

PART II –ENVIRONMENT AND AGRICULTURE

2. MORPHOLOGY, WEATHER, HYDROLOGY, VEGETATION, AND ENVIRONMENT

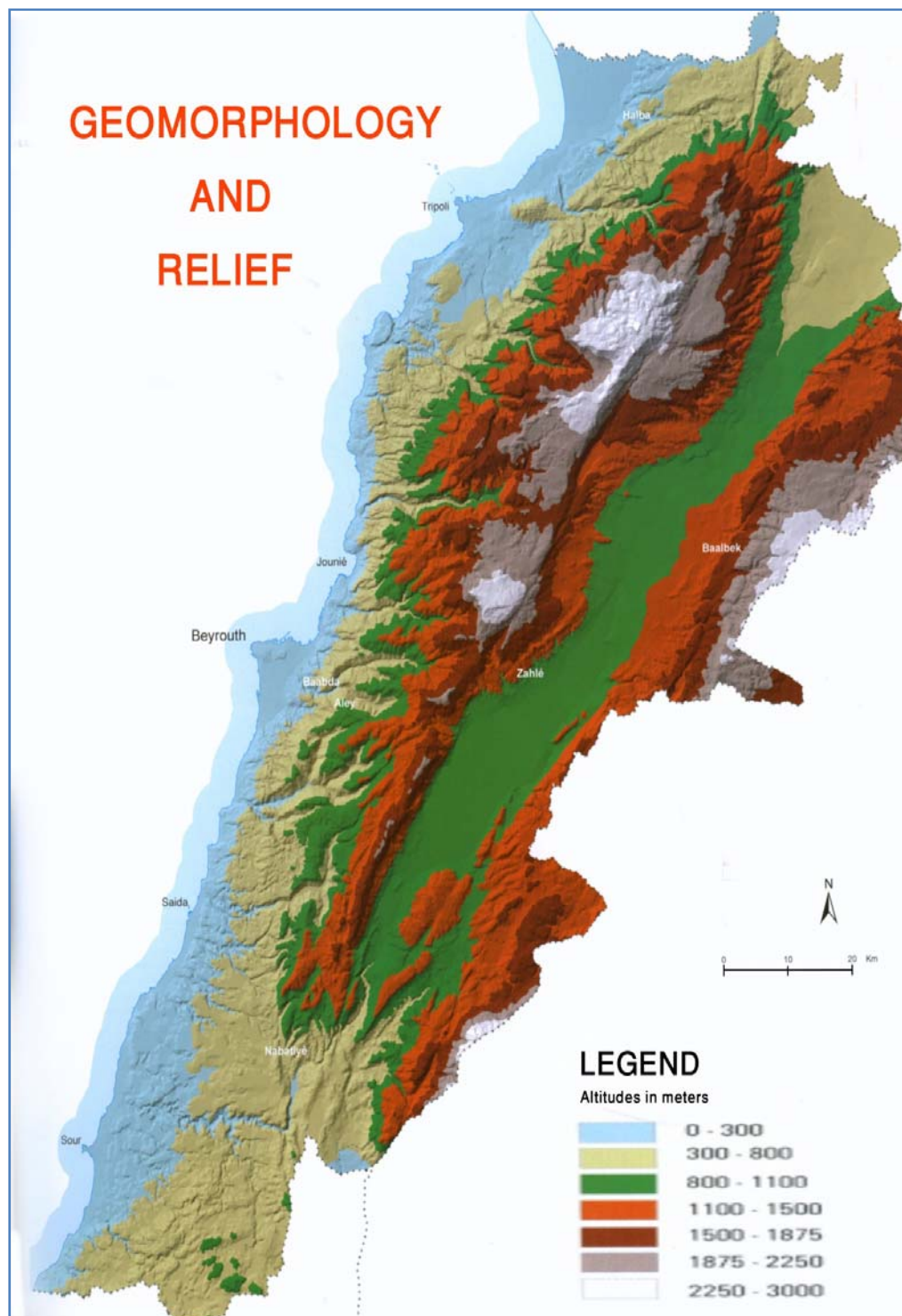
Geomorphology, geology and soil, weather and rainfall, hydrology, water sector calculations, vegetation zones, fire forests, and reforestation are the main topics of this chapter.

Geomorphology

Lebanon little area enjoys climatic and four geomorphologic zones, agricultural orientation, forest species.

Table 2.1 – Geomorphologic zones of Lebanon

Seashore and Coastal plain	
<i>Lebanese seashore</i>	Spreads over 220 km between Arida (North) and Ras Al-Naqoura (South). Deeply cut cliffs showing recent and accelerated erosion. Lie at the bottom of these cliffs, gravel beaches, often bordered by sandy beaches, with variable lengths (20% of the coast). Varies in width beneath the Mount-Lebanon range:
<i>Coastal plain</i>	<ul style="list-style-type: none"> • Very narrow along the majority of its length (7 km in average). • Wider at the Aakkar plain in the North: its width reaches 30 km with an elevation of 500 m. • Narrows between Tripoli and Jabal Terbol. • Excessively narrow (3 km in average) interrupted by the crests of Mount Lebanon. • Widens slightly near Beirut, the Choueifat plain, and near Saida plain, from where it spreads with no interruption towards the Tyr plain with an average width of 7 km.
Western mountain range (Mount Lebanon)	
<p>Mount-Lebanon extends from the North of Jabal Aakar southward up to an elevation of 3,008 m (Kornet el Saouda) and 1,809 m (Jabal Niha). Its total length is 160 km. Width varies between 25 km (central part) and 45 km (North). Mount Lebanon middle altitude area is the most diversified in Lebanon: the stiff elevation of abutments is followed by several small hills form an intermediate graduation between the sea and the peak.</p> <p>The western front is cut by parallel narrow valleys with an inclination seaward, carrying rivers and water courses.</p> <p>The eastern slopes overhanging the Bekaa valley are steeper than the western slopes. There are some seasonal rivers formed in spring as a result of the snowmelt.</p> <p>High altitudes have stiff elevations and scarps reaching the peak. With a big volume of rain and a two meters snow cover, the landscape is dry and stripped because water infiltrates through the karstic basins.</p> <p>Crest-line starts at around 1,800 m and is formed of large, circular and grayish peaks, especially in the North.</p>	
Interior plain (Bekaa valley)	
<p>Depression at an average elevation of 900 m, measures 120 km (North-South) by 8-12 km (East-West) in average, with an exceptional width of 25 km at Hermel (in the North).</p> <p>Soft slopes with a peak of 1,100 m located near Baalbek, where the valley mingles with Anti-Lebanon abutments.</p>	
<i>Northern and Central Bekaa</i>	This agricultural area expands from the valley of Nahr el Aassi till Haouch el Nabi in the south. It contains Litani river water sources.
<i>Southern Bekaa</i>	This agricultural area spreads from Zahleh-Rayak region down to Marjaayoun in the South.
Eastern mountain range (Anti-Lebanon)	
<p>High altitude consists of a dry plateau with a width of 30 km and an average elevation of 2,300 m (maximum is 2,616 m at Tallet Moussa). The plateau inclines southward to reach an elevated plain (1,400 m). This creates a natural break-up between Eastern part and Mount Hermon. Anti-Lebanon has no deep valleys.</p> <p>Mount Hermon extends over 100 km starting from Yanta in its north to Shebaa in the south. Its crests and slopes are a catchment feeding rivers flowing towards Bekaa valley (west), Houla Lake in Palestine (south) and Aaouej plain in Syria (east). Thus, Jabal el Cheikh intercepts and redistributes water resources in this arid region.</p>	



Geology and soil

Lebanon geological formations, settled until the Miocene-Pliocene periods, are formed mainly of sedimentary carbon rocks, limestone and dolomite. They seldom include clastic rocks (detritic rocks), sandstone, mudstone, marl and clay. Locally, some volcanic rocks such as pyroclastic basalt may be found. Jurassic and cretaceous limestone represents the main feature (armature) of Lebanon topography. Apart from recent sediments within the plain of Aakkar or the Bekaa valley, these are the core karstic formations that determine the landscape and water resources in Lebanon.

Table 2.2 - Stratigraphic column of Lebanon

Period	Epoch	Thickness	Lithology
Quaternary	Pleistocene / Recent	Variable	Eolian sands and alluvium
Tertiary	Pliocene	Up to 500m	Limestone, marl , volcanic material, sand and conglomerate
	Miocene	Up to 300m	Marly limestone, sand and conglomerate
	Eocene	Several hundred meters	Marly limestone
	Paleocene	Combined with Senonian	
	Senonian (Chekka marl)	100 to 500m	Marl
	Turonian (Maameltain Lst.)	200 to 300m	Marly limestone, limestone
Cretaceous	Cenomanian (Sannine Lst.)	Up to 700m	Dolomitic limestone, and marly limestone
	Upper Aptian/Albian (Hammana formation)	100 to 400m	Marl and limestone
	Lower Aptian (Mdeirij Lst.)	About 45m	Limestone
	Lower Aptian (Abeih sandstone)	80 to 170m	Sandstone and marlstone
	Neocomian (Chouf sandstone)	10 to 300m	Sandstone
Jurassic	Portlandian (Salima Lst.)	Up to 180m	Oolitic limestone and clay
	Kimmeridgian (Bikfaya Lst.)	Up to 80m	Dolomitic limestone
	Oxfordian (Bhannes volcanics)	Up to 150m	Marly limestone, volcanic complex
	Callovian (Kesrwan Lst.)	Over 1000m	Dolomitic limestone

Photo 2.1 - Limestone in the region of Kesrouane



Source: Picture taken by Vicken Ashkarian (2003)

Resulting from the transformation of rocks under the combined influence of weather, vegetation cover, and slope of the terrain, soils are typically Mediterranean.

The majority of soils are calcareous, apart from sandy gravelly soils formed on the cretaceous strata.

The most expanded soils are Terra Rossa and Rendzina.

Photo 2.2 – Terra rossa (red soil)



Source: picture retrieved of www.wikipedia.org

Photo 2.3 - Rendzina



Source: <http://www.inra.fr/internet/Hebergement/afes/Ressources/photos/sol115.php>

Lebanon soils are young, fragile and subject to erosion, especially in the mountains and hills that represent 73% of the country.

Topography, rain intensity and surface runoff are major factors increasing erosion caused by the precipitations, especially where the protective green cover has disappeared. The erosion intensity of Lebanon soils is proved by the stratification of alluvial loam terraces of the coastal rivers.

Lebanon's position at the northern temperate zone and at the Mediterranean zone and its morphology characterize its weather. The two mountain chains, Mount-Lebanon and Anti-Lebanon, expanding perpendicularly to the atmospheric circulation constitute the core of the country. They produce a climatic variability at small distances. Hence, a 50 km cross section shows climate variations: a subtropical coastal climate followed by a typically Mediterranean climate at low elevations and a cold weather at higher elevations covered with snow during the winter, reaching a semi-desert plain, too dry to allow agriculture. This variety means a great diversity in ecosystems and landscapes in a limited surface area.

Rafic Hariri International Airport (RHIA), Beirut Golf, Zahleh (Haoush al Oumara) and Tripoli measure stations provide the General Directorate of Civil Aviation, Climatology Service with weather data for 2009.

Table 2.3 – Temperature, rainfall and windspeed in 2009

Total/average 2009	Coastal Zones			Bekaa valley
	RHIA	Beirut Golf	Tripoli	Zahleh
Mean temperature (°C)	23.0	23.2	20.5	18.0
Rain (mm)	811.6	1163.6	968.1	836.4
Mean relative humidity (%)	55.0	56.7	59.7	54.1
Wind mean power (m/second)	3.1	2.5	2.5	2.1
Maximal wind direction (degrees)	209	234	308	249
Rainy days	81	88	85	91

Table made by CAS based on General Directorate of Civil Aviation, Climatology Service data (2009)

Temperature

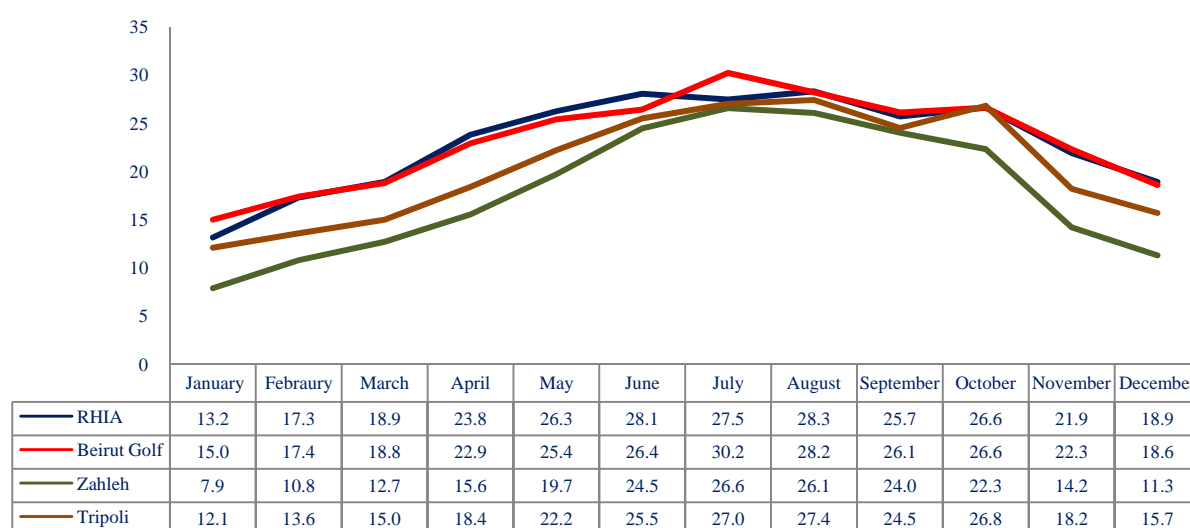
January is in general the coldest month, while July and August are the warmest months. Coastal zones (Beirut and Tripoli) are more humid than internal zones (Bekaa).

Table 2.4 – Maximum and minimum temperature. Degrees Celsius in 2009

Temperature (°C)	Coastal Zones			Bekaa valley
	RHIA	Beirut Golf	Tripoli	Zahleh
Mean temperature	23.0	23.2	20.5	18.0
General average: 19.5–21.5				
Minimum temperature	5.0 (January)	7.0 (January)	2.9 (January)	-3.3 (January)
General average: January 7				
Maximum temperature	37.1 (May)	37.3 (July)	37.7 (October)	38.0 (August)
General average: July-August 33				

Source: Table made by CAS based on General Directorate of Civil Aviation, Climatology Service data (2009)

Graph 2.1 –Mean temperature. °C in 2009



Graph made by CAS based on General Directorate of Civil Aviation, Climatology Service data (2009)

Rainfall

The average annual rainfall on the coastal zones varies between 700 and 1000 mm and increases towards the North-South direction.

Mount-Lebanon forms a barrier against the rain movement and the precipitations can reach more than 1400 mm per annum (the majority of which is snow). Rainfall decreases rapidly in the eastern slope of Mount-Lebanon and registers only 600 mm.

Rainfall in the Bekaa valley varies between 800 mm (southern Bekaa) and 200 mm (extreme north-east of the valley). As for the Anti-Lebanon, rainfall is around 600 mm and increases up to more than 1000 mm in Jabal el Cheikh.

The global amount of precipitations is estimated at 8 600 millions of m³ (MCM) per annum, to which it should be added the amount of snow, which is around 2 200 MCM.

The long term meteorological observations carried out for Beirut and Central Bekaa highlight the following characteristics:

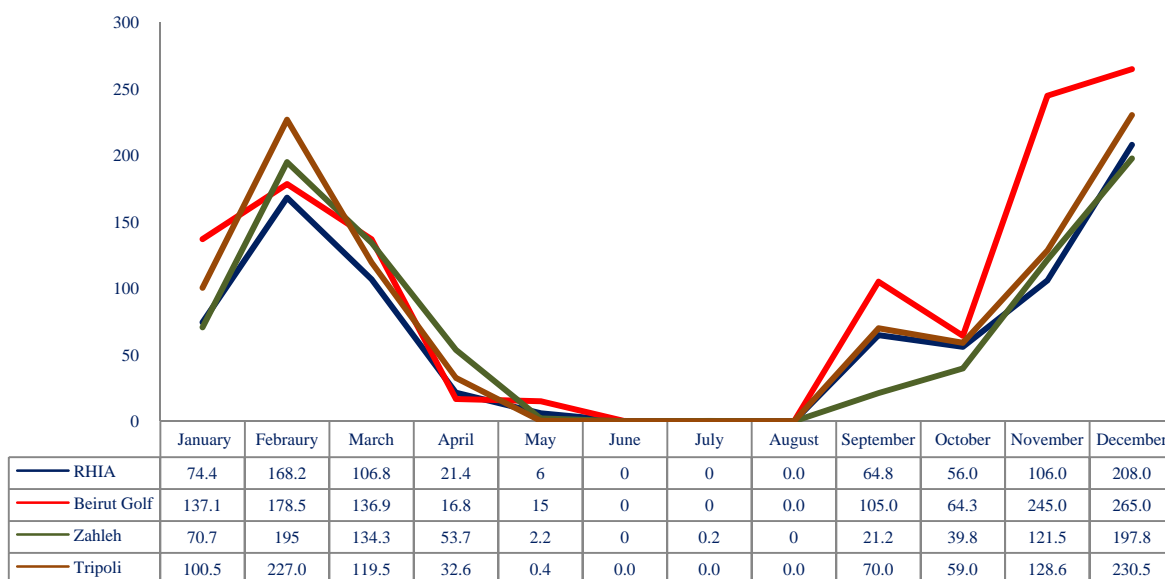
- Lebanon has a high average in rainfall per annum (Beirut, 893 mm).
- Great seasonal variations with 80-90% of the annual rainfall occurring between November and March, and less than 5% between May and September.
- Strong rain showers that can cause floods and erosion.
- Precipitations occur during 80 to 90 days per year, between the months of October and April.

Table 2.5 –Maximum and minimum rainfall. Mm in 2009

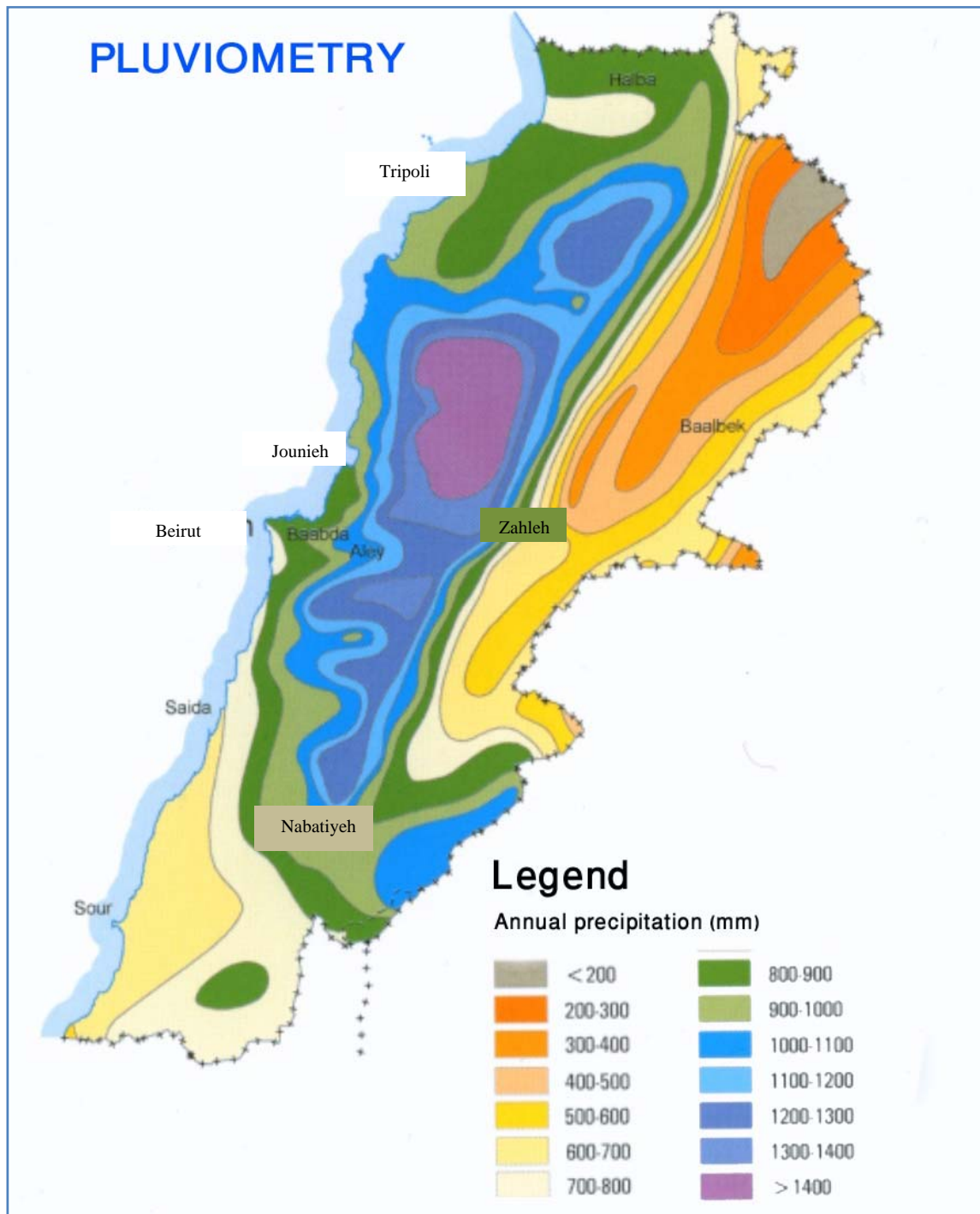
Rainfall. Mm	Coastal Zones			Bekaa valley
	RHIA	Beirut Golf	Tripoli	Zahleh
Total precipitation	811.6	1163.6	968.1	836.4
	General average: 700 – 1 000 mm			200–800 mm
Minimum precipitation	0	0	0	0
	(June-August)	(June-August)	(June-August)	(June, August)
Maximum precipitation	208.0	265.0	230.5	197.8
	(December)	(December)	(December)	(December)

Table made by CAS based on General Directorate of Civil Aviation, Climatology Service data (2009)

Graph 2.2 –Rain. Mm in 2009



Graph made by CAS based on General Directorate of Civil Aviation, Climatology Service data (2009)



Source: CDR (2004)

Relative humidity
Table 2.6 – Realtive humidity. % in 2009

Relative humidity. %	Coastal Zones			Bekaa valley
	RHIA	Beirut Golf	Tripoli	Zahleh
Mean relative humidity	55.0	56.7	59.7	54.1
Minimum relative humidity		0 (December)	15 (October)	6 (August)
Maximum relative humidity		96 (April-June)	95 (December)	99 (January)

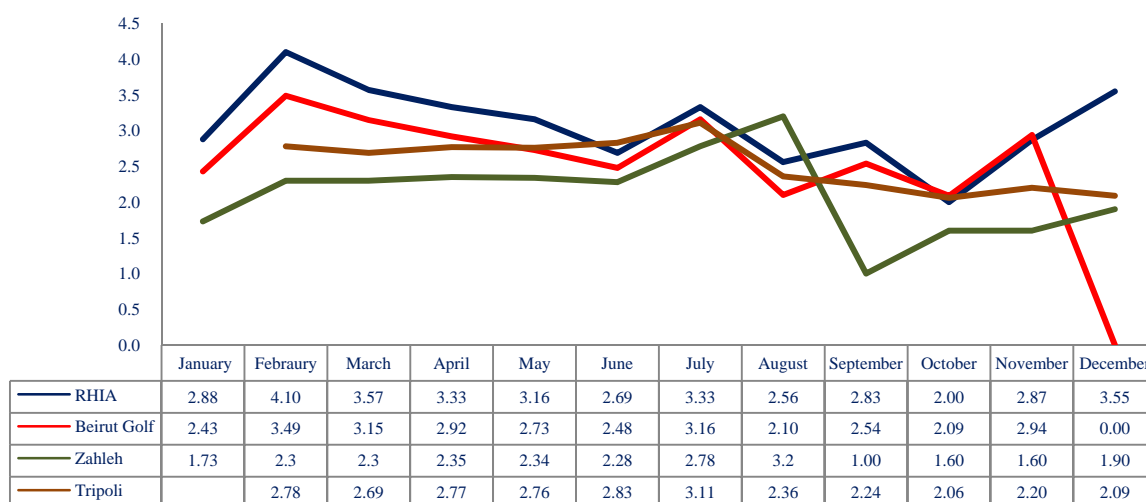
Table made by CAS based on General Directorate of Civil Aviation, Climatology Service data (2009)

Wind power
Table 2.7 – Wind mean power. M/s in 2009

Wind power. M/second	Coastal Zones			Bekaa valley
	RHIA	Beirut Golf	Tripoli	Zahleh
Wind mean power	3.1	2.5	2.54	2.9
	22	24.1	29	22
Maximum wind power	(February, April, November)	(March)	(November)	(February)

Table made by CAS based on General Directorate of Civil Aviation, Climatology Service data (2009)

Graph 2.3 –Wind mean power. M/s in 2009



Graph made by CAS based on General Directorate of Civil Aviation, Climatology Service data (2009)

Wind direction
Table 2.8 – Maximum wind. Degrees in 2009

Wind direction. Degrees	Coastal Zones			Bekaa valley
	RHIA	Beirut Golf	Tripoli	Zahleh
Average maximum wind direction	208.9	234.0	308.3	249.2
Maximum wind direction	240 (March)	270 (February-March)	360 (July)	320 (July)

Source: Table made by CAS based on General Directorate of Civil Aviation, Climatology Service data (2009)

Rainy days in 2009
Table 2.9 – Rainy days. Number in 2009

Rainy days	Coastal Zones			Bekaa valley
	RHIA	Beirut Golf	Tripoli	Zahleh
Number	81	88	85	91
Minimum number	0	0	0	0
	(June-August)	(June-August)	(June-August)	(June, August)
Maximum number	16	17	17	17
	(December)	(February)	(February)	(February)

Table made by CAS based on General Directorate of Civil Aviation, Climatology Service data (2009)

Hydrology

Lebanon has 40 rivers and water courses, originating from the Mount-Lebanon mountain range. These are internal short rivers with an East-West lateral orientation spilling into the Mediterranean, except for the two trans-border rivers which are the Orontes River (Nahr el Aassi) crossing towards Syria and the Hasbani River crossing towards Palestine.

The rivers and water basins maintain the Lebanese ecosystem and irrigate low and middle elevation areas of Mount Lebanon, as well as in the Bekaa valley. Besides, rivers enhance the flora and fauna of the country, particularly in deep valleys where local climate is softer.

Table 2.10 – Lebanese river system

North-Lebanon	
Nahr el-Kebir	Nahr Estouane
Nahr Aarqa	Nahr el Bared
Nahr Abou Ali	Nahr el Jaouz
Mount-Lebanon	
Nahr Ibrahim	Nahr el Kalb
Nahr Damour	
Beirut	
Nahr Beirut	
South-Lebanon	
Nahr Saïniq	Nahr Awali
Nahr Abou Asswad	Nahr el Zahrani
Nahr el Hasbani	
South-Lebanon – Bekaa	

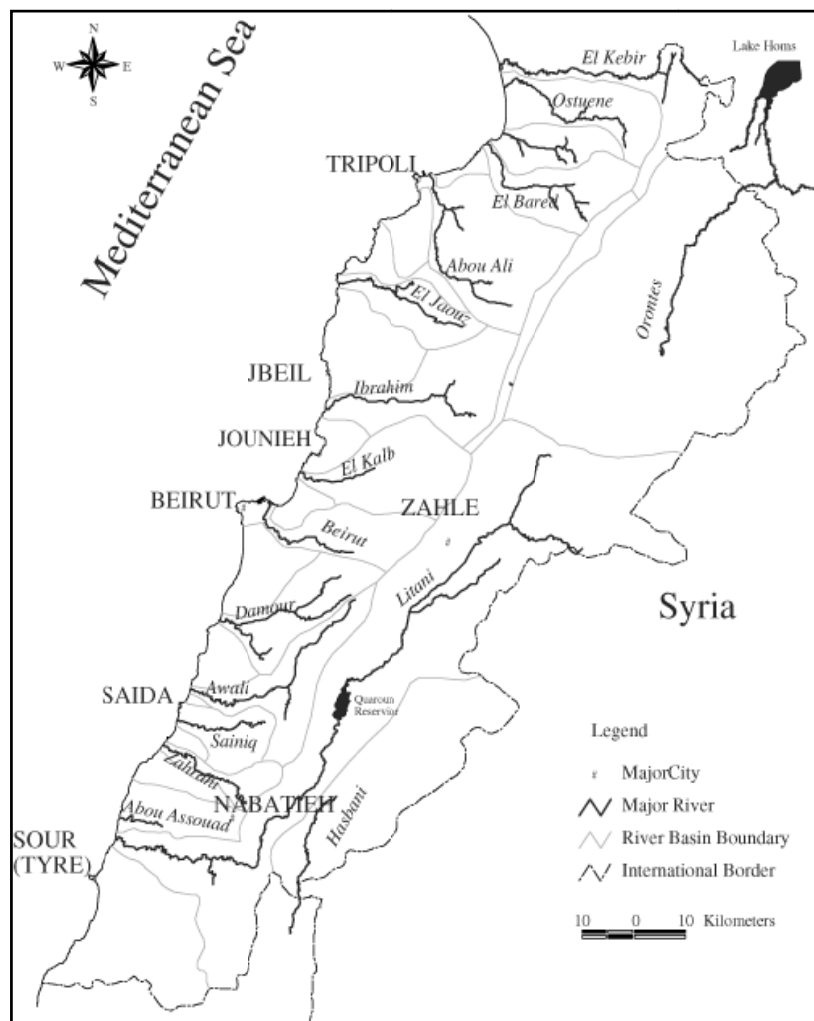


Table 2.11 – Hydrological cycle of Lebanon. Flow in 2009

Designation	Flow. MCM/year
Total annual precipitation	8,600
Natural evapotranspiration	4,500
Loss in surface waters to neighboring countries	648
Loss in underground water to neighboring countries	300
Sub-marine sources	385
Total renewable water in Lebanon	2,767
Surface water	2,200
Ground water	567

Sources: Comair, F. (2005), Lebanon water between loss and investment, Beirut, First Edition, Dakkash printing Est., p. 36 and Comair F. (2008), GESTION INTEGREE DES RESSOURCES EN EAU AU LIBAN, EFFICIENCE D'UTILISATION DE L'EAU, REUNION D'EXPERTS, PNUE et Plan Bleu, 5 Novembre 2008

Water sector in Lebanon

Water sector reform began in 1999 to implement the Integrated Water Resources Management which has four standard pillars: decentralization of water service; pricing incentive; Public-Private Partnership in water management; and finally, introducing a regulator.

Concretely, the Ministry of Energy and Water sketched a 10 years plan aiming to build 30 dams and hill lakes to increase available water quantity.

This 10 years plan will try to meet the needs of water in Lebanon with the available quantities:

- Total needs of water are 1,660 MCM.
- Expected stocking volume will be 806 MCM.
- Water shortage will be reduced to 854 MCM.

Laws 221/2000, 241/2000 and 337/2001 reduced the numbers of the 22 Autonomous Water Boards and the 210 Water Committees into 4 Water Authorities (Beirut and Mount-Lebanon, North-Lebanon, South-Lebanon and Bekaa) in charge of the production and distribution of drinking water and irrigation water, each in its geographic parameter.

To improve the sector performance, a specialized regulator was theoretically created: the Board of Performance Evaluation under the guardianship of the Ministries of Energy and Water.

The Office National du Litani created by the law published on 14/08/1954 manages and exploits irrigation water in its geographic parameter (South Bekaa and South Lebanon).

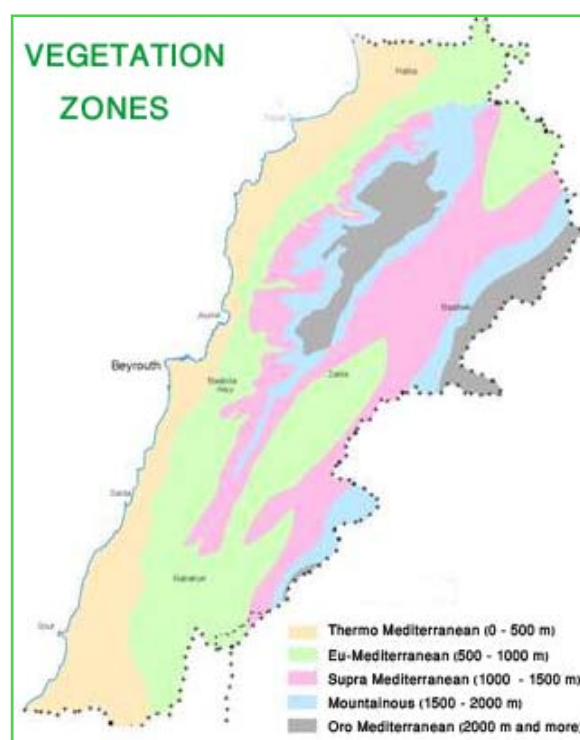
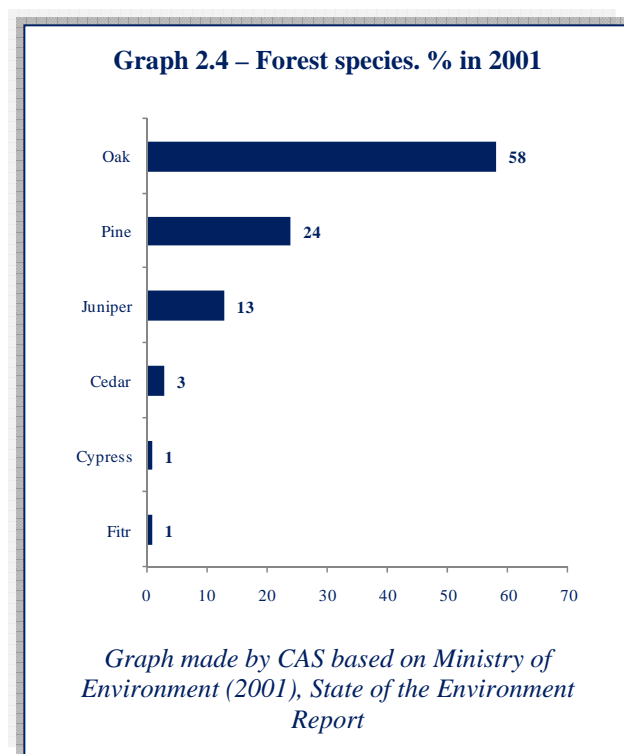
Vegetation zones of Lebanon

Vegetation zones display vegetation cover and protected vegetal areas.

Vegetation cover

Climate influences the vegetation cover in Lebanon. There are four major botanical levels, between the coastline, the mountain then the hinterland:

- Thermo-Mediterranean level (0-1,000 m): pines (Beirut and western slope of Mount-Lebanon), carob trees, storax, oak trees, willows (the slopes of Niha, Baruk Mountains, coastal zones, and the piedmonts of Mount Hermon in the hinterland).
- Supra-Mediterranean level (1,000-1,500 m): cypress, oak trees (Ehden, Sir ed-Dinniyeh, highlands of Qadisha, piedmonts of mount Mekmel, and Aakkar).
- Mediterranean mountainous level (1,500-2,000 m): cedars, fir trees (Bsharreh, Ehden, Qadisha, Hadath ej-Jebbeh, Tannourine, and Baruk).
- Oro-Mediterranean level (2,000 m -): no fruit trees, only thorn plants such as juniper (Talaat Moussa on the high altitudes of Anti-Lebanon, etc.).



Forest area is 13.1% of Lebanon area. Coniferous and deciduous forests cover 134,372 ha and other forested areas including woodlands with or without trees cover 120,574 ha [Ministry of Agriculture (2005), Atlas of Forests in Lebanon].

Protected vegetal areas

The continuous reduction of green cover in Lebanon has pushed the Government to edict a more strict Legislation, declaring forests of cedar, fir, cypress and juniper *de facto* protected.

Table 2.12 – List of protected forests in Lebanon

Forests protected by ministerial decisions as per the Code of Forest							
Decision	Date	Location	Description				
			Cedar	Fir	Juniper	Cypress	Other
499/1	14/10/96	Tannourine/Hadath ej Jebbeh, Jaj & Bcharreh	X				
587/1	30/12/96	Swayse (Hermel)	X	X	X	X	
588/1	30/12/96	Aamouah (Aakkar)	X	X	X	X	Pine
589/1	30/12/96	Karm Shbat (Aakkar)	X	X	X		
591/1	30/12/96	Bazbina (Aakkar)	X	X	X	X	
592/1	30/12/96	Knat (Knat)	X	X	X		Oak
10/1	17/1/97	Qaryet Sfina (Aakkar)	X				Oak
11/1	17/1/97	Merbine (Wadi Jhannam)	X	X	X		
8/1	17/1/97	Aïn el Houkaylat/Qornet el Kif (Dinniye)	X	X	X		Oak
9/1	17/1/97	Jurd Njas/Jabal el Arbain (Dinniye)	X	X	X	X	
174/1	25/3/97	Shebaa (Hbaline)	X	X	X	X	Pine
3/1	8/12/97	Bkassine (Jezzine)					Pine

Beside forest areas, Lebanon has protected areas since 1930. The current classification of Protected Areas in Lebanon consists of: 8 Nature Reserves, 24 natural sites, 5 himas, 12 protected forests, 14 touristic sites and other sites to be protected.

Forest fires in Lebanon

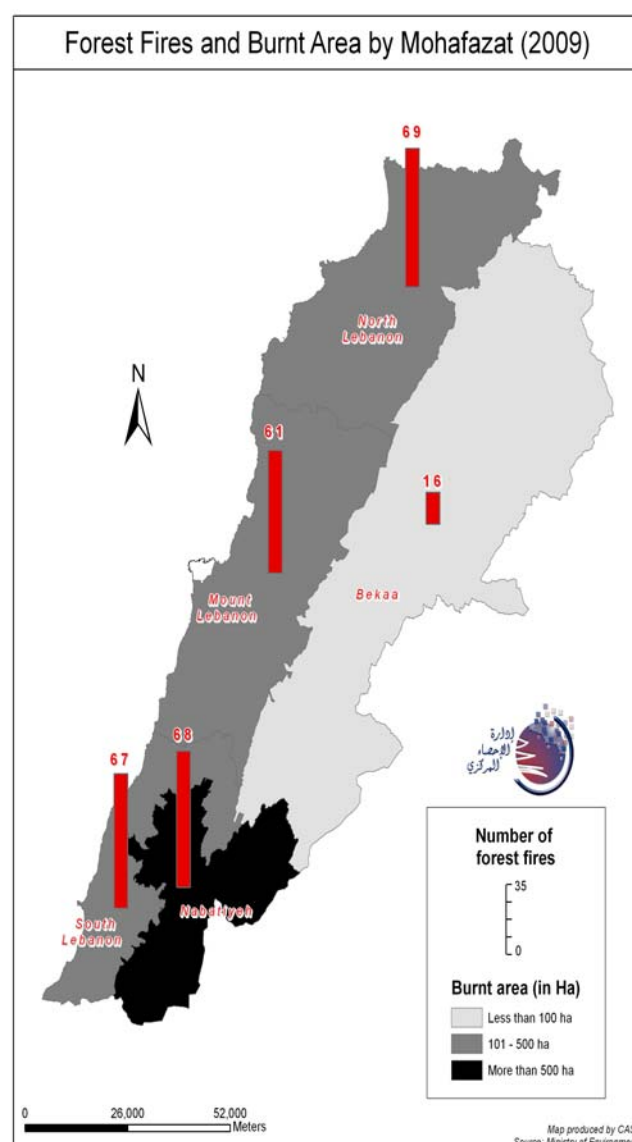
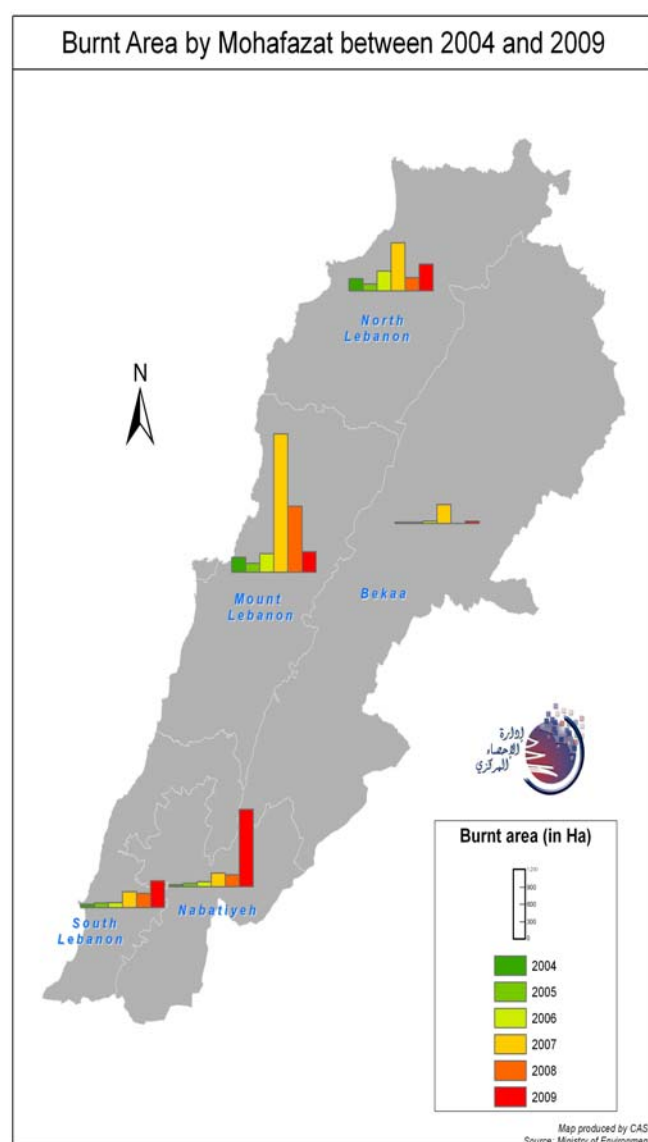
Forest fires in Lebanon increased since 2004 of 351.7% to reach 2643.91 ha in 2009. Total burnt area of Lebanon since 2004 is 10,386 ha, which is almost 104.4 square Km or 1% of total Lebanon area.

Table 2.13 –Burnt area by Mohafazat. Ha in 2009

Mohafazat	Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total. Ha
Nabatiyeh	0	0.0	0.0	0.0	10.5	517.2	485	173	11	131.7	0.0	0.0	1328.4
South Lebanon	40.5	0.0	0.0	0.1	2.9	32.8	38.6	215.1	34.4	97.7	0.0	0.0	462.1
North Lebanon	0.0	0.0	0.0	0.0	2.4	118.8	231.8	40.1	36	30.5	0.0	0.0	459.6
Mount-Lebanon	0.0	0.02	0.0	0.0	0.0	38.4	228.5	15.1	28.3	38	1.5	0.0	349.8
Bekaa	0.0	0.0	0.0	0.0	0.0	3.1	7.0	17.0	2.0	15.0	0.0	0.0	44.1
Lebanon	40.5	0.02	0.0	0.1	15.8	710.4	990.8	460.2	111.7	312.9	1.5	0.0	2643.9

Source: Ministry of Environment (2009)

Nabatiyeh (50.2%) registered the maximum of burnt hectares. South-Lebanon is second (17.5%).



Waste and quarries

In 2009, produced municipal waste increased of 19.4% to reach 1.72 million tonnes/year:

- Peak Mohafazat: Mount-Lebanon (42.6%).
- Trough Mohafazat: Nabatiyeh (6.4%).
- Landfill: 78.0% of waste.

There are 35 stone and sand quarries in Lebanon in 2009

- Peak Mohafazat: North-Lebanon (40.0%).
- Second Mohafazat: Bekaa (25.7%).

Managing the environment in Lebanon

The total number of environmental NGOs in Lebanon increased of 468% since 2000 to reach 551 in 2009.

The number of environmental complaints increased of 24% since 2000 to reach 245 in 2009.

Agricultural lands constitute 32.5% of total lands in 2009. They are followed by grassland (31.0%) and by wooded land (13.3%).

