REMOTE SENSING FOR VULNERABILITY ASSESSMENT AND HAZARD MAPPING IN LEBANON

Talal Darwish, Ghaleb Faour, Amin Shaban, Chadi Abdallah, Ihab Jomaa and Mohamad Awad

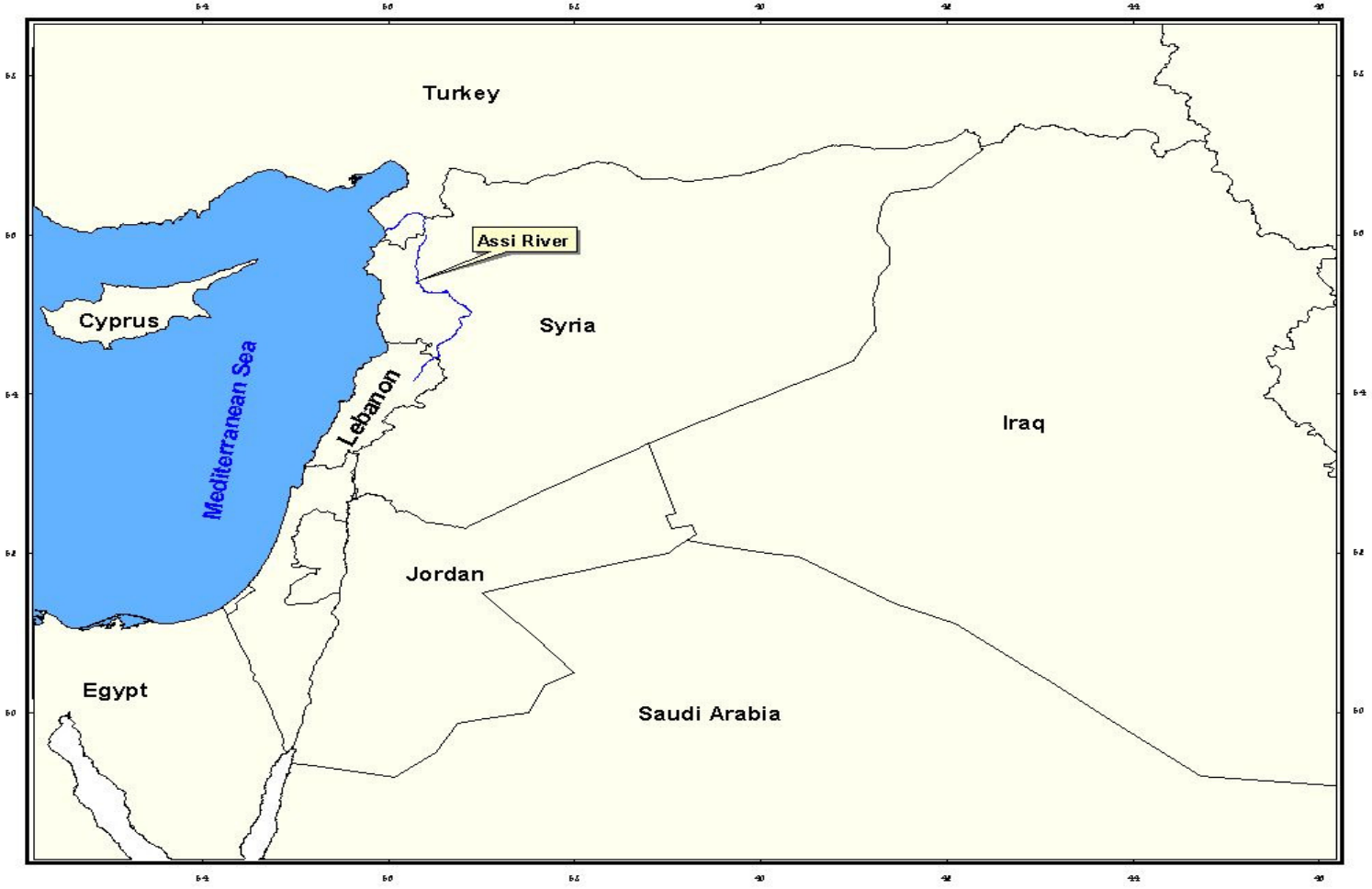
National Council for Scientific Research-Center for Remote Sensing.
Beirut, Lebanon

I. Introduction

Remote sensing technique provides precise images of large areas to study different environmental aspects and to assess natural resources, monitor urban expansion and monitor forest and agricultural crops.

RS provide the time scale and space dimension of the geographic information system, and thus became the major source of information for GIS.

Location of Lebanon in the Middle East



2. Establishing the National Center for Remote Sensing, CNRS-CRS

Receiving and analyzing satellite images require special equipment and skilled experts.

As early as in 1985, the National Council for Scientific Research decided to establish a Remote Sensing Center.

It took 10 years of preparation to found such center with permanent personal and modern equipment.


REPUBLIC OF LEBANON
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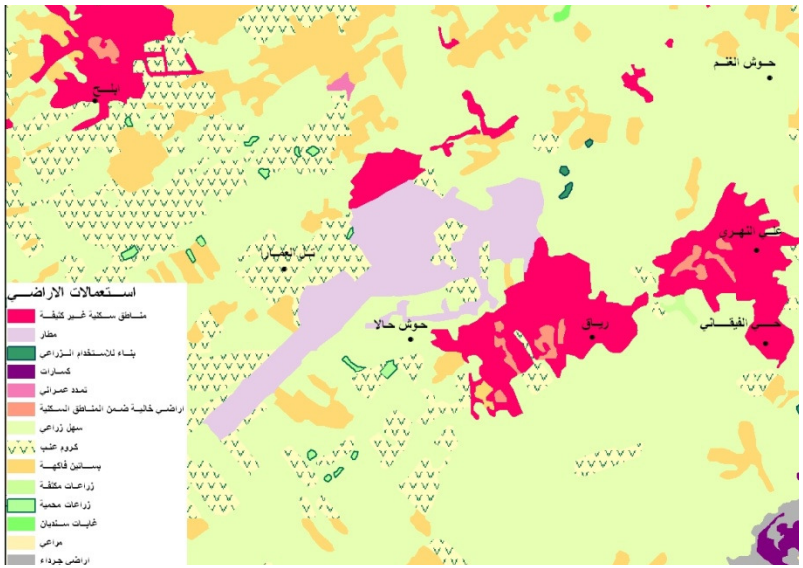
الجمهورية اللبنانية
المجلس الوطني للبحوث العلمية
المركز الوطني للاستشعار عن بعد
C.N.R.S.L

3. Production of the Land cover/use map

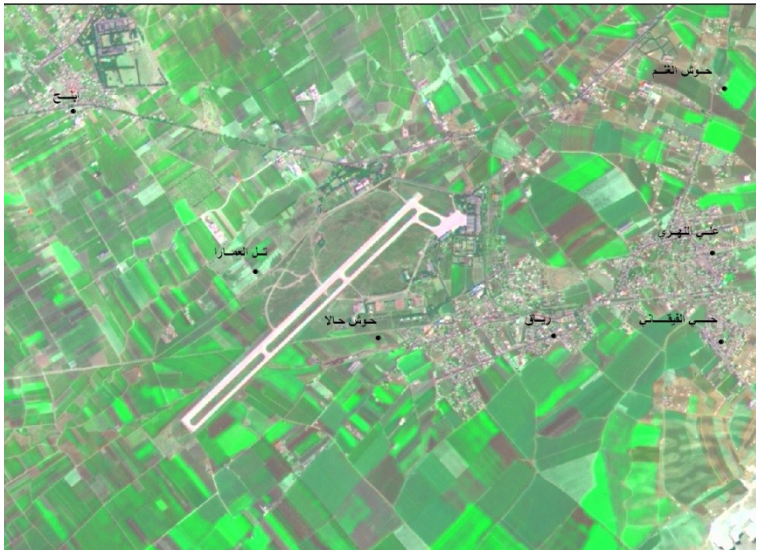
Remote sensing technique (SPOT and IRS-1C) was used in 2000 to produce the land cover map of Lebanon at 1:20.000 scale by visual interpretation due to small and fragmented land ownership.

This updated map replaced the previous version produced by FAO in 1990 at 1;50.000 scale.

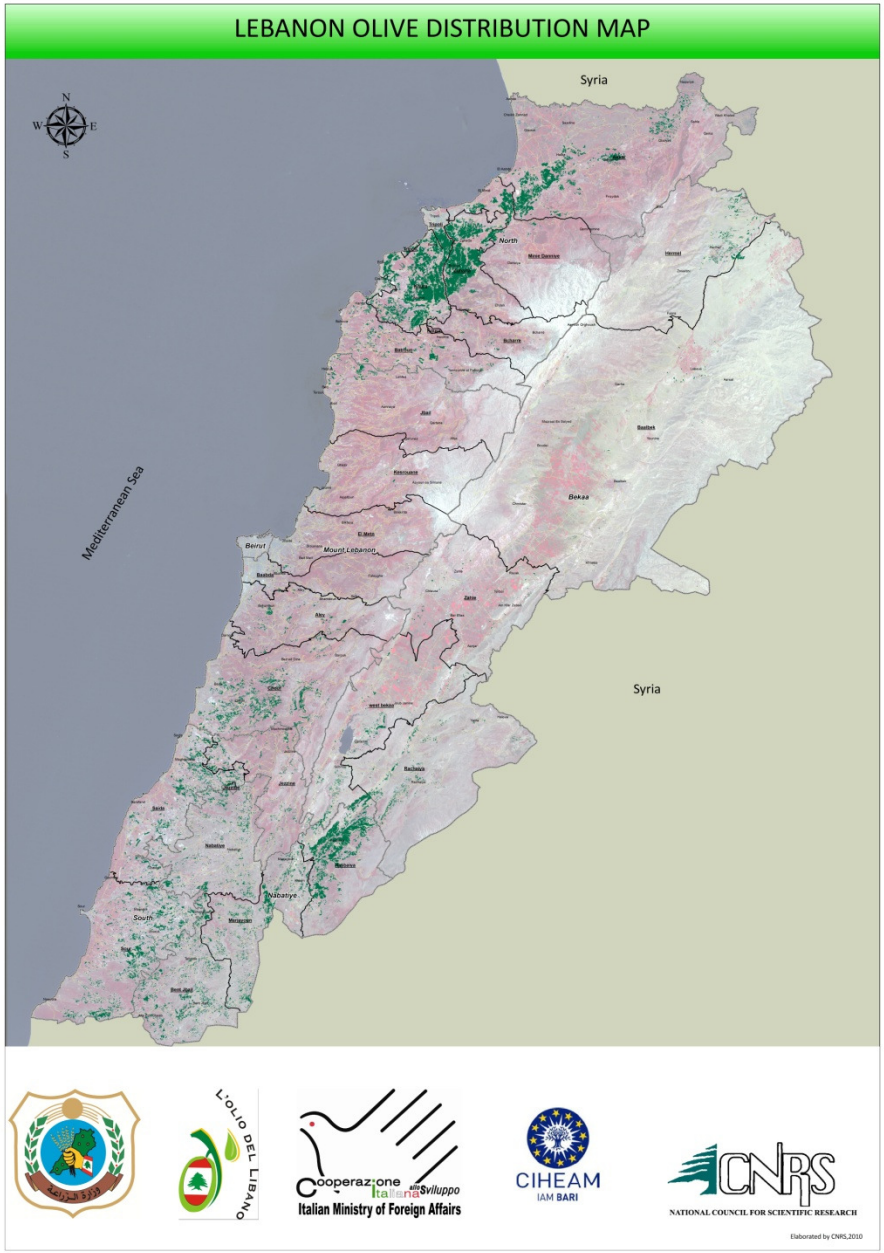
Currently, an updating of this map using Ikonos images is going in the CNRS-CRS which is expected to be finalized by 2010.



Detailed image from IKONOS showing the agricultural and urban area of Ryak.



Land cover/use map of Ryak classified according to CORINE adapted to Lebanon.

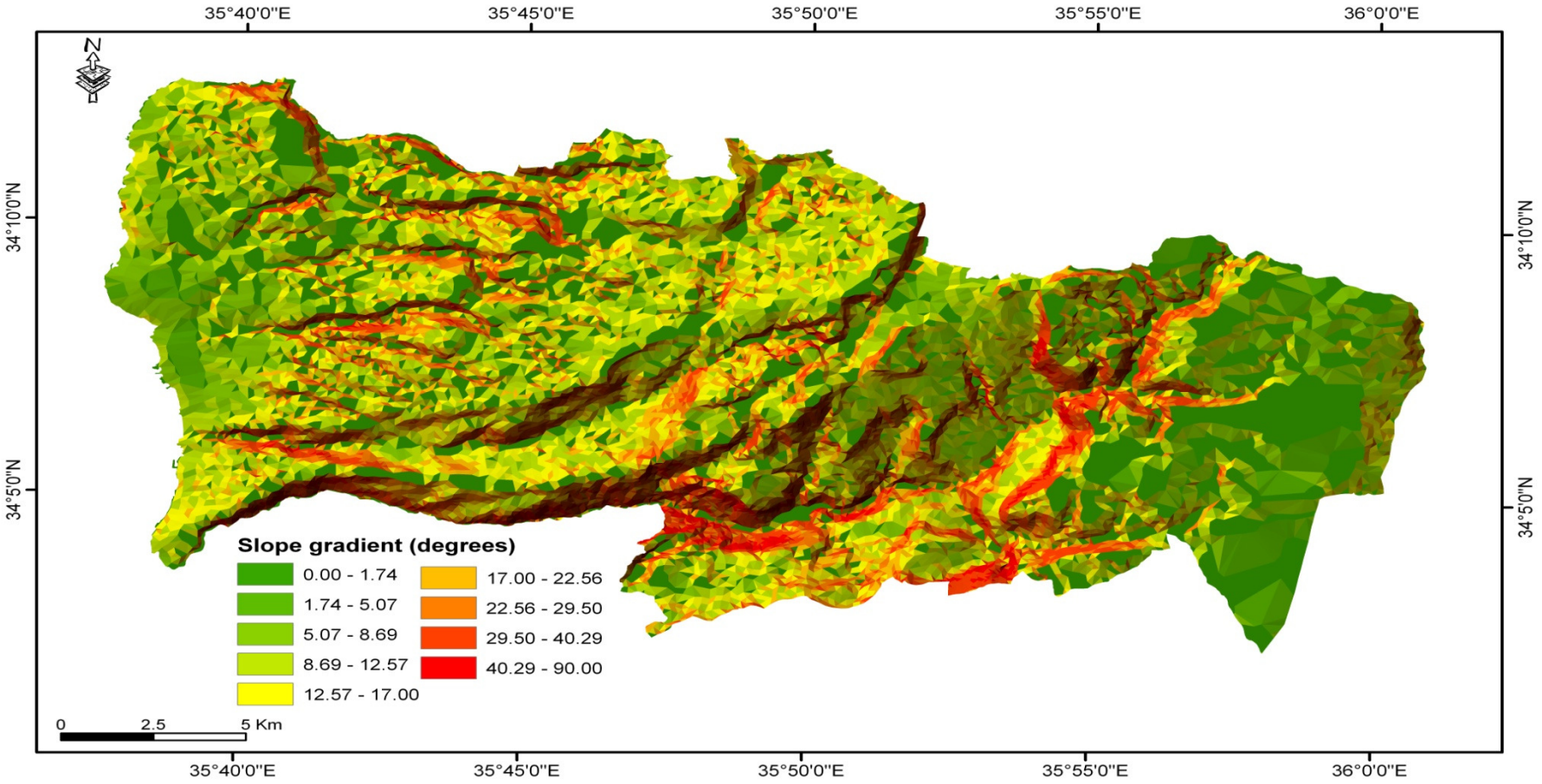

LEBANON OLIVE DISTRIBUTION MAP
Syria
Mediterranean Sea
Beirut
Mount Lebanon
Bekaa
Nabatiye
South
North
Syria
L'OLIO DEL LIBANO
Cooperazione Italiana allo Sviluppo
Italian Ministry of Foreign Affairs
CIHEAM
IAM BARI
CNRS
NATIONAL COUNCIL FOR SCIENTIFIC RESEARCH

4. Geomorphological and soil mapping

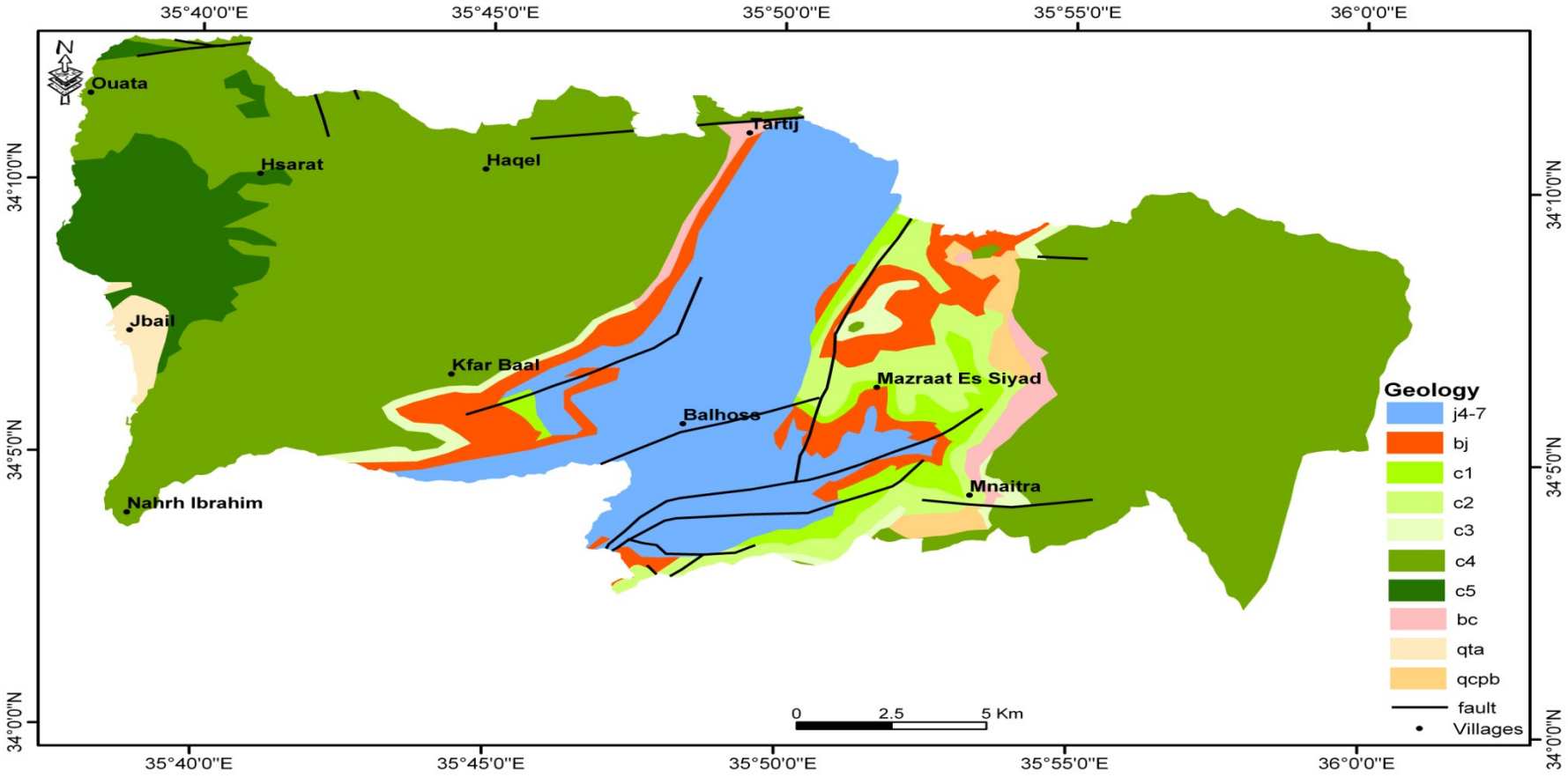
Remote Sensing and aerial photos contributed in several aspects to landform and soil mapping as well as water resources assessment. Combining slope gradient maps with geological maps resulted in the mapping of major Lebanese geomorphological units, Terrain Units and Terrain components. Recent extensive field work and laboratory analyzes allowed the production of the new soil map of Lebanon at 1:50.000 scale.

This map covering Lebanon with 27 soil sheets is accompanied by a soil book containing detailed information on the soil type location, morphology, physical and chemical properties, geology, hydrology, climate, landcover/use and agricultural potential. All this material is available at CNRS headquarter in Beirut for the cost of production.

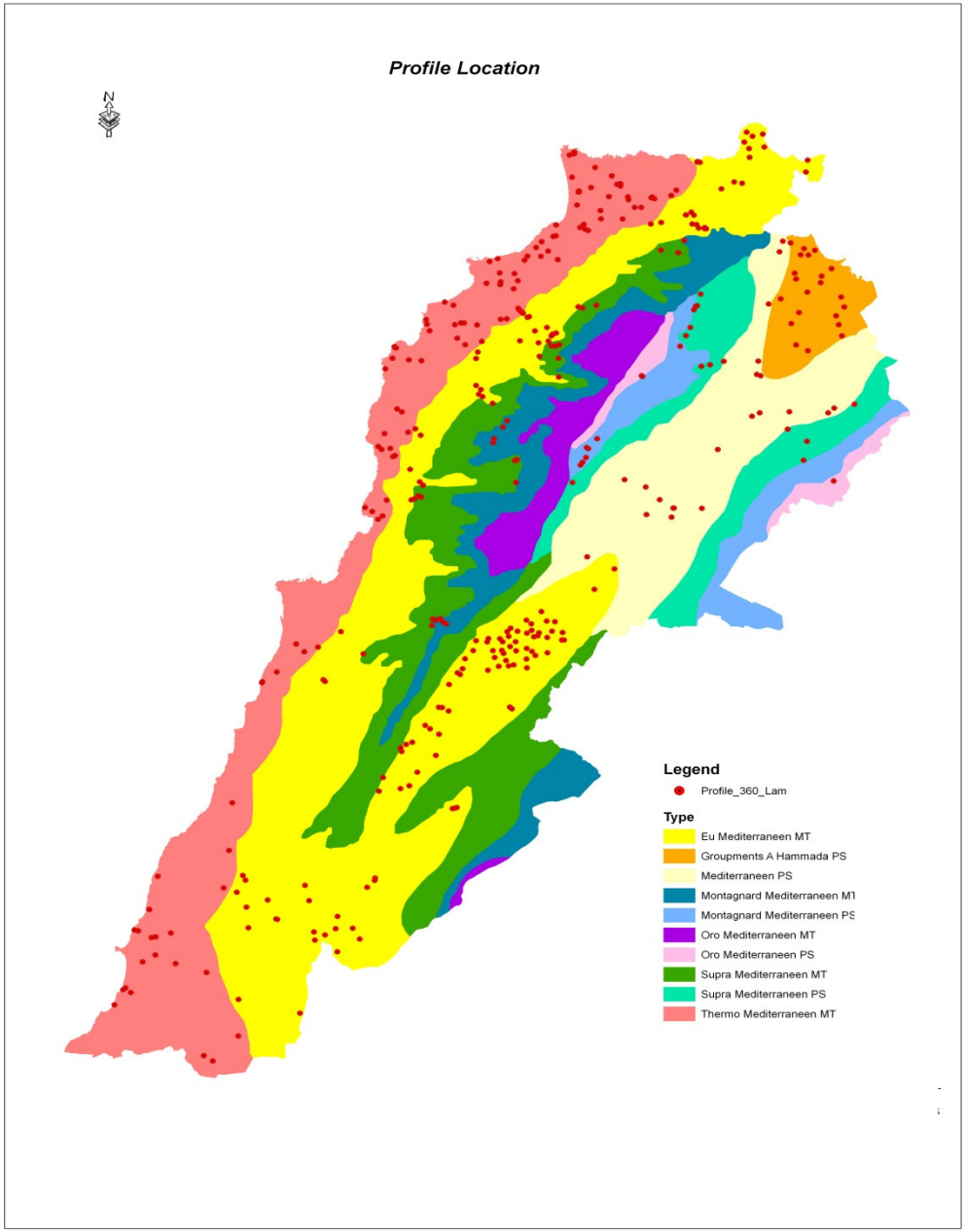
A continuous updating of the soil maps and database is going on in the CNRS-CRS.



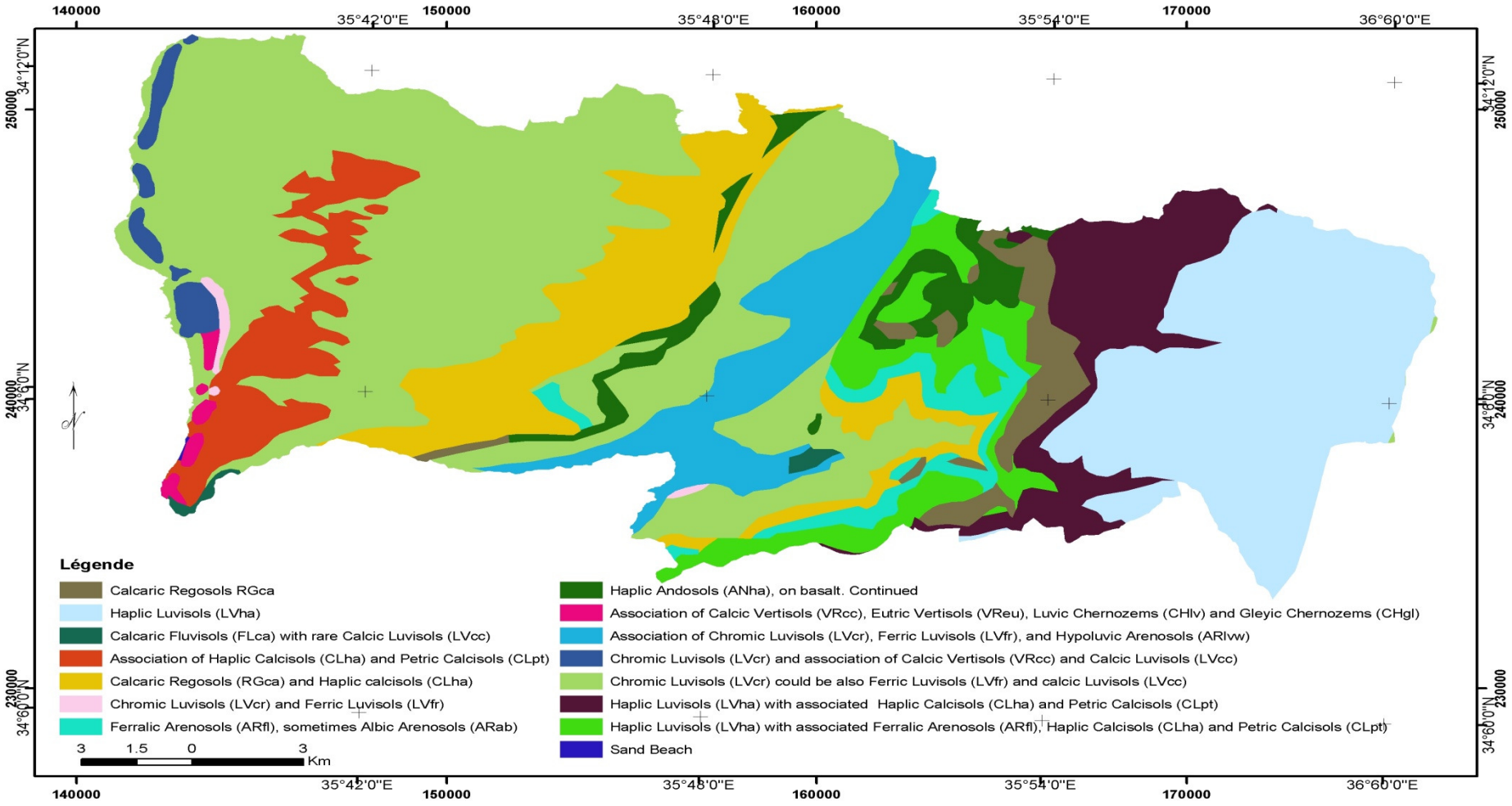
Slope gradient map of Byblos Caza



Geology map of Byblos Caza



5/31/2010
10th International Meeting on Soils With Mediterranean Type of Climate
Beirut, 23-26 June 2009
12



The new soil map of Lebanon at 1:50.000 scale

خريطة التربة اللبنانية

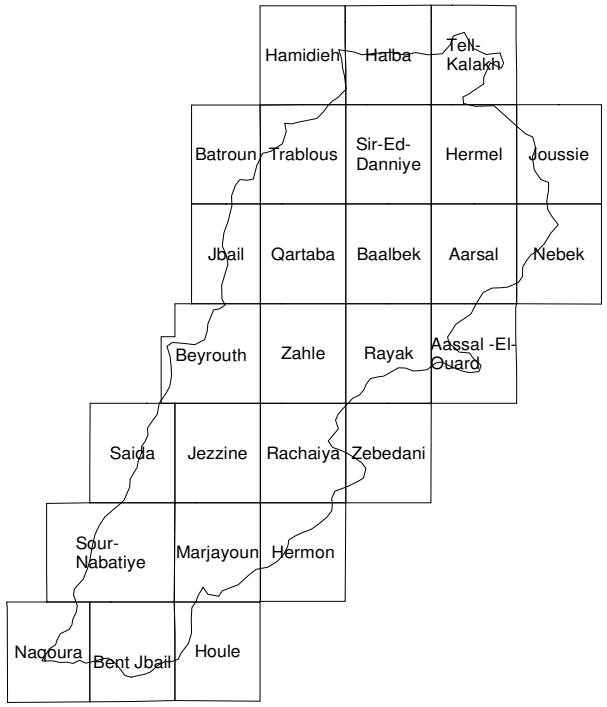
1:50000 بمقياس

Soil Map of Lebanon

Scale 1/50000

Carte des Sols du Liban

Echelle 1/50000



المجلس الوطني للبحوث العلمية

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National Council for Scientific Research

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Monograph Series No. 4

MONOGRAPH SERIES

SOIL MAP OF LEBANON 1:50 000

SOIL MAP OF LEBANON 1:50 000

Talal Darwish

Contribution by Sectors:

M. Khawlie (Geology), I. Jomaa & M. Abou Daher (Soil, Physiography), M. Awad (GIS), T. Masri (Agriculture), A. Shaban (Hydrology), G. Faour (RS), R. Bou Kheir (Climate), C. Abdallah & T. Haddad (Physiography)

2006 CNRS – Remote Sensing Center, Lebanon 2006

BAALBEK

1st Edition-2004 NI - 37 - XIII - 1a

National Council for Scientific Research — National Center for Remote Sensing

Soil Map of Lebanon

BAALBEK

Assessment of Land Resources Using Remote Sensing for Soil Studies

Legend*

- Leptic Andosols (ANle)
- Haplic Arenosols (ARha)
- Calcaro-Hortic Anthrosols (AThh-ca)
- Haplic Calcisols (CLha)
- Calcaric Cambisols (CMca)
- Humi-Eutric Cambisols (CMeu-hu)
- Haplic Cambisols (CMha)
- Endostagnic Vertic Cambisols (CMvr-stn)
- Vertic Cambisols (CMvr)
- Calcaric Fluvisols (FLca)
- Eutric Fluvisols (FLeu)
- Calcaric Gleysols (GLca)
- Eutric Gleysols (GLeu)
- Mollic Gleysols (GLmo)
- Areno-Eutric Leptosols (LPeu-ar)
- Gleyic Leptosols (LPgl)
- Hyperskeletic Leptosols (LPhk)
- Lithic Leptosols (LPli)
- Rendzic Leptosols (LPrz)
- Eutric Luvisols (LVeu)
- Leptic Luvisols (LVle)
- Calcaric Regosols (RGca)
- Eutric Regosols (RGeu)
- Skeletic Regosols (RGsk)
- Endoskeletic Regosols (RGskn)
- Haplic Cambisols (CMha) and Mollic Gleysols (GLmo)
- Aridic Fluvisols (FLad) and Haplic Calcisols (CLha)
- Calcaric Fluvisols (FLca) and Calcaric Regosols (RGca)
- Calcaric Leptosols (LPca), Haplic Leptosols (LPha) and Skeletic Regosols (RGsk)
- Calcaric Leptosols (LPca) and Leptic Luvisols (LVle)
- Endocalcaro-Hyperskeletic Leptosols (LPsk-can), Calcic Vertisols (VRcc) and Vertic Cambisols (CMvr)
- Lithic Leptosols (LPli), Leptic Luvisols (LVle) and Eutric Luvisols (LVeu)
- Rendzic Leptosols (LPrz) and Haplic Cambisols (CMha)
- Rendzic Leptosols (LPrz) and Calcaric Leptosols (LPca)
- Chromic Luvisols (LVcr) and Ferric Luvisols (LVfr)
- Eutric Luvisols (LVeu), Leptic Luvisols (LVle) and Lithic Leptosols (LPli)
- Leptic Luvisols (LVle) and Calcaric Leptosols (LPca)
- Eutric Regosols (RGeu), Eutric Luvisols (LVeu), Eutric Fluvisols (FLeu) and Vertic Cambisols (CMvr)
- Cliffs
- Cities/Villages
- Roads
- Rivers
- Contours 100 m

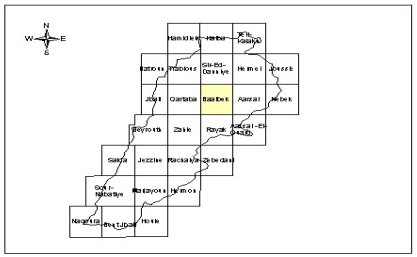
* Lower Level Units (WRB, 1998), Second Level (FAO-Rev. 1997)

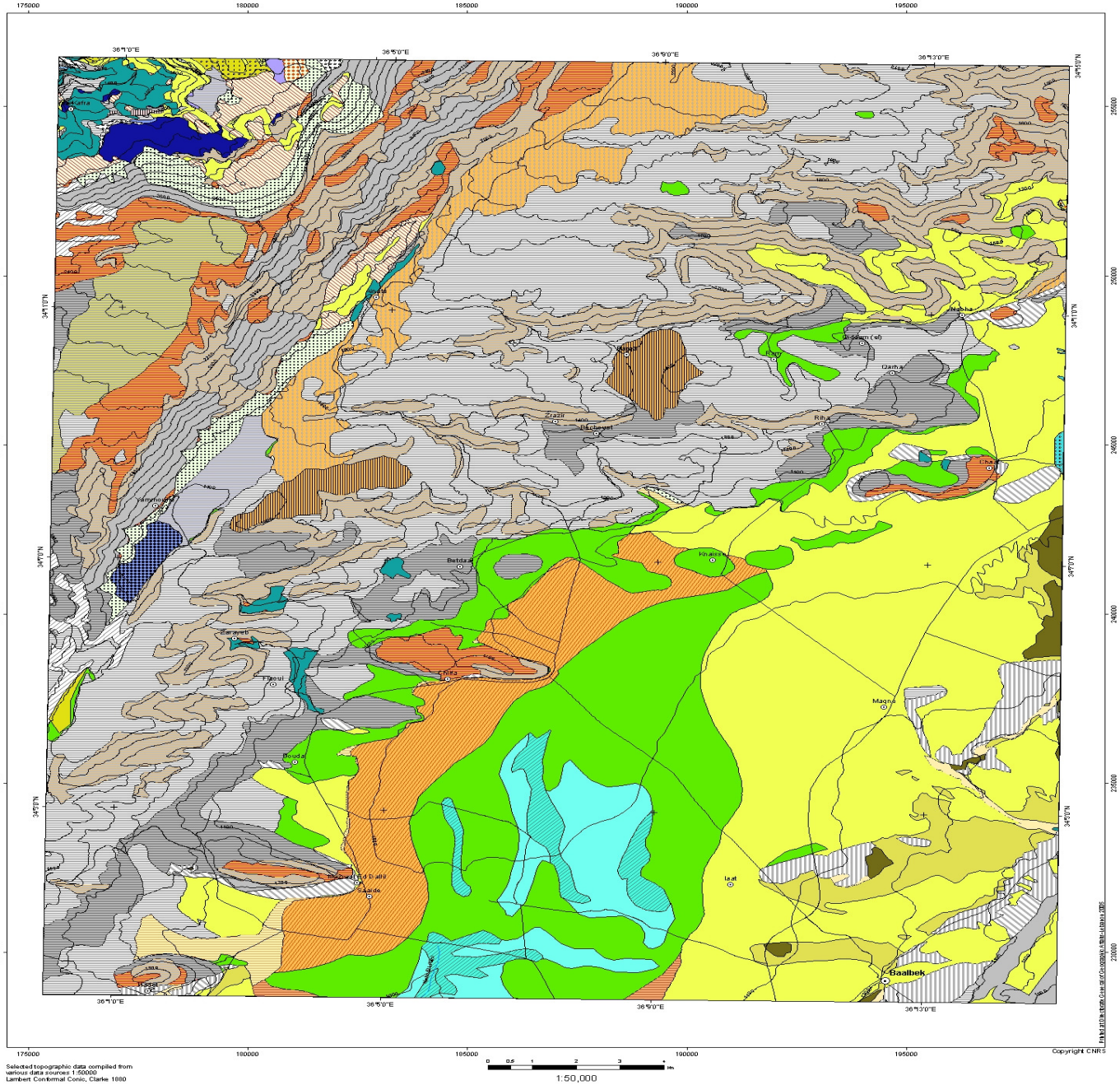
Authors

Project Investigator : **T. Darwish**

Sectors Contribution

Soil	*Geology*	*GIS*	*Remote Sensing*	*Agriculture*
T. Darwish I. Jomaa M. Abou Daher	M. Khawlie A. Shaban	M. Awad	G. Faour	T. Masri

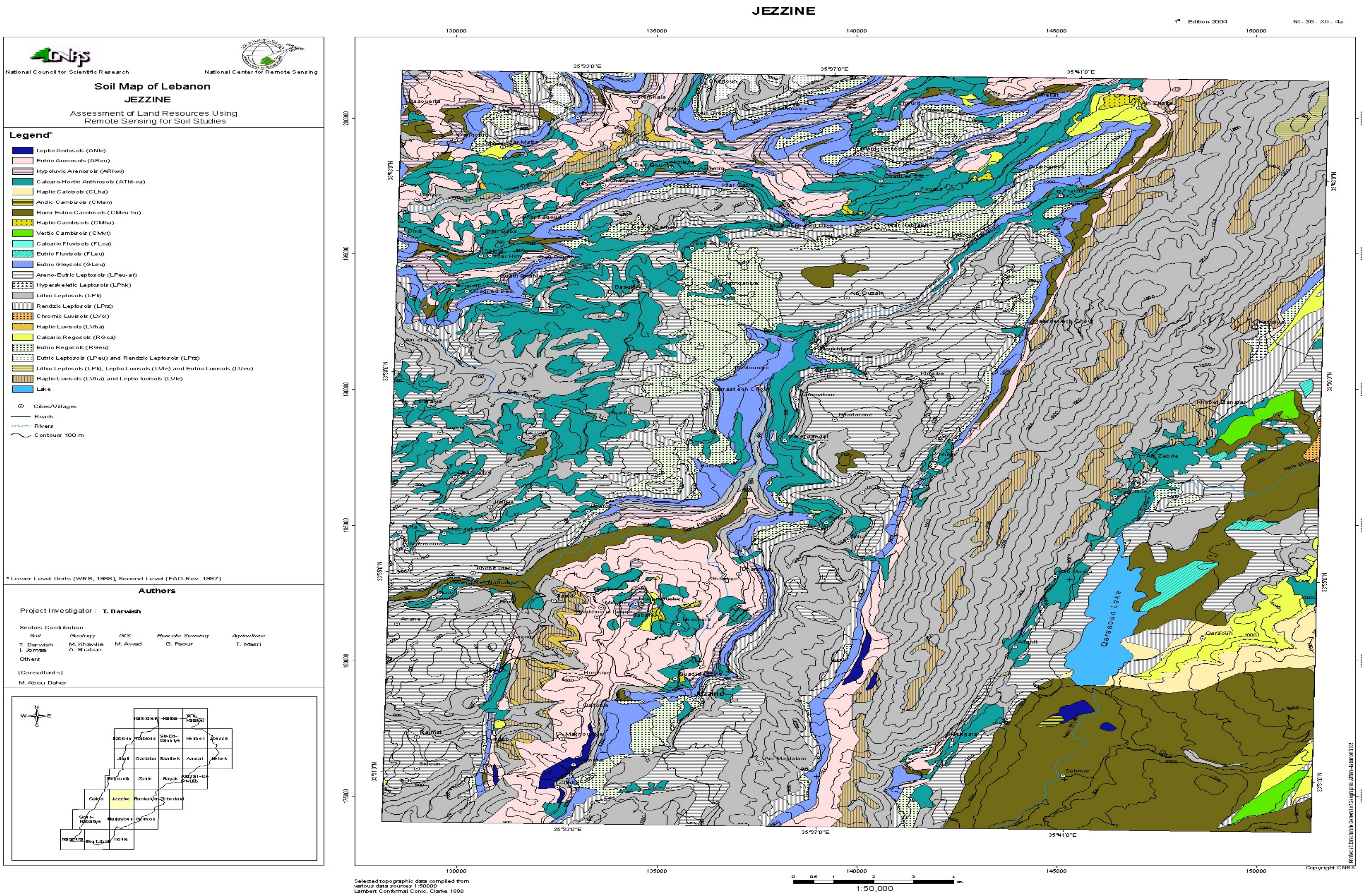




Selected topographic data compiled from various data sources 1:50000
Lambert Conformal Conic, Clarke 1880

0 0.5 1 2 3 4 km

1:50,000



United Nations/Moldova/United States of America Workshop on the Applications of Global Navigation Satellite Systems
Chisinau, Moldova, 17 – 21 May 2010

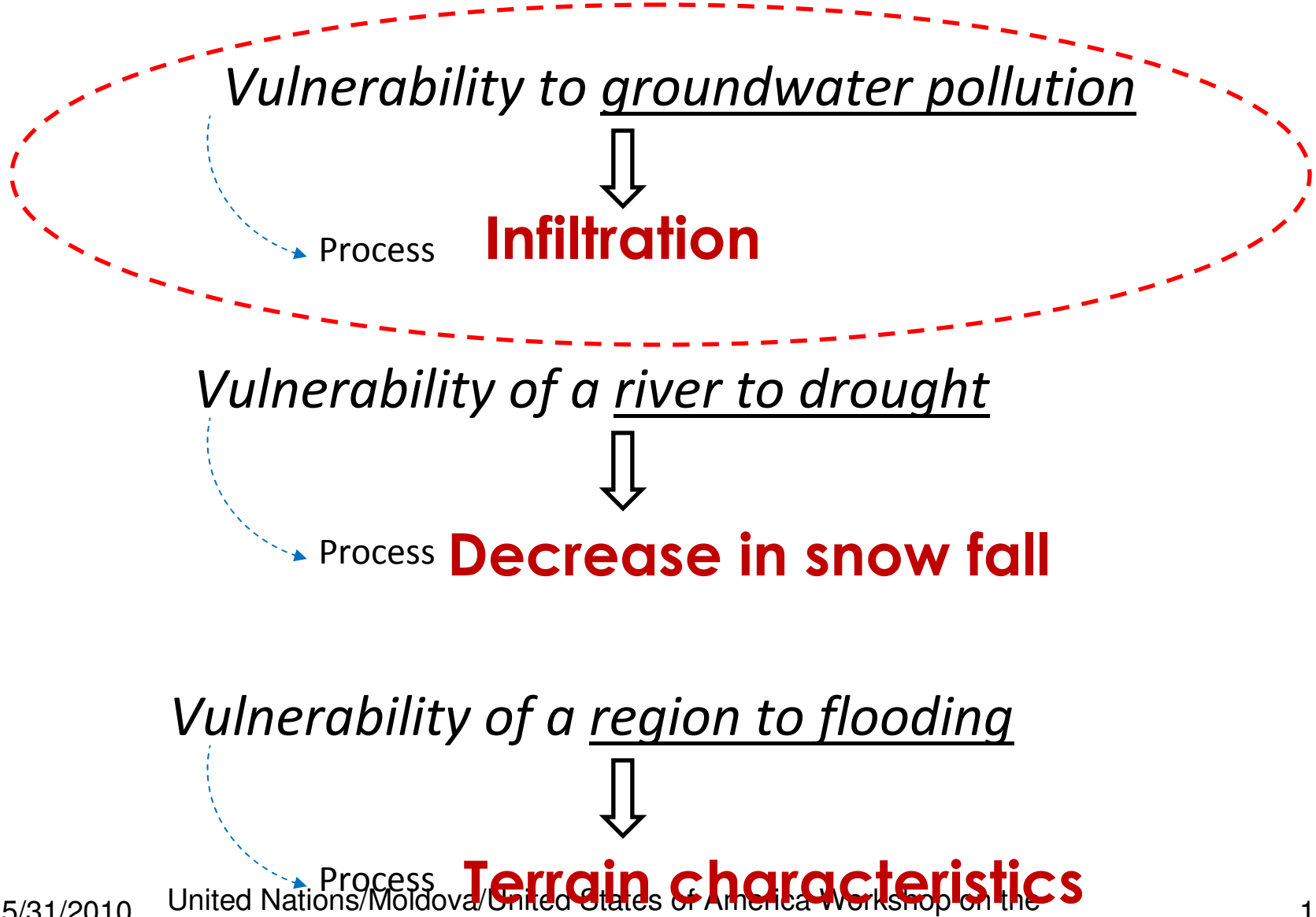
5. *Vulnerability Assessment in Water Resources Concepts*

⊙ **Water system:** is the zone, which contains/or susceptible to include water, such as: aquifer, rivers, spring, canals, streams, lakes, wetlands, marshes, etc.

⊙ **Vulnerability assessment of water system** is assessed through the hydrologic process controlled by a number of physical and anthropogenic factors.

⊙ Usually vulnerability is viewed from a hazards point of view, thus vulnerability assessment is often linked with hazard mapping.

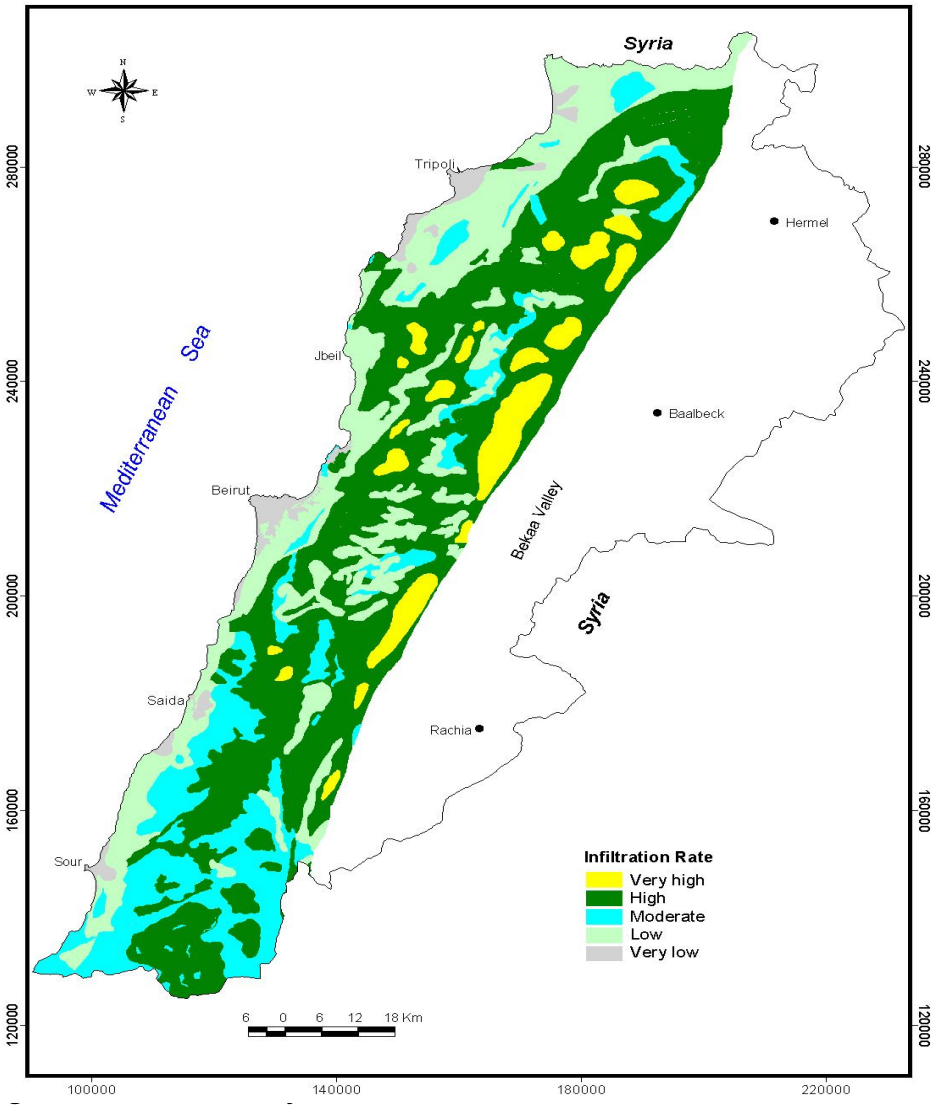
Examples on: vulnerability assessment in water resources



Vulnerability to groundwater pollution

1. **FRACTURES**
2. **DRAINAGE**
3. **LITHOLOGY**
4. **KARSTS**
5. **LAND C/U**

Remote Sensing + GIS



35% of occidental Lebanon is characterized by high infiltration rate

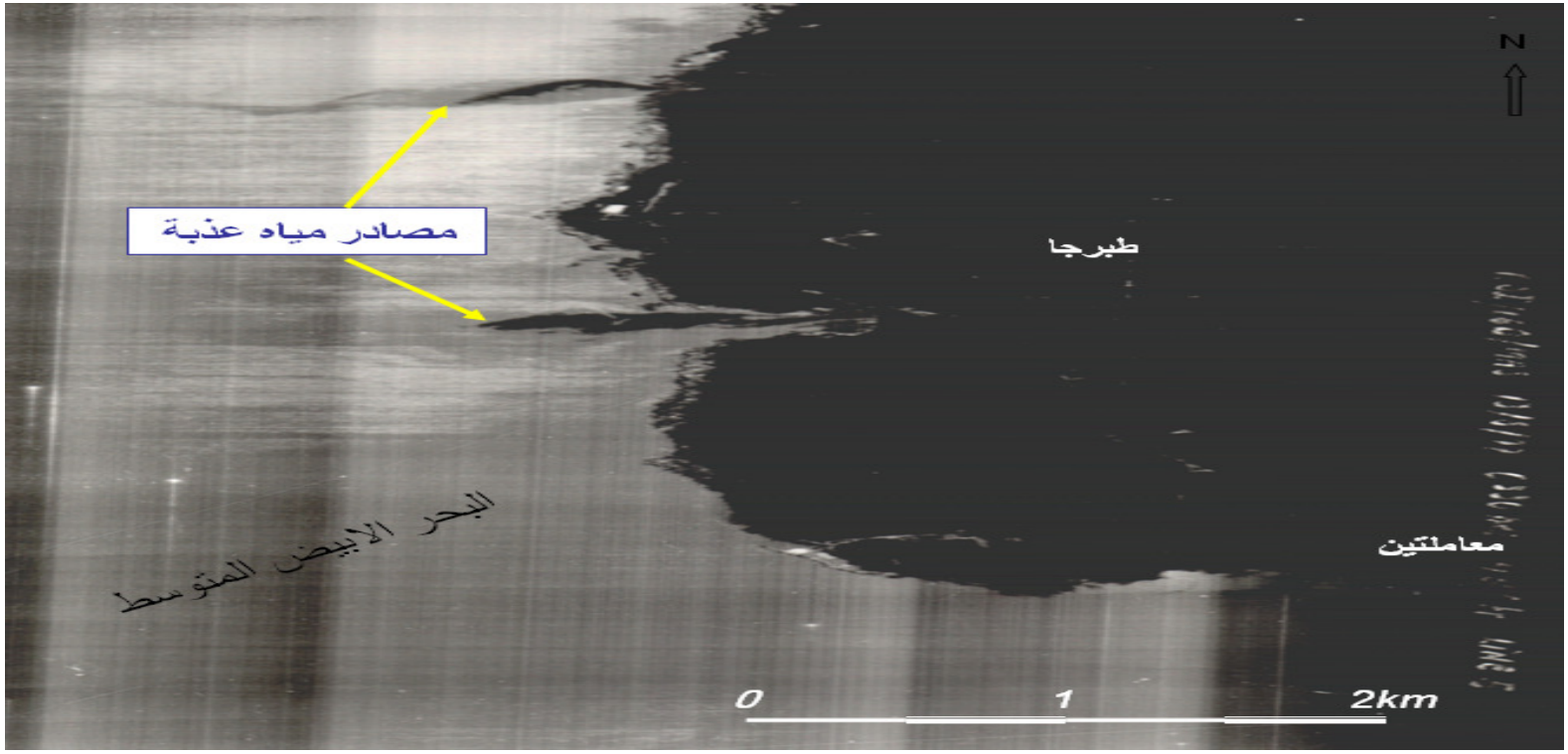
6. Hydrogeological studies

In addition, RS enabled identifying indicative geological clues that provide information on hydro geological elements.

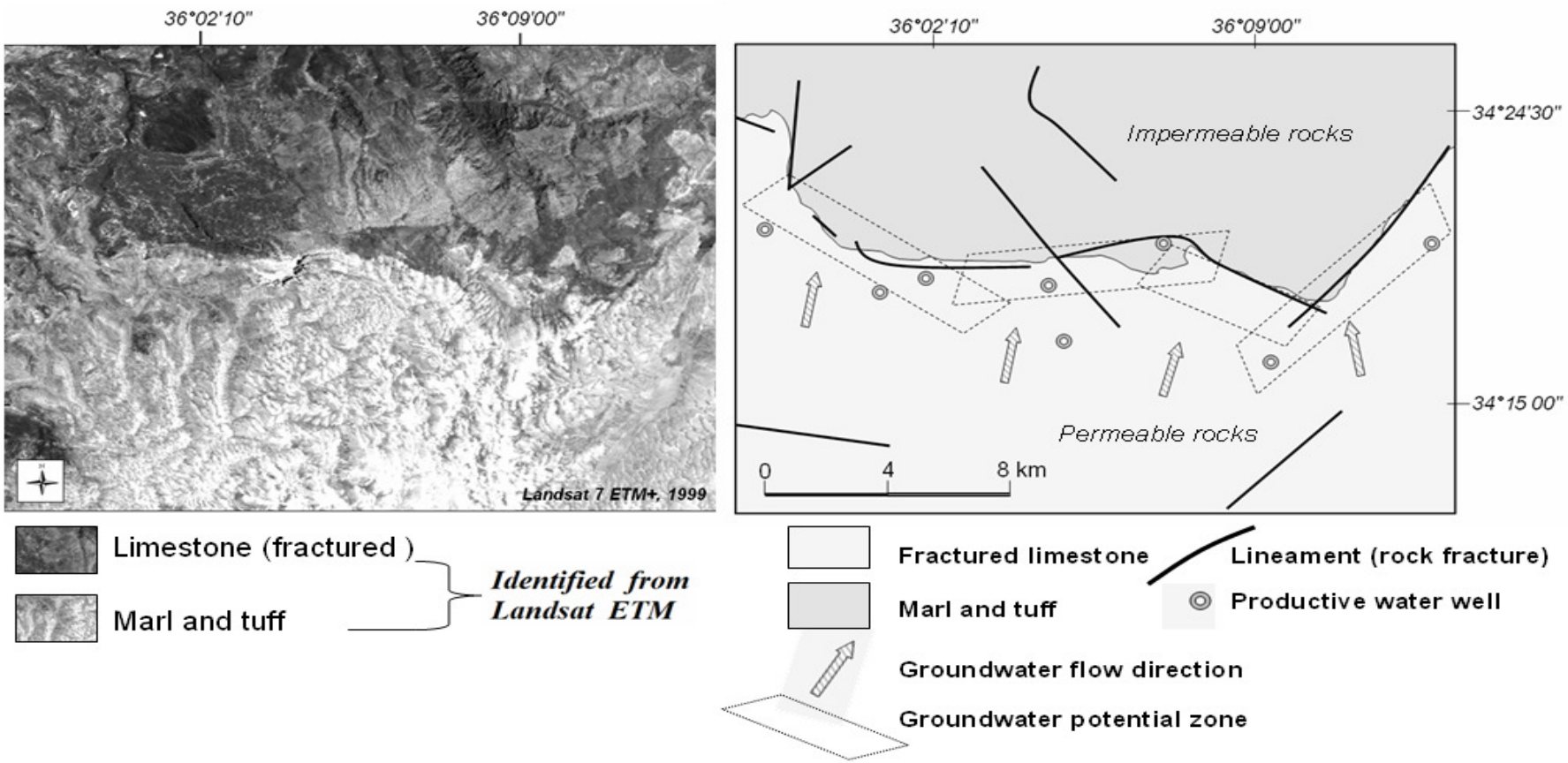
The analyzed satellite images helped identifying new water sources, detecting water loss to the sea as well as monitoring snow cover and water discharge from rivers.

Fresh water resources were detected form aerial photos using the thermal infrared analyzes.

A comparison of the recent results with a prior assessment done by FAO in 1969 showed a reduction of fresh sources from 79 to 56.



Thermal radiometric photo from air plane showing the fresh water resources in the sea



Example of using landsat 7 ETM+ to delineate the groundwater resources and water flow by studying lineaments and geographical distribution of different geological formations.

Example: Extraction of fracture systems from satellite image

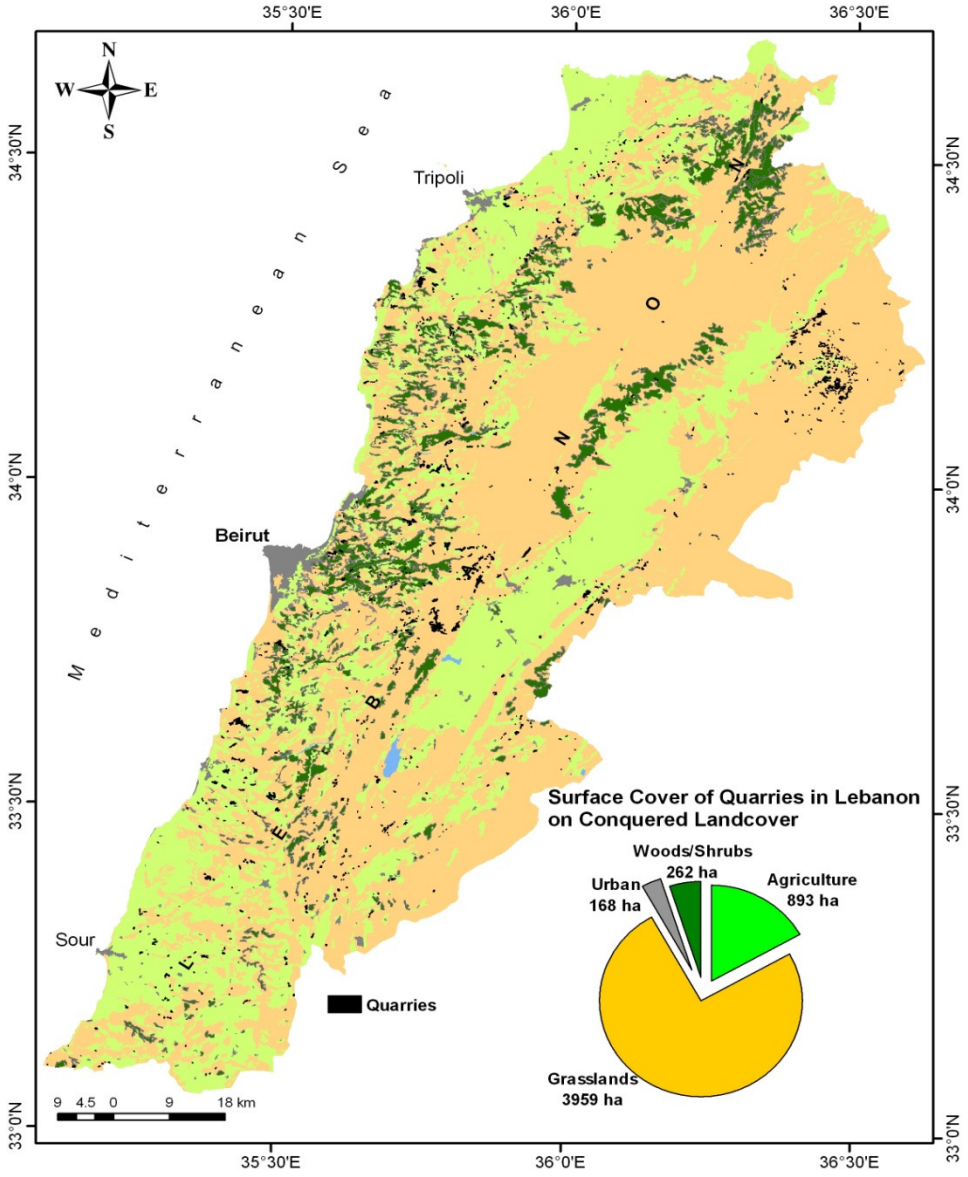
- **Landsat 7 TEM+**

- **Resolution**
  30m

- **Revisit time**
  16 days

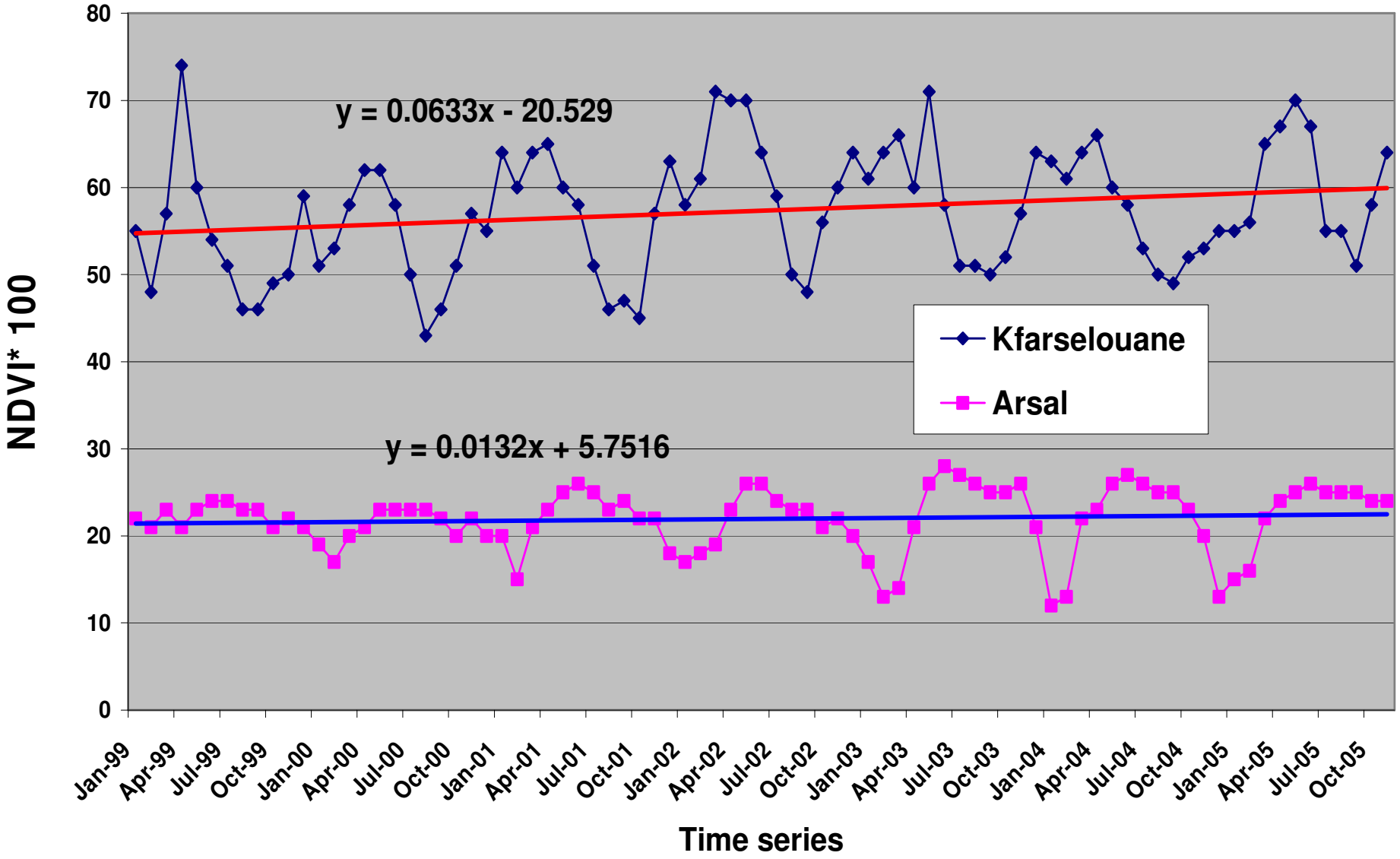
- **Number of bands**
  7 bands
  (1 band is Thernal)

7. Impact of quarries on natural resources LD

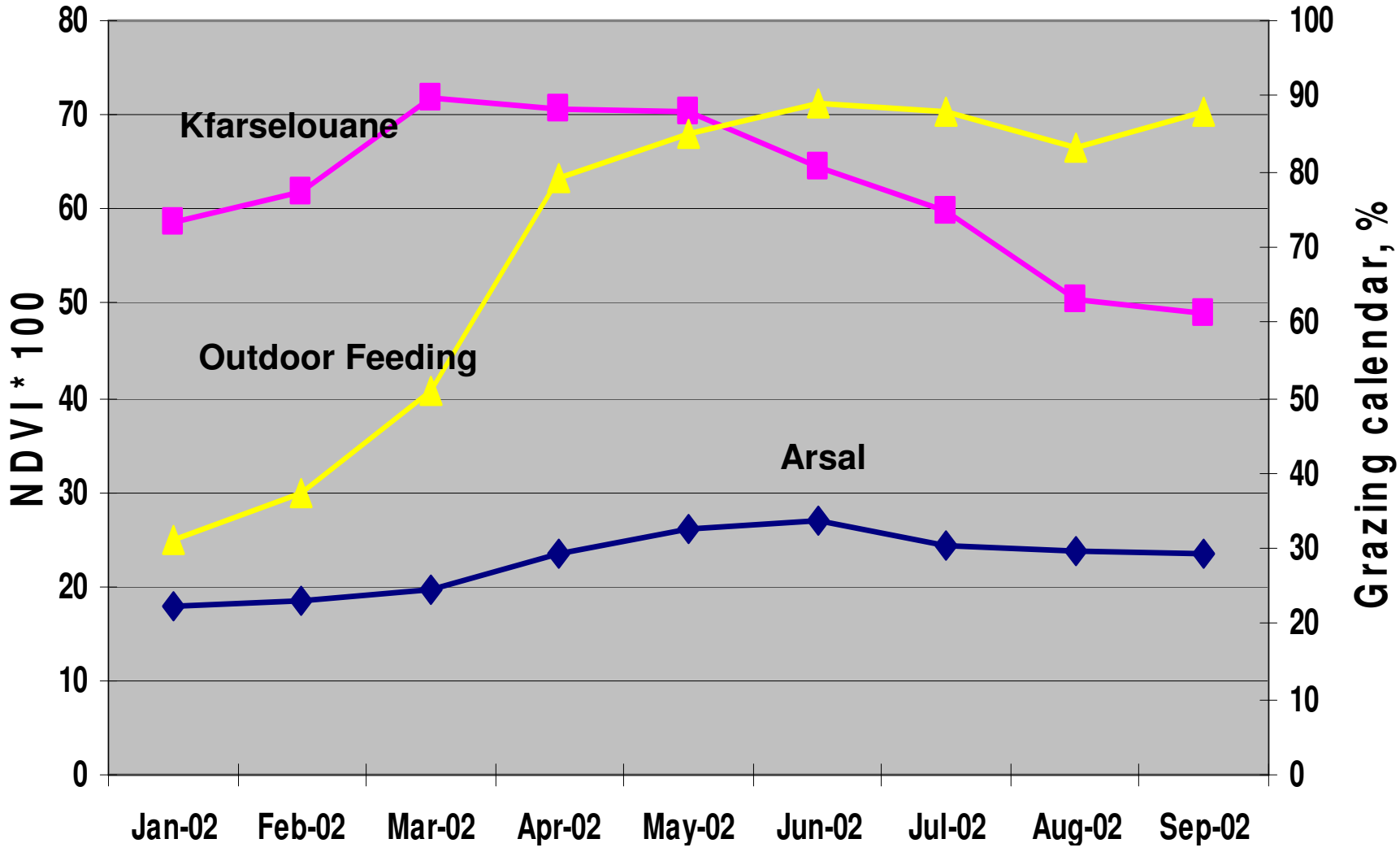


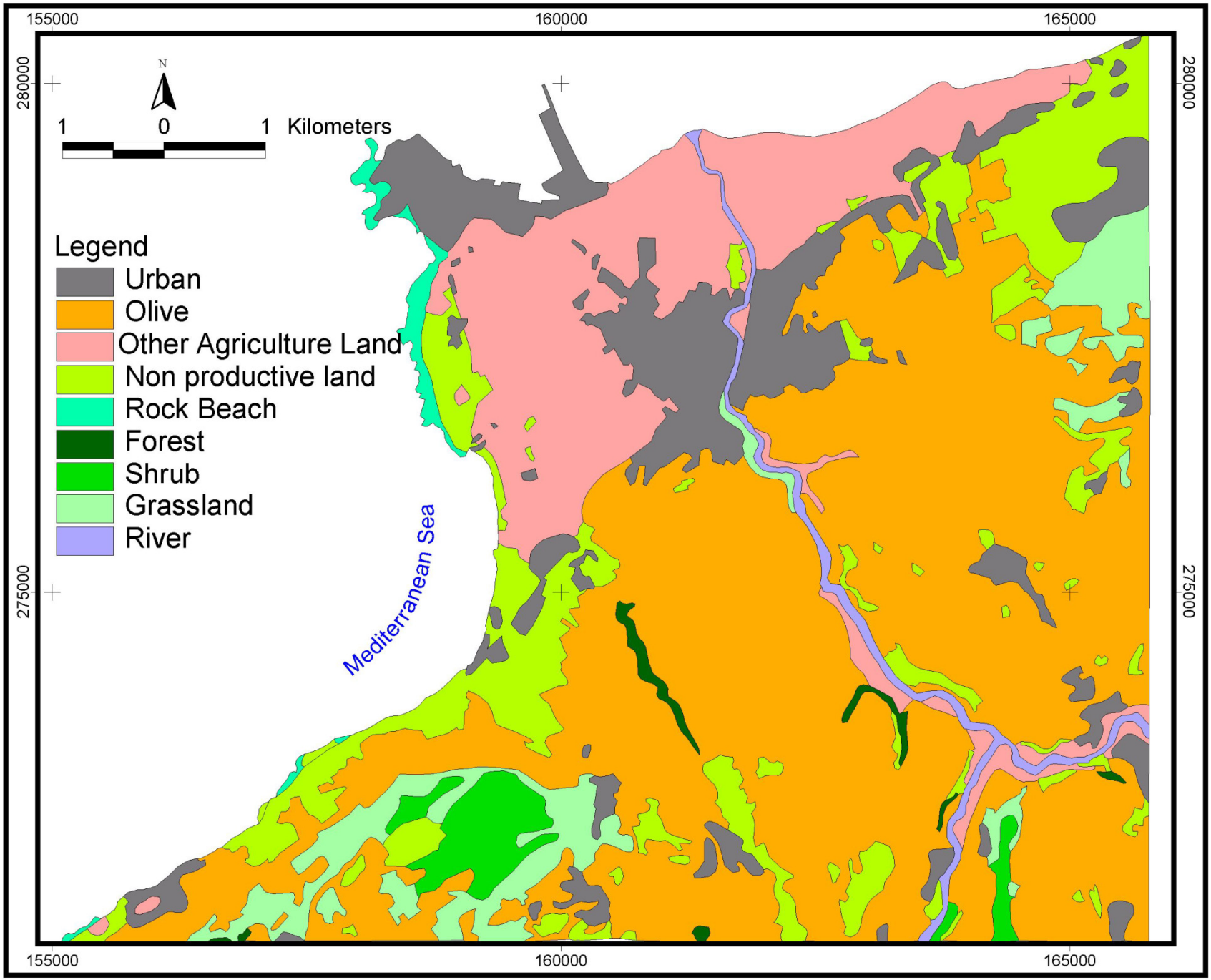
Distribution of quarries on land cover/use.

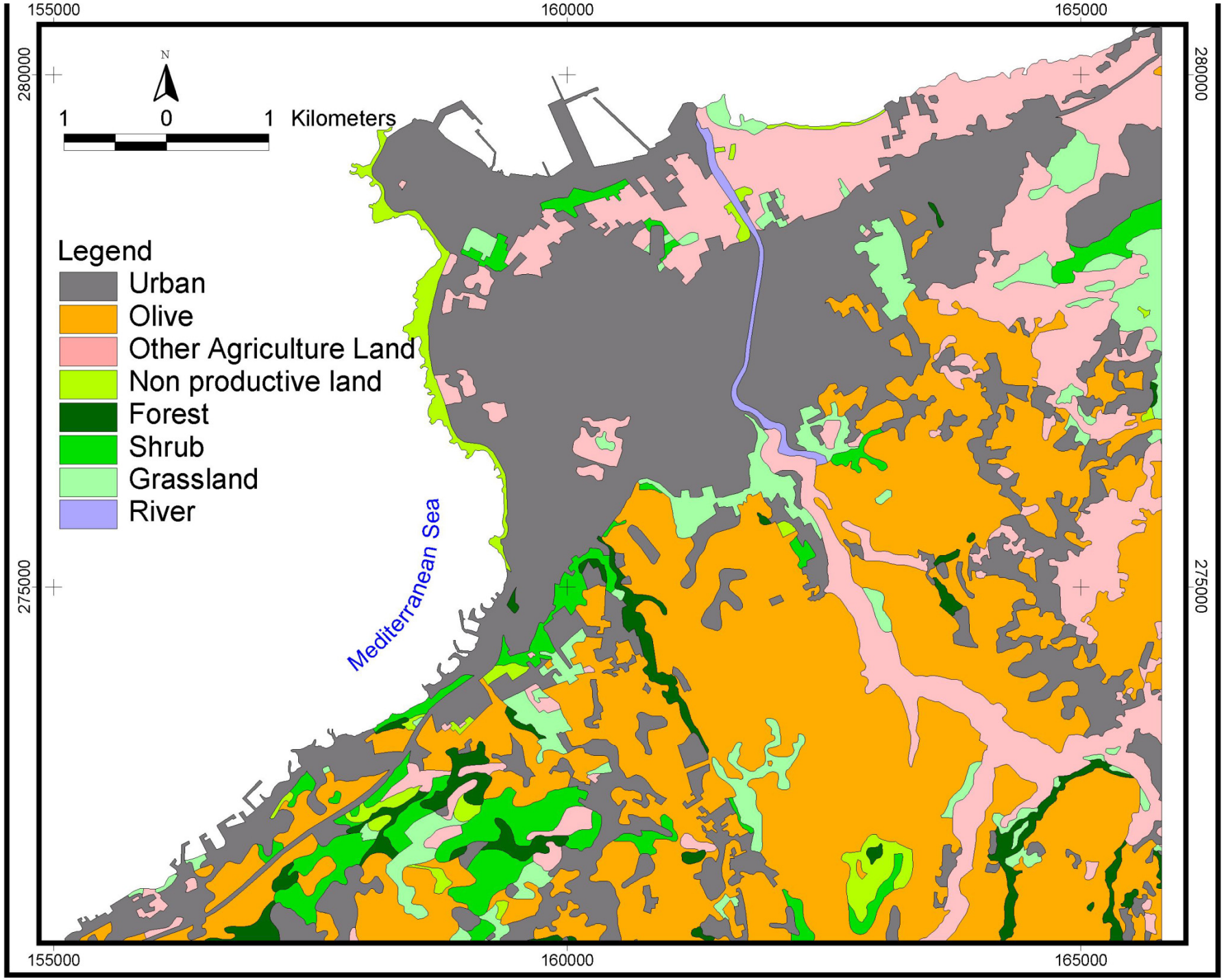
Long term time series analysis of NDVI in Kfarselouane and Arsal



Seasonal vegetation signal of Kfarselouane and Arsal watersheds and the practiced grazing calendar




155000
160000
165000
280000
275000
N
1 0 1 Kilometers
Legend
Urban
Olive
Other Agriculture Land
Non productive land
Rock Beach
Forest
Shrub
Grassland
River
Mediterranean Sea


155000
160000
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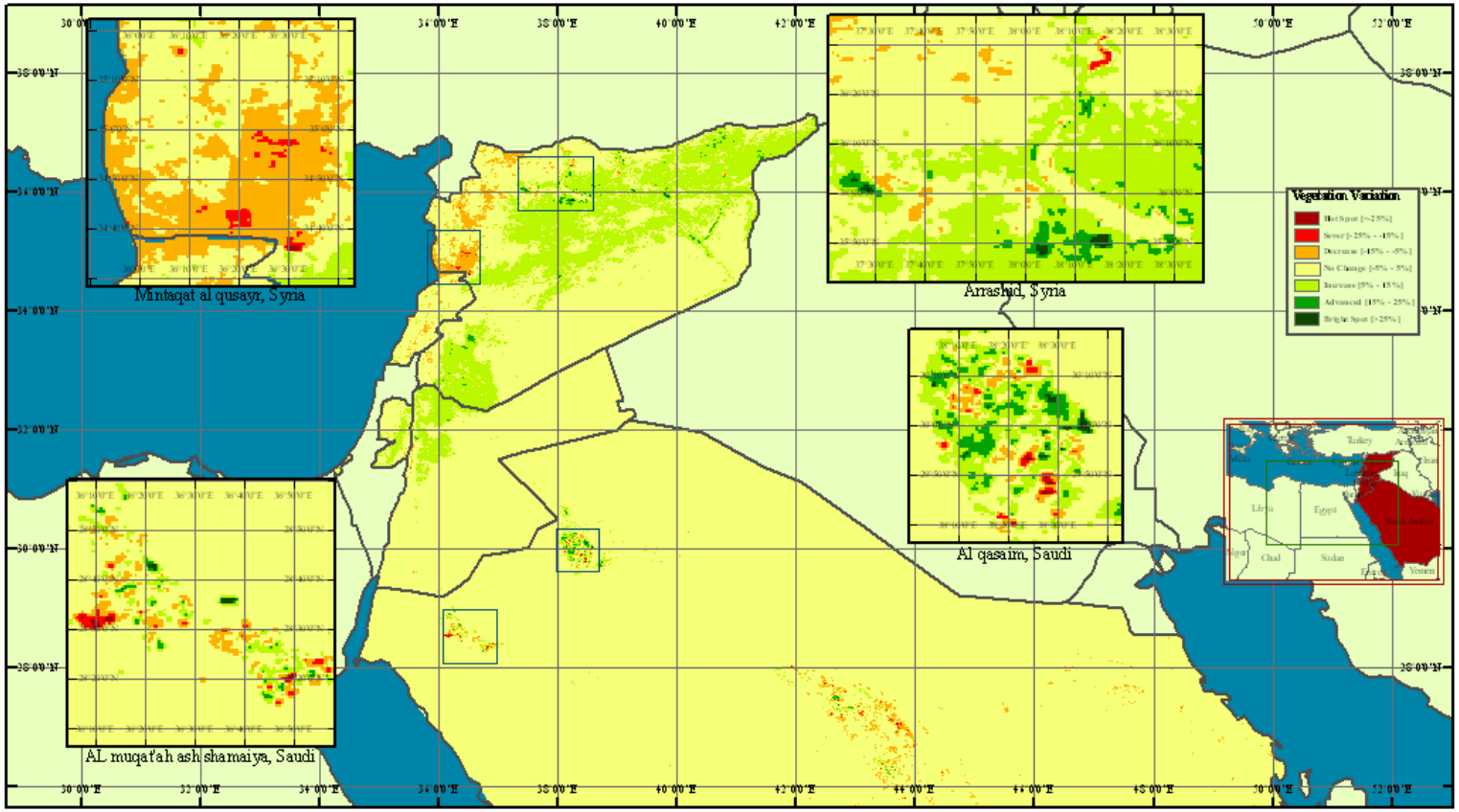
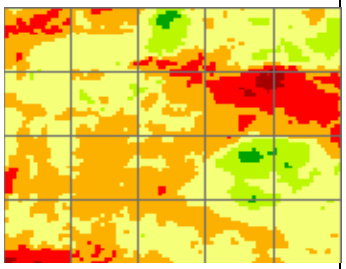
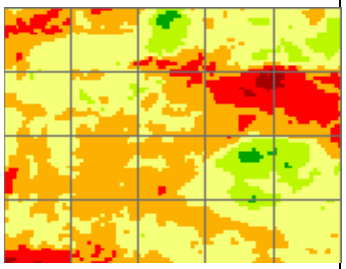
275000
N
1 0 1 Kilometers
Legend
Urban
Olive
Other Agriculture Land
Non productive land
Forest
Shrub
Grassland
River
Mediterranean Sea

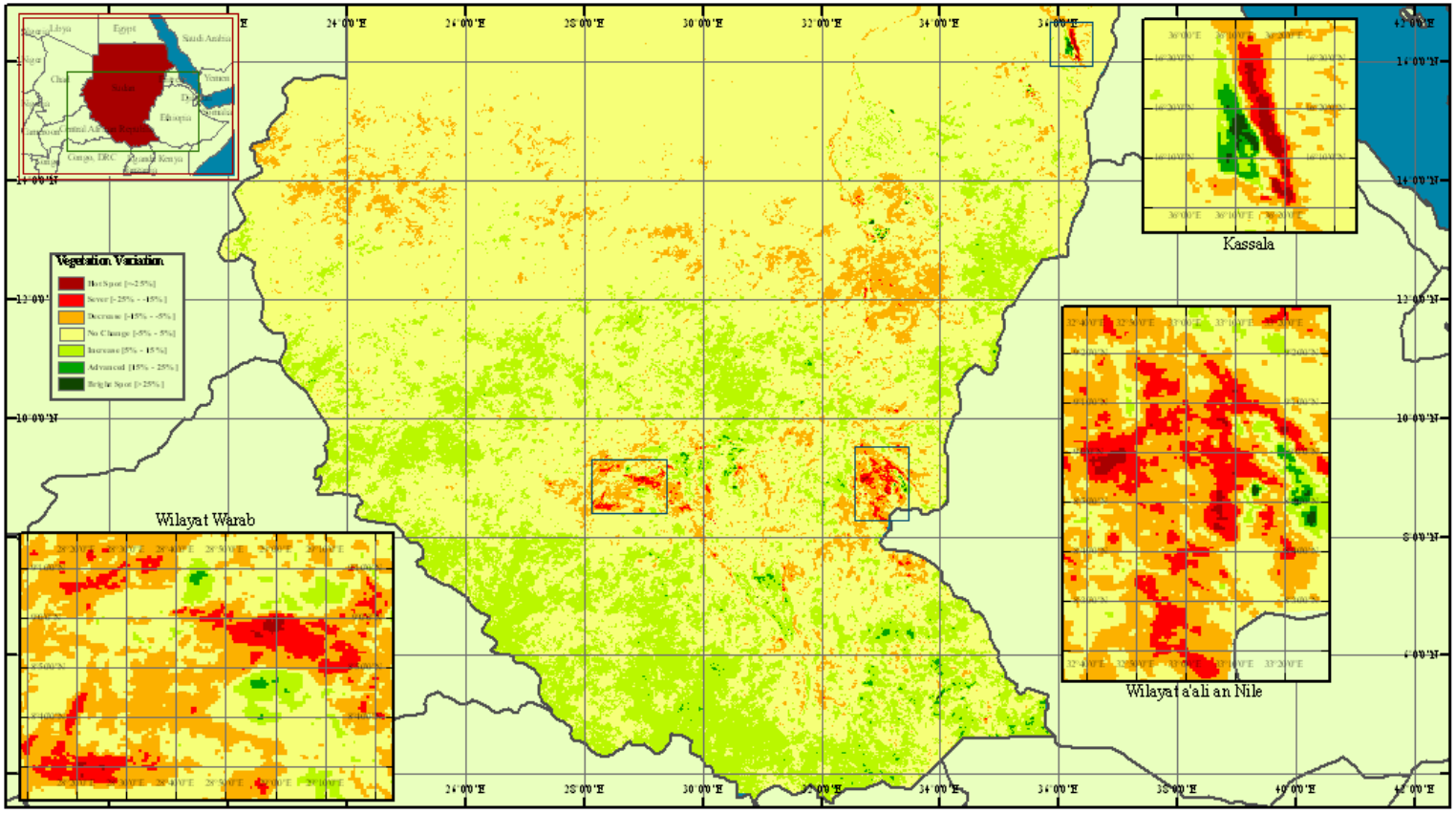
NDVI Analyzes SPOT





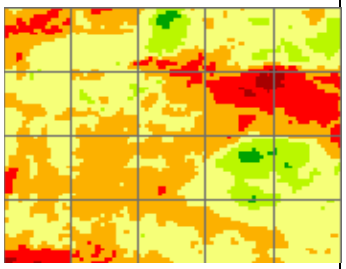
NDVI analyzes SPOT





Results SPOT Vegetation

Country	System: Spot 10 days 1999-2004 \ Areas in Km2						
	Hot Spot	**Severe**	**Moderate Decrease**	**No Change**	**Moderate Increase**	**Advanced**	**Bright Spot**
Lebanon	0	3	818	9203	334	2	0
Syria	11	172	6406	118783	67441	1164	77
Jordan	0	4	116	81391	6846	26	0
Iraq	141	905	17125	343925	70727	7194	686
Kuwait	0	3	31	15536	4	0	0
Saudi	90	657	29220	1780697	4593	770	117
Palestine	0	1	106	4299	1807	0	0
Bahrain	0	1	38	469	0	0	0
Qatar	0	1	99	10392	9	0	0
Yemen	17	142	13204	359468	500	1	0
Emirates	3	27	1887	62646	335	13	1
Oman	76	193	5745	272768	154	0	0
Egypt	21	152	4313	932059	8066	745	209
Somalia	79	661	18555	425450	89611	9330	382
Djibouti	0	93	2672	15919	14	0	0
Sudan	393	4466	90797	1792270	289140	3637	293
Libya	20	94	9401	1530597	397	11	0
Tunisia	40	191	4183	141123	12448	79	22
Algeria	3	237	10840	2162960	55227	950	10
Morocco	16	478	7868	328395	63661	1090	121
Mauritania	0	3	9385	920683	9347	63	21
West Sahara	1	20	152	250613	28	0	0



8. After War assessment

Southern Suburb of Beirut 2006

Quick Bird Satellite

9. Monitoring of Oil Spill

LandSat ETM

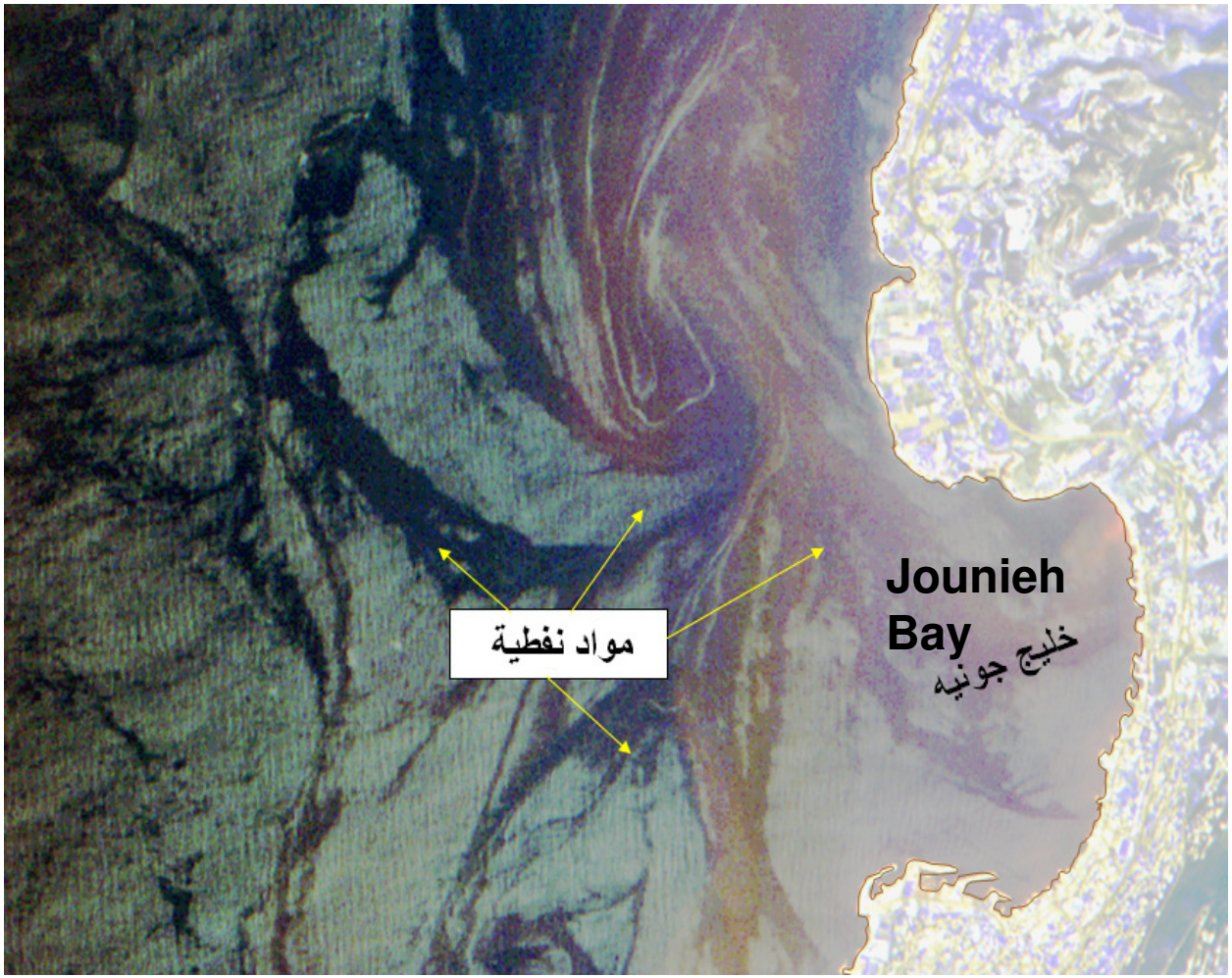
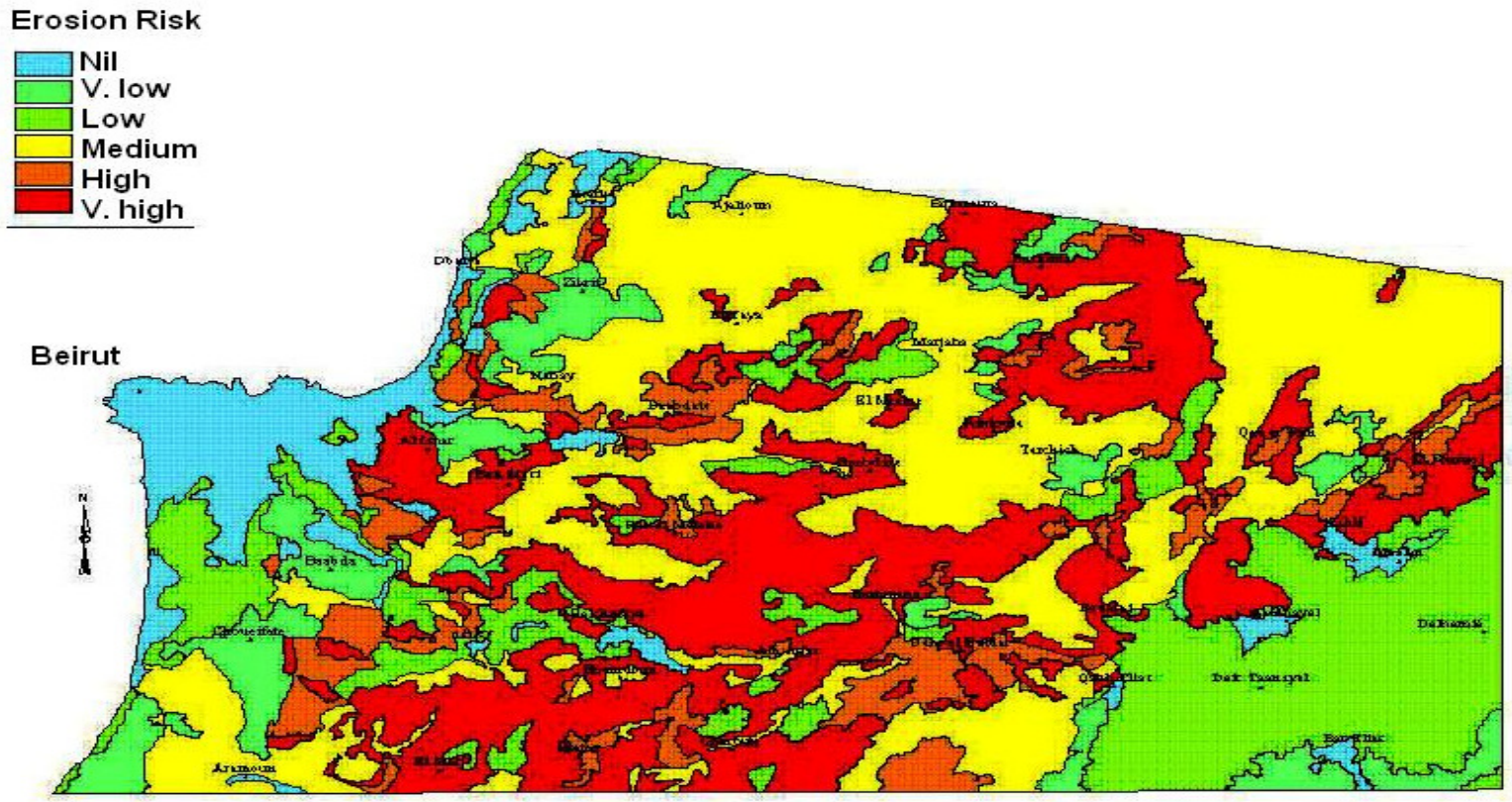


Image from ASTER shows the distribution of oil spill off shore Lebanon during the July 2006 war

10. Natural risks mapping

Studies of erosion risk assessment using remote sensing and GIS in the central Lebanese karstic mountains showed that around 36% of territories is under high risk of water-erosion.

Moreover, about 52% of that erosion is observed on the rugged mountainous region.



Map derived from satellite image and field work showing the rrisks of soil erosion in Central Lebanon

Detecting MM using Remote Sensing techniques

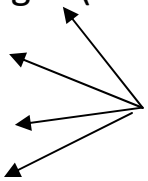
- Satellite imageries:

  * 2 panchromatic stereopairs SPOT 4 images (10 m resolution) (2.3 & 30.3 incident angles)

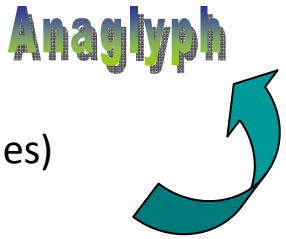
  * Landsat TM (30 m)

  * IRS-1C (6 m)

  * IKONOS (1 & 4 m)



Ortho-rectified



- Data combination and treatments:

FCC	**Landsat TM (3,5,7 & 4,5,7)**
Panchromatic	**SPOT4**
Anaglyph	**SPOT4**
Pan Sharpen	**Landsat TM-IRS** **IKONOS**
PCA	**Landsat TM** **Pan Landsat TM-IRS**

d) Pan-Sharpen IRS + LANDSAT

e) PCA (IRS + LANDSAT)

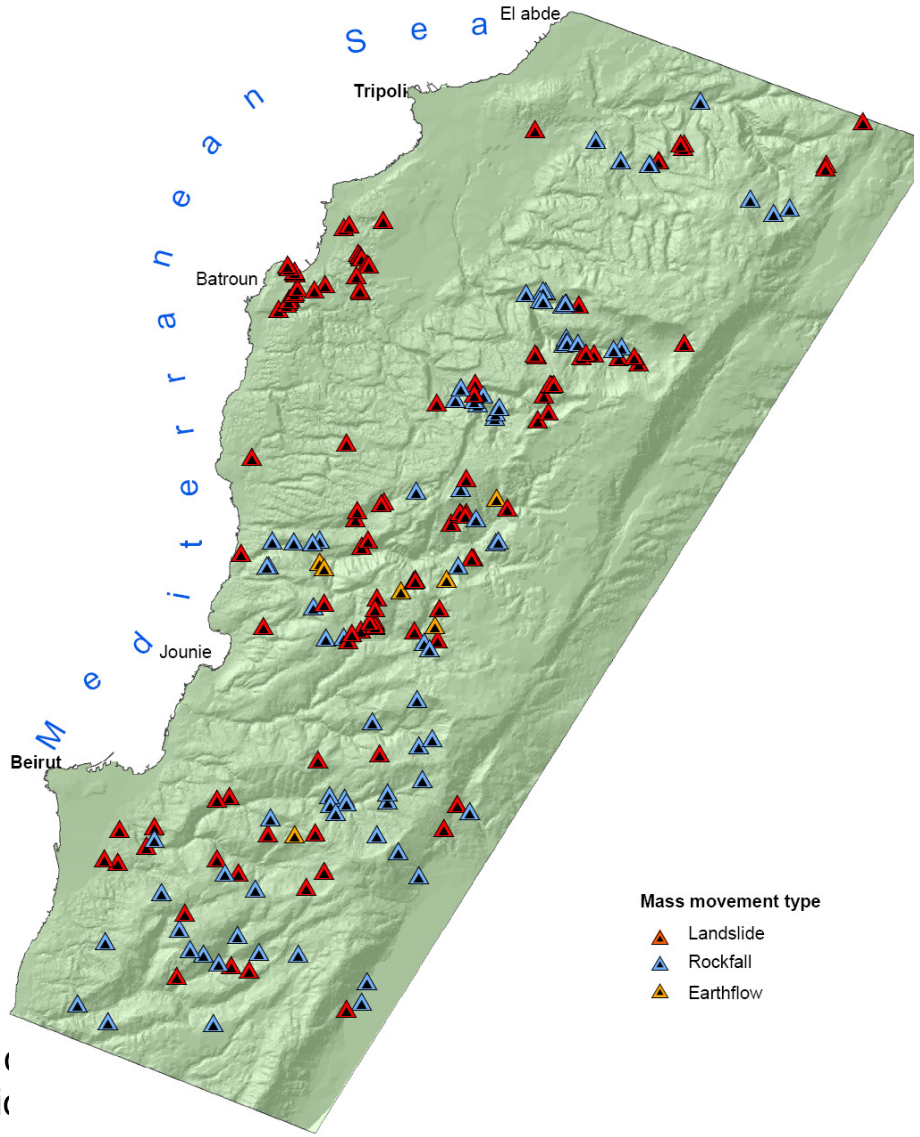
f) SPOT 4

Used satellite images	Landslides (L)			Rock and debris falls (RDF)			Earth flows (Ef)		
	The few known-mapped + the detected number of L on the image (a)	Verified number of L in the field (b)	% of accuracy [(b/a) * 100]	The few known-mapped + the detected number of RDF on the image (a)	Verified number of RDF in the field (b)	% of accuracy [(b/a) * 100]	The few known-mapped + the detected number of Ef on the image (a)	Verified number of EF in the field (b)	% of accuracy [(b/a) * 100]
FCC 457 Landsat TM	*96*	*55*	**57**	*43*	*22*	**51**	*1*	*1*	***100***
FCC 357 Landsat TM	*94*	*48*	**51**	*63*	*30*	**48**	*1*	*1*	***100***
Pan-sharpen Landsat TM-IRS	*109*	*61*	**56**	*83*	*47*	**57**	*1*	*1*	***100***
PCA Landsat TM	*107*	*57*	**53**	*82*	*42*	**51**	*1*	*1*	***100***
PCA Pan-sharpen Landsat TM-IRS	*123*	*74*	**60**	*111*	*69*	**62**	*1*	*1*	***100***
SPOT4	*138*	*86*	**62**	*119*	*75*	**63**	*1*	*1*	***100***
Anaglyph from stereo-pairs panchromatic SPOT4	*166*	*115*	**69**	*125*	*80*	**64**	*13*	*7*	**54**

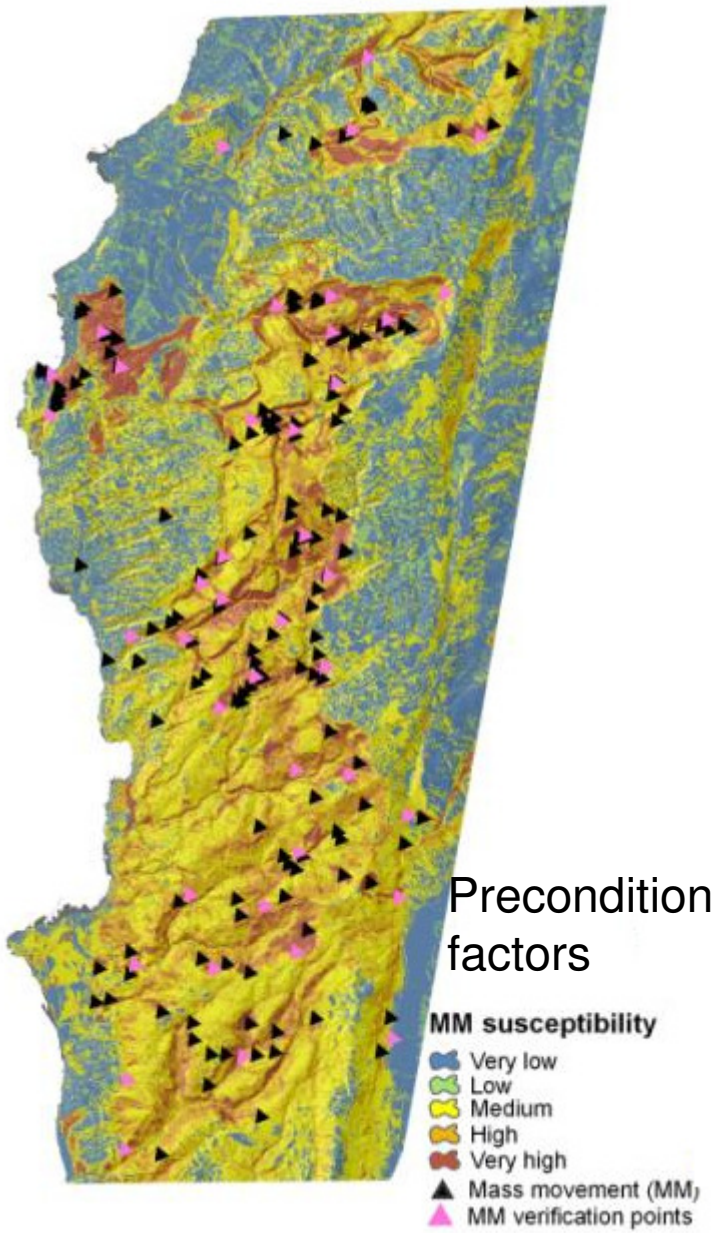
Detecting MM using Remote Sensing techniques

202 MM were detected

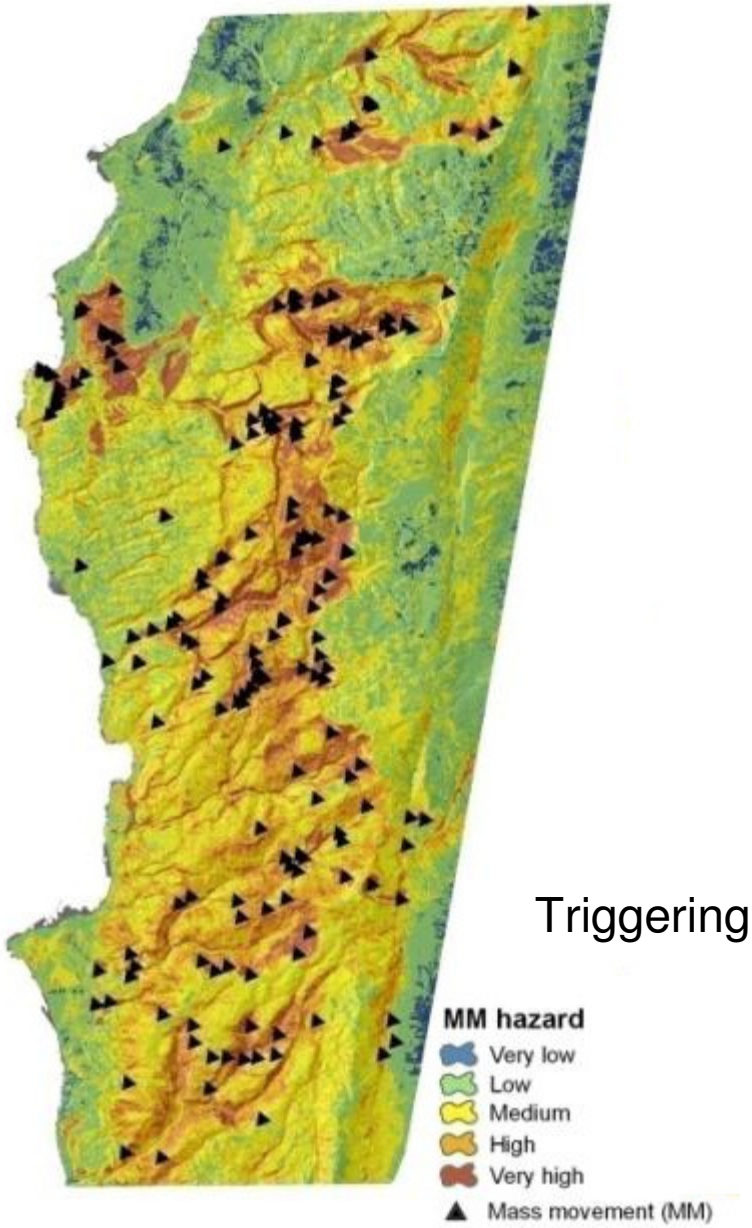
Correlated with terrain parameters using GIS – Statistical correlations



Detecting MM using Remote Sensing techniques

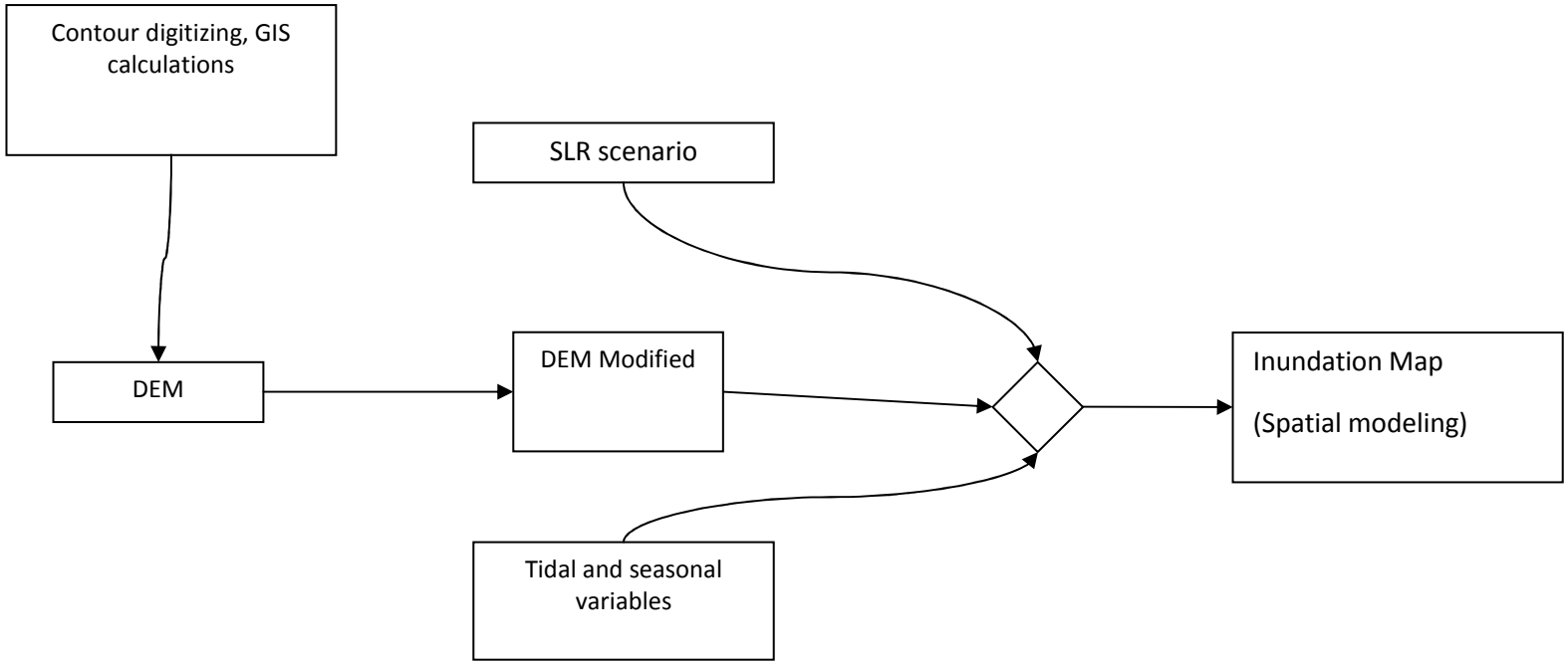


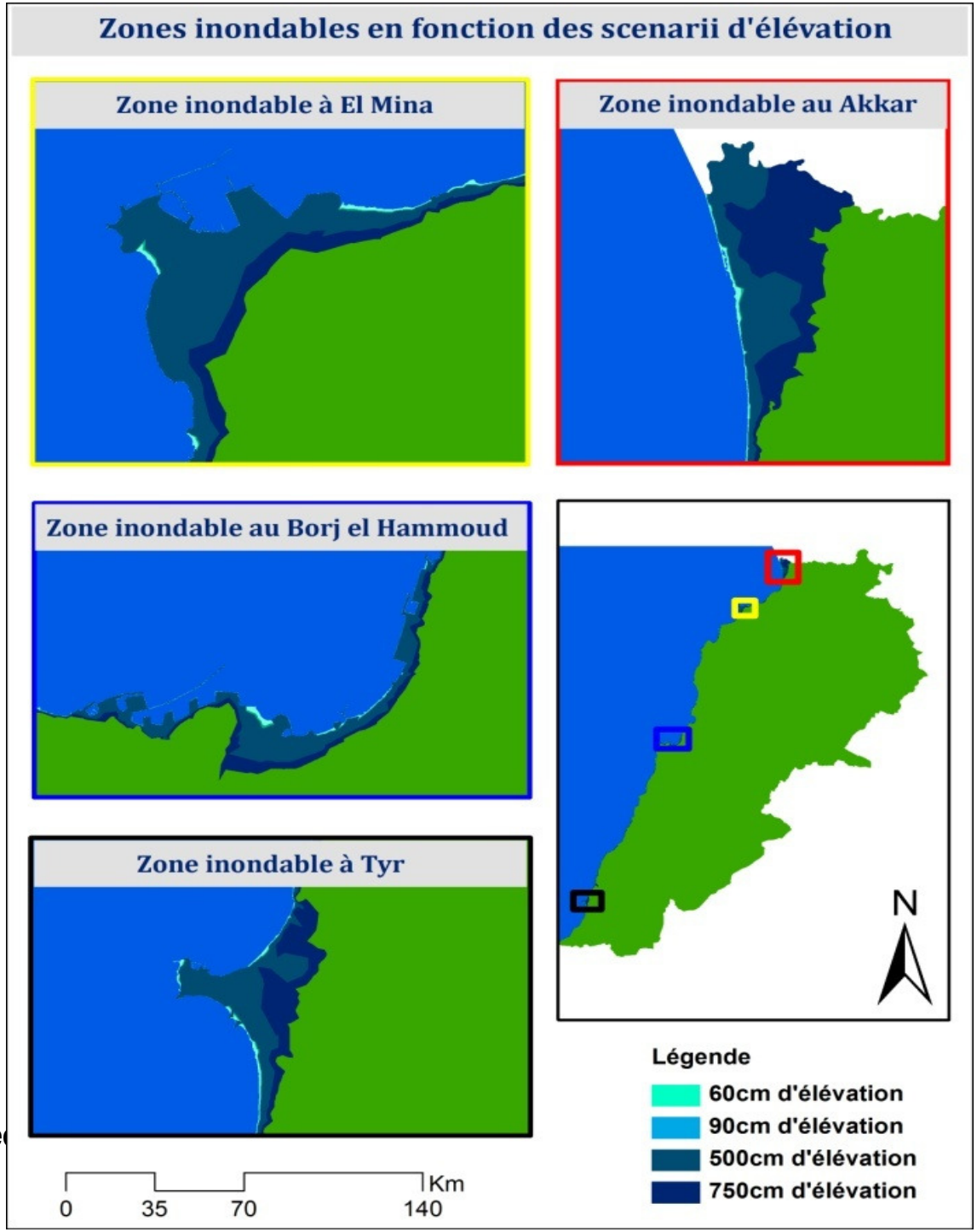
Preconditioning factors



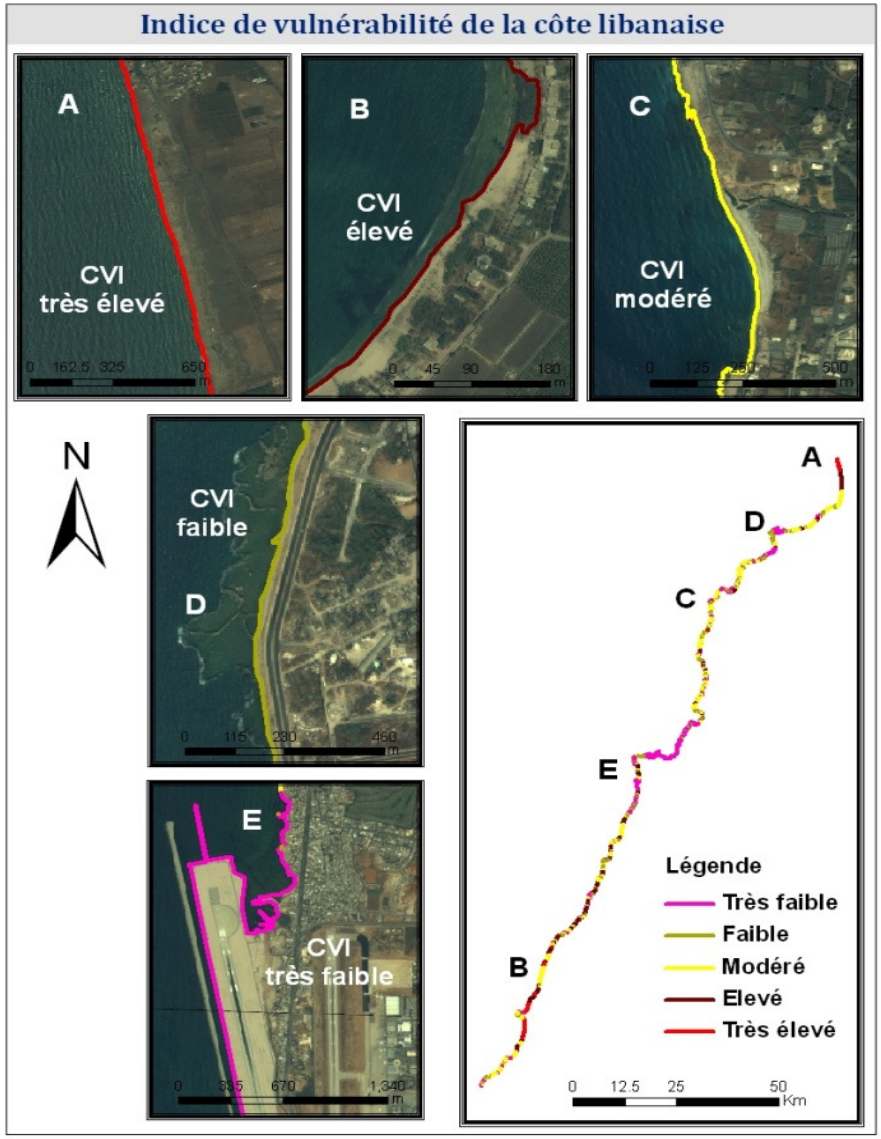
Triggering

11. Sea-Level Rise Induced Inundation

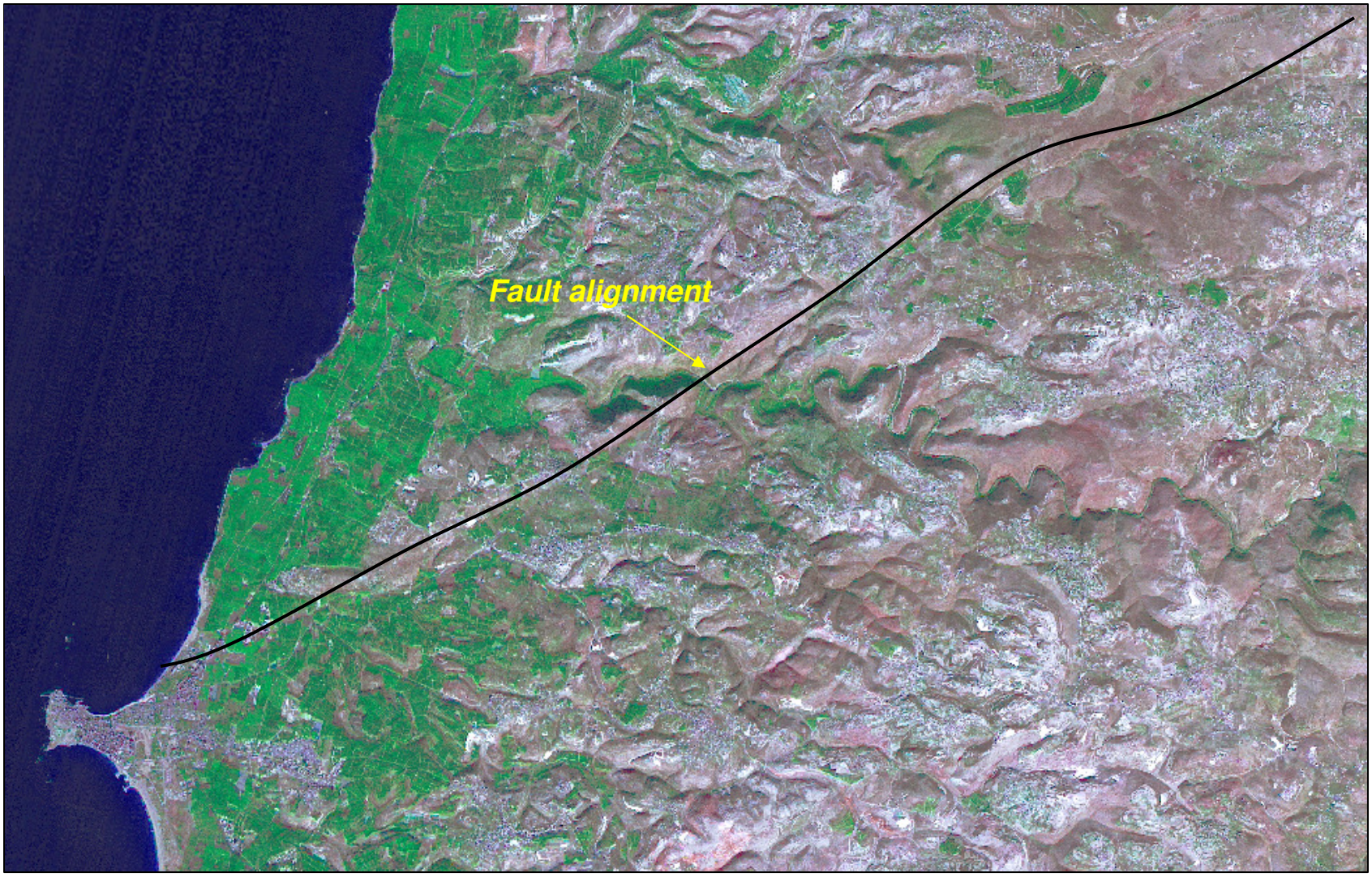



Zones inondables en fonction des scenarii d'élévation
Zone inondable à El Mina
Zone inondable au Akkar
Zone inondable au Borj el Hammoud
Zone inondable à Tyr
N
Légende
60cm d'élévation
90cm d'élévation
500cm d'élévation
750cm d'élévation
0
35
70
140
Km

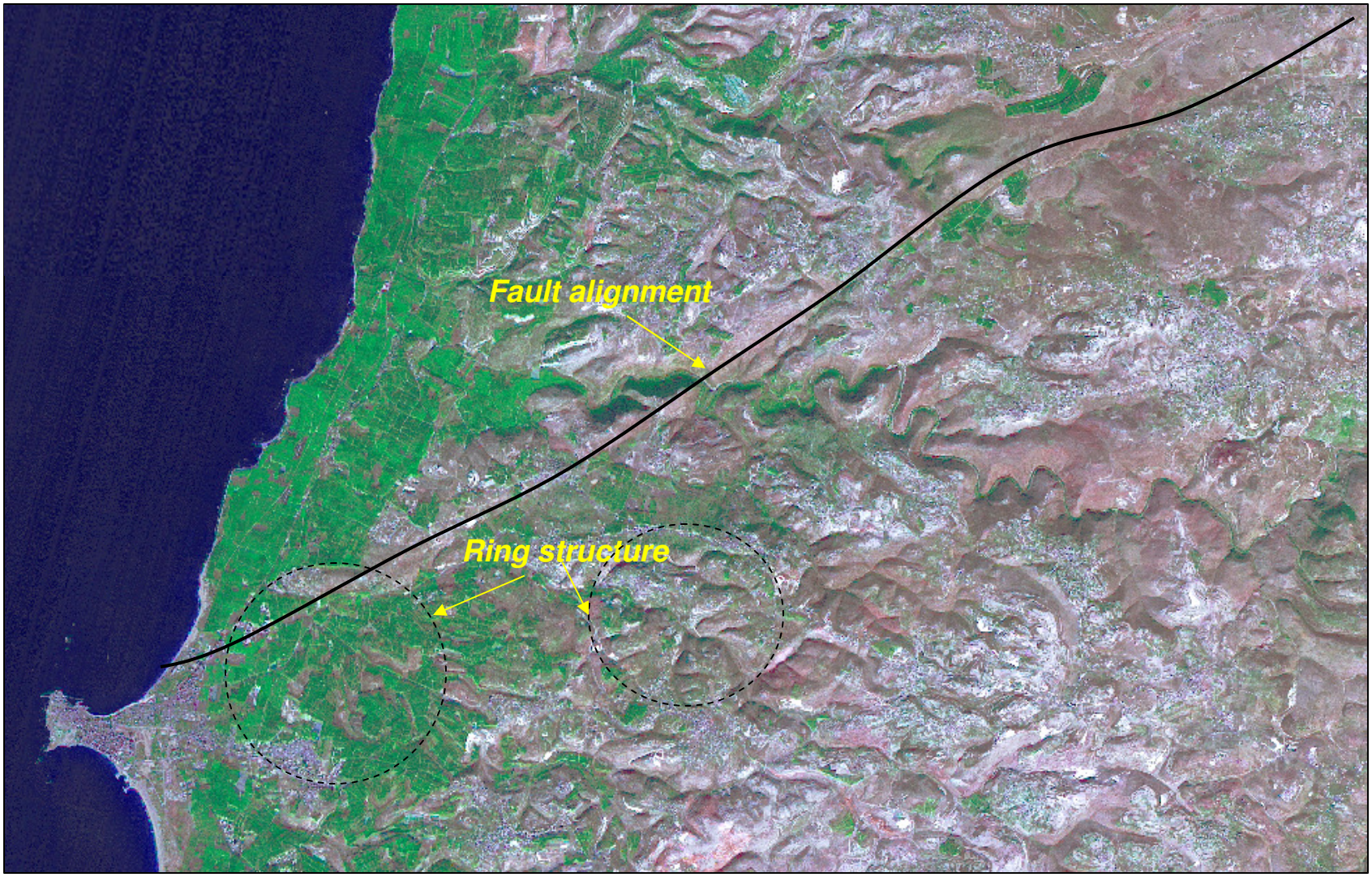
COASTAL VULNERABILITY INDEX LEBANON



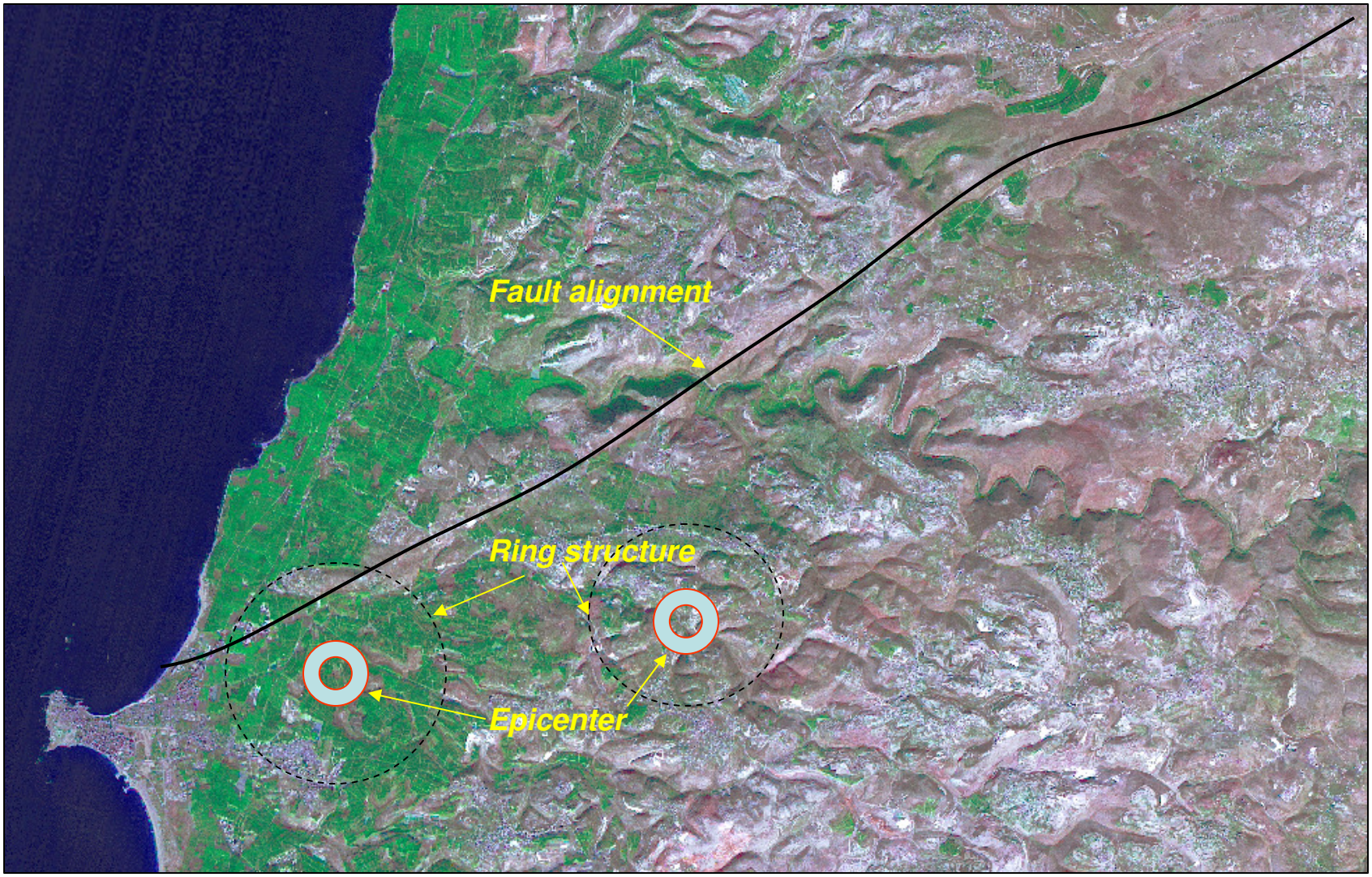
Earthquakes may exist along fault alignments, but almost appear on non-irrupted volcanics. These volcanics are revealed as *ring structures*. The above figure includes a fault alignment and a ring structure, both located east of Sour.



Obviously, you can see the fault alignment



Just click ! And you can see the ring structures east of Sour

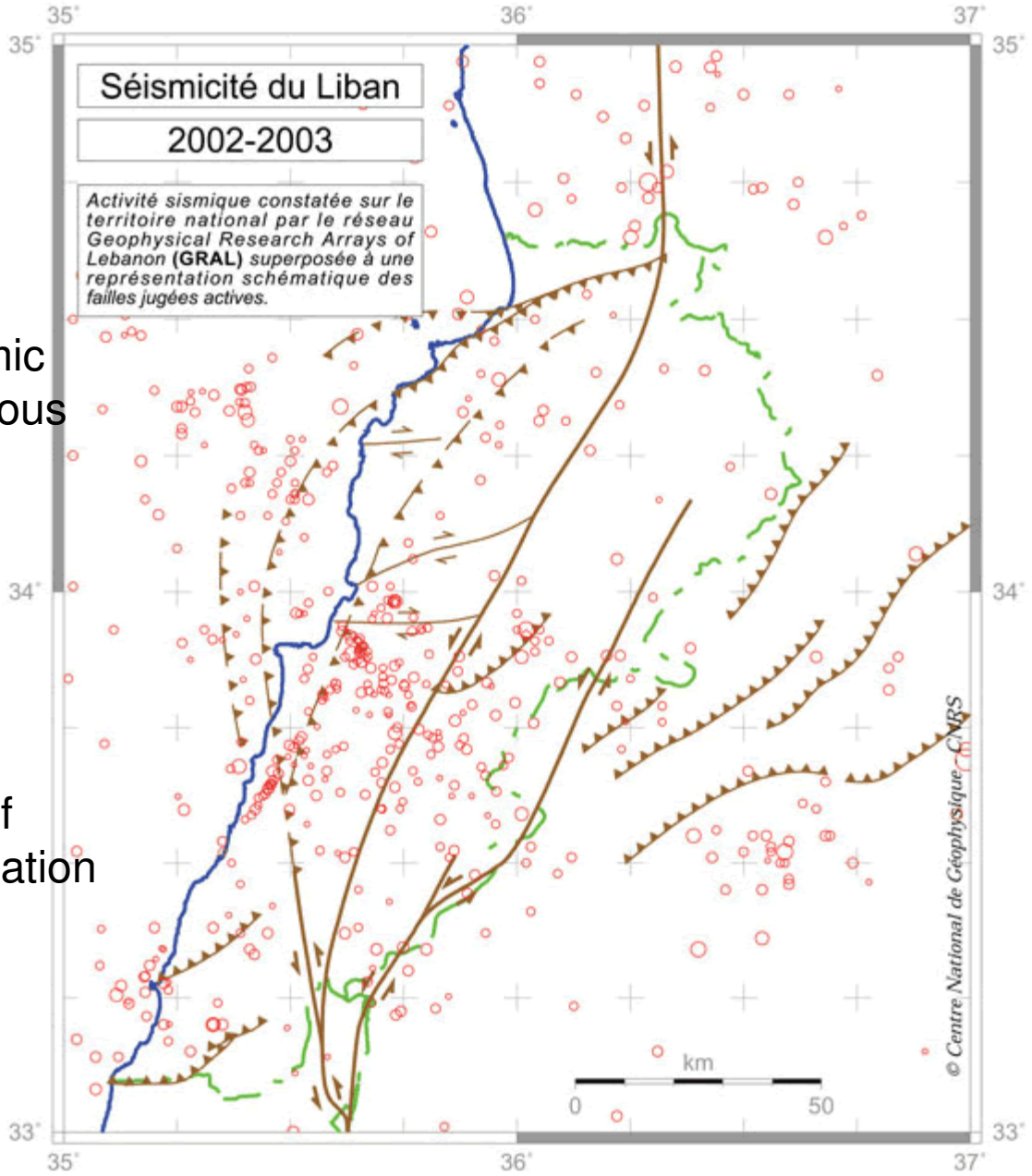


Click ! The epicenter of the earthquakes in South Lebanon, is almost located within the mi-point of the ring structure. This indicates the relationship between the earthquake and the non-irrupted volcanic activity in the area.

Results from CNRS-Center of Geophysics

This network has 8 permanent seismic stations and will have also 6 continuous permanent GPS stations next year.

uplift of Mount Lebanon at the rate of 5mm/year and the horizontal deformation has almost the same velocity.



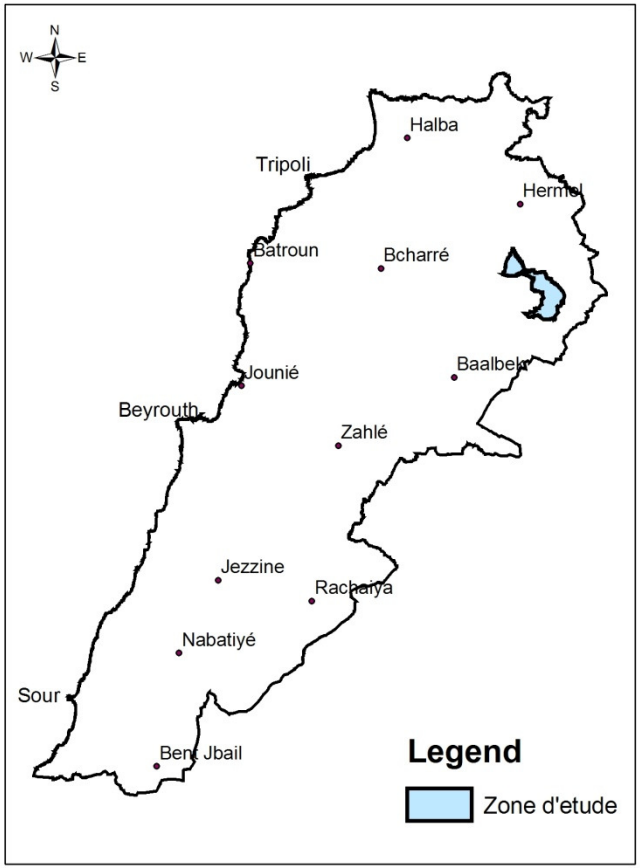
12. Torrential Rain and Flood

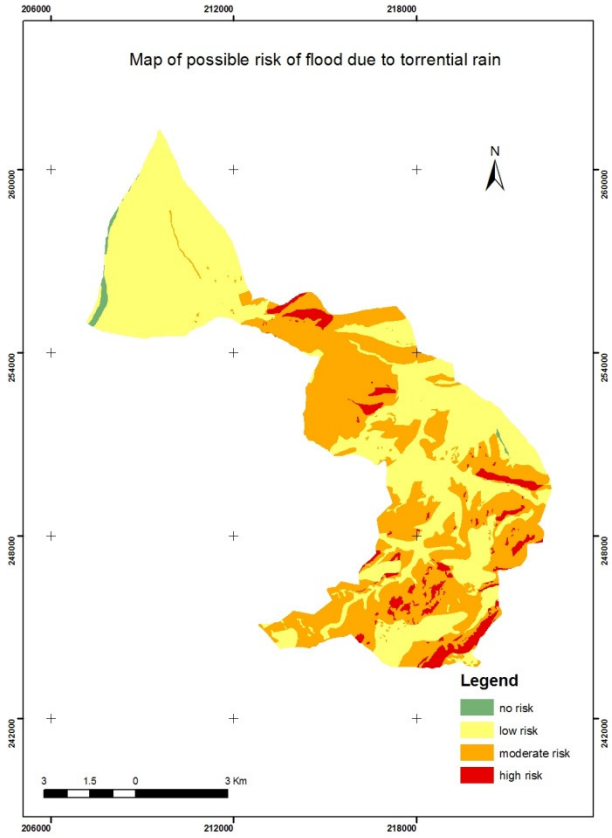




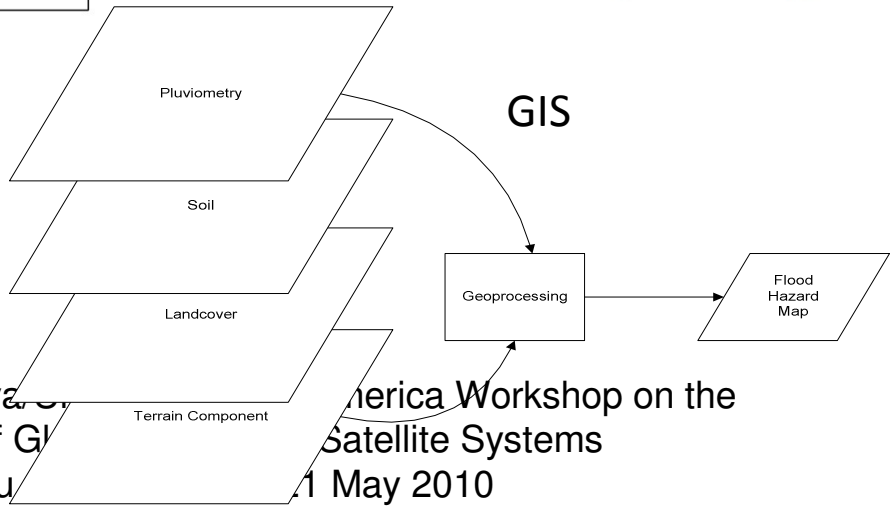


Torrential Rain and Flood





GIS

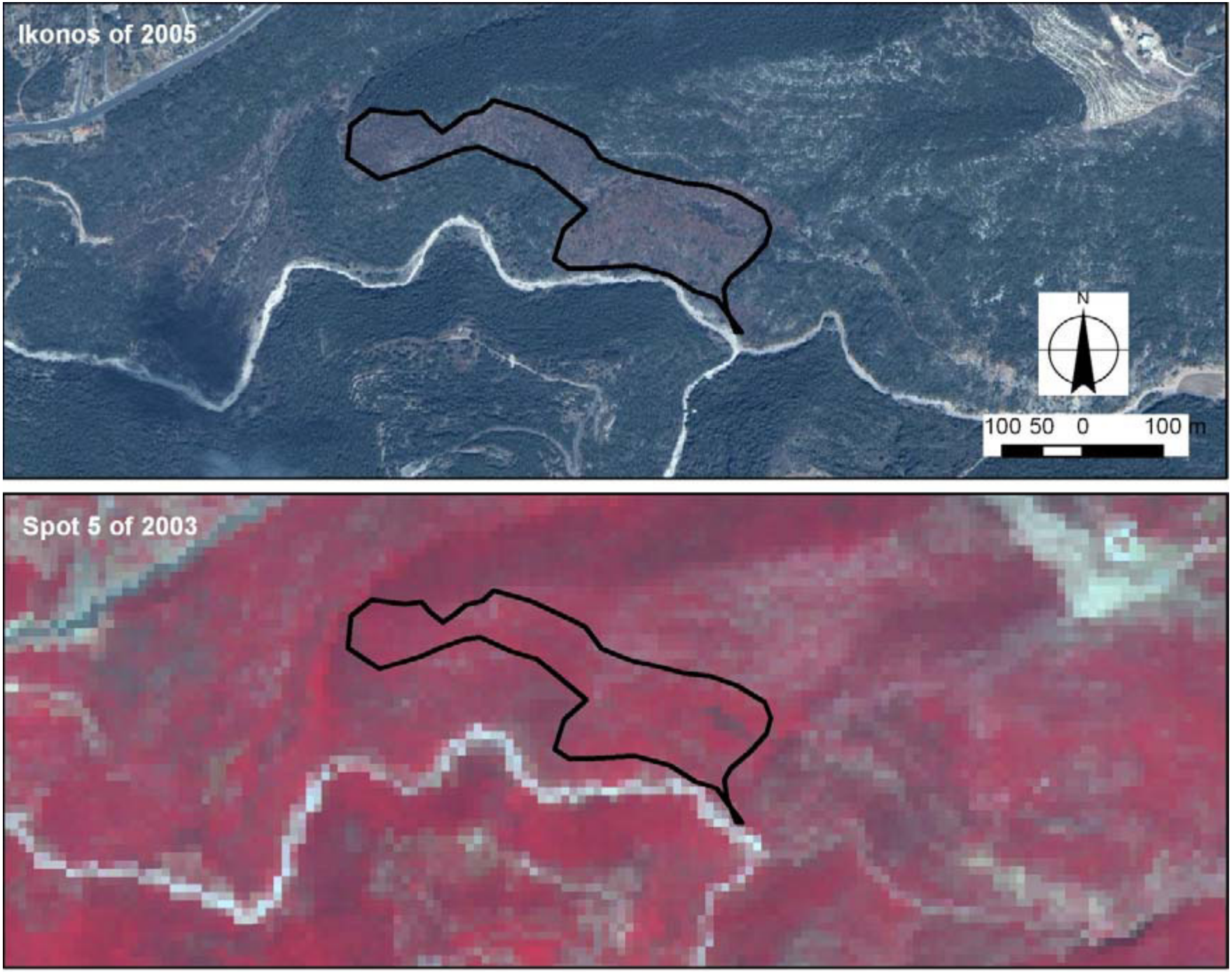


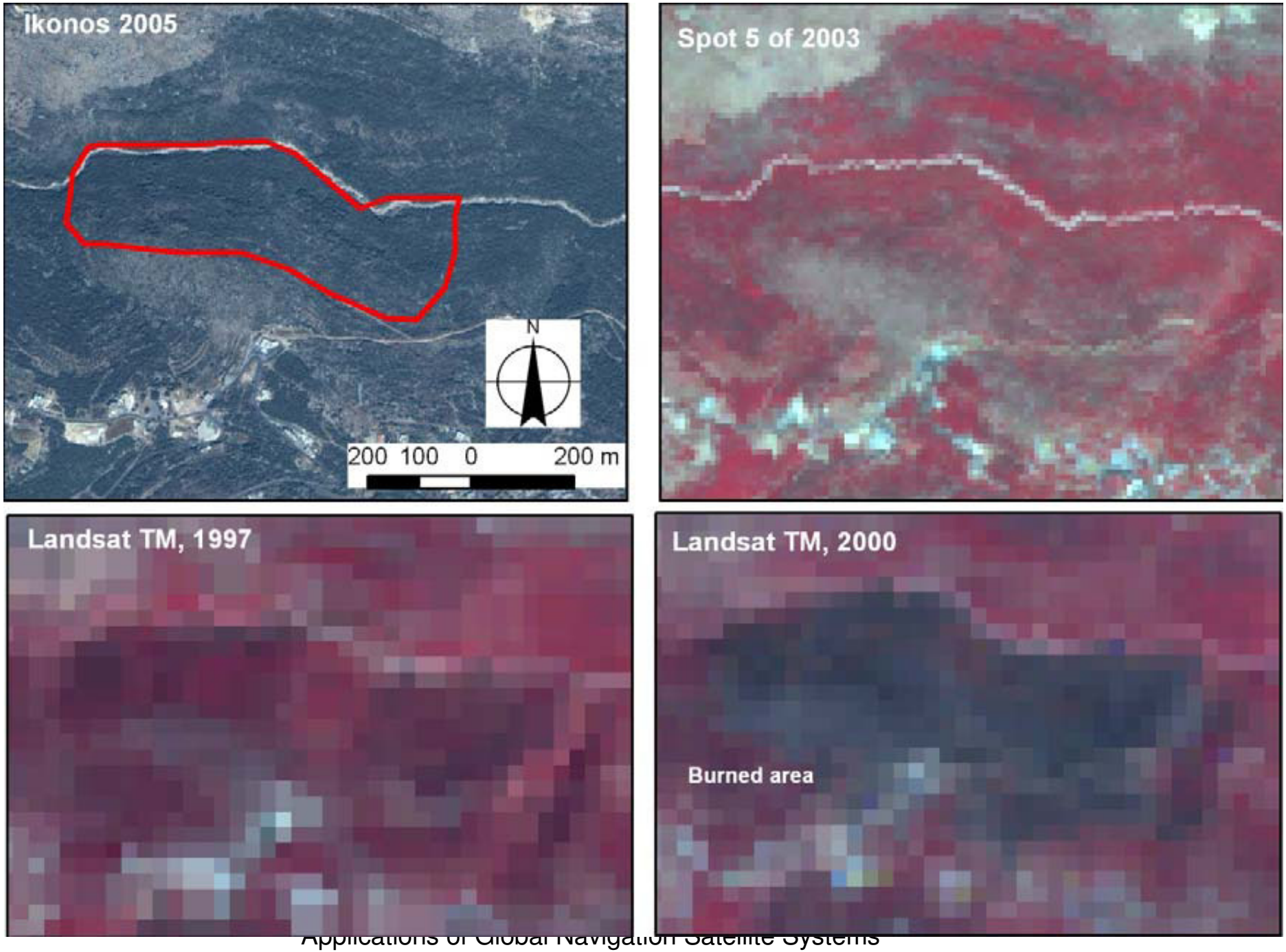
13. Forest cover

For the monitoring of climate change impact, remote sensing techniques have opened endless perspectives in ecology and ecosystem dynamics as it has given appropriate tools enabling to monitor changes of forest cover and especially forest fragmentation risks of fires.


Under forest canopy fuel


Burned forests that has under canopy fuel


Ikonos of 2005
N
100 50 0 100 m
Spot 5 of 2003


Ikonos 2005
N
200 100 0 200 m
Spot 5 of 2003
Landsat TM, 1997
Landsat TM, 2000
Burned area

14. Conclusion

Remote Sensing allowed Lebanon to keep path with science and information technology. It provided the researchers and decision makers a powerful means to reach studies and innovations and maps assessing land resources and climate as well as land cover and land uses.

Producing basic and derived maps like soil maps, urban expansion, coastal and maritime pollution, water resources studies promoted the modeling of natural hazards, like soil erosion, mass movement, monitoring of desertification risks through measuring the dynamics of the vegetation cover and its state (NDVI).

RS technique helped producing raster and vector images, thematic maps on natural resources, using GIS, in an effectives and cost justified way. These data, thematic maps and reports assist planning and decision making regarding urban planning and sustainable management of land resources.

RS possess another important privilege by playing crucial role in the early warning systems from catastrophic events like forest fires, adaptation to climate change and drought.