BUILDING A DECISION SUPPORT MODEL FOR PROTECTION FOREST PLANNING USING GIS AND MULTI-CRITERIA MODEL

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ABSTRACTS

This research aims to integrate the potential soil loss into the regulation of DARD about the classifying the protection forest. Therefore, we tried to produce a pilot and then introduce our steps which can be used as reference procedure for the planners. The result was validated in several workshops between us and planners in Thua Thien Province, and it is confirmed that it is quite useful for making the protection forest classification map.

1. INTRODUCTION

Acdoring to the law on forest development and protection 2004, the protection forest is categorized into 4 types, in which the upper-river protection forest accounts the most area. It is functioning to control water, runoff, reservoirs, flood control, soil protection, and river and reservioir sediment deposition. The circular 38/2005/CT-TTg regulates the forest planning and the decision 61/2005/QĐ-BNN of Ministry of agriculture and forestry uses various criteria to select the protection forest, including rainfall, slope, relative elevation, soil type and properties, and area scale. However, there is a lack of soil erosion layer which should be incoopertated into the model since it is closely related to the function of protection forest.

The soil erosion risk map could be mapped by using the RUSLE model of Wischmeier and Smith, 1978 and then categorized into different classes according to the classification system of Morgan, 2005. The multiple critertial model of Saaty, 1992 can be integrated with GIS to implement the suitability selection model. Therefore, we will combine the criteria set by the decision 61/2005/QĐ-BNN with the soil erosion risk map and the AHP model to make a guideline for selecting the appropriate regions for protection forest planning.

2. OVERVIEW OF PROTECTION FOREST PLANNING IN TERMS OF THE DECISION 61/2005/QĐ-BNN

There are five criteria to identify the critical regions of protection forest as follows.

Criteria 1: Rainfall

Table 1. The influence of rainfall factor

Level	Code	Indicator
Level 1	M_1	- rainfall > 2.000 mm/year, or - rainfall from 1.500 to 2.000mm/year concentrated in 2 or 3 months
Level 2	M_2	- Rainfalltừ 1.500-2.000mm/year, or - Rainfall1.000-1.500mm/year concentrated in 2 or 3 months
Level 3	M_3	- Rainfall< 1.500mm/year or - Rainfall< 1.000 mm/year concentrated in 2 or 3 months

Criteria 2- Slope: There are three main terrains considered in the model:

- Region A: hilly and mountainous with terrain devision > 50m

- Region B: hilly and mountainous with terrain devision from 25 - 50m.

- Region C: hilly and mountainous with terrain devision <25m,

From that, the influence of slope on soil erosion, runoff and water control is devided into three levels:

Table 2. The influence of slope criteria

Level \ Slope \ Region	Code	Slope indicator in terms of terrain		
		A	B	C
Level 1	$\propto_1$	$> 35^0$	$> 25^0$	$> 15^0$
Level 2	$\propto_2$	$26^0 - 35^0$	$15^0 - 25^0$	$8^0 - 15^0$
Level 3	$\propto_3$	$< 26^0$	$<15^0$	$<8^0$

Criteria 3: Relative elevation

Based on the elevation interval between the highest and lowest in the region of upper-river protection forest to categorise into three levels of elevation for various critical levels.

Table 3. The influence of relative elevation criteria

Level	Code	Relative elevation
Level 1	C_1	1/3 of the elevation interval to the upmost mountain
Level 2	C_2	1/3 of the elevation interval in the middle
Level 3	C_3	1/3 of the elevation interval in the bed of the mountain

Criteria 4: Soil

Depending on the soil texture and soil depth, the influence of soil on the critical protection level of forest is devided into three levels:

Table 4. The influence of soil factor on the protection forest

Level	**Code**	**Soil indicators**
Level 1	$Đ_1$	- Sandy soil, mixed sandy soil, average soil depth (depth ≤ 80 cm), or light or moderate soil with the depth <30 cm.
Level 2	$Đ_2$	- Sandy soil, mixed sandy soil, average soil depth (depth > 80 cm), or light or moderate soil with the depth from 30 -80 cm.
Level 3	$Đ_3$	- Heavy or clay soil with the depth > 30 cm, or - Light or average soil with the depth > 80 cm

Criteria 5: The scale of area

The area used to evaluate and identify the critical protection level is the plot, about 100ha.

3. THE STUDY SITE

The study area is located in the mountainous area of Huong Tra district belonging to the Huong River watershed. It is characterized as the hilly region with the total area of 408km^2, accounting for 78 % of the total region. The center of the study site is about 15km from the Hue city. The rainfall changes differently in terms of time, it concentrates from September to December. Ho Kiet (1999) measured soil losses on seven cropping systems from 1996 to 1998 and indicated that annual soil loss rates varied from 18.28 ton/ha^{-1} (dry crops applying soil conservation practices) to 204.56 ton/ha^{-1} (agro-forestry systems) illustrating soil loss rates are very severe.

4. RESEARCH METHODS

The classification of critical level for protection forest used six map layers, including potential soil loss, rainfall, slope, relative elevation, soil depth, and soil texture. The land units are created by intersecting those layers, we consider the land unit as the critical classification unit for protection forest. The level of critical level for protection forest relies on the total scores of each land unit which is identified by the multi-criteria methods (Saaty, 1992 and Huynh Van Chuong, 2009). The final score of each land unit is used to classify the critical level. The score of each criterion is determined by the forest land use planning staffs in Thua Thien Hue province.

5. RESULTS

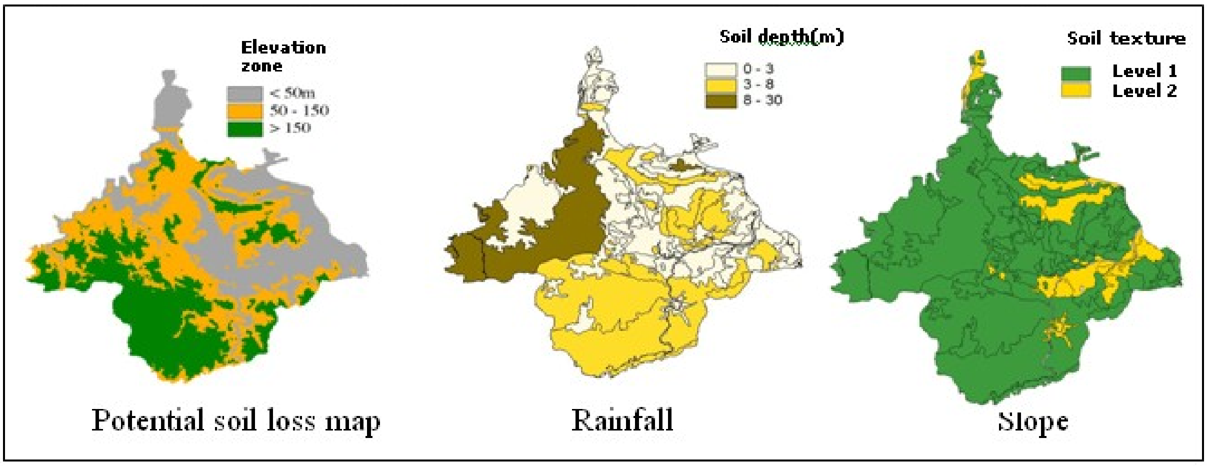
After completing the research, we come up with the steps to produce the classification map of critical level for protection forest as follows:

Step 1: Identify the criteria for classifying the critical level.

As regulated in the decision 61/2005/QĐ – BNN, we selected rainfall, slope, relative elevation, soil depth, and soil texture but also added one more criteria which is potential soil loss map produced by estimating soil loss from the RUSLE model.

Step 2: Collect data and maps related to the selected criteria

Erosion factors within RUSLE model are determined by using remotely sensed data. The rainfall and run-off factor (R) is calculated by using monthly accumulated rainfall from the Tropical Rainfall Measurement Mission satellite and freely downloaded from the website: http://lake.nascom.nasa.gov . The topographic factor (LS) is estimated by using the Digital Elevation Model from the International Center for Tropical Agriculture (CIAT), a member of the Consultative Group for International Agricultural Research (CGIAR). Also, the Landsat ETM+ image in 2010 was downloaded from the Global Observatory for Ecosystem Services. A soil map was obtained from the Department of Science and Techonlogy in Thua Thien Hue province. Each soil polygon is attributed to several soil properties such as organic matter content, soil particle structure, and nutrient content. These data are used to generate the potential soil loss by using the RUSLE equation, and they are also utilized to create thematic maps, including rainfall, slope, relative elevation, soil depth, and soil texture map.



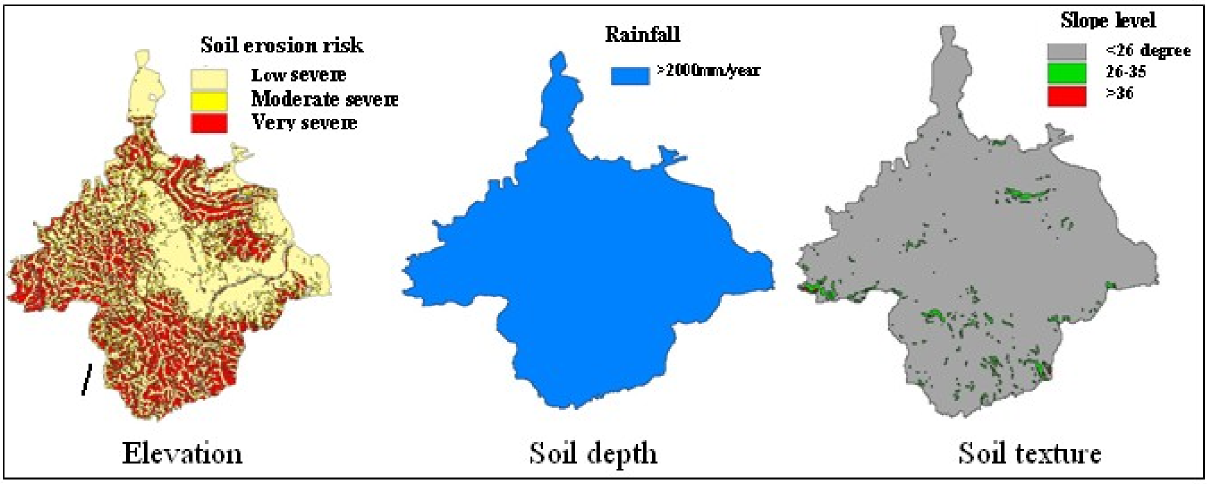


Figure 1: Criteria map for classifiying the protection level

Step 3: Buidling the critical unit map for protection forest

The criticial unit map is created by overlaying those criteria maps. Each critical unit can be characterized with different attributes; therefore they have various influences on the level of protection.

Step 4: Identify the weight of each criterion

The importance of each criterion is determined by consulting the forest planning staffs in the center for forest planning and surveying in the Central Central region in Thua Thien Hue province. Afterthat, it weight is calculated by comparing those criteria in the matrix of Saaty, 1992.

Table 5: Weight calculation for each criterion

Criteria	Potential soil loss	Slope	Elevation	Rainfall	Soil depth	Soil texture	Weight wi
Potential soil loss	1	3	3	3	7	7	0,351
Slope	1/3	1	5	5	7	7	0,268
Elevation	1/3	1/5	1	5	7	7	0,188
Rainfall	1/3	1/5	1/5	1	7	7	0,127
Soil depth		1/7	1/7	1/7	1	1/3	0,011
Soil texture	1/7	1/7	1/7	1/7	3	1	0,036

The importance level of criteria is measured as in the table 6:

Table 6: Score for important levels

Ref	Important level	Socres	Ref	Important level	Socres
1	Equally important	1	4	Much more important	7
2	Less important	3	5	Absolutely more important	9
3	More important	5	6	Interval scores	2,4,6,8

The second important orders are estimated for each criterion as the table 7:

Table 7: Score for each criterion

Criterion	Important levels	Score Xi	Criterion	Important levels	Score Xi
Potential soil loss	Very severe	9	Slope	$>35^0$	9
	Severe	7		$26 - 35^0$	7
	Low severe	5		$< 26^0$	5
Rainfall	> 2000mm/year	9	Elevation	> 150m	9
	1500 – 2000mm/year	7		50 – 150m	7
	< 1500mm	5		< 50m	5
Soil texture	Light soil	9	Soil depth	< 30cm	9
	Moderate soil	7		30 – 80cm	7
	Heavy soil	5		> 80cm	5

The total score for each critical unit of protection forest is calculated as the following equation:

$$Si = \sum Xi * wi \qquad [1]$$

Where:

- Xi is the score of the criterion
- wi is the weight of each criterion

Based on the total score, the critical level for protection forest is classified for each score band:

- S1: very critical – RXY with scores from 8 to 9
- S2: critical – XY with scores from 7 – 8
- S3: less critical – IXY with scores from 5-6
- N: not critical – KXY with scores lower than 5

Step 5: Building the critical classification map for protection forest

According to the total score, the critical unit map is classified as follows:

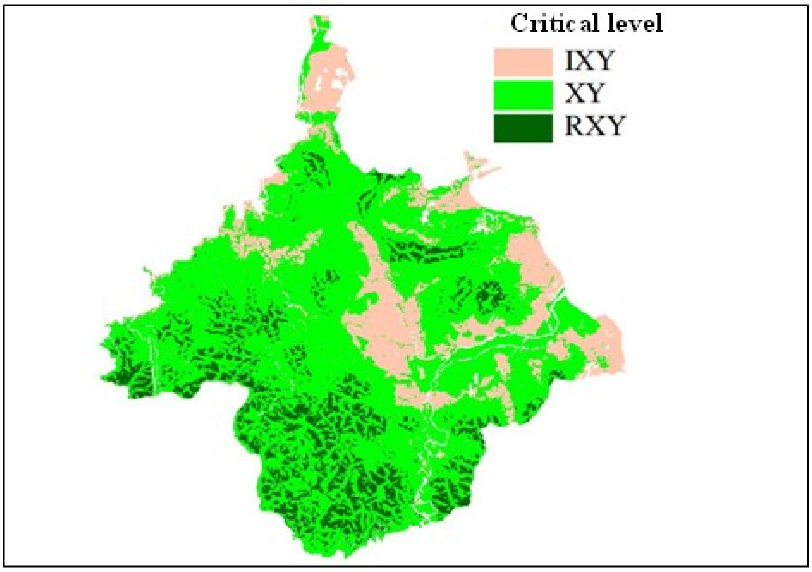


Figure 2: Critical classification map for protection forest

6. CONCLUSION

It is crucial to balance among three types of forests because they are important for the sakes of economic development, environmental protection, and biodiversity conservation, respectively. Determining the most appropriate areas for protection forest will resolve the conflict between the use of production and protection forest, and therefore we can have appropriate land for farmers to develop their economic forest along with relocating the right protection forests. From the available maps, GIS can help planners run the multi-criteria model to produce the important maps for protection forest planning. More importantly, the model integrates the soil erosion risk map into the set of criteria regulated by the misnistry of agriculture and rural development to establish 5 steps to implement the model.

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