Partnerships for Enhanced Engagement in Research (PEER)

Increasing Fire Danger Preparedness in Lebanon's Forest Sensitive Areas

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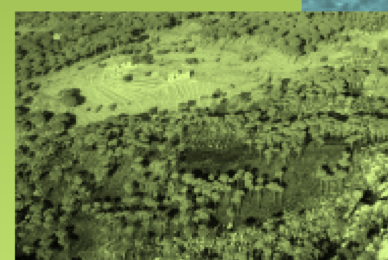
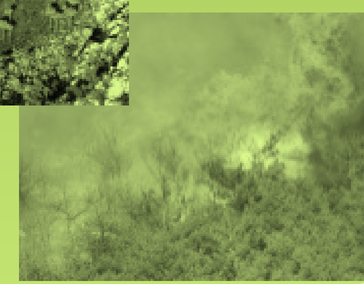
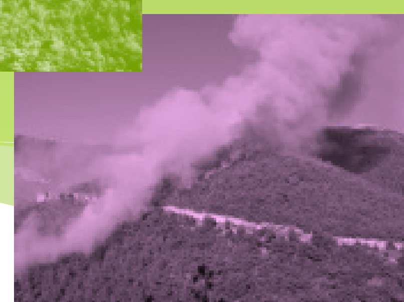
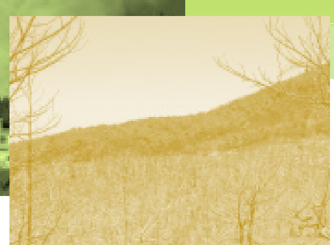








USAID MENA Research Partnerships Forum

March 13th -16th 2016
Amman, Jordan

Structure

1. Summary info about the project
2. Background information
3. Conducted work
4. FireLab
5. Ongoing activities (Evidence to Action Supplemental Fund)
6. Impact on national policies and institutions

Mitri, G. 2016, Peer meeting, Amman

Project’s summary info

Project "Towards a better assessment and management of wildfire risk in the Wildland-Urban Interface (WUI) in Lebanon: gaining from the US experience" (2012-2016).

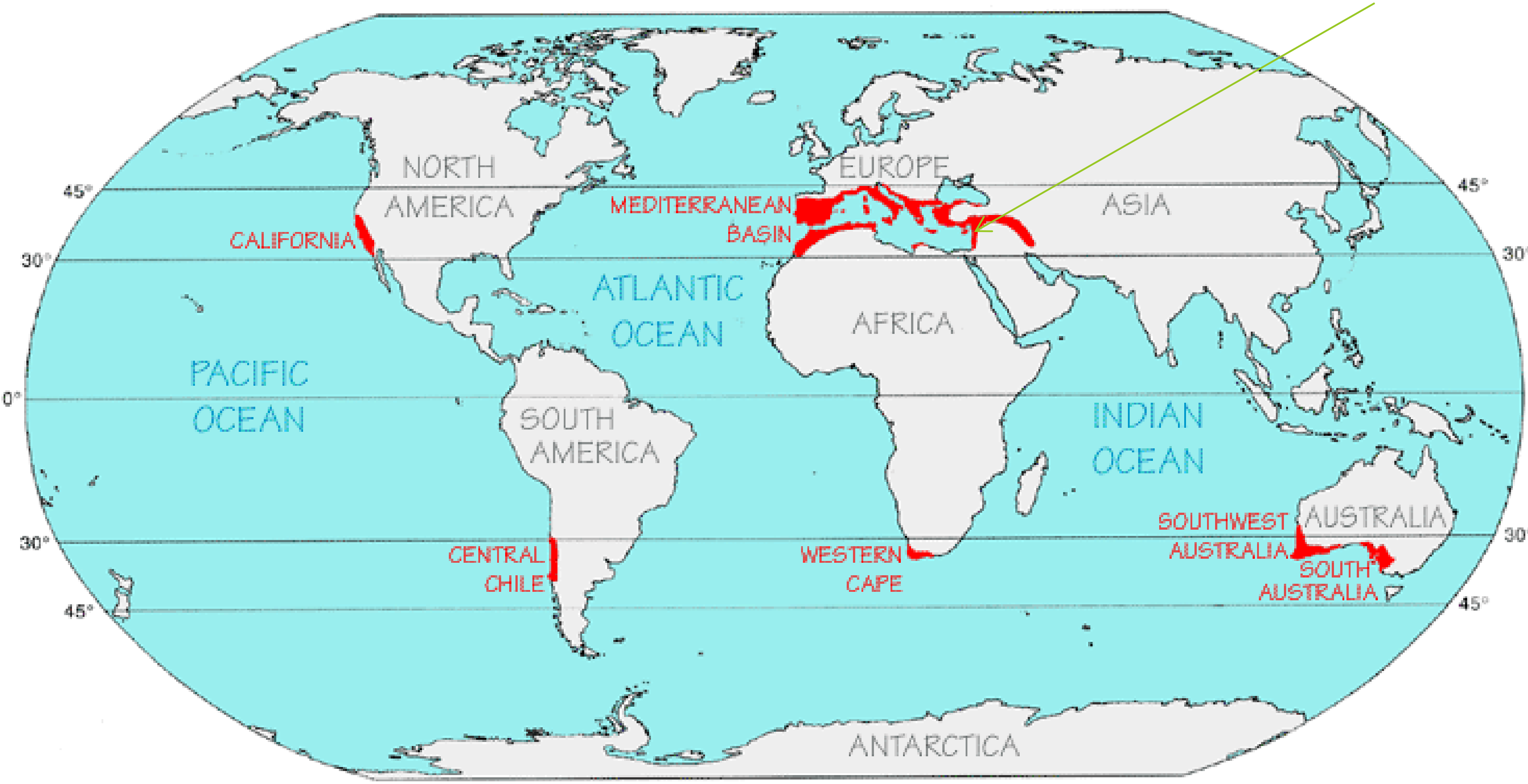
- ✓ Funded within the framework of Partnerships for Enhanced Engagement in Research (PEER), sponsored by USAID.
- ✓ Collaboration with the Department of Earth Sciences Montana State University (US collaborator: Dr. David McWethy)
- ✓ Implementation period: 2012-2016
- ✓ Study area: the entire Lebanese territory

Mitri, G. 2016, Peer meeting, Amman

Background information

Mediterranean climate

Lebanon



Background information (Contn'd)

- ✓ Unique feature in the semi arid environment of the Mediterranean
- ✓ Important ecosystems of the Mediterranean
- ✓ Very rich in biodiversity
- ✓ Provide a variety of goods and environmental services

Mitri, G.

Background information (Contn'd)

Few of the factors impacting upon Lebanon's forests and provoking their degradation:

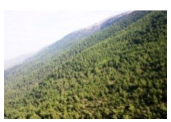
- Overexploitation
- Natural habitats' degradation and loss (including fragementation)
- Forest Fires




Background information (Contn'd)



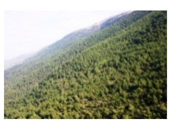





Highlights from the National Strategy of fire management (No.52/2009):

- ✓ A common database on forest fires is still missing. Data, when it exists, is scattered, non-homogenous and difficult to process.
- ✓ Research on forest fires is weak.
- ✓ The analysis of the actual direct and indirect effects of forest fires is at a very preliminary level,
- ✓ Lack of a clear management approach on forest fires issues.
- ✓ Lack of information to describe the magnitude and urgency of the problem to decision makers and make them prioritize the necessary measures to prevent or minimize fire risk.

Background information (Contn'd)



The needs as per Lebanon's National strategy:

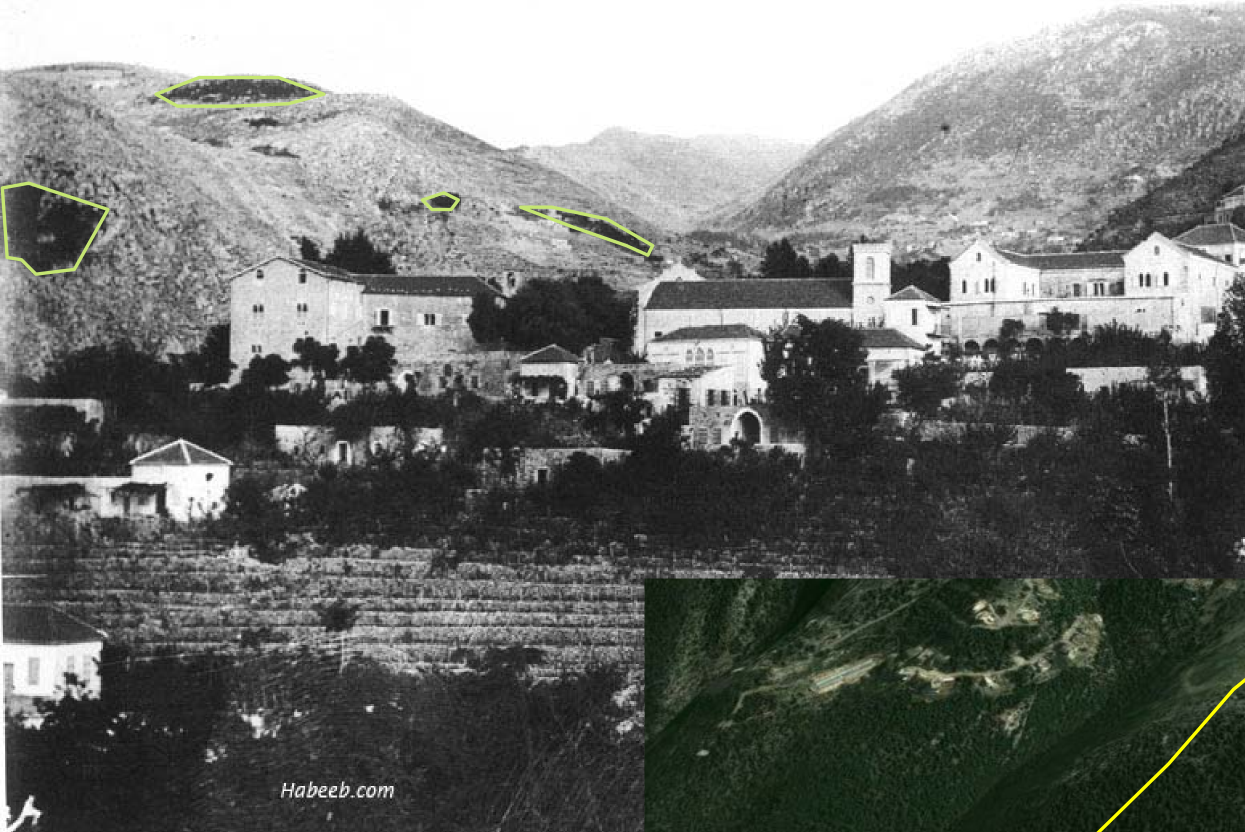
- ✓ A shift towards an enhanced capacity of stakeholders in Lebanon to assess and manage wildfire risk in light of future climate change
- ✓ Studies and researches to support and promote the improvement, know-how sharing, monitoring and dissemination of knowledge on wildfire risk and fire management under a climate change scenario among all relevant actors.

Indirect causes of fires

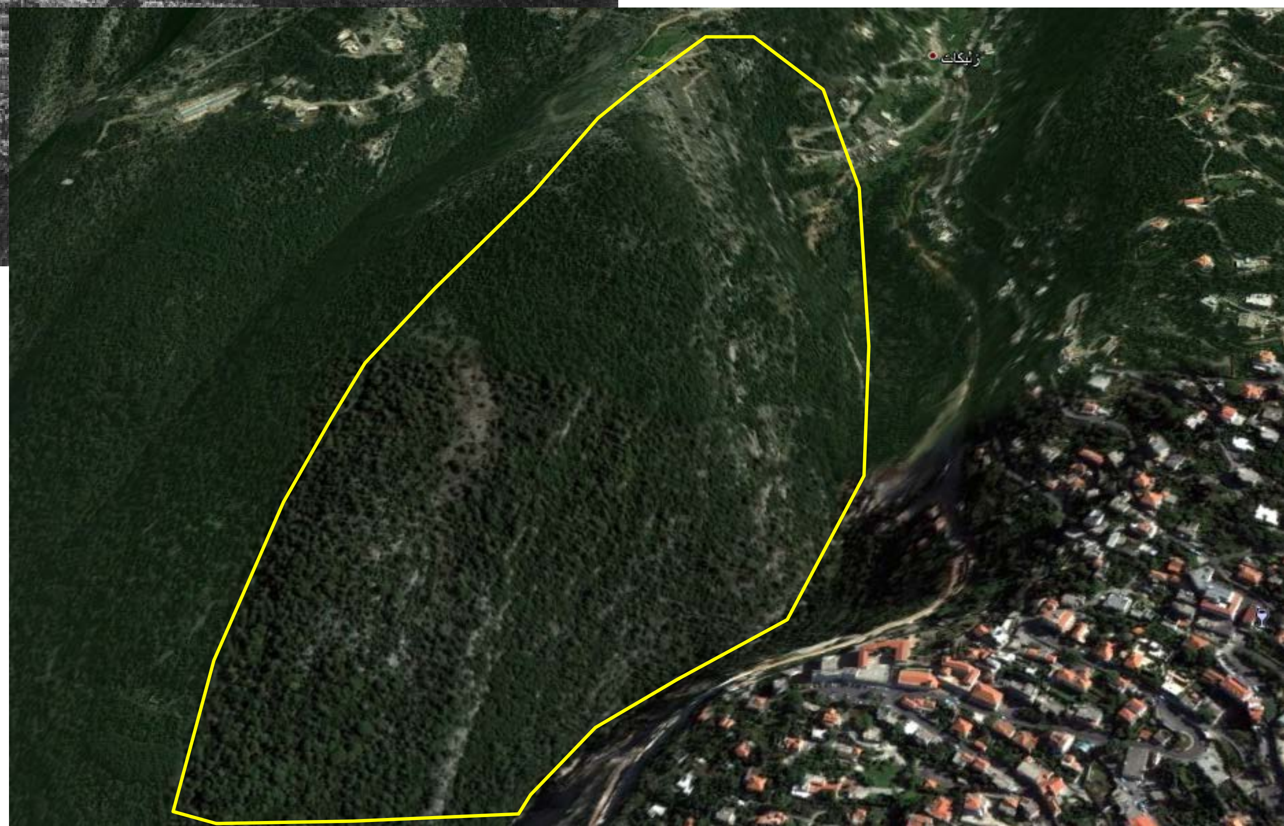
Changes in agricultural habits and disappearance of traditional agricultural industries

Disappearance of traditional clay production, molasses, silk production

Marginalization of land



Ghazir - circa 1893 - Lebanon



Ghazir surrounding mountains - Present

Nahr Al Kalb
from Louaizeh -
circa 1894 -
Lebanon

Nahr Al Kalb from
Louaizeh –
Present time

Indirect causes of fires

Impenetrable thick scrub vegetation

Mitri, G. (2004)

Dense forest fuel

Thick biomass

Indirect causes of fires

Average annual precipitation from 200 mm to 1100 mm - Dry season: 7 to 8 months

Adaptation of certain species to frequent fire occurrence

Main direct causes of fires

- Burning agricultural wastes
- Land clearing by fires
- Uncontrolled waste disposals
- Fireworks and campfires
- Arson

As a result….

Increase in fire occurrence and burned areas

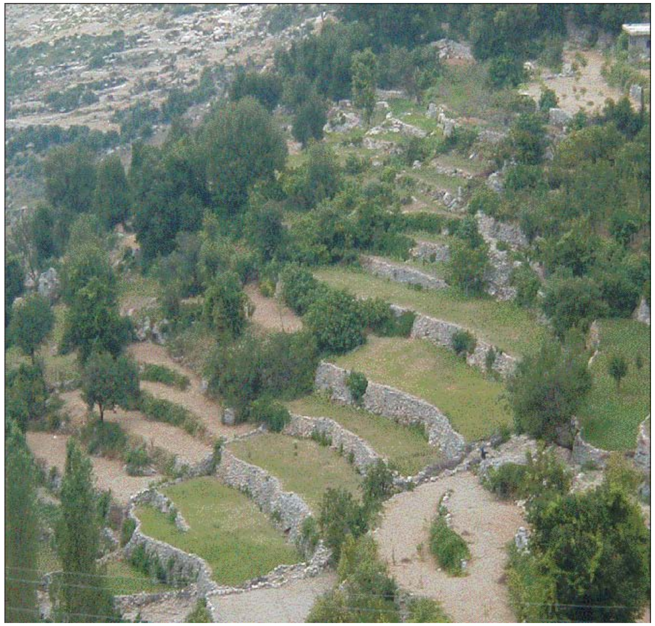
- Relatively large scale wildfires affecting Lebanon's forests
- Increase of frequency, intensity and extent of fires

UNIVERSITY OF BALAMAND 1988 - 2013

A changing world

The relatively recent increase in forest fires can be attributed to:

1. land-use changes; and
2. climatic warming (which is reducing fuel humidity and increasing fire risk and fire spread)



Land use changes

Lebanon has experienced:

1. Depopulation of rural areas

2. Decreases in grazing in different rural areas

These changes in traditional land-use and lifestyles have implied the abandonment of large areas of agricultural land, which has led to the recovery of vegetation and an increase in accumulated fuel.


Intense fires

Urban sprawl: increased risk in the wildland-Urban Interface

- Most recently, there has been an increasing claim for wildland (places where people can live or spend their holidays).
- This becomes more obvious near cities and large urban settlements
- This situation is generally known as Wildland Urban Interface (WUI).
- The WUI is described as the line, area, or zone where structures and other human developments meet or intermingle with undeveloped wildland or vegetative fuels (United States Department of the Interior, 1995).


Mitri, George (2010)


Mitri, George (2010)

Wildland Rural Interface, the agricultural Interface

The agricultural interface can be defined as an interface where farms, crops, and orchard, irrigated or non-irrigated, are exposed to forest fires.

Weakening of agricultural activities in Lebanon

In the last decades, a weakening of the agricultural activities has been observed.

Cultivated lands have been regressed.

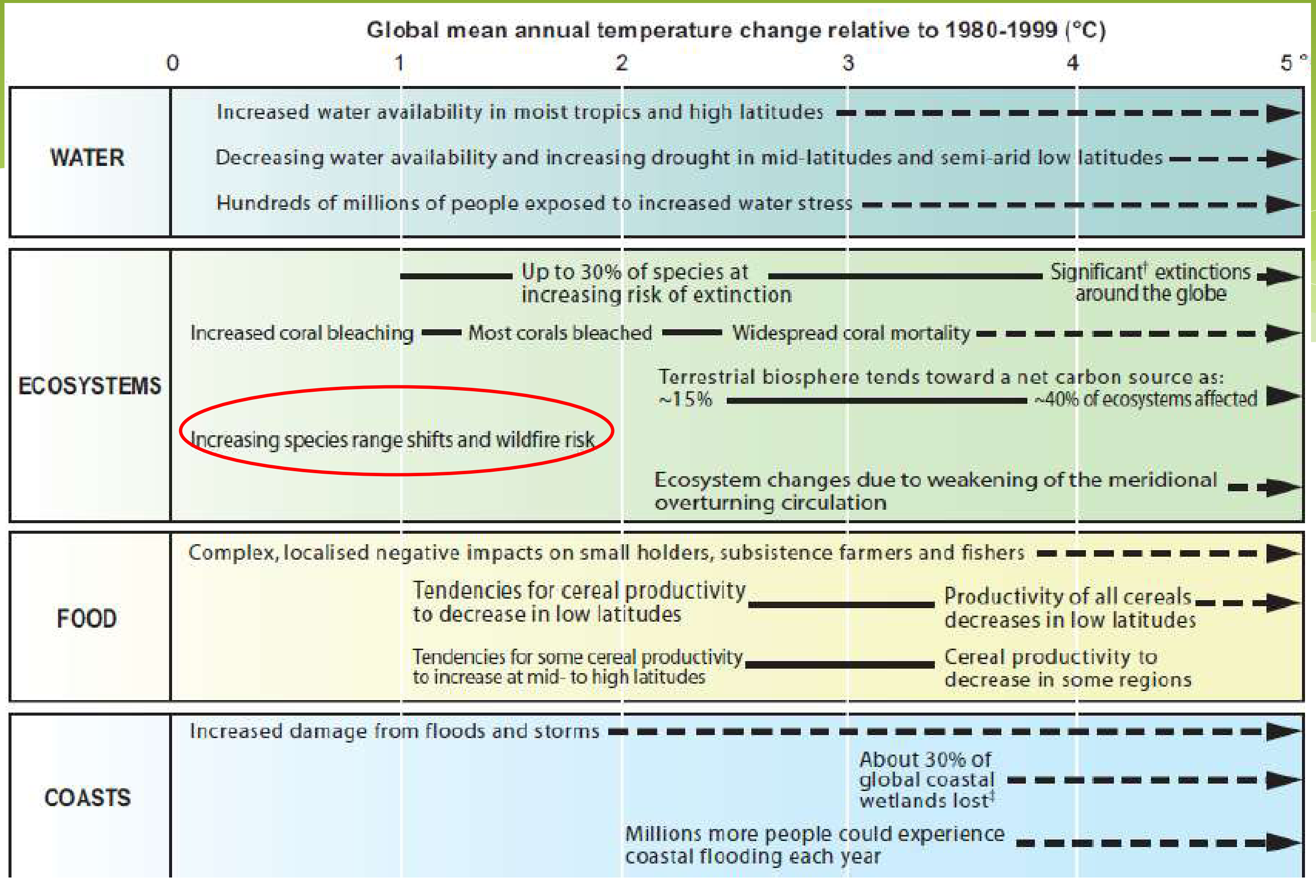
Fertile lands have been rapidly overgrown by garrigue.

There has been an incessant expansion of the vegetation between both parts.

This has caused a new form of danger which assembles both


Homes near marginalized lands

Climate change is worsening the situation: highlights from IPCC 2007

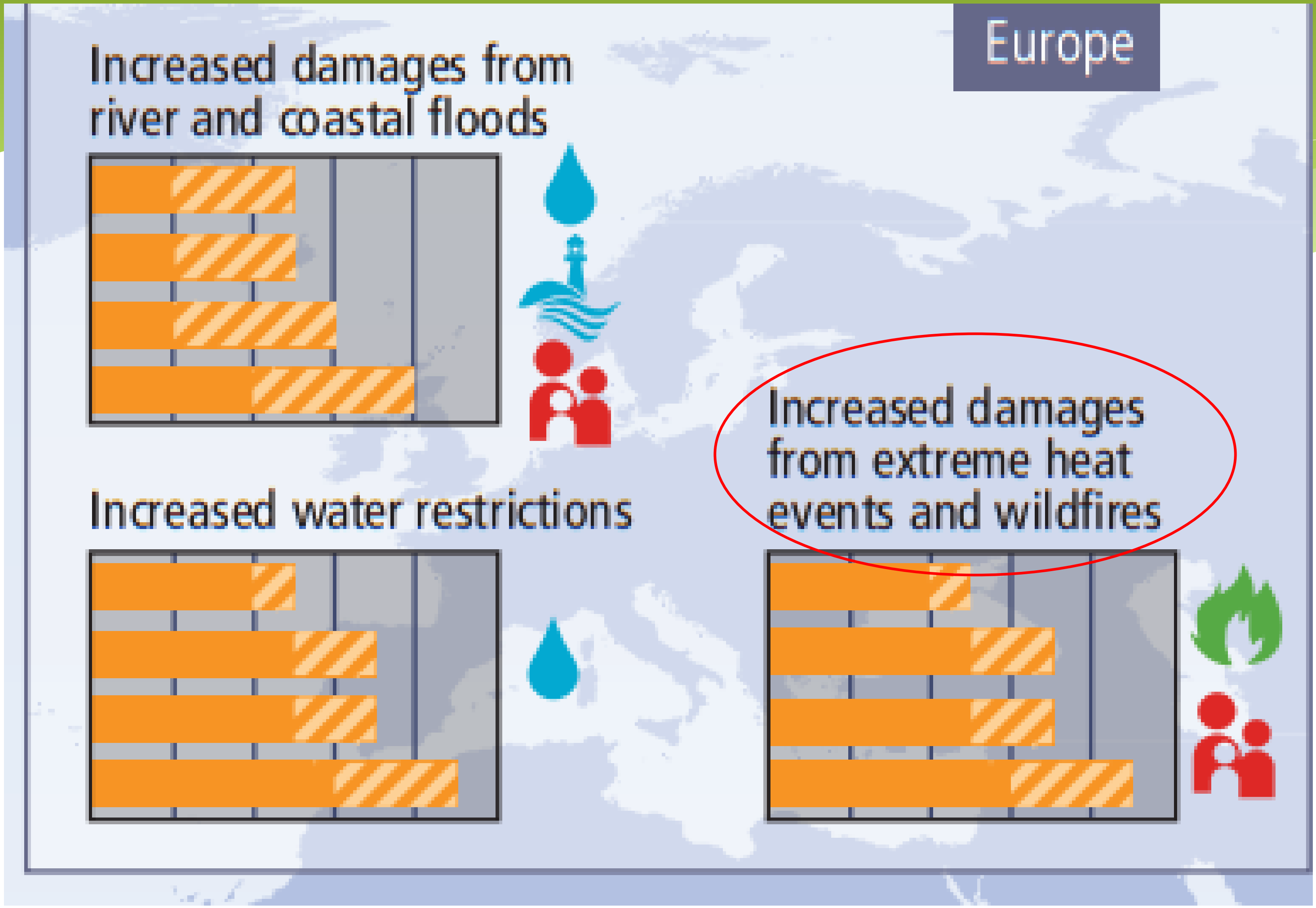


Source: IPCC AR 4 WGII (2007)

Extreme event and forest fires:

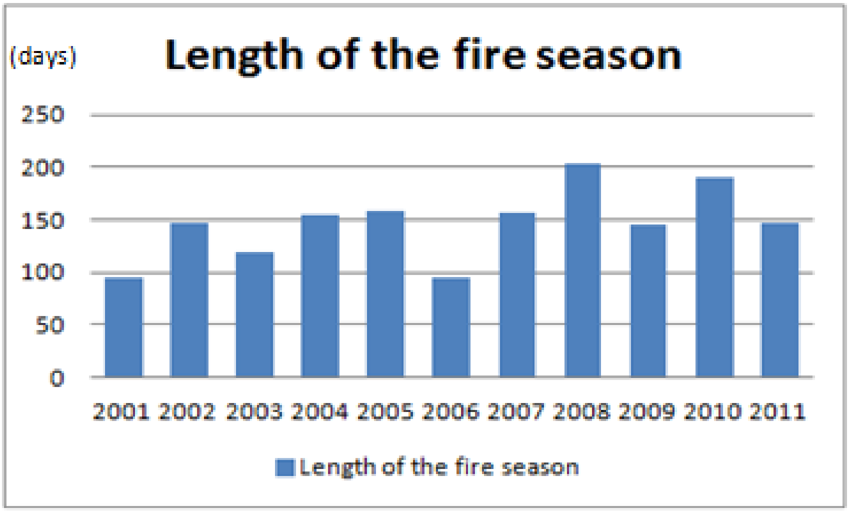
- Heat weaves / Large scale fires
- Drought periods / Forest dieback
- Heavy rainfall / Soil erosion, soil water scarcity & Floods

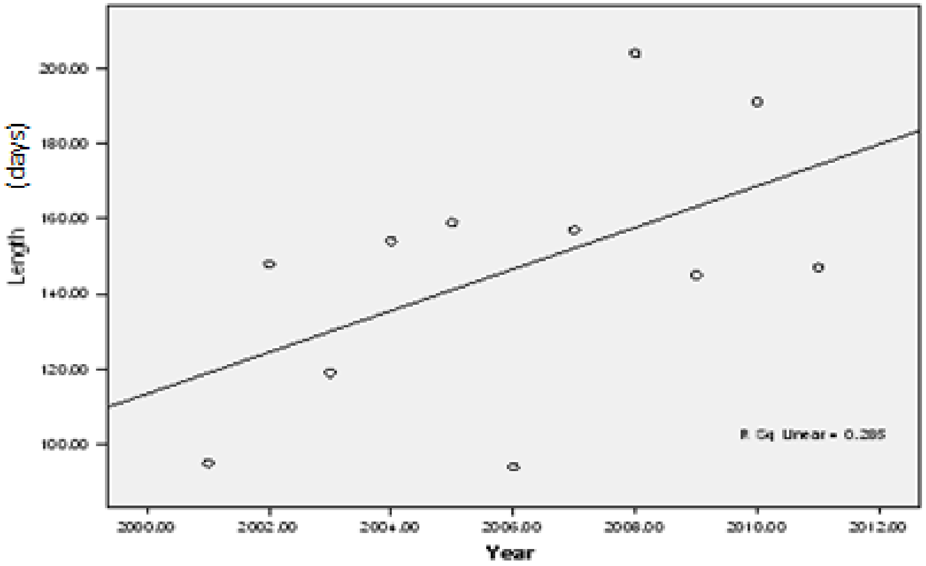
Climate change is worsening the situation: highlights from IPCC 2014



Climate change 2014: Synthesis Report, Summary for Policymakers

Increasing length of fire seasons

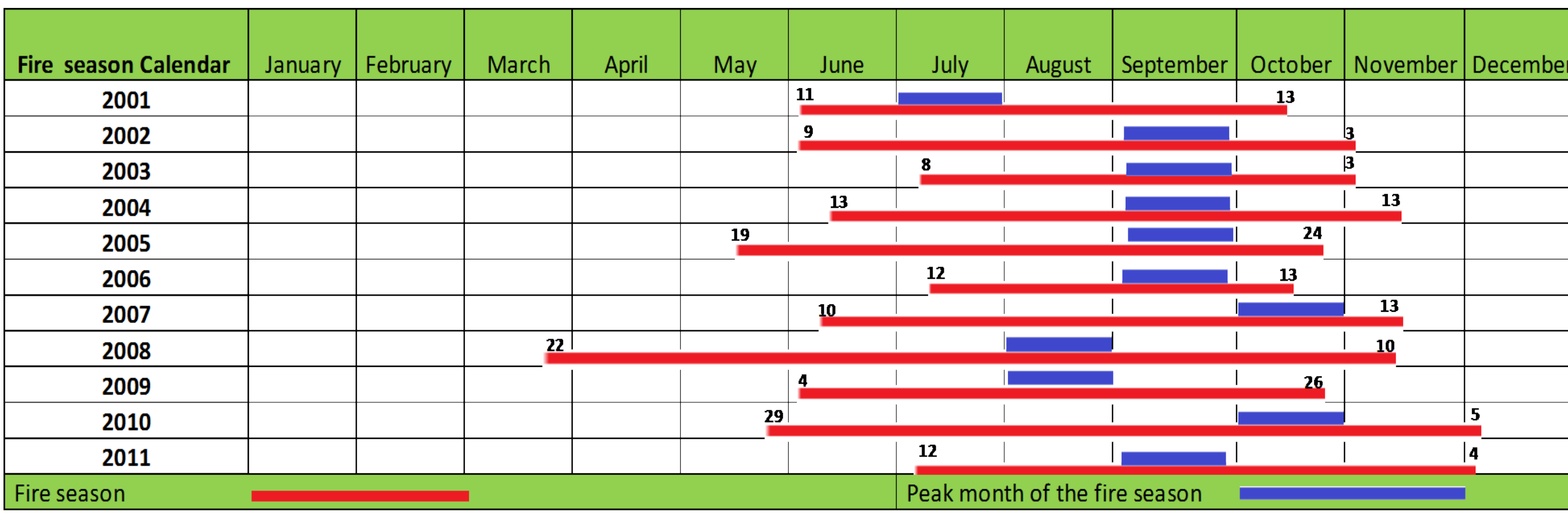




Temporal variation in the length of the fire season (left), and a scatter plot of the variation (right) - (Salloum and Mitri, 2012)

Increasing length of fire seasons

- Average **start date** of the fire season is **June 14,**
- Average **end date** of the fire season is **November 12**
- Length of the fire season has exhibited an increase over the past decade
- Average **peak month** is **September**
- The largest number of fires that took place during a peak month was in October 2007
- The current forest law refers to a fire risk period between July 1 and October 31.
- Time to re-define the dates of the of the fire risk period?



Fire season calendar (Salloum and Mitri, 2012)

Large scale and recurrent fires

A serious threat to:

- Human lives
- Private property
- Infrastructure
- Environmental quality
- Natural resources

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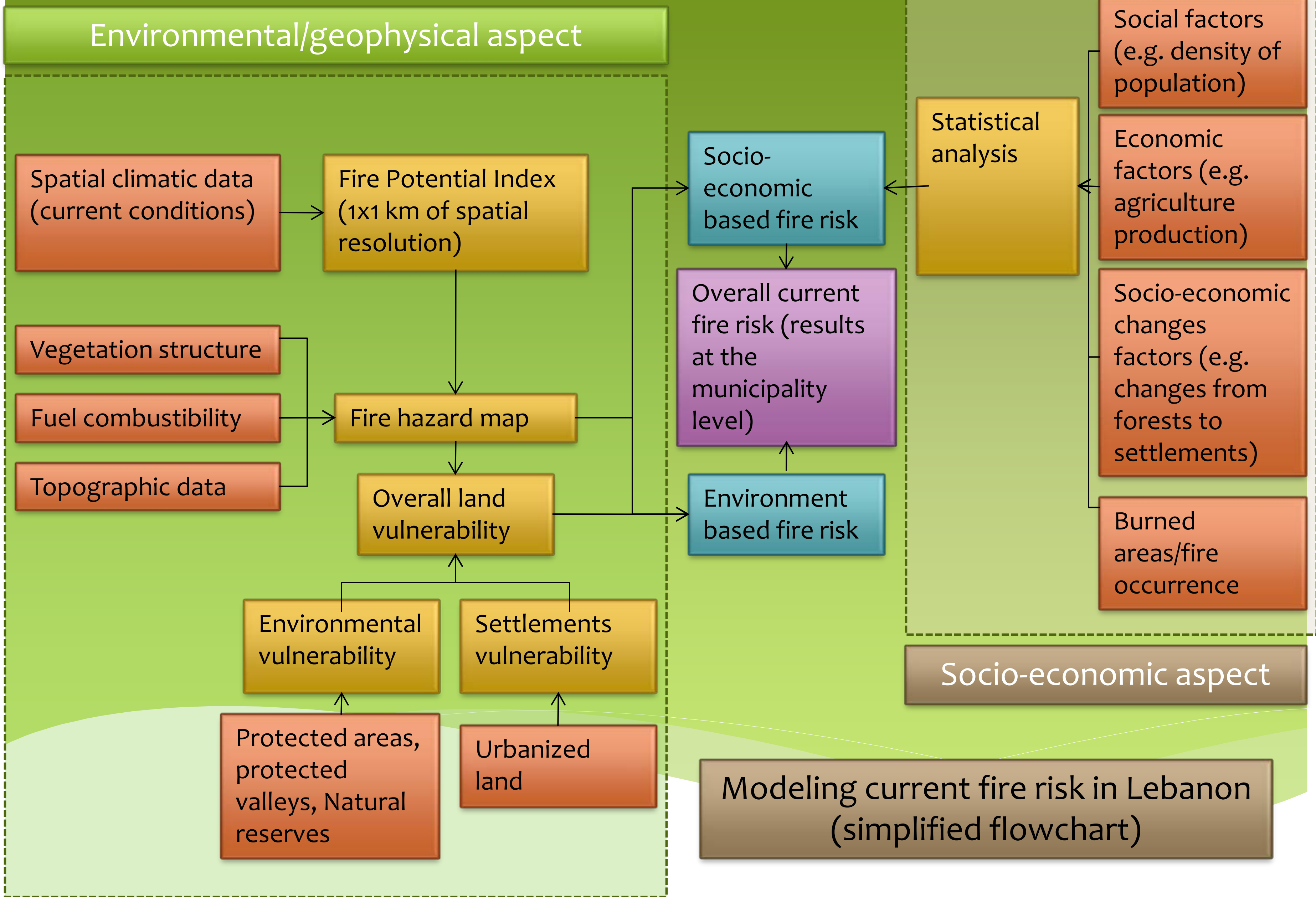
Citizens check a charred car near in a fire affected area in Betshai (May 5, 2014) near the Capital Beirut (source: The Daily Star/Mohammad Azakir).

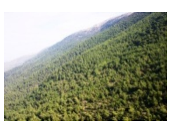
Conducted work



Dataset description

- ✓ High to moderate resolution satellite imagery (SPOT, Landsat, DMC, etc.)
- ✓ Landcover Land use map of Lebanon
- ✓ Global climatic datasets
- ✓ Administrative maps
- ✓ Digital Elevation Model (25 m)
- ✓ Global datasets (e.g. precipitation)
- ✓ National reports and datasets (socio-econ)
- ✓ Field data collection

Field-based data



Internal security forces (police)

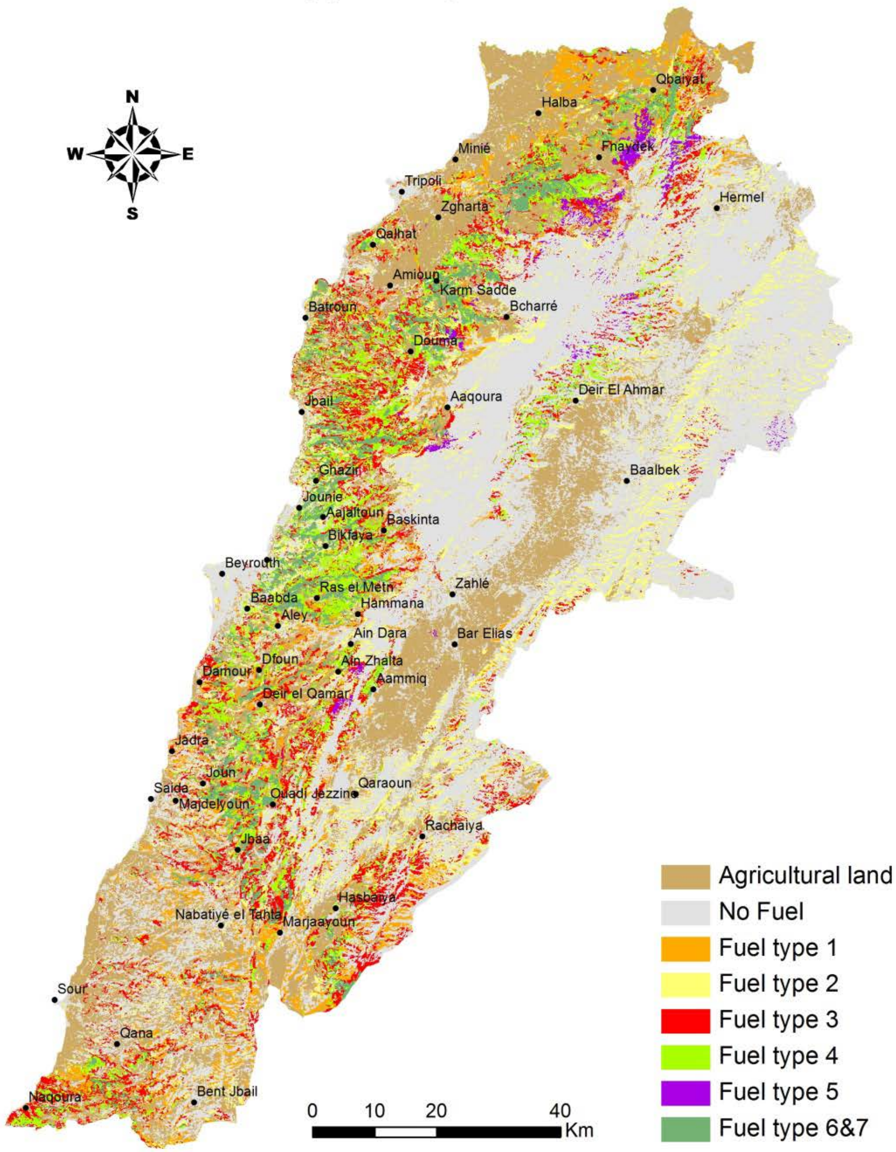
Ministry of Environment

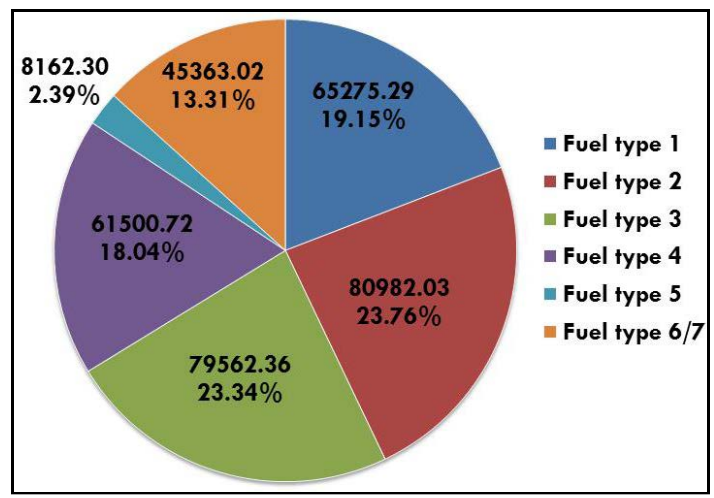
University of Balamand

S83 Agricultural Seasonal crop

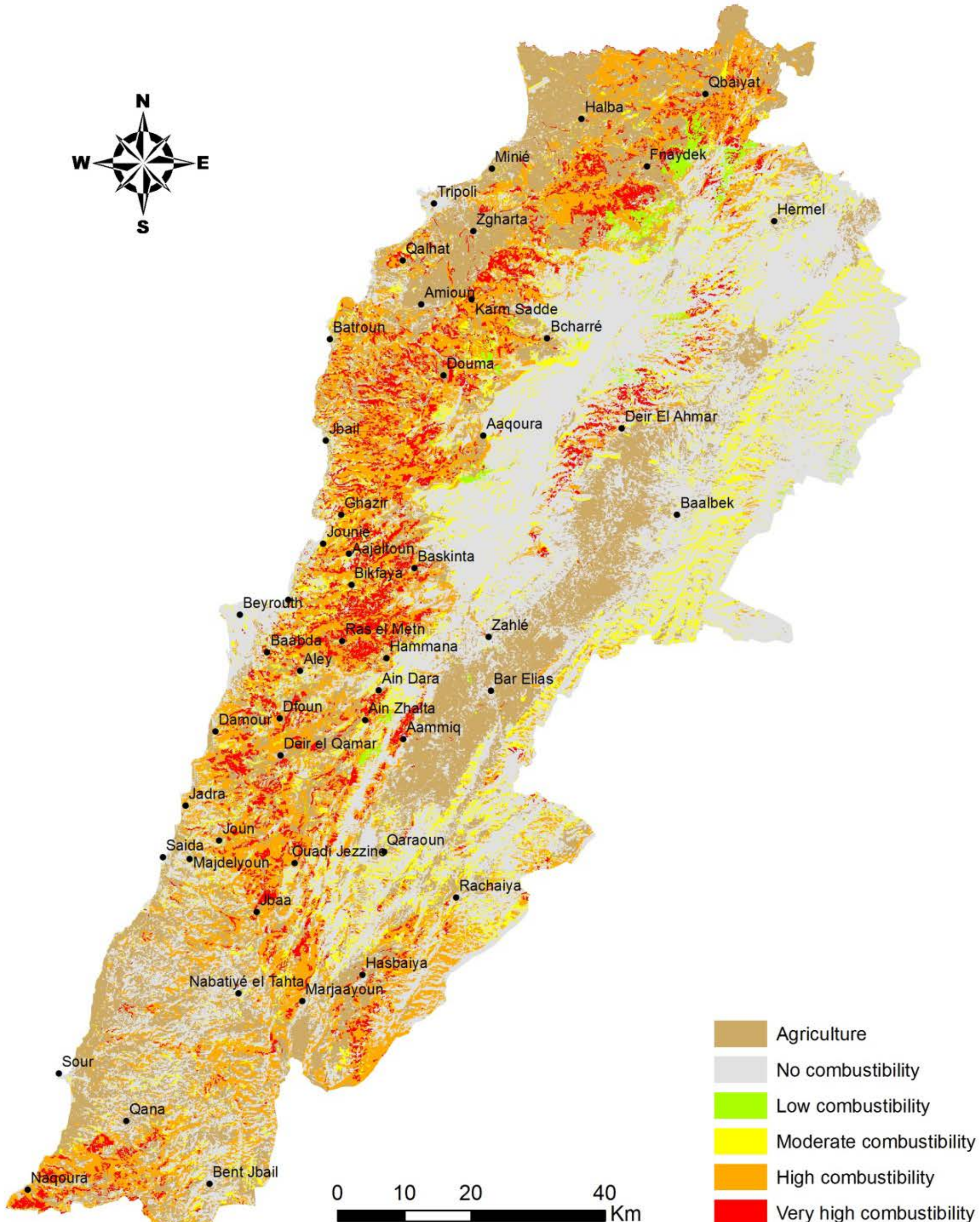
	G	H	I	J	K	L	M	N	O
1	1.1 Ownership Private	1.2 Administrative Location_Mohafaza	1.2 Administrative Location_Kadaa	1.2 Administrative Location_City/Village	1.2 Administrative Location_Place	1.3 Landuse	1.4 Topographic Characteristics_Land	1.4 Topographic Characteristics_Slope %	1.4 Topographic Characteristics_A
2	Private Owner	Nabatiye	Bint Jbeil	Aain Ibl	Aain ibil	Agriculture	Mountain	N/A	N/A
3	Private Owner	Mount Lebanon	Chouf	Kahlouniet Ech-Chouf	Main road Kahlouniet	Grassland	Mountain	N/A	N/A
4	Private Owner	Mount Lebanon	Chouf	Kahlouniet Ech-Chouf	Chouf Farm	Forest/Woodlot	Mountain	50 +	W
8	Private Owner	Mount Lebanon	Chouf	Joun	Kroum l homer	Constructions	Mountain	50 +	S
9	Private Owner	South	Jezzine	Ghaziye	behnin	Grassland	Mountain	20 to 30	W
10	Private Owner	North	Zgharta	Aalma	Beit awkar	Agriculture	Mountain	30 to 40	N/A
11		Mount Lebanon	Jbeil	Jbayl	Cheikhan	Forest/Woodlot	Mountain	N/A	N/A
13	Private Owner	Nabatiye	Bint Jbeil	Aain Aata		Agriculture	Mountain	50 +	E
14	Private Owner	Mount Lebanon	El metn	Zaraaoun		Forest/Woodlot	Mountain	50 +	N/A
17		South	Sour	Markaba		Forest/Woodlot	Mountain	30 to 40	N/A
19		Nabatiye	Marjeoune	Houla	El Aabad	Forest/Woodlot	Mountain	N/A	N/A
21	N/A	South	Sour	Other (Kana)	jabal ghasyoun	Grassland	Mountain	50 +	SE
24	Waqef Land	North	Zgharta	Aalma	Aarbaein chahid	Forest/Woodlot	Mountain	N/A	N/A
31		Mount Lebanon	Aley	Souq El-Gharb	ras el jabal	Forest/Woodlot	Mountain	N/A	N/A
32		North	Zgharta	Aachach	Aachach	Forest/Woodlot	Mountain	N/A	N/A
37		South	Sour	N/A		Forest/Woodlot	Mountain	N/A	N/A
38	Private Owner	North	Zgharta	Bnechaai	Bnechaai	Forest/Woodlot	Mountain	N/A	N/A
43	N/A	Nabatiye	Marjeoune	Honin	honin valley	Grassland	Mountain	50 +	E
45		Nabatiye	Hasbaya	Rachaiya El-Foukhar	khraybi	Forest/Woodlot	Mountain	50 +	E
47	Waqef Land	Mount Lebanon	Jbeil	mayfuk	mayfuk	Forest/Woodlot	Mountain	N/A	N/A
48	Private Owner	Aakar	Aakar	Aakar denneyi		Forest/Woodlot	Mountain	N/A	N/A

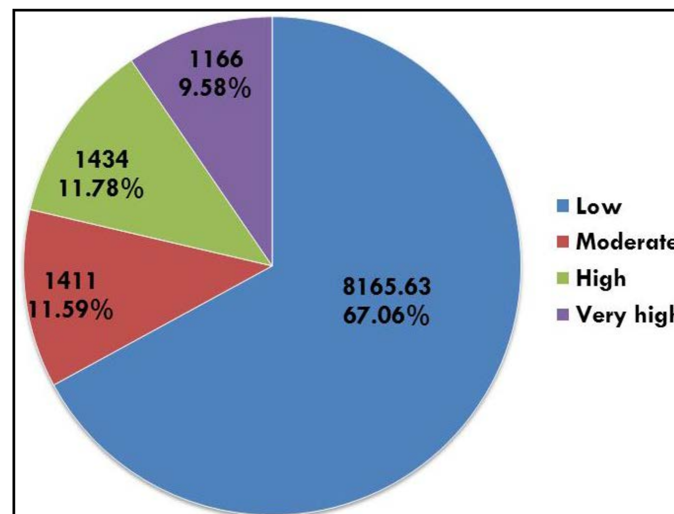
Fuel type map of Lebanon



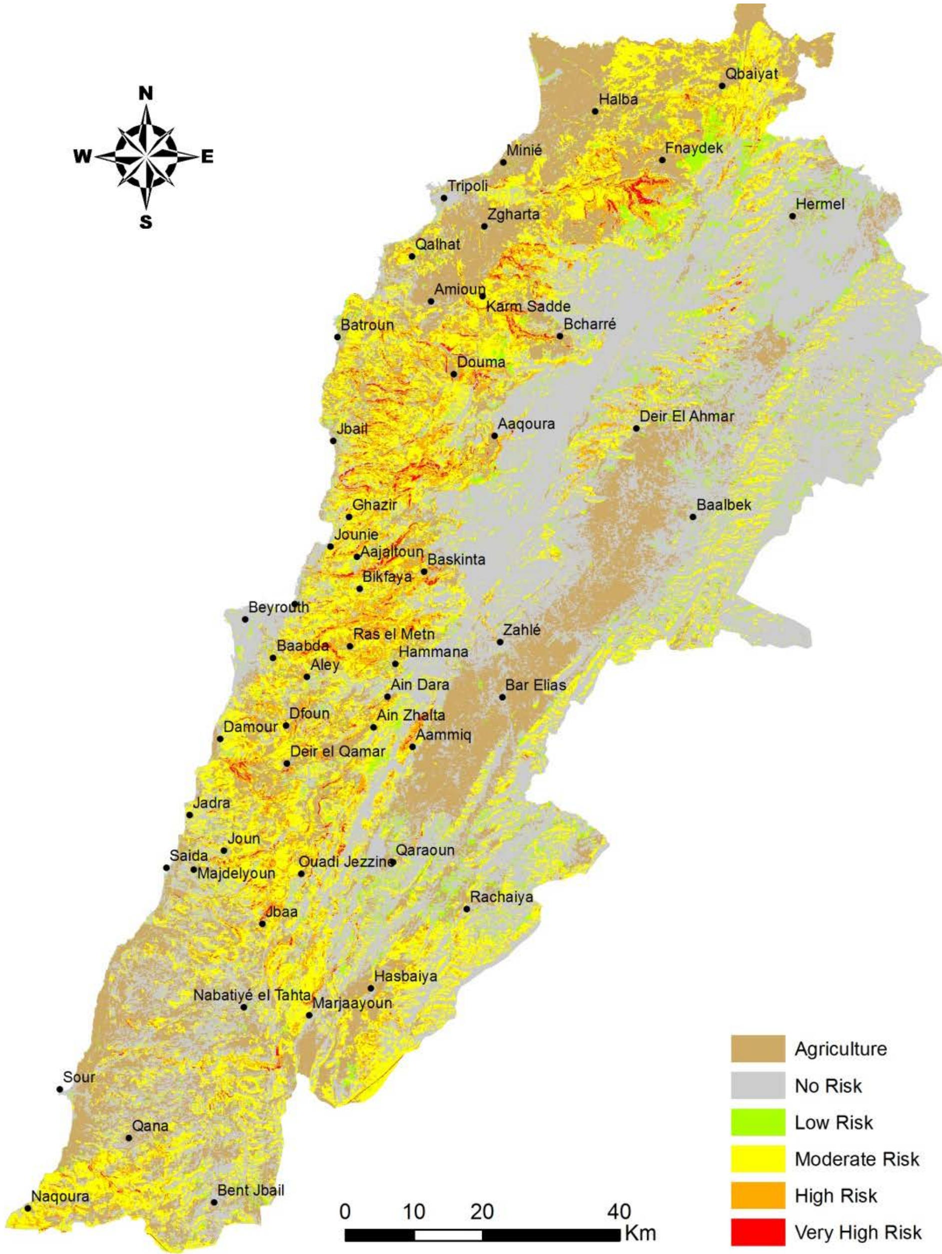


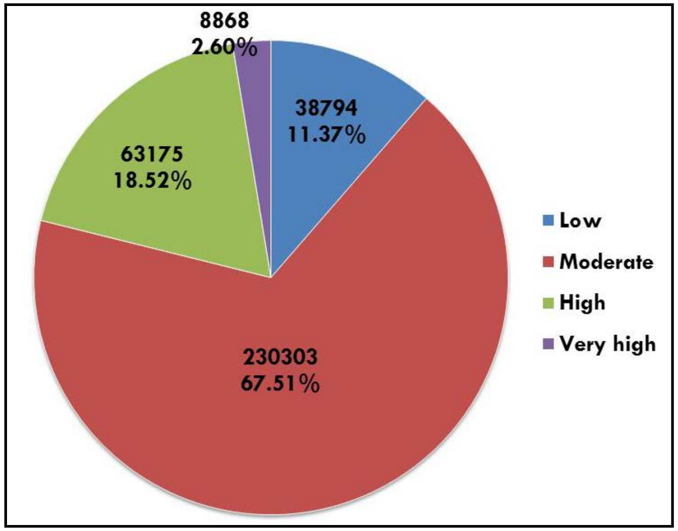
Fuel combustibility map of Lebanon



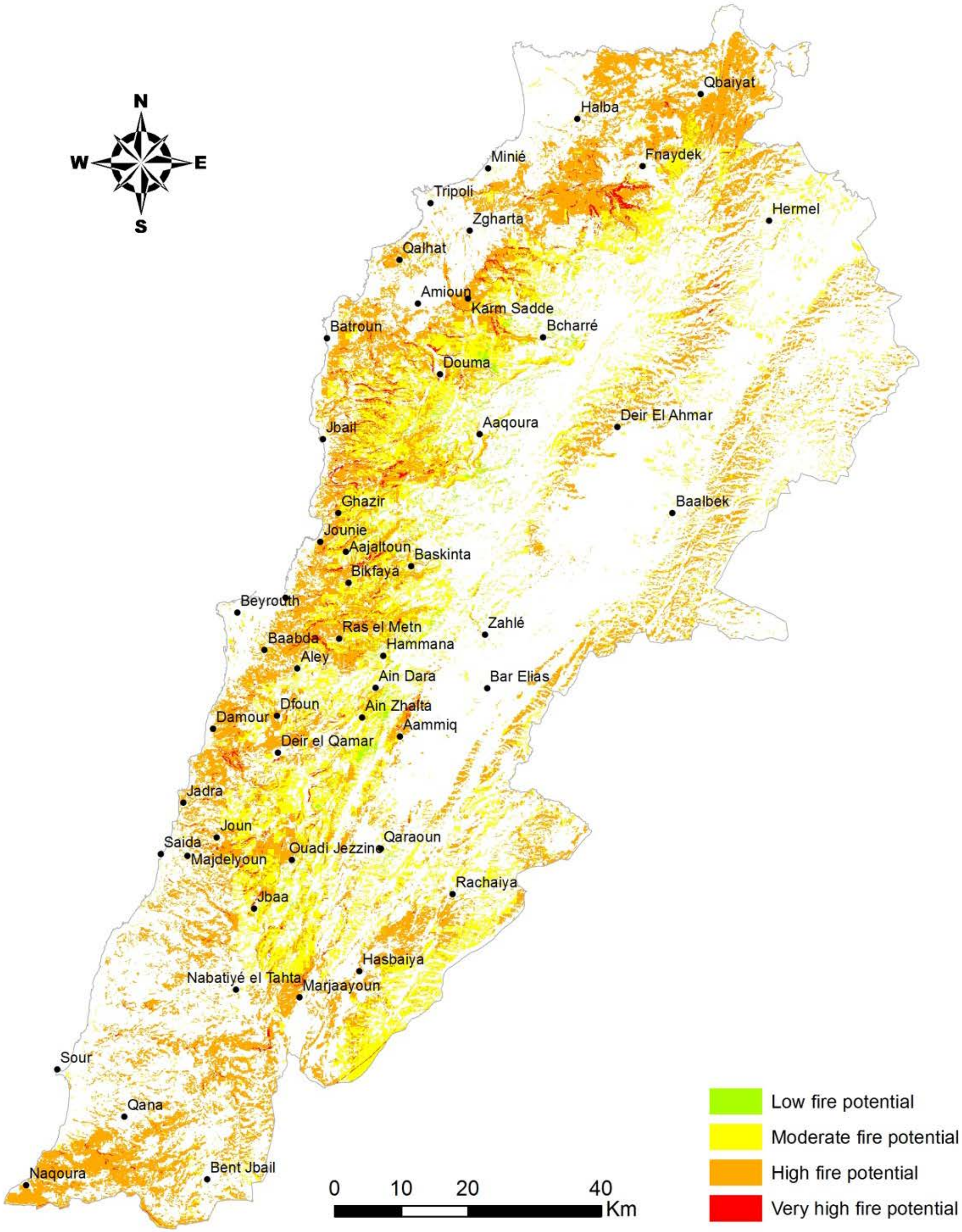


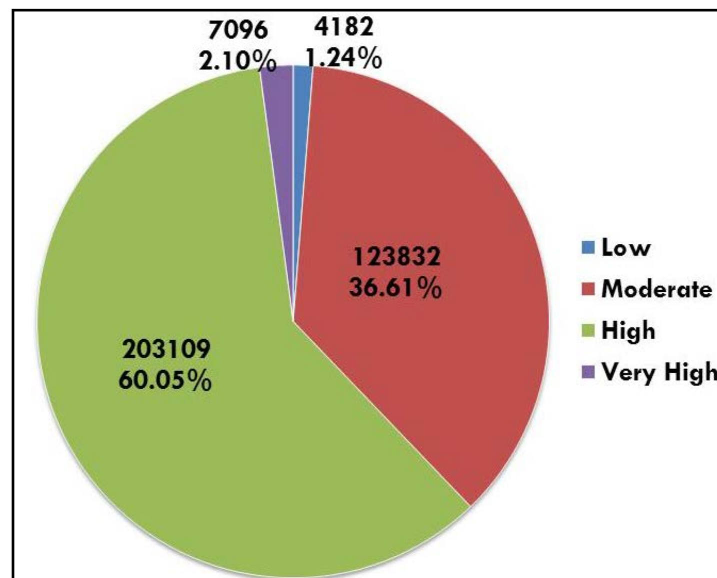
Fire spread map of Lebanon





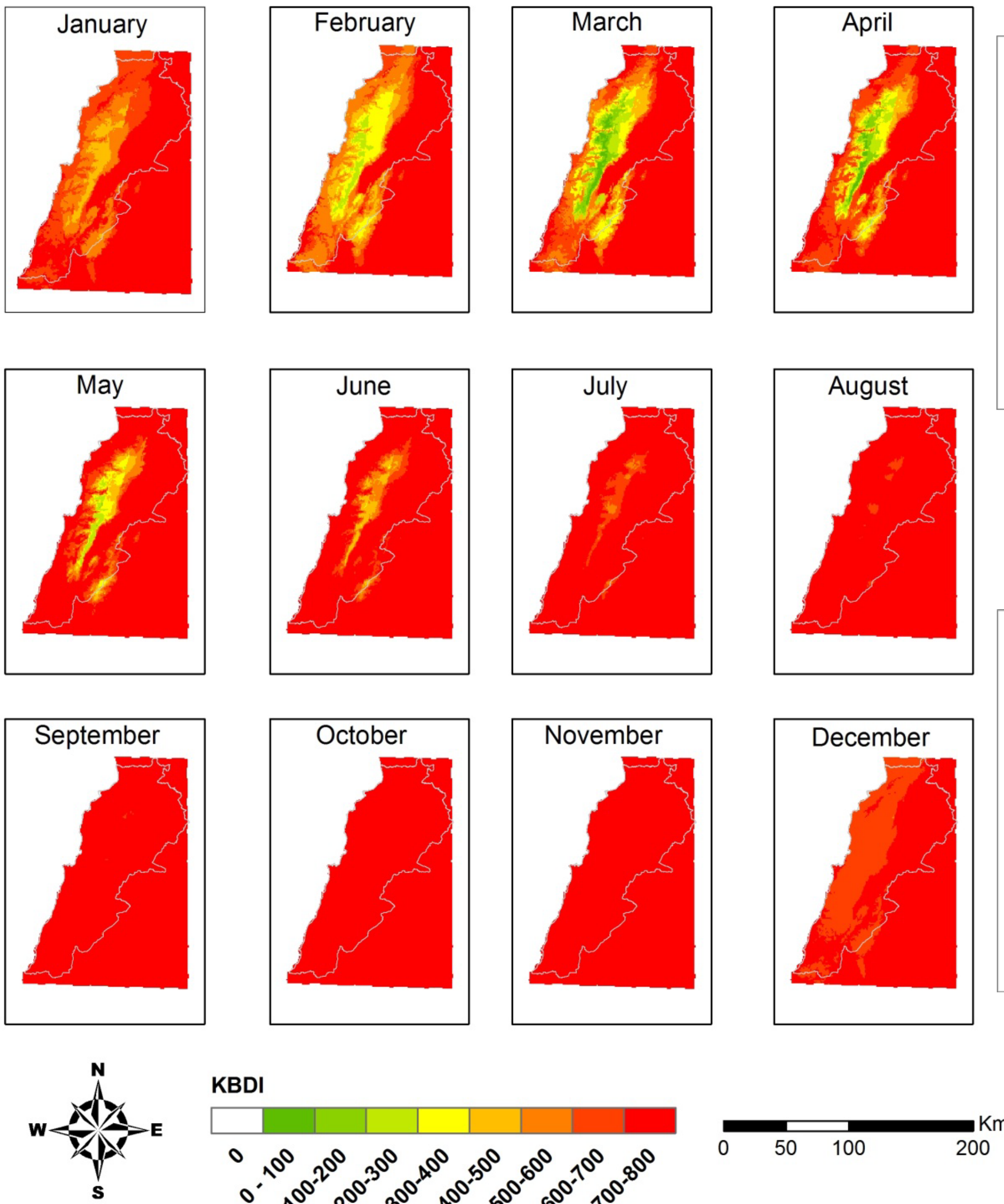
Current fire hazard map of Lebanon

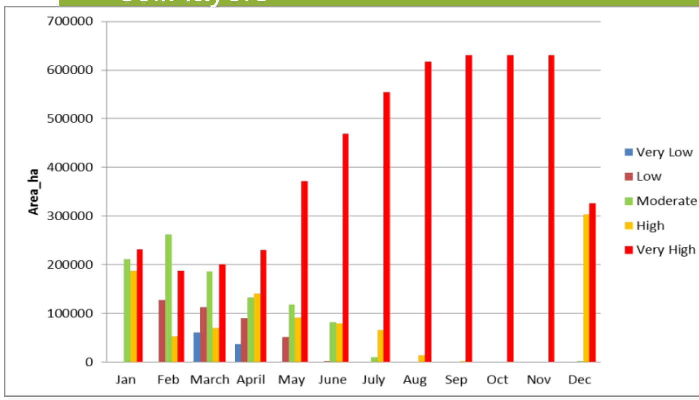




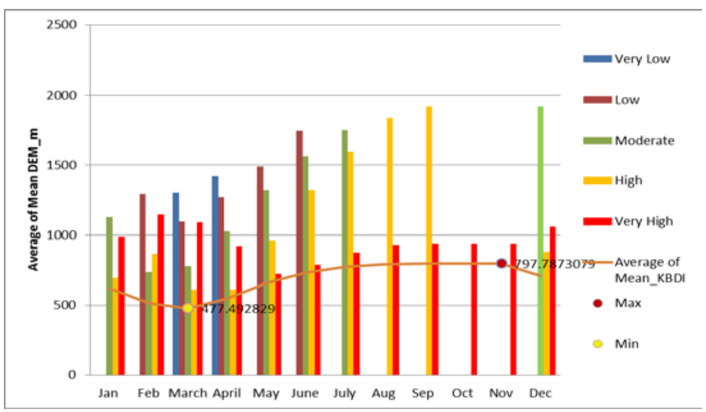
Monthly KBDI maps of Lebanon

The KBDI is a measure meteorological drought; it reflects water gain or loss within the upper soil. layers



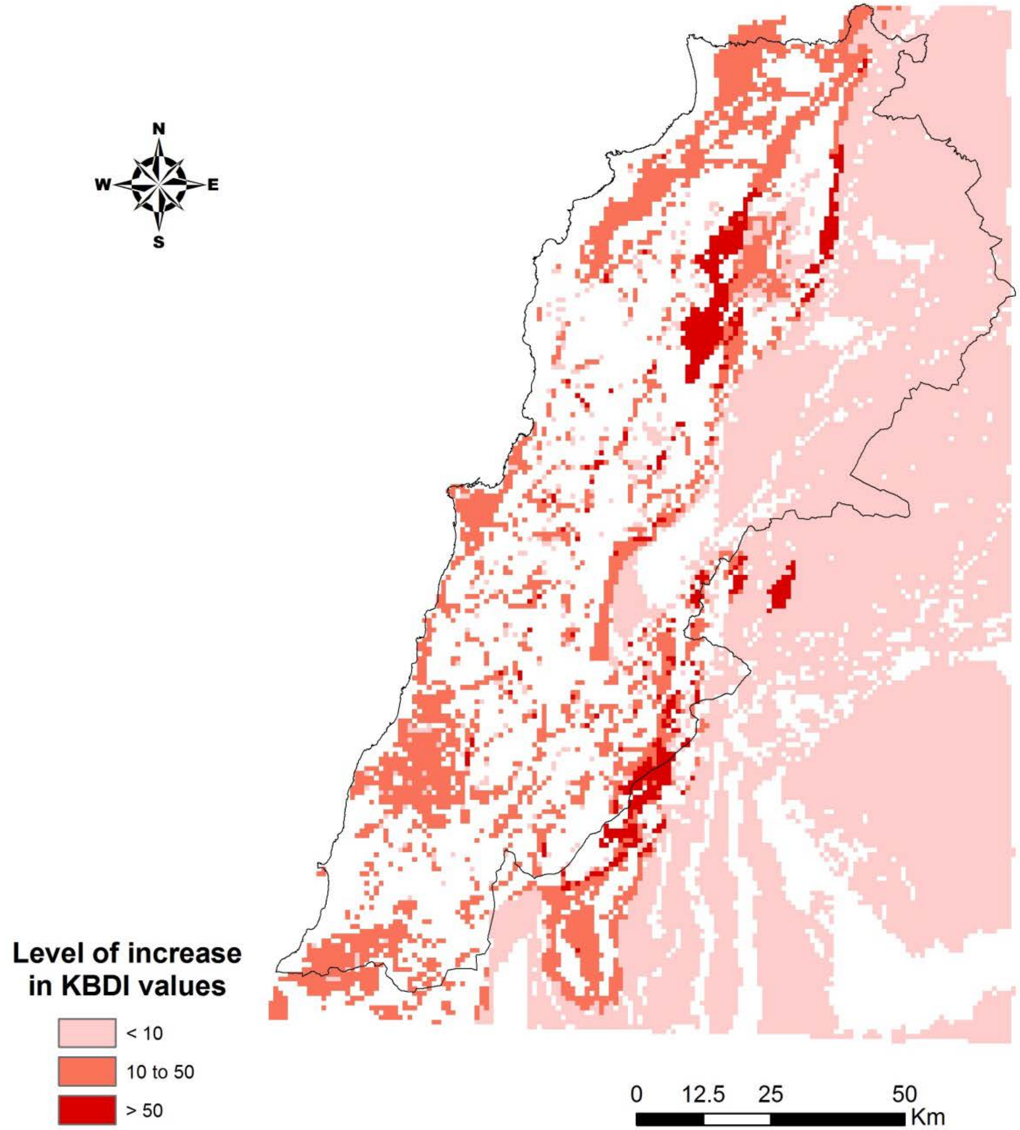


Spatial distribution of KBDI classes throughout the year (excluding agricultural and un-vegetated areas)

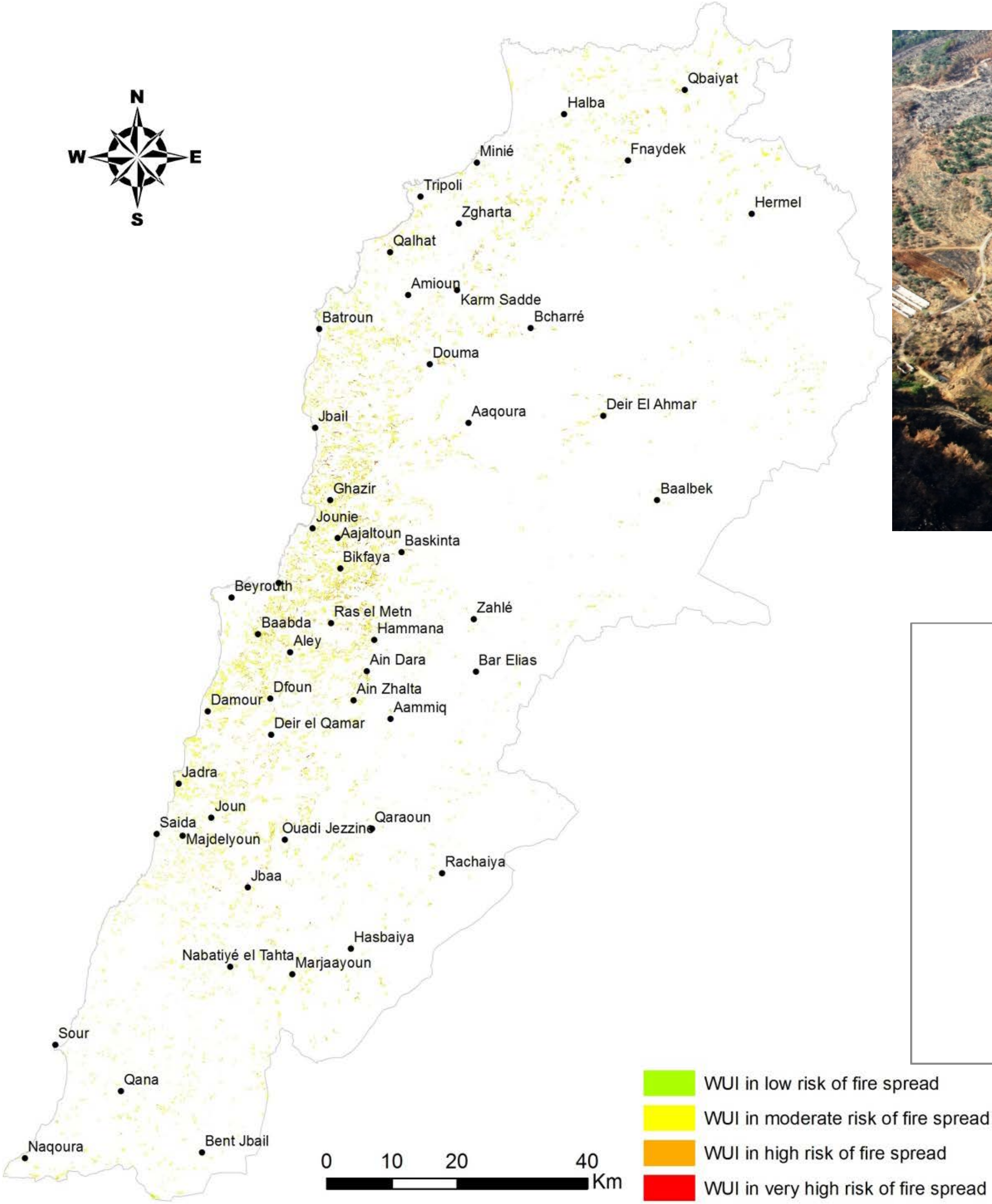


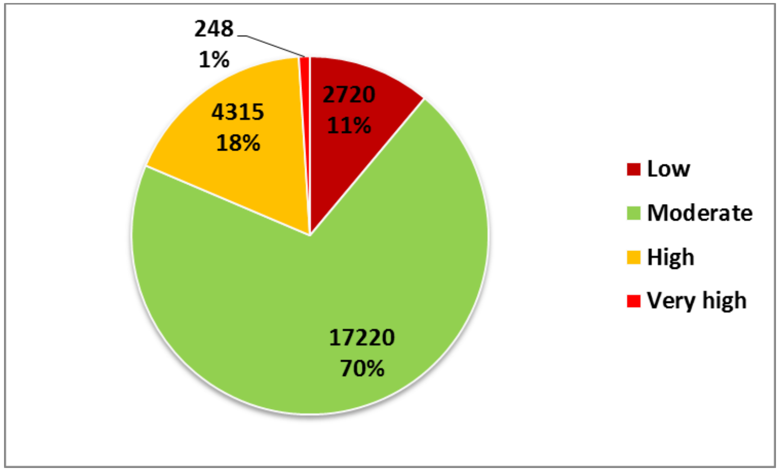
Distribution of the average monthly KBDI in function of average mean elevation (excluding agricultural and un-vegetated areas)

Areas of Increase in Fire Potential (KBDI) Present vs 2020s



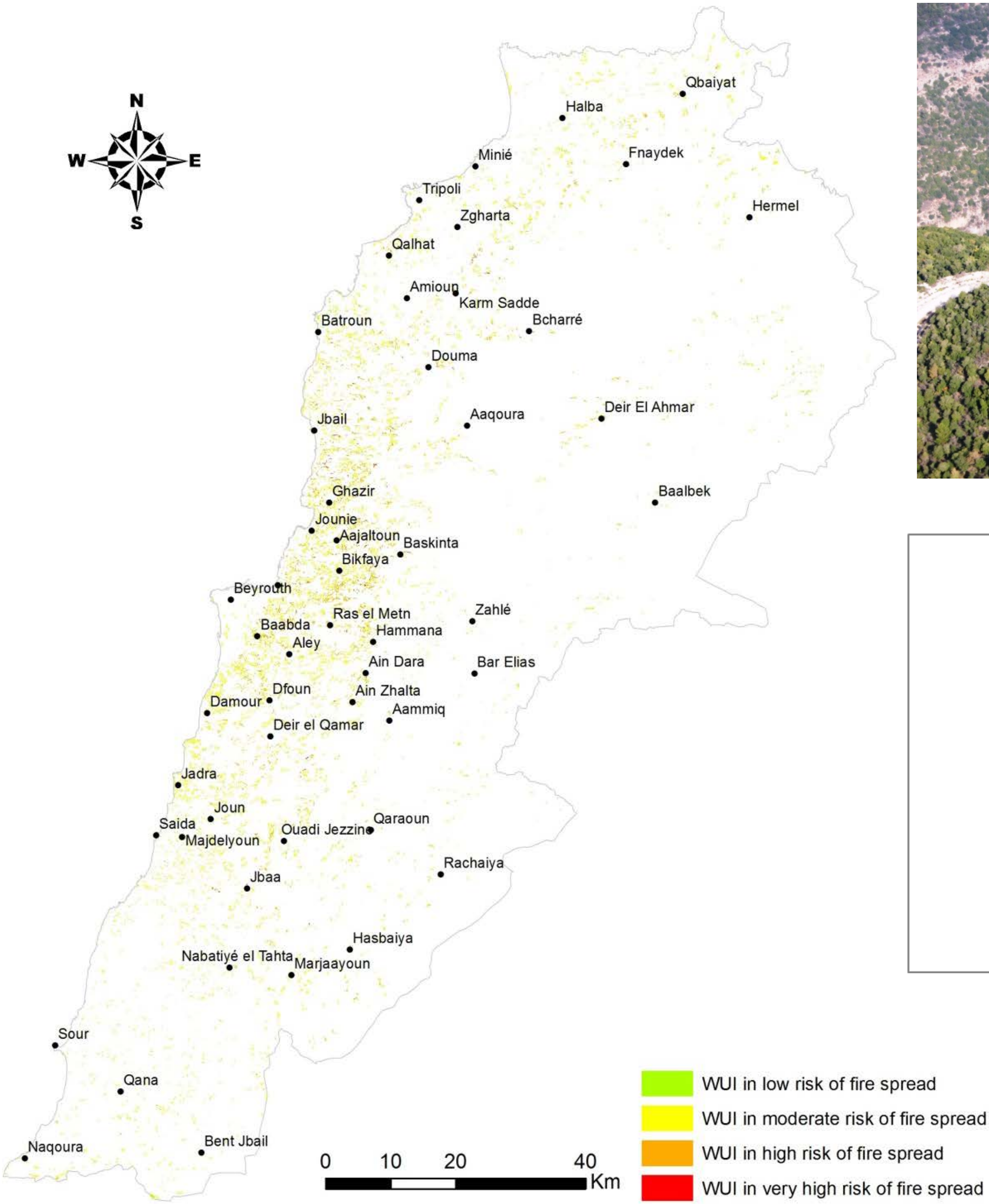
Wildland-Urban Interface in Risk of Fire Spread

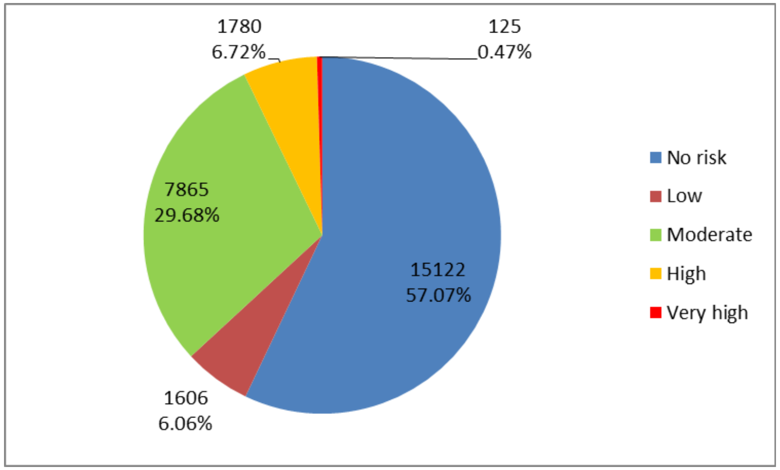




WUI area (ha) in risk of fire spread

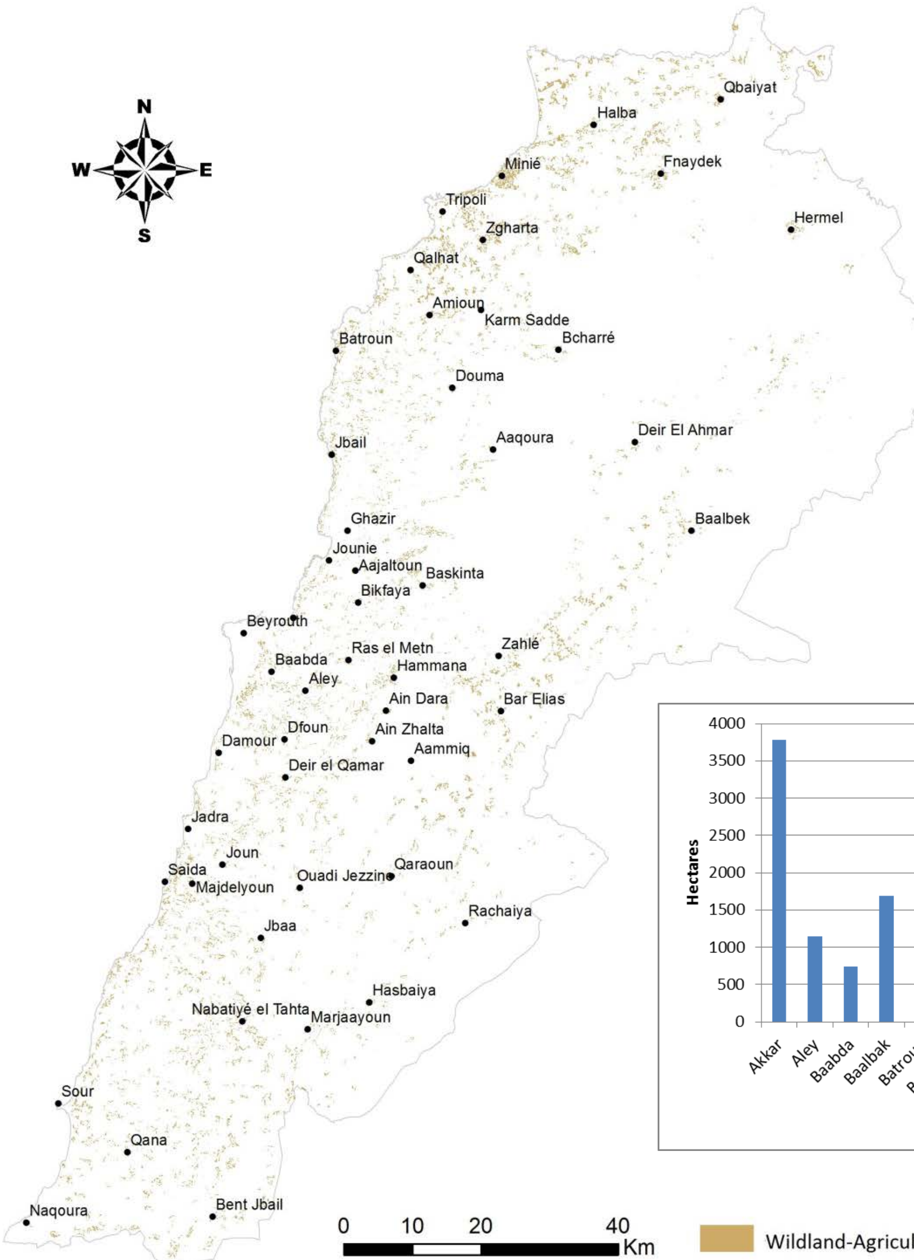
Wildland-Urban Interface in Risk of Fire Spread



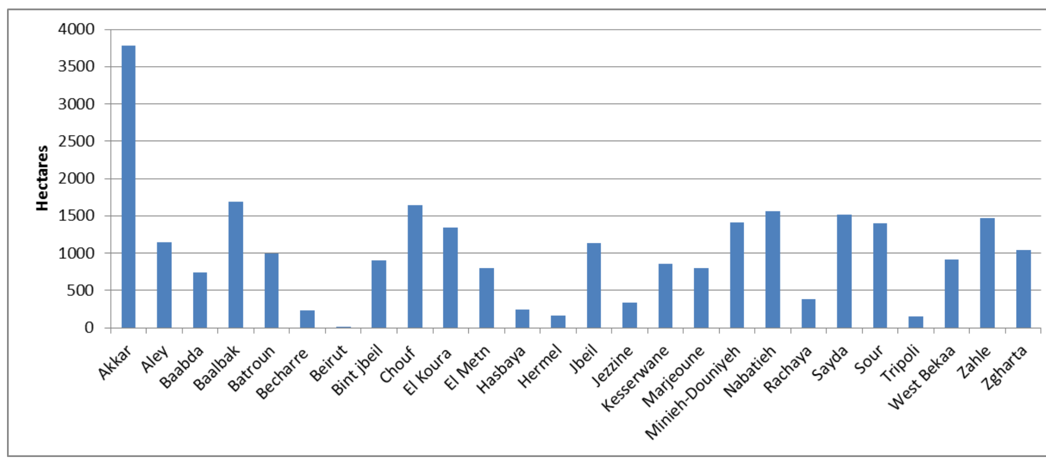


Roads length (Km) in risk of fire spread

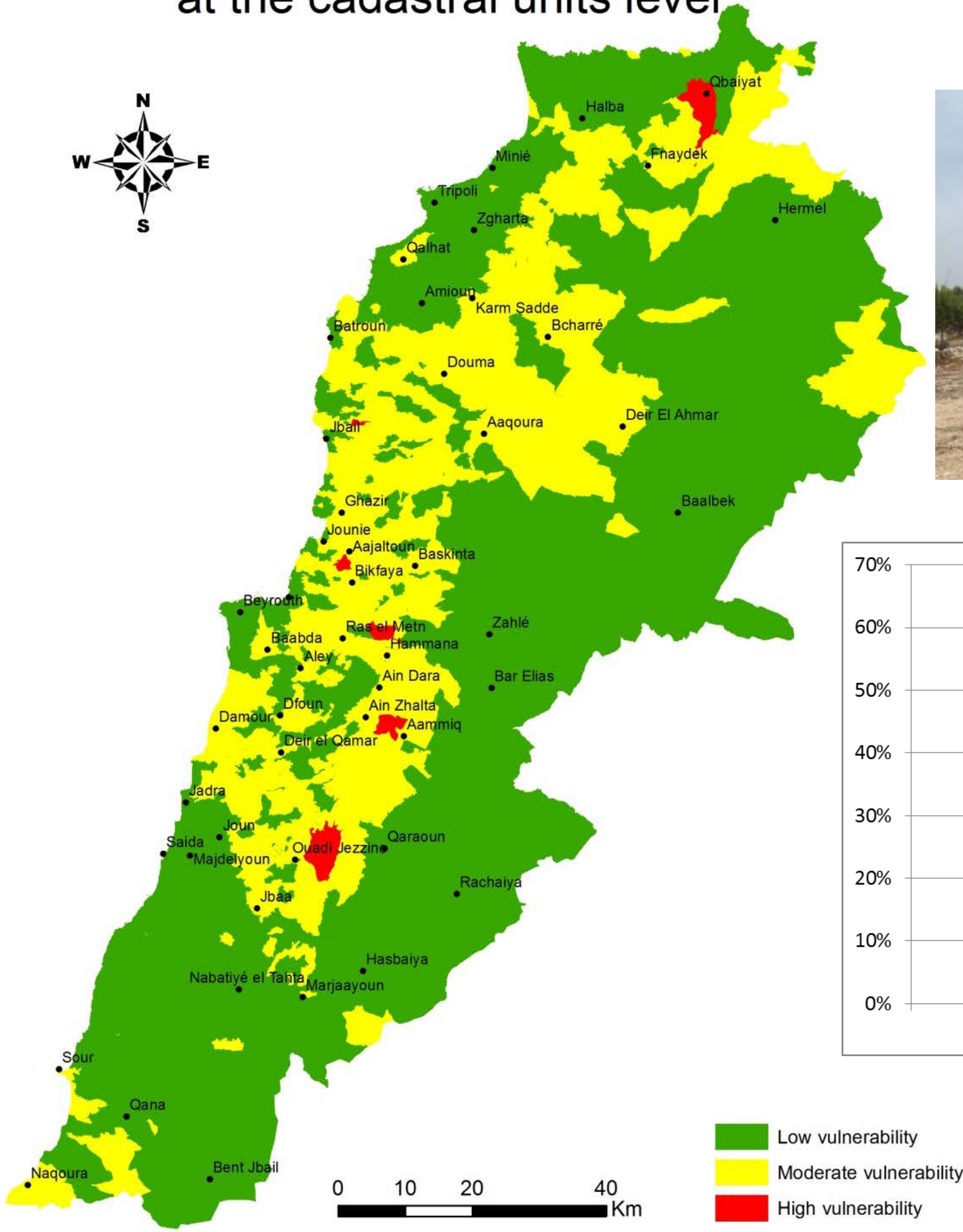
Wildland-Agriculture Interface

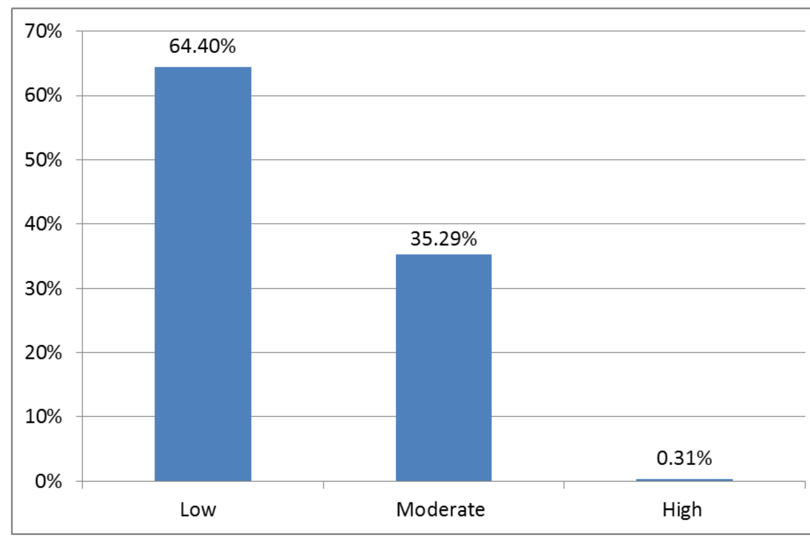


Wildland-Agriculture Interface

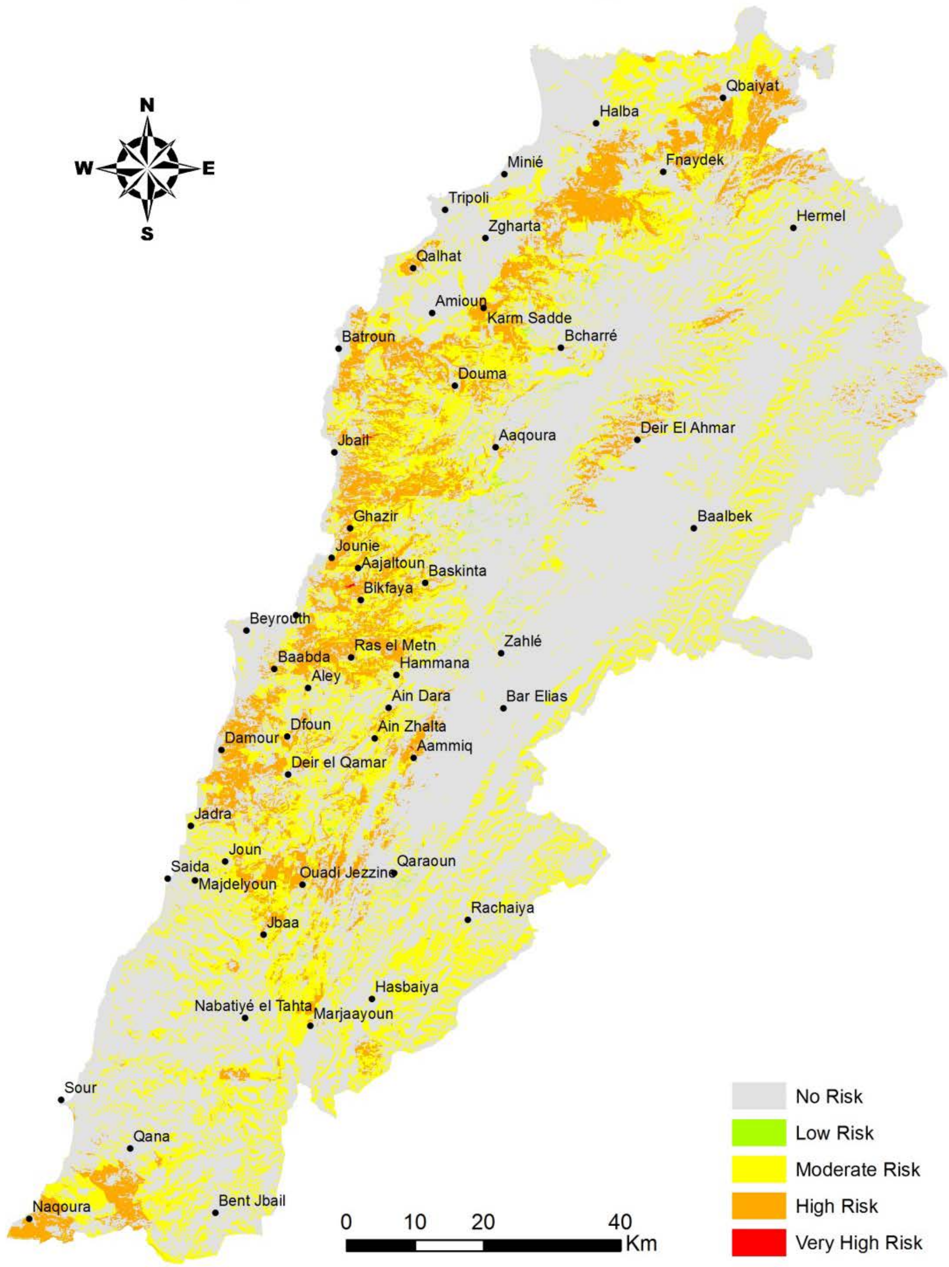


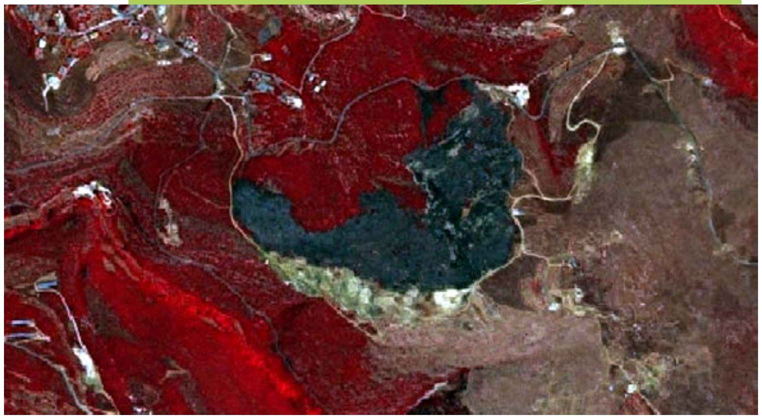
Overall vulnerability map of Lebanon at the cadastral units level

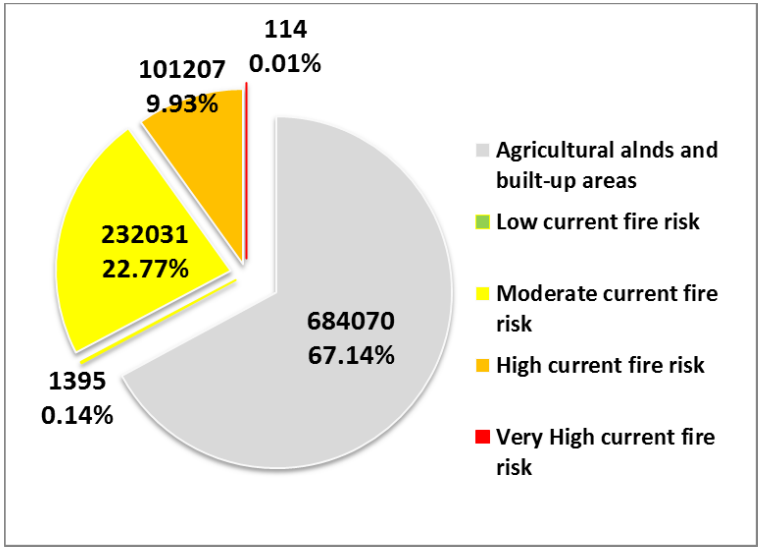




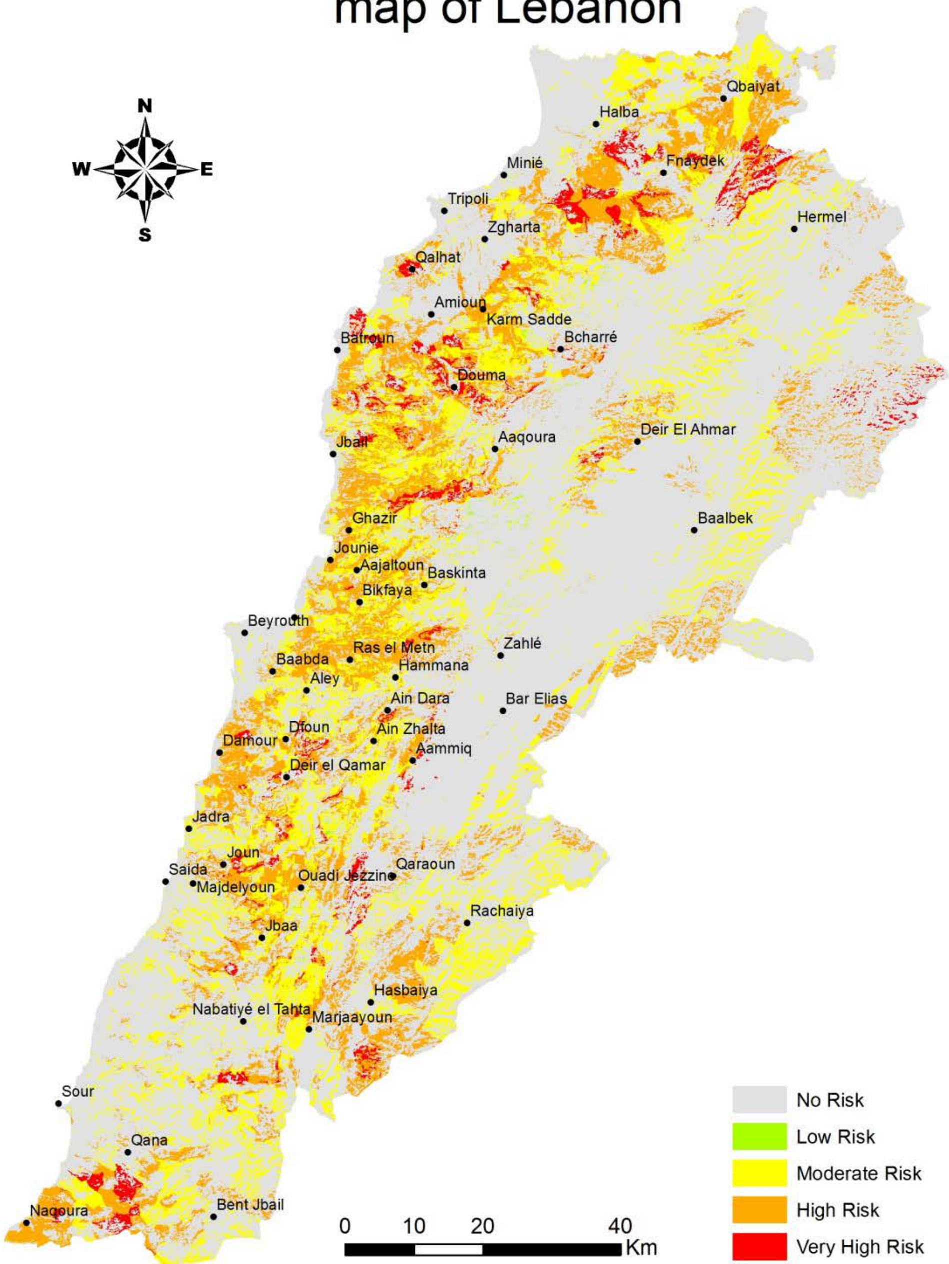
Biophysical fire risk map of Lebanon

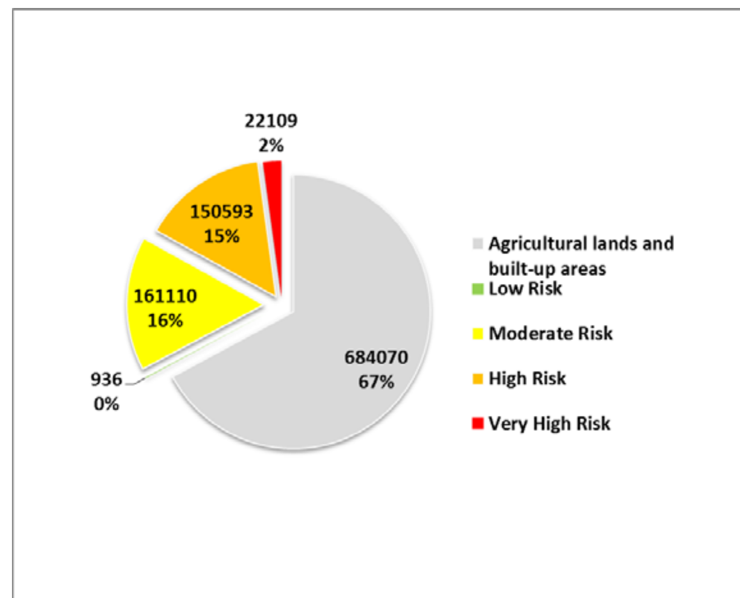






Overall fire risk (biophysical and socioeconomic) map of Lebanon

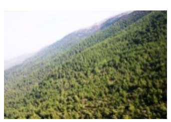




FireLab







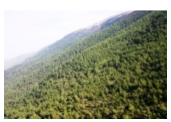

To accommodate the large fire datasets, we developed a web-based application to host multiple data types related to fire risk and management*.

The primary objective of the application (called FireLab) was to provide an online user-friendly interface where relevant fire data can be accessed to make informed fire-management decisions.

FireLab (contn'd)








The database comprised **257 variables** generated at the village level and covering the entire country.

The variables included information about landcover/landuse, fire hazard, vulnerability, overall fire risk, future fire hazard in association with projected climatic data, and Wildland-Urban Interface (WUI), among others.

A comprehensive glossary was developed and integrated in the system describing the main terminologies employed in the queries of the application.

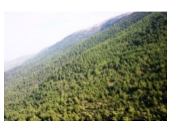
FireLab (contn'd)

The user interface was designed to be self-exploratory and easy to use.

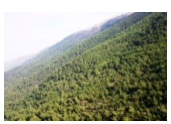
Users only need to provide minimal input to achieve the desired outputs.

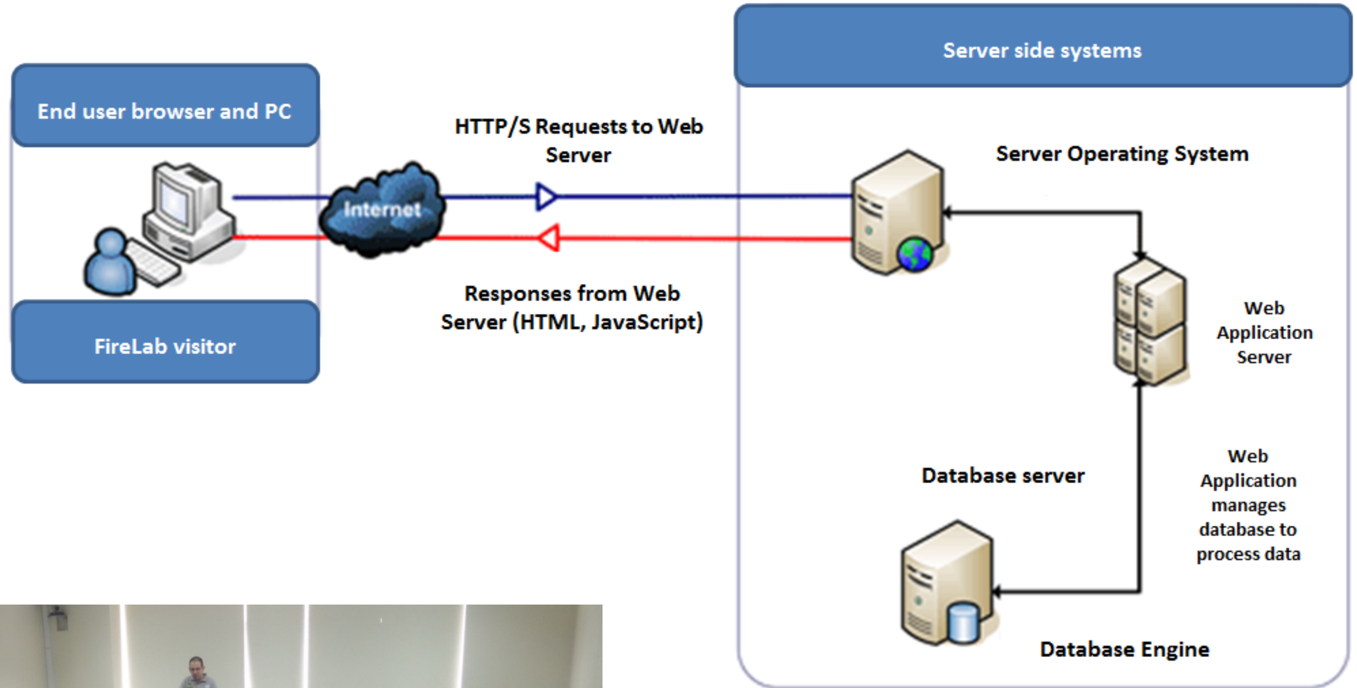
Technically, the web-application queries the content server (a content repository database) and dynamically generates web documents to serve to the user.

The documents are generated in a standard format to allow support by all browsers (e.g., HTML).



The use of Microsoft Visual Studio 2010, C#, asp.net and Jquery which is accessible by all electronic tablets and mobile phones, easily accessed by mobile operators, reliable, secure, and without major technological restrictions.

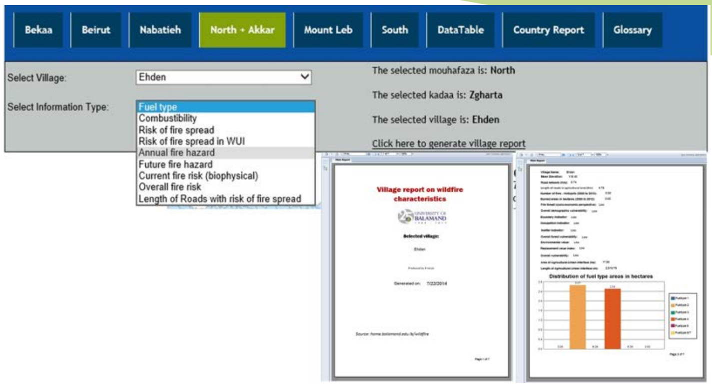


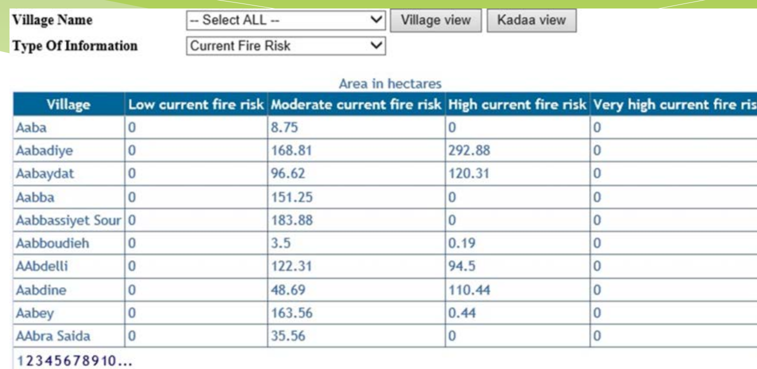


The development of the web-application model comprised:

1) the web browser or the user interface,
2) the dynamic content generation technology, and
3) the database server containing all generated data

FireLab (http:ioe-firelab.balamand.edu.lb

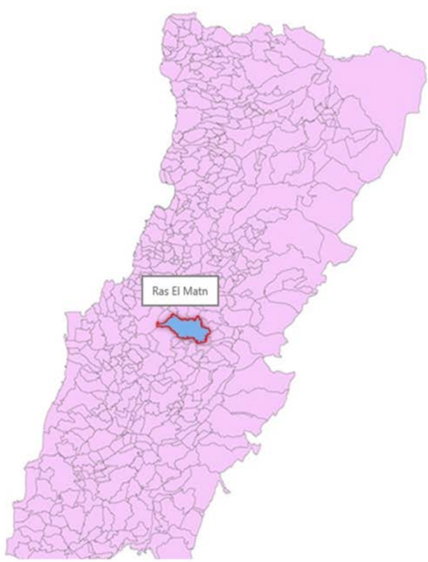


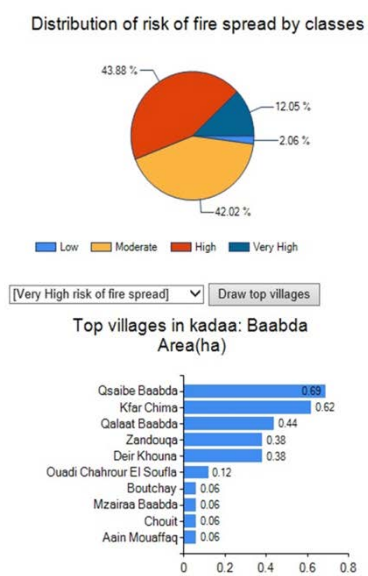


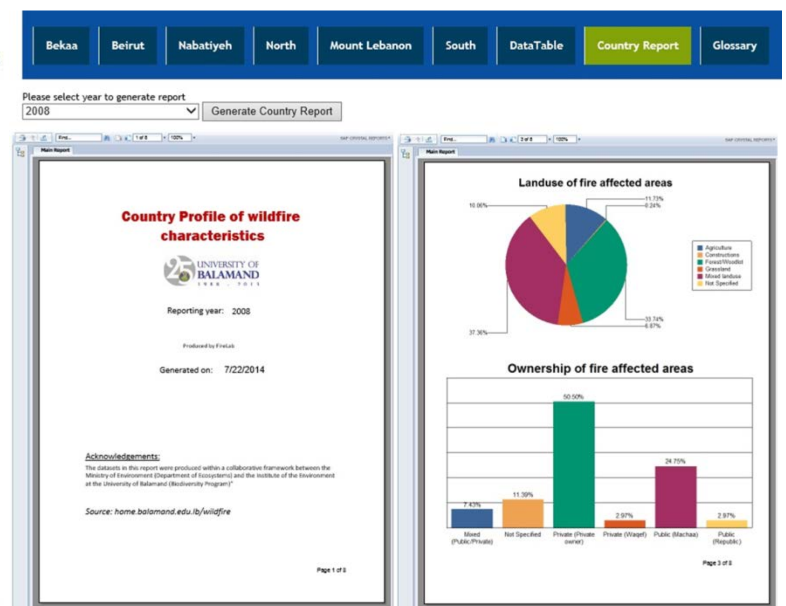
Area in hectares

Village	Low current fire risk	Moderate current fire risk	High current fire risk	Very high current fire risk
Aaba	0	8.75	0	0
Aabadiye	0	168.81	292.88	0
Aabaydat	0	96.62	120.31	0
Aabba	0	151.25	0	0
Aabbassiyet Sour	0	183.88	0	0
Aabboudieh	0	3.5	0.19	0
AAbdelli	0	122.31	94.5	0
Aabdine	0	48.69	110.44	0
Aabey	0	163.56	0.44	0
AAbra Saida	0	35.56	0	0

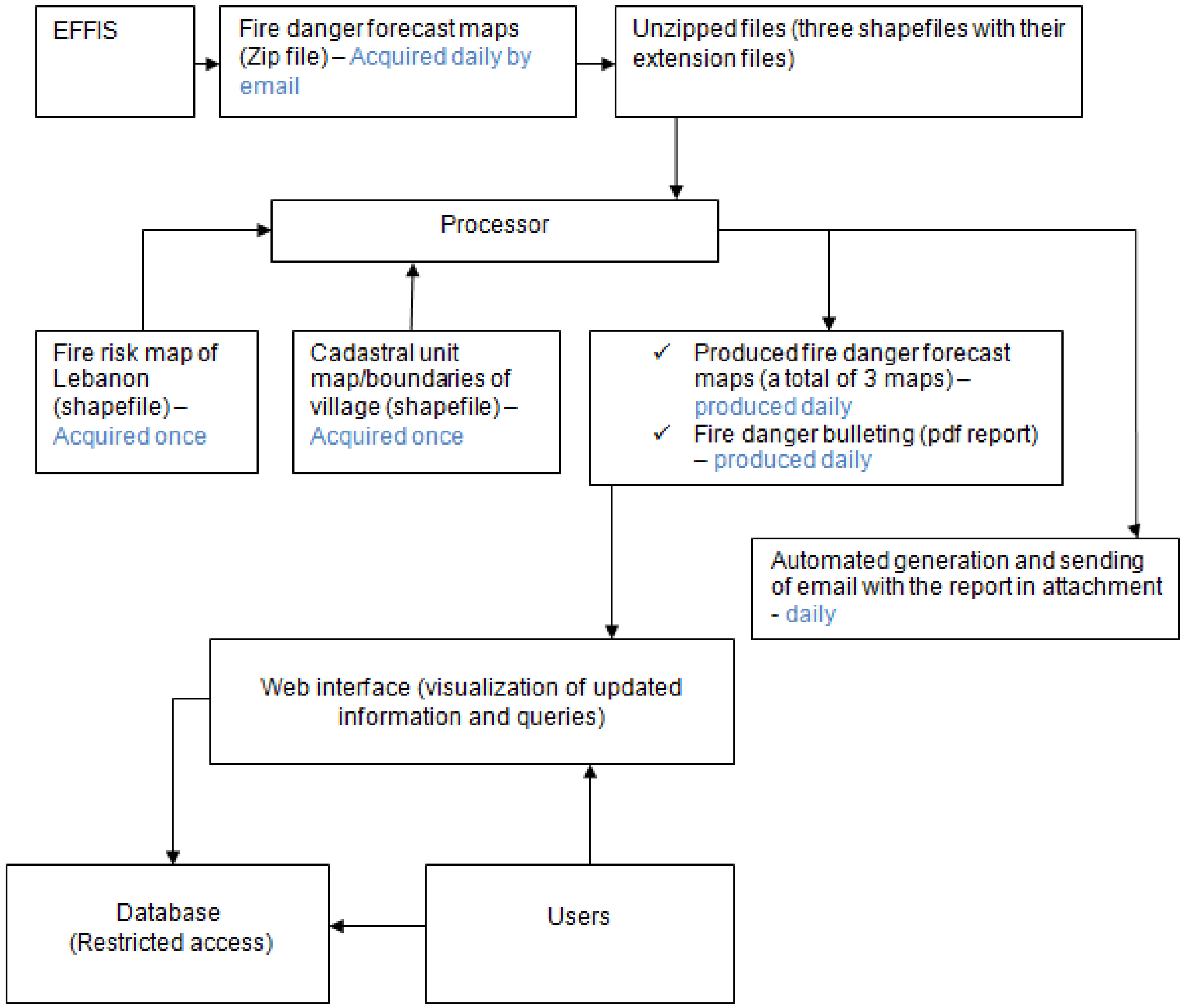
12345678910...





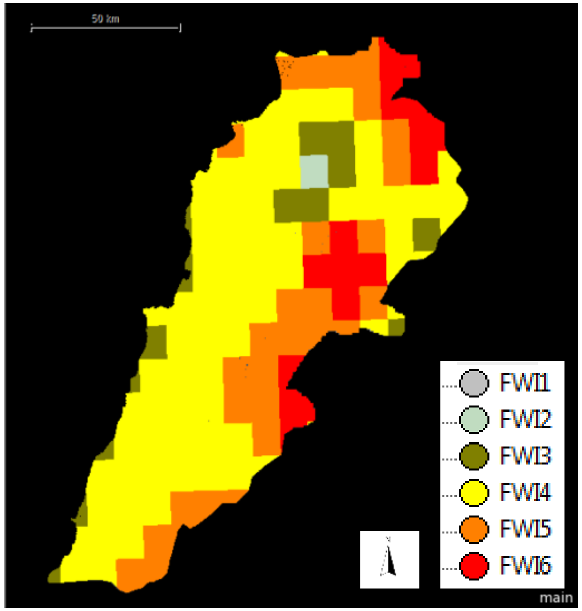


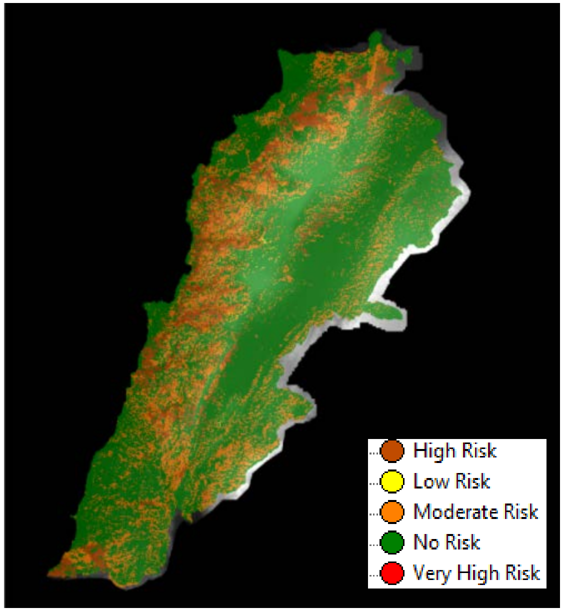
Ongoing activities



A comprehensive fire danger index

The composition of a comprehensive and site-specific fire danger index for Lebanon involving the use of **5 fire risk classes** (as per Lebanon's fire risk map) and **6 fire danger classes** (as per the FWI maps).

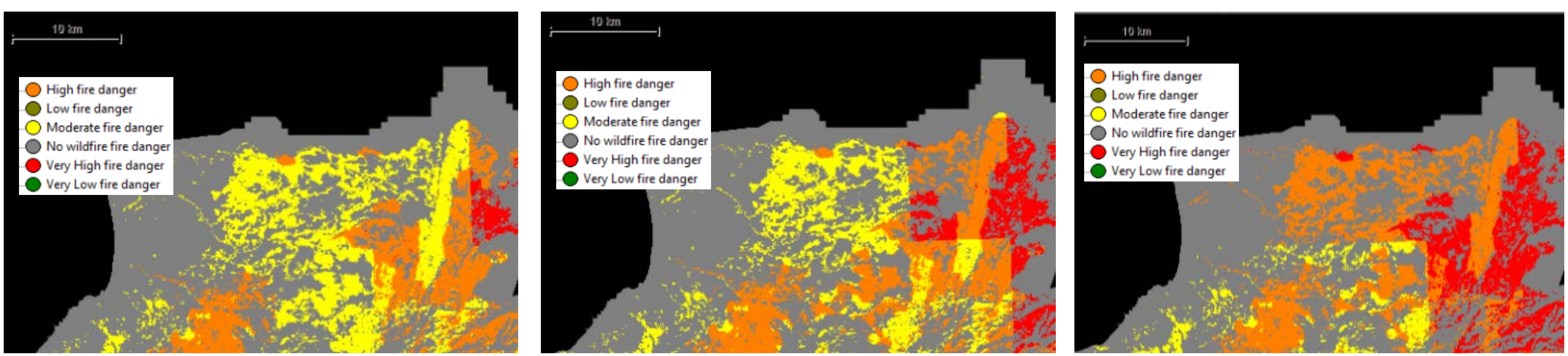




FWI map on 25-7-2014 (left) and the fire risk map (right)

Expected results

- 6 classes of fire danger
- A 3-day fire danger forecast on a **daily basis**
- Automated generation and dissemination of fire danger forecast.



Subset maps of the produced fire danger index on 23, 24, and 25 July 2014, successively

With the sole use of a Fire Weather Index

Limited resources

Area 1: High Fire Weather (FWI) Index

Area 2: High Fire Weather Index (FWI)

Unique fire danger forecast system (accounting for both fire risk and FWI

Helps in efficient mobilization of resources

Limited resources

With the use of FireLab

Area 1: High FWI but moderate to low risk

Area 2: High FWI and high risk

Overall impact on national policies and institutions

- The proposed fire danger forecast is listed as top priority action in the developing **Air Quality Management Strategy**

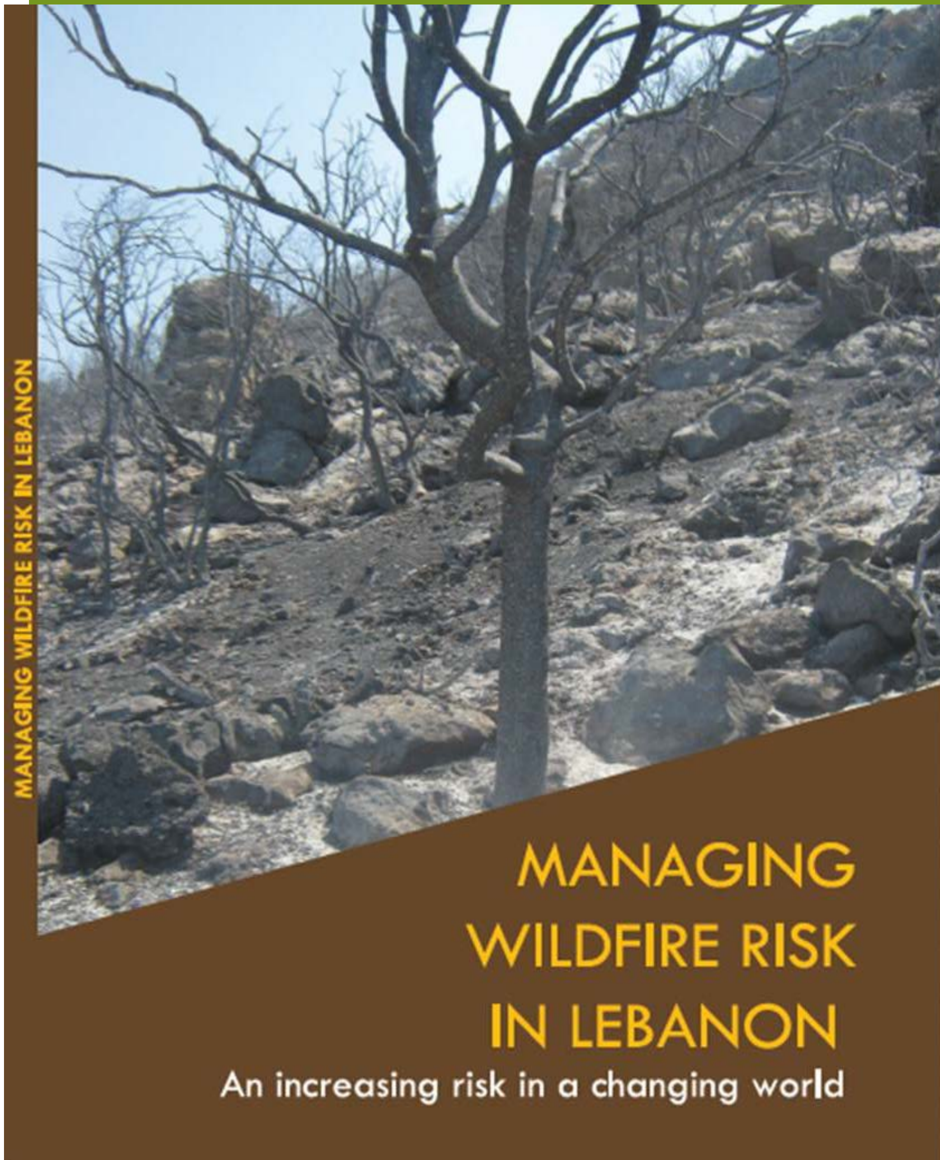
- Lebanon's fire risk map was adopted by the **Ministry of Agriculture** for identification of new sites for reforestation within the national **40 million trees programme of reforestation**

- The fire risk map of Lebanon was employed within the framework of STREG project at the **Ministry of Environment** to identify the locations for deploying strategic meteorological stations

- The fire risk map of Lebanon was adopted by other **USAID projects in Lebanon** (i.e., Lebanon Reforestation Initiative) for selecting sites for Firewise projects interventions.

- The project results were reported in the recently published **National biodiversity strategic Action Plan** of the Ministry of Environment

- The project results were reported in several **national communications** (i.e., Bi-annual update report to the UNFCCC, EFFIS reporting, among others)



Assessment of Wildfire Risk in Lebanon Using Geographic Object-Based Image Analysis

George Mitri, Mireille Jazi, and David McWethy

Abstract

During the past decade, Lebanon has experienced a large number of severe wildfires that have had significant social and ecological consequences. In this context, the assessment of wildfire risk is important to support planning of fire prevention measures and risk mitigation. The purpose of this study was to assess the spatial distribution of wildfire risk in Lebanon. The objectives were to identify and map (a) wildfire hazard, (b)wildfire vulnerability, and (c) wildfire risk. We developed a model using geospatial biophysical and climatic data and Geographic Object-Based Image Analysis (GEOBIA). Development of the wildfire hazard map included classification of forest fuel type, combustibility, and fire spread whereas the vulnerability map included classification of demographic vulnerability (i.e., boundary, occupation and scatter indicators) and forest vulnerability (i.e., environmental and replacement values). The resulting geospatial map of wildfire risk provided important information for potential use in fire risk management.

Introduction

Wildfire is an important disturbance process that has shaped the structure, composition, and function of Mediterranean forests for centuries (Liu *et al*, 2010). However, in recent decades, increases in wildfire occurrence, size and intensity are having profound and perhaps unprecedented impacts on Mediterranean ecosystems (Chuvieco *et al.*, 2010; Dimitrakopoulos *et al.*, 2010; FAO, 2013; Liu *et al.*, 2010).

Like other Mediterranean countries affected by wildfires, Lebanon's forested ecosystems have been severely impacted the increase in the number and size of fires (Salloum *et al.*, 2013). Research has shown that recent fire occurrence in Lebanon was positively correlated with mean monthly temperatures and negatively correlated with mean monthly precipitation (Salloum and Mitri, 2014). Increasing fire occurrence was also observed in association with high maximum temperatures and long dry seasons. In addition, average length of the fire season extended over 146.6 days and was negatively correlated with mean annual precipitation (Salloum and Mitri, 2014).

The social and ecological impacts resulting from increasing number of large fires in Lebanon is a National concern (Mitri and Gitas, 2011). Most recently, a National Strategy for Forest Fire Management (Decision No. 52/2009) was endorsed by the Lebanese Council of Ministers (MOE/AFDC, 2009). This strategy highlighted the need to reduce risk of intense and frequent forest fires while allowing for fires that are socially, economically, and ecologically sustainable. Important components of this strategy include: (a) developing improved models of wildfire risk assessment, and (b) outlining strategies for responding to and adapting to projections of future climatic conditions that will likely further promote large and intense fires in the Mediterranean. These tasks will be critically necessary for implementing effective fire prevention policies.

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Research demonstrates that fire risk models represent characteristics of fire behavior under specific climatic conditions (Sharples, 2009). Climate models have been used to assess fire risk, anticipating potentially dangerous conditions (Liu *et al.*, 2010). Several fire danger rating systems are used around the world, and one of the most widely employed indices is the Fire Weather Index (FWI) used by the Canadian Forest Fire Danger Rating System (Dimitrakopoulos *et al.*, 2010). The FWI uses surface daily temperature, precipitation, relative humidity, and wind speed to represent fuel moisture changes and their effects on fire behavior (Dimitrakopoulos et *al.*, 2010; Karali et *al.*, 2012). The Keetch-Byram Drought Index (KBDI) is another fire danger index, which is a part of the National Fire Danger Rating System (NFDRS) in the United States (Keetch and Byram, 1968; Melton, 1989). KBDI is a cumulative estimate of fire potential based on meteorological input parameters and an empirical approximation for moisture depletion in the upper soil and surface litter levels (Keetch and Byram, 1968). KBDI uses temperature and precipitation to estimate fire potential (Janis *et al.*, 2002).

Many of these models rely solely on climatic variables even though biophysical factors such as fuel type and topography play a major role in determining fire spread and behavior. The complex interactions between these components directly influence fire spread and flammability of fuels. Moreover, demographic variables are critical for predicting risk and hazard of fires on communities (Bühler *et al.*, 2013; Chuvieco *et al.*, 2010). To improve the assessment of both social and ecological aspects of fire risk it is important to incorporate spatial distributions of populations and settlements and the presence and distribution of protected areas and biodiversity hotspots.

Overall, fire risk is a combination of likelihood, intensity, and effect (Miller and Ager, 2013). Understanding the components that comprise wildfire risk is important for predicting when and where a fire is more prone to occur and spread and the degree to which it will have negative impacts on communities and ecosystems. Our study explicitly estimates biophysical and climatic spatial characteristics for fire occurrence (Pinol *et al.*, 1998), expressed here as "fire hazard," and the potential damage that it may cause, expressed here as "fire vulnerability" (Chuvieco *et al.*, 2010).

In this context, this study evaluated the spatial distribution of wildfire risk in Lebanon. The specific objectives were to identify and map (a) wildfire hazard, (b) wildfire vulnerability, and (c) wildfire risk.

To address these objectives we used geospatial datasets that included biophysical and climatic data. Because we used multi-resolution data in addition to multi-source bio-physical and climatic data, it was necessary to develop new methods

Photogrammetric Engineering & Remote Sensing
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Selected publications

Mitri, G. **2015**. Advancing Lebanon's fire danger forecast. In 10th EARSeL Forest Fire Special Interest Workshop Sensors, multi-sensor integration, large volumes: new opportunities and challenges in forest fire research" (Themistocleous, K., Hadjimitsis, D., Gitas, I., and Boschetti, L. Ed.), 2-5 November 2015, Limassol, P.33.

Mitri, G., Jazi, M., McWethy, D. **2015**. Assessing Lebanon's wildfire potential in Association with current and future climatic conditions. In: Keane, Robert, E.; Jolly, Matt; Parsons, Russel; Riley, Karin. 2015 Proceedings of the large wildland fires conference; May 19-23, 2014; Missoula, MT. Proc. RMRS-P-73. Fort Collins, CO: U.S. Department of Agriculture (USDA), Forest Service, Rocky Mountain Research Station, pp 318-321.

Mitri, G., Jazi, M., McWethy, D. **2015** Assessment of wildfire risk in Lebanon using Geographic Object-based image analysis. Photogrammetric Engineering & Remote Sensing. Vol. 81, No. 6, June 2015, pp. 499–506

Mitri, G., Jazi, M., Antoun, E., McWethy, D., Kahaleh, R., and Nader, M. **2014**. The development of a web-based application for improved wildfire risk management in Lebanon. In Advances in fores fire research, Viegas, Domingos Xavier (Ed.). Imprensa da Universidade de Coimbra, Portugal, p. 1276-1280.

Mitri, G., Jazi, M., and McWethy, D. **2014**. Investigating temporal and spatial variability of wildfire potential with the use of object-based image analysis of downscaled global climate models. South-Eastern European Journal of Earth Observation and Geomatics. Volume 3, No. 2S, 251-254.

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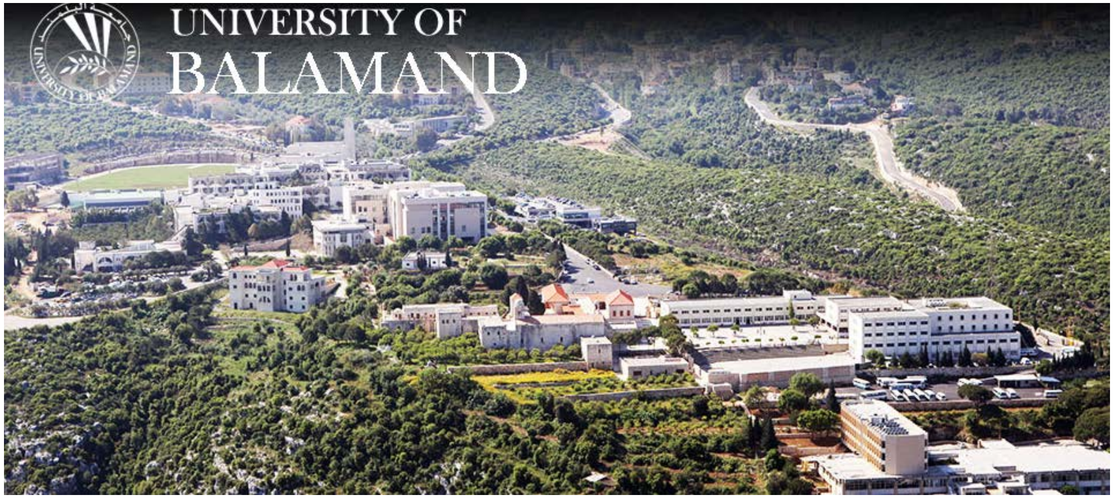

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