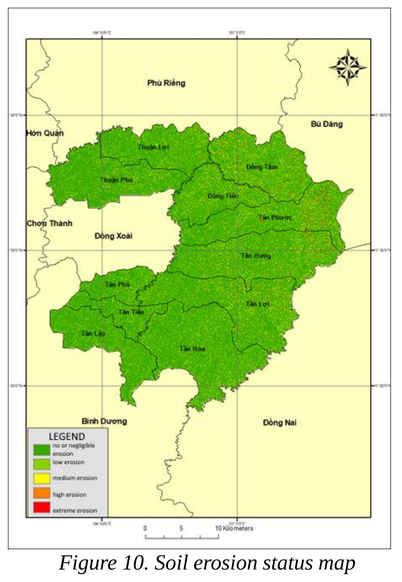

Figure 10. Soil erosion status map

CONCLUSIONS

The erosion map of Dong Phu district shows that in areas with high vegetation cover (high NDVI index), erosion value is low. Erosion in Dong Phu District is uneven among areas. In most of the district, area of negligible erodibility (from 0 to 5 ton/ha/year) is about 84,524.55 ha, accounting for 90.36% of the total land area. Extreme erodibility only accounts for 0.33% of the entire area. Therefore, it is necessary to take measures to prevent erosion especially on sloping land.

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