ORIGINAL RESEARCH PAPER

Environmental Management of Forest Fire Risk Using A'SWOT Analysis Model (a Case Study: Forest Parks in the Southern Slopes of Alborz, Iran)

Behzad Bozorgmer[1], Mina Macki Aleagha[2*], Azita Behbahani[2]

[1] Ph.D. student in environmental management, Department of Environmental Sciences and Engineering, Rudehen Branch, Islamic Azad University, Rudehen, Iran

[2] Assistant Professor, Faculty of Environmental Sciences, Department of Environmental Sciences and Engineering, , Rudehen Branch,Islamic Azad University Rudehen, Iran

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ABSTRACT

Fire can destroy forest areas along with air pollution and health hazards. The forest parks of the southern slopes of Alborz, Iran, are amazing tourist destinations for people in surrounding cities. Therefore, we determined the capabilities and limitations and formulated the best strategies to prevent and control fires using SWOT-AHP (A'SWOT) combined method. First, SWOT technique detected internal factors (strengths, or S, weaknesses, or W) and external factors (opportunities, or O, threats, or T) based on open-ended questions from local communities and experts. Then, AHP analysis model and Likert scale were performed to prioritize the best strategies as SO, WO, ST, WT solutions. The results showed that the most important factors in fire risk management, in order of the highest relative weight, were "easy access to forest park" (0.77), "lack of budget" (0.459), "existence of road networks" (0.76), "decrease in motivation and interest of volunteer and public forces" (0.417) in the strength, weakness, opportunity and threat groups, respectively. Further, the most important fire risk management strategies from the SWOT matrix and AHP method and scoring with a Likert scale, respectively, were "planning in accordance with the degree of fire risk for each part of the forest park" (0.715), "deploying quick reaction force and firefighting equipment at the appropriate point of the forest park" (0.685) and "updating knowledge in the field of fire risk management" (0.635). The A'SWOT technique was found to be appropriate in identifying the effective factors and providing operational strategies to prevent and control forest fires

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Corresponding author: mackialeagha@yahoo.com

1. Background

Environmental risks have always been one of the most important concerns in natural resources, and planning to deal with and prevent these risks and their harmful effects has been one of the most fundamental issues of natural resource management (Ghasemi Aghbash and Fataei, 2006). The collection of environmental and natural factors such as topological, geomorphological, climatic and hydrological features along with anthropogenic factors, generally provide the strengths (S), weaknesses (W), opportunities (O) and threats (T), called SWOT, to the biosphere of forest areas (Haji Alizadeh et al., 2011). One of the most important hazards in forest areas is fire, which can be caused by environmental or anthropogenic factors (Sarvar et al., 2012).

Fire, as one of the most common and important environmental disasters, causes numerous and irreparable damages with profound environmental, social and economic effects (Jellouli, Bernoussi, 2022). Therefore, finding appropriate solutions at any time in order to prevent and manage this harmful phenomenon has always been one of the needs of environmental managers and planners (Gazmeh, 2012). Many factors may affect a forest fire. Height, slope and proximity to roads and residential areas have been among the main factors influencing the occurrence and spread of fire in eastern Kentucky in the United States. In addition, distance to railways and roads and daily maximum temperature and rainfall have been found to influence the occurrence of anthropogenic fires in the Madrid region of Spain (Maingi and Henry, 2007).

Forest fire prevention is one of the examples of natural crises, and dealing with it is called crisis management (Hosseinali, 2007). Therefore, identifying the major factors of fire crisis in the forest is of great importance (Gorte and Bracmort, 2012). In general, forest fire crisis management includes not only the process of predicting and preventing the occurrence of a crisis, but also dealing with, intervening and recovering after a crisis (Taleai et al., 2009).

One of the management analysis methods that is used in combination with Analytic Hierarchy Process (AHP) analysis is SWOT (strengths, weaknesses, opportunities, and threats) analysis (Fataei et al., 2022). In the SWOT analysis, it is not clear which group is more important among the four constituent groups. In these groups, only the most important factors of the four are identified, without specifying the superiority of each of these factors or criteria over each other (Miraki et al., 2014). In other words, the SWOT analysis is qualitative in nature and this cannot be a comprehensive assessment of the strategic situation of the system. The fact that the significance of each factor cannot quantitatively measure the criterion for decision-making is considered as the main limitation of SWOT analysis (Zandbasiri and Ghazanfari, 2010). Therefore, in order to improve this decision-making system, AHP is used to compare factors within each category of the four groups (Fataei et al., 2013). In this method, the most experienced experts are used to compare the factors of the SWOT table in pairs, instead of using the quantity of decision makers (Fataei, 2015). In other words, all the weaknesses, strengths, threats and opportunities of the organization are compared in pairs based on the comparison of the role of each factor in the performance of the organization's program (Nami et al., 2017; Fataei and Alsheikh, 2018).

Limited research has been done regarding the presentation of management strategies using SWOT-AHP (A'SWOT) combined method. A group identified and compared the factors affecting the exploitation of pastures using the AHP-SWOT model from the point of view of operators and experts (Kargar et al., 2019). They found that only three factors, including "lack of coordination and lack of trust between experts and operators of pastures", "the existence of the feudal system in pasture livestock farming" and "the opportunity to expand income from livestock production" had the same priority from the point of view of experts and operators (Sharifiyan et al., 2014). In providing management solutions to deal with fire using decision support system in Northern Zagros forests in Marivan city area, Iran, using A'SWOT method (Miraki et al., 2014), it was found that "employment and income" with a final weight of 0.106, "timely access" with a final weight of 0.069, and "efficiency" with a final weight of 0.068 were the most important factors influencing crisis management solutions, and "preventing the spread of fire in the forest" with a final weight of 0.123, "speed of action" with a final weight of 0.120 and "possibility of creating employment" with a final weight of 0.118 were recognized as the most important risk management solutions in the region. Mohammadi et al. (2010) used the AHP method to identify the effective factors in the occurrence and spread of fire and showed that the obtained map was very similar to the actual locations of fire.

The forest parks of the southern slope of Alborz in the watershed of the Vesiye Valley region in Alborz province, Iran, are exposed to risks due to their special geographical location and the accessibility of local people and their strong dependence on these resources, especially in its rural areas. This forest area is affected by many destructive factors, including natural and unnatural fires, agricultural land development, livestock breeding, fuel supply, exploitation of by-products, and pests. At the time of the fire crisis in this area, there was no written management solution reported by the relevant organizations, and most of the methods are traditional and based on experience. Therefore, it is necessary to use comprehensive scientific tools and the experiences of experts in order to make a suitable decision in this field. Therefore, the present study identified and evaluated the most important influencing factors to deal with the risk of forest fire from inside (strengths and weaknesses) or outside (opportunities and threats) the organization, as a basic strategy to deal with fire in the forest park of the southern slopes of Alborz using the multi-criteria decision-making method of AHP-SWOT (A'SWOT) in order to provide a scientific solution.

2. Materials and methods

Forest fire risk management requires solving existing gaps and identifying appropriate solutions to solve this problem. There are various tools to investigate this issue and identify the strengths, weaknesses, opportunities and threats of fire risk. One of these techniques is SWOT analysis based on the opinions of experts and local people. The most important feature of SWOT is the ability to analyze data and develop strategies without the need for quantitative analysis and mathematical calculations (Kazana et al., 2015). SWOT analysis is an efficient tool to identify the environmental conditions and internal capabilities of the organization, where strengths and weaknesses are internal factors and opportunities and threats are external factors. Practical and suitable strategies are deduced from this method (Table 1).

The strategic SWOT analysis method includes actions and plans that result in maximizing opportunities and strengths and minimizing weaknesses and threats. This is one of the most important tools for adapting the strengths and weaknesses of the organization to the opportunities and threats, and provides a systematic analysis to identify the factors in choosing the right strategy. The current research uses the integrated method of SWOT and AHP in order to normalize the weights of the factors in each category of

the four SWOT groups.

In order to identify the factors affecting the fire risk of the studied forest park, first a list of strengths, weaknesses, opportunities and threats of fire was prepared in the form of a questionnaire and then it was confirmed by a group of elites and professors in fields related to environment and forestry. The number of questionnaires was estimated using Krejcie and Morgan's table. In order to reduce the error rate, the maximum number of expert groups was used and 35 questionnaires were distributed and 30 questionnaires were returned, which resulted in the finalization of 20 factors affecting fire risk in the study area.

Based on the identified weaknesses, strengths, opportunities and threats, fire risk management strategies were obtained based on the SWOT matrix table (Table 1). To determine the normal weight of each factor and SWOT strategies, the AHP analysis model was used through questionnaires and experts' opinions. SWOT factors and strategies were scored using a 5-point Likert scale (1=very little importance, 2=low importance, 3=moderate importance, 4=high importance and 5=very high importance). In the AHP process, pairwise comparisons were made using a scale ranging from equally preferred to extremely preferred in Expert choice software (Table 2).

Table 1. Types of SWOT analysis strategies

External factors Internal factors	Opportunities (O)	Threats (T)
Strengths (S)	Aggressive strategy	Conservative strategy
Weaknesses (W)	Competitive strategy	Defensive strategy

Table 2. Pairwise comparison in AHP analysis model (Fataei, 2013)

Degree of significance in pairwise comparison	Numerical value
Equally Preferred	1
Equal to relatively preferred	2
Relatively preferred	3
Relatively to strongly preferred	4
Strongly preferred	5
Strongly to very strongly preferred	6
Very strongly preferred	7
Very strongly to extremely preferred	8
Extremely preferred	9

3. Results

1.3. Strengths, weaknesses, opportunities and threats effective in fire

Based on the investigation of the existing situation of the region, effective criteria on fire management in the studied forest park areas were identified. The result of this stage was the identification of 20 factors, separated by strengths, weaknesses, opportunities and threats, affecting the fire risk management of the forest park in the southern slopes of Alborz (Table 3).

3.2. Prioritization of strategies for fire risk management

The strategies derived from the weaknesses, strengths, opportunities and threats based on the SWOT matrix, which included nine management strategies in dealing with the risk of fire in the forest park on the southern slopes of Alborz, were prioritized using the AHP analysis model and Likert scale coefficient (Table 4).

Table 3. Prioritization of effective criteria on crisis management and forest fire risk management in the framework of SWOT analysis

SWOT groups	Factors of each group	Relative weight of AHP	Likert score	Weighted score
Strengths	S_1: Easy access to forest park	0.154	5	0.77
	S_2: Experiences of personnel	0.078	5	0.39
	S_3: Cooperation of media and social networks	0.125	3	0.375
	S_4: Ease of action	0.091	3	0.273
	S_5: Public participation	0.058	4	0.232
Weaknesses	W_1: Lack of budget	0.153	3	0.459
	W_2: Failure to establish water tanks	0.094	4	0.376
	W_3: Absence of suitable rescue base	0.093	4	0.372
	W_4: Failure to inter-departmental coordination	0.088	3	0.264
	W_5: Failure to closely monitor the Natural Resources Authority	0.078	3	0.234
Opportunities	O_1: Existence of road networks	0.152	5	0.76
	O$_2$: Increasing public belief regarding the vulnerability of forest areas	0.099	4	0.396
	O$_3$: Presence of military and police forces and Red Crescent	0.087	4	0.348
	O_4: Increasing attention to non-governmental organizations (NGOs)	0.093	3	0.279
	O_5: Proximity to Tehran province	0.070	3	0.210
Threats	T_1: Decrease in the motivation and interest of volunteers and the public	0.139	3	0.417
	T_2: Failure to operational readiness at times	0.137	3	0.411
	T_3: Increase in maintenance costs	0.069	4	0.276
	T_4: Incompetence of executive bodies	0.127	2	0.254
	T_5: Failure to use the private sector in forest park management	0.058	4	0.232

Table 4. Prioritization of fire risk management strategies in the forest park in the southern slope of Alborz using AHP method and Likert scale

Management type	Criteria	AHP relative weight	Likert score	Weighted score	Ranking
Risk management	Planning in accordance with the degree of fire risk for each area and preparing fire control management plans for each part of the forest park	0.143	5	0.715	1
	Deploying quick reaction force and firefighting equipment at the appropriate point of the forest park	0.137	5	0.685	2
	Updating knowledge in the field of fire risk management	0.127	5	0.635	3
	Periodic trainings for local communities to reduce the risk of fires caused by anthropogenic factors	0.139	4	0.556	4
	Designing or modifying fire break line in order to prevent fire spread	0.152	3	0.456	5
	Using the capacity of mass media and social networks to attract public participation	0.125	3	0.375	6
	Establishing forest aid bases in areas with higher fire risk (problems related to the settlement of people in the area)	0.093	4	0.372	7
	Construction of fire lookout towers	0.094	3	0.282	8
	Institutionalizing the presence of NGOs and trusting them during fires	0.093	2	0.186	9

4. Discussion

Examining the weaknesses, strengths, opportunities and threats in the fire risk management of the forest park in the southern slopes of Alborz (Table 3) showed that the most important influential factors in fire risk management solutions, in order of the highest relative weight, were "easy access to forest park" (0.77) in the strength group, "lack of budget" (0.459) in the weakness group, "existence of road networks" (0.76) in the opportunity group, "decrease in motivation and interest of volunteer and public forces" (0.417) in the threat group. Local people are an integral part of the forest system and its related ecosystem and are considered as an essential element in forest management. Failure to pay attention to this issue makes it impossible to achieve the goals of the plan and causes a more negative attitude towards the forest, natural resources, and ultimately failure in cooperative management plans (Zandbasiri, 2010).

Ghazanfar Pour et al. (2017) concluded that one of the weaknesses in fire risk management in the forests of Golestan, Iran, was "the lack of funds for the proper management of fire suppression", which has caused a weakness in providing adequate manpower, and necessary equipment to contain the fire and inform the people. In addition, the absence of forest aid stations as a fire management center has been one of the weaknesses of fire control management in these forests. However, in the aforementioned research, the existence of road networks, quick access, and identification of fire-prone spots have been identified as a good opportunity in fire management. Zarekar et al. (2013) reported "construction of fire lookout towers, especially in fire-prone areas" as one of the effective solutions for fire control.

Further, the most important fire risk management strategies obtained from the SWOT matrix and their evaluation through the AHP method and scoring with a Likert scale (Table 4), respectively, were "planning in accordance with the degree of fire risk for each part of the forest park" (0.715), "deploying quick reaction force and firefighting equipment at the appropriate point of the forest park" (0.685) and "updating knowledge in the field of fire risk management" (0.635).

In the study of fire control management of Golestan forests through AHP-SWOT, Ghazanfar Pour et al. (2017) announced that cooperation between agencies can effectively help in reducing the effects of fire crisis. In addition, some factors such as fire control in a short period of time, quick access to fire extinguishing agents, professional preparation in fire control, having fire control tools, permanent presence of physical fire control forces on site, quick access to its location and quick access to the place, timely presence at the fire place and the availability of individual and collective facilities are very important in increasing the efficiency of fire suppression. Gorte and Bracmort (2012) came to the conclusion that the cooperation of media and publications and its strengthening, as well as the coordination of the crisis headquarters with the people of local areas through holding training courses and attracting practical, material and spiritual support, increase awareness, motivation and sense of responsibility and the participation of local and popular forces in extinguishing the fire. Mohammadi et al. (2010) found that regular planning and increasing the awareness of local people, as well as the use of indigenous knowledge in forest management, are the best, cheapest, and easiest possible solutions in forest fire risk control and prevention.

5. Conclusion

One of the most important factors threatening the forests of the southern slopes of Alborz, Iran, is intentional and unintentional fires that have led to the destruction of a large part of these forests in the last few years. The present study was conducted in order to identify and evaluate the most important factors affecting the fire risk in the forests of the southern slopes of Alborz and to develop management strategies using the SWOT analysis method (A'SWOT). The results of the analysis of internal and external factors affecting fire risk control with SWOT-AHP combined technique showed that "easy access to forest park", "lack of budget", "existence of road networks" and "decrease in motivation and interest of volunteer and public forces" had the highest weighted score in terms of strengths, weaknesses, opportunities and threats, respectively. Among the fire risk management strategies in the forest park, "Planning in accordance with the degree of fire risk for each area and preparing fire control management plans for each part of the forest park", "Deploying quick reaction force and firefighting equipment at the appropriate point of the forest park" and "Updating knowledge in the field of fire risk management" were identified as the first priorities.

According to the results, the A'SWOT method could identify the weaknesses, strengths, opportunities and threats and rank the fire management strategies of the forest park in the southern slopes of Alborz. In this way, it is possible to effectively play a positive role in the fire risk management of the forest park in the southern range of Alborz by using a detailed planning that includes different levels of planning and implementation (macro, basics, micro and local) and by providing specialized human resources, and the necessary hardware and software facilities, as well as the participation of local people and non-governmental organizations.

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