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Reducing the Risk of Fire Danger in Lebanon Based on Predictive Analysis and Preliminary-Proactive Actions

Ali Karouni[1, 3], Alaa Hilal[1], Bassam Daya[1,2] and Pierre Chauvet[4]

[1] Lebanese University, University Institute of Technology, Saida – Lebanon
[2] Umm Al-Qura University, Faculty of Social Sciences, Information Science Department, Makkah – KSA
[3]LARIS EA, L'UNAM Université, Université d'Angers, Angers – France
[4] LARIS EA, L'UNAM Université, Université Catholique de l'Ouest, Angers – France

Abstract. Forest fire prediction and management is a worldwide concern that aims to reduce and limit fire occurrence and caused damage. These domains gained lately important attention in Lebanon due to the high percentage of fires across the Lebanese forests. It was reported that about 95% of forest fires in Lebanon were deliberated due to human-related induced factors and hence necessary actions are demanded. To solve this problematic several studies have been conducted in order to develop a fire danger meter, based on meteorological and topographic parameters, which measures the risk of having a fire. Sequentially this fire danger risk meter is used to predict when and where a forest fire is highly expected to happen. Following our previous work where a hybrid fire danger risk meter is developed and optimized to the Lebanese forests nature, we develop in this paper a set of actions that are necessary to reduce the fire danger risk. Fire danger index values are first quantified into 6 levels with increasing danger rating. Next algorithmic proactive actions are developed that serves as a first-level fire preventive measures. These preliminary actions constitute a danger-level specific protocol and a first action trigger necessary to anticipate significant fire activity. The proposed actions are optimized to the Lebanese forest nature and following recommendations observed from forest fire cases in Lebanon.

Keywords: Fire danger risk, fire prediction, proactive actions.

1. Introduction

Forest fires are considered as the main reason of the decrease in green area of Lebanon Mountains. While about 95 % of these fires are related to human-related induced factors, necessary proactive and preliminary actions are needed.

A first approach into this problematic is to develop and to make use of an index meter that reflects that danger or the risk of having a fire. Different approaches are proposed in this domain; among them we use our hybrid index meter that combines meteorological and topographic parameters. The outcome of this combination is an index value that is always positive. A low value of the fire danger risk signifies a low risk of having a fire whereas a high risk of fire is expected in the opposite case.

Knowledge about fire danger index is better understood by quantizing the index values and relating them to a set of possible fire behaviour and impact in case of a fire. This would further permit to propose and to develop a set of proactive actions that serves to reduce or to limit the danger.

In parallel to proactive actions, a better plan to face forest fires is to propose a strategy plan that can always be implemented, before, during and after a fire.

In the following sections, we detail the quantification of the fire danger index in section II. Next, potential fire impact, proactive actions and strategy plan are discussed in section III to conclude finally in the last section.

2. Quantification of Fire Danger

Fire Danger Rating is an early indicator of potential danger. It is considered as an assessment of the potential fire behaviour, the difficulty of suppressing a fire, and the potential impact on the community should a fire occur on a given day.

In our previous work [1], [2], a hybrid Fire Danger risk (or index) meter is developed. It makes use of meteorological data including air temperature, relative humidity, precipitation and evaporation, as well as infrastructure data such as topographical conditions, slope of mountains, map of flammable materials and moisture level of vegetation. All of these parameters are combined in order to create an index that measures the risk of a fire danger at every time (t) and location (x, y, z).

Considering the combination of all possible parameters, the fire danger index can take any value between 0 and + ∞. While a value is close to zero nearly means an absence of fire danger, an increase in this value reflects the fact of having a higher risk or a more important fire danger. The possible values of fire danger index are quantified into 6 levels with increasing danger rating. In addition we relate to each fire danger rating a description of potential fire behaviour [3], [4].

Table 1 details the fire danger quantification as well as the expected fire scenario in case of a fire.

Table 1: Fire Danger Index, Fire Danger Rating and Potential Fire Behaviour

Fire Danger Index	Fire Danger Rating	Potential Fire Behavior
>100	Catastrophic (Code Red)	• Fires might probably be very fast moving, uncontrollable and unpredictable. • Fire flames will be highly aggressive and extending high above tree tops and buildings. • Important intensity of embers will be violently blown into and around forests and homes. • New fires can start and spread quickly up to 20 km ahead of the main fire.
75-99	Extreme	• Fires might probably be very fast moving, uncontrollable and unpredictable. • Fire flames will be moving in the tree tops. • Important intensity of embers will be violently blown into and around forests and homes. • New fires can start and spread quickly up to 6 km ahead of the main fire.
50-74	Severe	• Fires might probably be very fast moving, uncontrollable and unpredictable. • Fire flames will be highly aggressive and extending high above tree tops and buildings. • Important intensity of embers will be violently blown into and around forests and homes. • New fires can start and spread quickly up to 4 km ahead of the main fire.
25-49	Very high	• Fires can be difficult to control and present a real threat. • Fire flames will be high and might reach tree tops. • Embers can probably be blown into and around forests and homes. • New fires can start and spread up to 2 km ahead of the main fire.
12-24	High	• Fires can be controlled but still present a threat. • Fire flames will not be so high. • Embers may be blown into and around near forests.
0-11	Low to moderate	• Fires can be controlled but still present a threat.

3. Potential Fire Impact, Proactive Actions and Strategy Plan

In order to determine the proactive actions that are needed to evade a potential fire as well as the necessary actions needed in case of a fire, the impact and the importance of a possible fire should be first determined. Based on the potential fire behaviour within every fire danger rating, we have interpreted in Table 2 the possible impact of occurring fires.

Based on the fire impacts, a set of proactive actions is proposed in order to anticipate the fire occurrence or at least limit their extreme impact. Those results were interpreted and concluded based on observations of forest fires in Lebanon and the correspondent meteorological and topographic parameters during the ten pass years as well as at recommendations from different associations that are concerned in reforestation and firefighting [3], [5]. Even that those proactive actions do not decrease directly the fire danger index it helps decrease the danger's impact.

The necessary proposed actions to anticipate fire occurrence are detailed in Table 3. Catastrophic and extreme fire danger rating are considered with the same proactive actions. The same goes for the severe and the very high fire danger rating as well as for the high and to the low to moderate fire danger rating.

Moreover the best solution to face a fire danger of any rating is to develop a plan that is all time executed. This suggests acting before, during and after a fire according to a five steps action strategy as detailed in Table 4.

Table 2: Fire Danger Rating and Fire Danger Potential Impact

Fire Danger Rating	Potential Fire Impact
Catastrophic (Code Red) Extreme	• Fire can threaten suddenly, without warning. • Temperature inside the fire can reach dangerous high values. • Very high speed winds are expected. • People in the path of the fire will face an extreme danger as they might get burned or might suffocate from fire smokes. • Significant numbers of homes and buildings in the path of the fire might get extremely damaged. • Power and phone networks are expected to fail as severe winds bring down trees and power lines. • Firefighting resources will be stretched and are highly unlikely to be available to help all properties.
Severe Very High	• Fire can threaten suddenly, without warning. • Temperature inside the fire can reach dangerous high values. • Very high speed winds are expected. • People in the path of the fire will face an important danger as they might suffocate from fire smokes. • Well-constructed homes are likely to offer safety during a fire. • Power and phone networks might fail as severe winds bring down trees and power lines. • Firefighting resources are unlikely to be available to help all properties.
High	• Fire still presents a threat but its behavior and path can be expected and it can be controlled. • Power and phone networks are not expected to fail. • Loss of life is highly unlikely and damage to homes and buildings is limited. • Firefighting resources are expected to be available to help all properties.
Low to moderate	• Fire presents a small threat, its behavior and path can certainly be expected and it can be easily controlled. • Power and phone networks are not expected to fail. • No risk of loss or damage in life, homes or buildings. • Firefighting resources are expected to be available to help all properties.

Table 3: Fire Danger Proactive Actions

Proactive Actions	Catastrophic and Extreme Rating	High and Low to Moderate Rating
Control Open Burning	• Restrict burning to early mornings and late evening hours when winds are lower and humidity is higher. • Use fire tools and monitor the fire at all times.	• Clear the area around the fire. • It is preferable to carry fire tools all times.
Control Off-Road Motorized Travel	• Fire extinguishers and fire tools within each vehicle are required. • Pay attention to fire hazards created by exhaust systems and catalytic converters.	• Pay attention to fire hazards posed by exhaust systems and catalytic converters.
Restrict smoking	• Restrict smoking to free of combustibles areas. • Use ashtray and proper disposal containers.	• Use ashtray and proper disposal containers.
Restrict Fireworks	• Restrict burning to early mornings and late evening hours. • Fire extinguishers and fire tools are required.	• Follow safety guidelines for projected aerial devices. • Fire extinguishers are required.
Control Equipment Operations	• Water tanks, fire extinguishers and fire tools are required within the area of equipment operations. • Conduct frequent inspections of farm machinery to reduce debris accumulation. • In welding operations, make use of spark arresters and keep a 20 meter radius surrounding a welding site cleared of combustible materials.	• Fire extinguishers are preferred to be always present within the area of equipment operations. • Conduct routine maintenance to reduce conditions that may cause a fire.
Warnings broadcast	• Broadcast warnings, evacuation recommendations hours or the day before a fire occurs and as long as the fire danger is always high.	• Broadcast warnings if a fire occurs.

Table 4: Five Steps Action Strategy Plan Details

Action Strategy Steps	Details
Continuous Information Gathering and Analysis	• Study fire patterns, analyze fire investigations results. • Prepare a database of fire map occurrence through the years. • Activate the role of local organizations and programs concerned with fire prevention. • Build effective monitoring system
Decrease Fire Danger Rate	• Encourage development strategies that repair and facilitate access to terrains. • Identify and rehabilitate dangerous infrastructure. • Increase the awareness of society of the personal responsibility in fire prevention. • Secure necessary firefighters tools and supplies. • Enforce the law in order to limit breaches in fire restrictions.

Increase Preparedness and Standby to Face a Fire	• Build and activate the technical and logistical capacities for fire-fighting teams. • Make use of the fire danger rate information. • Prepare a well-established infrastructure to help facing a fire. • Repair trail and off-roads. • Clean the terrain from highly combustible vegetation and fuel. • Increase the coordination between the different concerned organizations.
Immediate and Effective Response to a Fire	• Contribute in the immediate response to limit the fire propagation. • Activate the technical and logistical capacities to respond for a fire. • Facilitate the work process and coordination between fire-fighting teams. • Keep attention and respond to recommendations broadcasting and follow fire survival plan if requested. • Keep surveillance of the terrains after a fire.
Rehabilitation After Fire Occurrence	• Assess the surface of scorched lands. • Study the nature, vegetation and fuel of the scorched lands. • Reforestation of the scorched lands.

4. Conclusion

In order to limit fires in the Lebanese forests, or at least reduce their damage a well optimized strategy is needed. In this paper we have proposed a quantification of a fire danger index that measures the danger index of having a forest fire. In this process, fire danger can be categorized into one of five ascending danger rating. Following each fire danger rating, the potential fire behaviour and its impact are interpreted. Then a set of proactive actions that aim to reduce the danger are proposed. Moreover to best act before, after and during a forest fire and in parallel to the proactive actions, a 5 steps strategy is proposed.

This set of actions is necessary to anticipate a fire occurrence, to get prepared to extinguish it and to reduce the correspondent damage. Following the fact the first minutes or to say first 15 minutes of a fire occurrence are the most critical and important to respond, we aim by the proposed study to optimize our reaction to this threatening danger.

5. References

[1] Ali Karouni, Bassam Daya and Pierre Chauvet, *Forest Fire Prediction: A Proposal for a Hybrid Index*, The 3rd International Conference on Computer Science and Logistics Engineering, ICCSLE 2013, Hong Kong, China, 13-15 September 2013.

[2] Ali Karouni, Bassam Daya and Samia Bahlak, *Forest Fire Prediction: A comparative study of application of the weather indices for Lebanon*, The 4th World Conference on Information Technology, WCIT 2013, BRUSELLS, BELGIUM, 26-28 November 2013.

[3] *A Case Study on Lebanon's National Strategy for Forest Fire Management*, Issam Fares Institute for Public Policy and International Affairs.

[4] Francis M. Fujioka, A. Malcolm Gill, Domingos X. Viegas and B. Mike Wotton, *Fire Danger and Fire Behavior Modeling Systems in Australia, Europe and North America*, 2009.

[5] Lebanon's National Forest Fire Management Strategy, 2nd draft, December 2008, AFDC/IUCN/MOE/MOA, Georges Mitri, adopted by the Council of Ministers in May 2009.