APPLYING GIS AND MULTI CRITERIA EVALUATION IN FOREST FIRE RISK ZONING IN SON LA PROVINCE, VIETNAM

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ABSTRACT

One of the reasons responsible for reduce forest cover is forest fire. Fire could damage forest such as: losing vegetation, losing habitat for animals, increasing erosion and it can spread to other areas, especially in the harsh topography. The warmer climate makes the forest fire situation become more complicated with the increase in number and impact of forest fires in Vietnam. Spatial analysis by GIS provides a tool for accurately zoning the area with high risk of forest fire, where the fire frequently begins, or from it fire can easily spread to other places. Forest fire "forecasting" accordingly can be done by studying the factors influencing the occurrence and the dynamic behavior of fire. This study is implemented in Bac Yen District, Son La Province, Northwest of Vietnam due to the historic forest fire happened. In this study, a classified image, digital elevation model, topographic map of the study area were collected and used to extract necessary information of causing factors. Each criterion was assigned different weight, indicating the different level of sensitivity to fire or its fire inducing capability. The innovation of this study is combination of GIS in spatial analysis and multi criteria evaluation in offering various ways to assess criterion weights. Moreover, in this study, the temperature in the dry season is involved so it can clearly estimate the most vulnerable zone. The result expressed the most sensitive area to forest fire, counting for maximum of 45 percent of the total area.

1. INTRODUCTION

In general scale, hot weather plays an important role in lasting the fire. For example, in 2010, hot weather is partly the cause of the long lasting fire in Moscow, Russia which cleared millions of hectares of forest. This dilemma does not only happen in other countries but also in Vietnam. First two months in 2010, Vietnam experienced the amount of affected area larger than the entire area in 2009 and this trend is going to continue in the next months.

In small scale, some other factors plays role in starting and spreading the fire such as topography, demography, weather, vegetation cover, etc. To protect forest from fire, the strategy is preventing fire happening rather than fighting to it. Accordingly, forecasting the region has a high risk of fire occurring is an extremely urgent task. Based on these information, managers could issue proper policies in order to reduce chance of burning.

Fire risky area is the place where has potential fire or from which the fire easily spread to other areas. The risk from fire can be mapped commonly from related factors with remote sensing and GIS data. In particular, a weight is assigned to each factor, according to its *sensitivity* of causing forest fire. This process can be considered to be a multi criteria evaluation (MCE) which involves the fire-influencing factors. MCE proved to be effective in handling decision problems that involve a number of conflicting objectives (Malczewski,

1999) like the case of factors causing forest fire.

This paper presents a raster based operating method for the identification of the most risky area of forest fire. This information will help to choose the suitable protecting priority area in circumstance of lacking of labor and financial aid.

2. METHODOLOGY

2.1 Study area

The study area (see figure 1) is Bac Yen District, Son La province, a mountainous place located in the Northwest of Vietnam. It covers about 110,000 ha and falls between 21^{o} – 21,441^{o} N and 104,17^{o} – 104,57^{o} E.

Figure 1. The study area

2.2 Data used

To prevent the fire, we need to consider the causing factors and the factors responsible for the spread of fire. In this paper, only the manmade forest fires are taken into account; and this kind of forest fire directly relates to places with high density of people or human activities (farming, transportation).

Moreover, the main factors affecting the spread of forest fire are inflammable materials like type and characteristics of forest; topography factors such as slope, elevation, aspect. Fire tends to easily spread in steep slopes, lower elevation, and south/ southwest slopes. In detail, the factors responsible for forest fire are: *vegetation type; climate; topography; distance from road; proximity to settlements.*

The needed data for this study was collected from project Raising capacity for sustainable forest management and natural resources conservation in Vietnam (2008-present).

2.3 Data modeling

All the thematic map were integrated (see figure 2), a cumulative fire risk index values map obtained by using map calculation function is as follows:

$$CFRISK = 0.4379*FUI + 0.2190*SLI + 0.2437*ASI + 0.0994*ACI$$

Where, CFRISK= Cumulative fire risk index value;
SLI=Slope index;
ASI=Aspect index;
ACI=Accessibility index;
FUI=Fuel type index.

The index was acquired by analytical hierarchical process, available integrated in IDRIS Andes.

Based on statistics of different weighted classes, these thematic maps was reclassified into final fire risk zone map for the study area with a integration of various influencing factors has been done by a hierarchical system. On the basis of experience and the opinion of experts in the fields weighted were assigned to different variables.

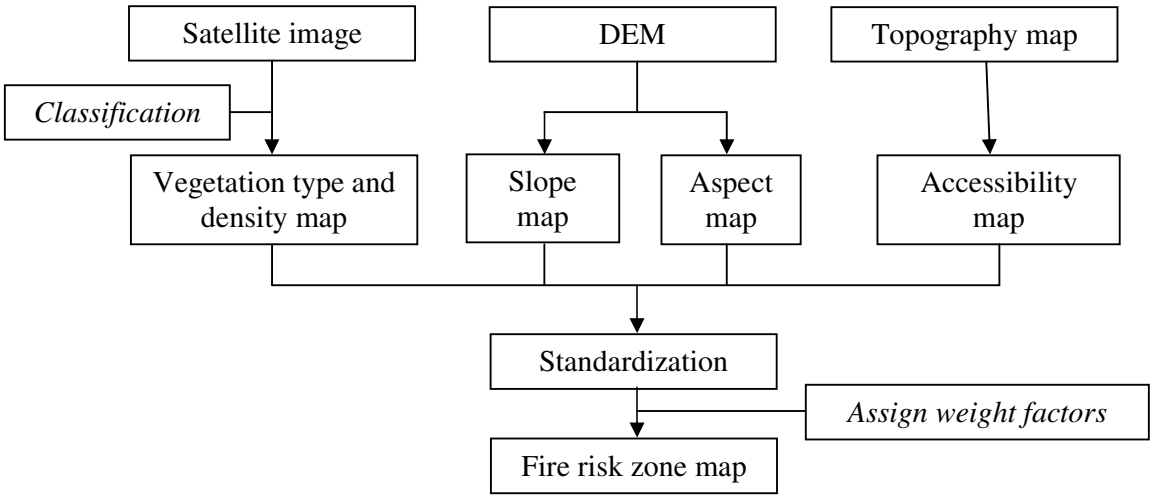

Figure 2. Data integrated and fire risk zone mapping

3. RESULT AND DISCUSSION

3.1 Factors

3.1.1. Vegetation

A vegetation type map was classification from satellite image by object-based method

(Tuan, 2010; Neubert et.al., 2006) and ground survey, showing 10 types of forest and 6 non-forest types. In all the factors mentioned, fuel type have got the maximum influence on fire occurrence because forest fire behaves different in different forest types. Low and degraded forests are having maximum chances of forest fire because they contain maximum grasses and unrecompensed leaf litter. Fire incidences in the past have also helped, while assigning values to various fuel types. The different classes were labeled separately according to their sensitivity to forest fire from 1 to 8 (table 1).

Table 1: Rating assign to vegetation type

Type	Rating
Rock mountain, residents, agriculture fields, other lands	1
Rich forest	2
Medium forest	3
Regenerated forest, plant forest	4
Forest on Karst	5
Poor forest, Bamboo forest	6
Mixed broad leaves and bamboo forest	7
Grassland and Shrub	8

3.1.2. Topography

From topography data, the DEM (Digital Elevation Model), slope and aspect map were extracted. DEM is created by interpolation from digitized contour lines. Frequency of the point selected on the land and the mathematical method used in conversion are important for quality and accuracy of DEM. Then, the DEM has been used to generated slope, and aspect map.

The slope and aspect were classified gradually into eight classes. Because the steep increase the rate of spread of fire more efficiently due to convective preheating and ignition, the more slope, the higher value is given. Warmer condition occurs when direct rays of sun is on south and south western aspects, make more prone to fire and are given higher values (table 2).

Table 2: Rating assign to slope and aspect

Slope (percentage)	Rate score	Aspect	Rate score
0 – 5	1	N	1
5 – 10	2	NE	2
10 – 20	3	E	3
20 – 30	4	W	4
30 – 40	5	NW	5
40 – 50	6	SE	6
50 – 60	7	SW	7
>60	8	S	8

3.1.3 Administrative data

Distance map: As mentioned in previous researches, the others factors responsible for forest fire happen are distance from road, settlement. The advantages of GIS allow to integrate these information into risk accessing process which managers could not do this in past due to the lack of clear relation between distance and fire risk.

With distance factor, assigning higher values to the areas nearer to the roads (up to 500 metres in the present study) because people can easily approach these are so that there are more chances of fire occurrence.

3.2 Forest fire zoning map

Finally the fire risk map generated in the above studies accounted for 5 to 15 % total area, depends on which method is proposed, and then was compared with the actual sites effected by fire in the past. It is observed that the areas identified as under high/moderate risk were having agreement with the burnt area on the ground during previous year.

The forest fire risk map is shown on figure 3 and figure 4.

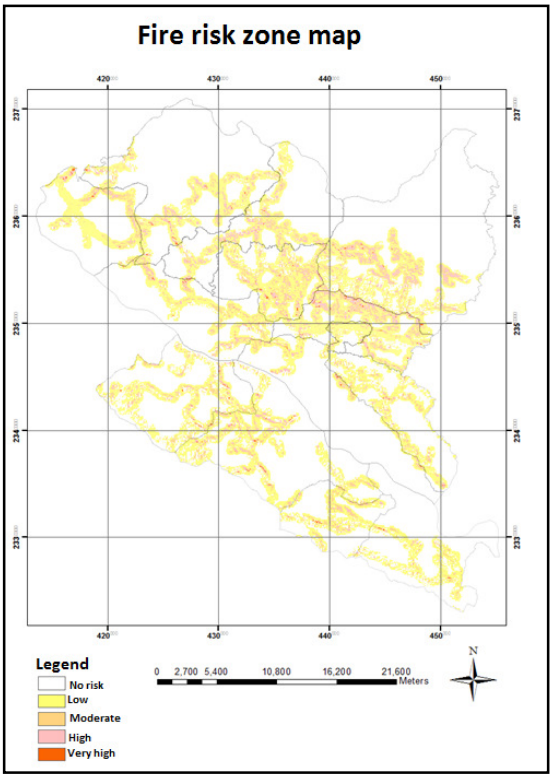

Figure 3: Fire risk zone map calculated by risk taking method

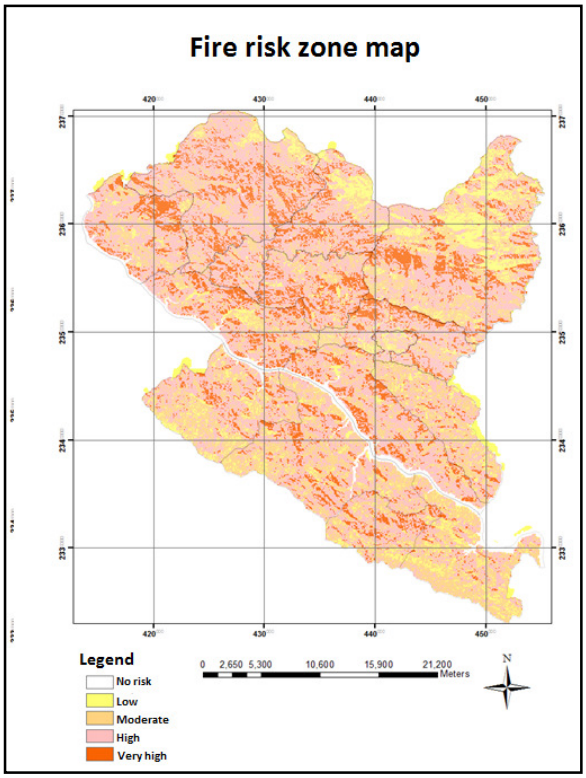

Figure 4: Fire risk zone map calculated by trade off method

The areas of high fire risk not only have the possibility of fire happening, but also are places where fire easily spread to other areas. The model of forest fire risk is to explain the relationship between the factors in charge of forest fires: risk of forest fires is not only highly

dependent on vegetation cover but also on other factors, reflecting the fact that most forest fires occur because of people, while other factors such as slope, aspect or the vegetation cover are closely related to the spread of fire.

4. CONCLUSION

There are various causes leading to forest fires, but the number of fires is negligible, so the construction of risk maps from the above factors are necessary. From fire risk maps, the manager needs to have proper planning of roads, residential areas or construction of fire fences around the areas with higher fire risk.

This study concludes that the approach of combining field observations, remote sensing and GIS can be efficiently used for fire prone area zoning. However in the coming research we would fulfill the task here, with deeper look at the appropriate way of assigning weight.

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