Development of a GIS-based forest fire risk map: case of Kuan Kreng swamp forest, Southern Thailand

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Abstract:
The objective of this study was to assess risk area and its severity classification of forest fire covering the area of Kuan Krang swamp forest using the application of geographic information system (GIS) based on forest fire influencing factors. These factors included land uses, soil types, distance to streams, distance to roads and distance to communities. Each factor was assigned for weighting and rating scales following the literature data, interview data of representative from the Forest Fire Control Station at Kuan Kreng and hotspot (fire) data collected from 2001 to 2013. A GIS-based multi-criteria techniques using weighted overlay method was used to classify risk level of forest fires. The level of risk was divided into 3 types: high, medium and low risks. Results indicated that the most important factor for the forest fires of Kuan Kreng was land use. The degraded swamp forest was found to be the most vulnerability area for the origin of forest fires. The highest risk areas of forest fires in Kuan Kreng were found at Amphoe Cha Uat and Amphoe Ron Phibun, Nakhon Si Thammarat and Amphoe Khuan Khanun, Phattalung.

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1. Introduction

Forest fires are sources of ecological deterioration, air pollution, adverse health impacts on humans and climate changes. Rapid and vast fires destroy the ecological balance of forest by reducing number of wildlife, plants and seeds and consequently changes the abundant forest to the degraded forest. Large quantity and various species of pollutants, i.e. carbon monoxide (CO), carbon dioxide (CO_2), sulfur dioxide (SO_2), particulate matter (PM), black carbon (BC) and organic carbon (OC) were emitted to the atmosphere during the fires that could be adversely human health impacts to the community residing nearby the forest area. Particular species, i.e. CO_2, BC and OC were considered to be climate forcing agents (UNEP, 2011).

Main causes of forest fires in Thailand were generally from human initiations. There were such as gathering non-timber forest products, hunting and crop residue field burning (Akkaak, 2000; Tiyapairat and Sajor, 2012). For gathering non-timber forest products, fires were used to clear sidewalk and light up the area in the night as well as to stimulate proliferation of mushrooms. In addition, fires were used for chasing of animals from their hiding places for hunting purpose. Field burning of crop residues was a common practice to clear the land for next growing season that can lead to spreading of fires from crop area to nearby forests. Tiyapairat and Sajor (2012) also highlighted that the origins of forest fires in Thailand were connected to the livelihood of people. Solving forest fires problems would be rather complicated.

Kuan Kreng swamp forest is located at Upper Southern Thailand covering area of 350,437 Rai (around 560 km^2) in Nakhon Si Thammarat, Phatthalung and Songkhla Provinces. In 2012, particularly during May to August, it was reported the severe forest fires at Kuan Kreng that affected the natural resources and air quality, particularly haze pollution due to burning smoke (PCD, 2012). Lack of information on precise risk area of forest fires could reduce the effectiveness of prevention measures. Geographic Information Systems (GIS) is a powerful tool that can be used for assessment and analysis of the forest fire risk map. The objective of this study was to develop a

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GIS-based forest fire risk map and classify its severity level in Kuan Kreng swamp forest.

2. Material and methods

Factors associated with the occurrences of forest fires were used for analysis. Factors included land use, soil types, distance to streams, distance to roads and distance to communities. We used a GIS multi-criteria techniques based on overlay analysis to classify risk level of forest fires (see also Fig. 1 and Eq. (1)).

$$S = W_1R_1 + W_2R_2 + W_3R_3 + \ldots\ldots\ldots + W_nR_n \tag{1}$$

Where S = Total score (risk level of forest fire),
$W_{1, 2, 3, \ldots, n}$ = Weighting scale for factor no. *1* to *n*,
$R_{1, 2, 3, \ldots, n}$ = Rating scale for factor no. *1* to *n*.

Forest fires risk area was classified into 3 levels: high risk ($> \bar{x}+$s.d.), medium risk ($\bar{x}\pm$s.d.) and low risk ($<\bar{x}-$s.d.). Note that $\bar{x}$ is average of total score (S) and s.d. is standard deviation.
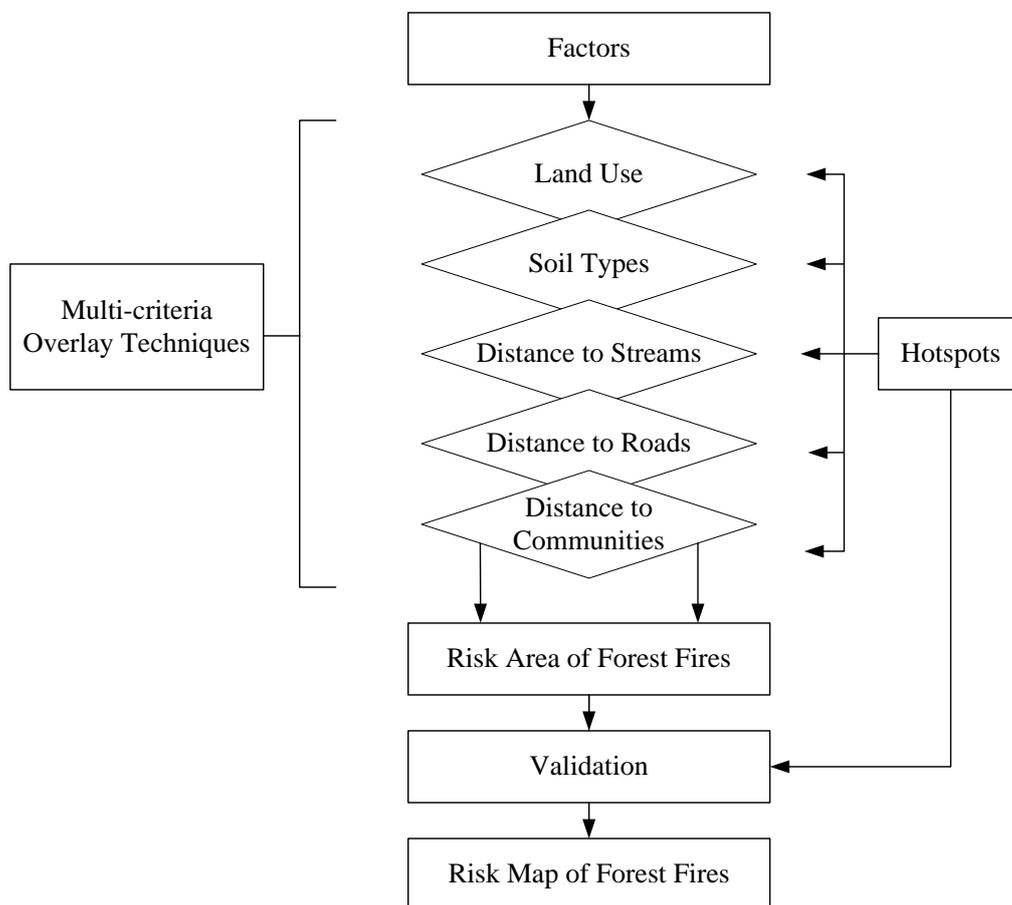

Fig. 1 Multi-criteria techniques for forest fire risk classification.

Each factor was assigned for weighting and rating scales following the literature information and interview data of the representative from the Forest Fire Control Station at Kuan Kreng. Previous fire occurrences as hotspot data collected from 2001 to 2013 were used for validation (see also Fig. 1). Table 1 summarizes weighting and rating factors used in this study.

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Table 1 Weighting and rating of factors

Factors	Weighting	Rating	Total score
1. Land Uses			
Level 1 Distributed swamp forest	5	4	20
Level 2 March and swamp		3	15
Level 3 Agriculture		2	10
Level 4 Dense swamp forest		1	5
2. Soil Types			
Level 1 Peat soil	4	2	8
Level 2 Non-peat soil		1	4
3. Distance to streams			
Level 1 0-1,000 m.	3	4	12
Level 2 1,000-2,000 m.		3	9
Level 3 2,000-3,000 m.		2	6
Level 4 3,000-4,000 m.		1	3
4. Distance to roads			
Level 1 0-2,000 m.	2	3	6
Level 2 2,000-4,000 m.		2	4
Level 3 4,000-6,000 m		1	2
5. Distance to communities			
Level 1 0-2,000 m.	1	4	4
Level 2 2,000-4,000 m.		3	3
Level 3 4,000-6,000 m		2	2
Level 3 6,000-8,000 m.		1	1

3. Results and discussion

Summary results were indicated in Table 2 and revealed that high risk area of forest fires at Kuan Kreng swamp forest was found to be around 218 km^2 (39% of total area) with hotspot number of 255 points (67% of total hotspots), following by medium risk area of around 378 km^2 (50%) with hotspot number of 119 points (31%) and low risk area of around 65 km^2 (11%) with hotspot number of 6 points (2%). The risk classifications were consistent with the hotspot data.

Table 2 Summary of forest fire risk level in Kuan Kreng

	Forest fire risk area		Hotspot	
Risk level	Area (km^2)	Percentage	Number	Percentage
Low	65	11	6	2
Medium	378	50	119	31
High	218	39	255	67
Total	560	100	300	100

In addition, land use was considered as the most important factor affected the risk level of forest fires. Particularly, the degraded swamp forest was regarded as the high potential area for forest fires. High risk area was found mainly in Amphoe Cha Uat, Nakhon Si Thammarat indicating the requirement of urgent prevention measures to tackle the problems (see also Fig. 2).
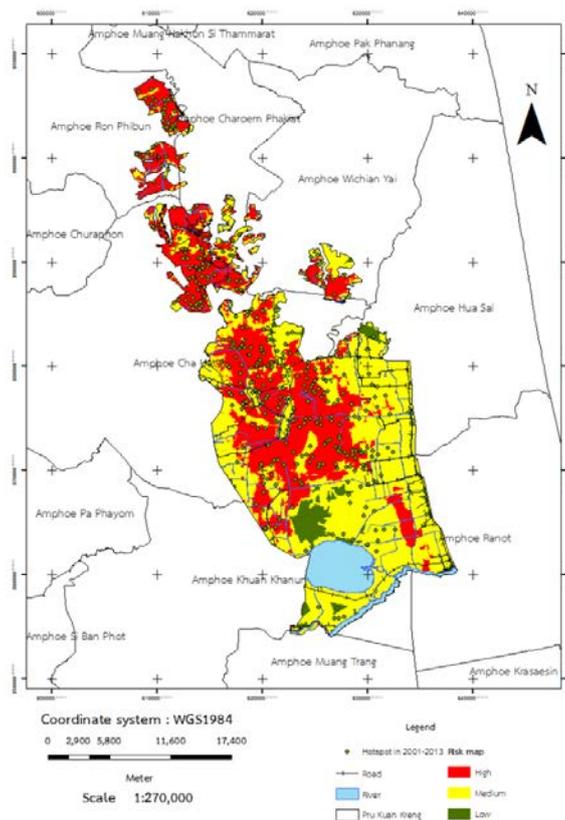
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Fig. 2 Forest fire risk map of Kuan Kreng swamp forest (red, yellow and green denotes high, medium and low levels of risk).

4. Conclusion

With the proposed factors for multi-criteria overlay techniques, high risk area of forest fires at Kuan Kreng swamp forest was found to be around 218 km^2, while medium and low risk areas were found to be around 378 km^2 and 65 km^2, respectively. The risk classifications were consistent with 10 year hotspot data.

5. Acknowledgement

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