CHAPTER 2 – ENVIRONMENT

Lebanon enjoys four seasons given the following factors: geological climate, morphology, geology, and climatology which offer it several advantages and exposing it to natural risks.

The advantages are numerous: biodiversity, agriculture, hydraulic resources, etc. The variety of its natural conditions enriches its ecosystems, thus, enjoying the existence of a variety of plant and animal species. Natural risks are lesser but are very dangerous: land slides, floods and torrential rains, desertification especially in the North-East, land hydro erosion, forest fires, earthquakes, and tides (CAS & al., 2006).

1 Environment degradation

The environment suffers from the fatal consequences of human intervention such as uncontrolled well digging and proliferation of crushing plants, air and water pollution and wastes, etc. Due to this bad situation, the Ministry of Environment was created in 1993. The average cost of environment degradation was estimated in 2000, to 565 millions USD which are generally distributed between water (31.0%) and air (30.0%).

Table number 8 – Average cost of environment degradation in 2000

Category	Millions USD	Percentage
Water	175	31.0
Air	170	30.1
Land and wild life	100	17.7
Coastal zones and cultural heritage	110	19.5
Wastes	10	1.8
Total	**565**	**100.0**

Source: Sarraf & al.(2004)

This environment suffered also in 2006 from the extremely dangerous consequences of the the 33 days Israeli aggression in July-August 2006.

2 Morphology and Climatology

Lebanon topography in not plain because of its mountainous areas varying vary between 400 m and 3 088 m in height; which means that Lebanon enjoys a geographical and environmental diversity and suffers at the same time from a congestion of its medium high zones because of the difficulty to live above the height of 1 500 m. Two mountain chains parallel to the coast – Lebanon and Anti-Lebanon – separated by the Bekaa plain provide Lebanon with its climate, water, landscapes, and rich biodiversity. The four successive geographic units form West to East are:

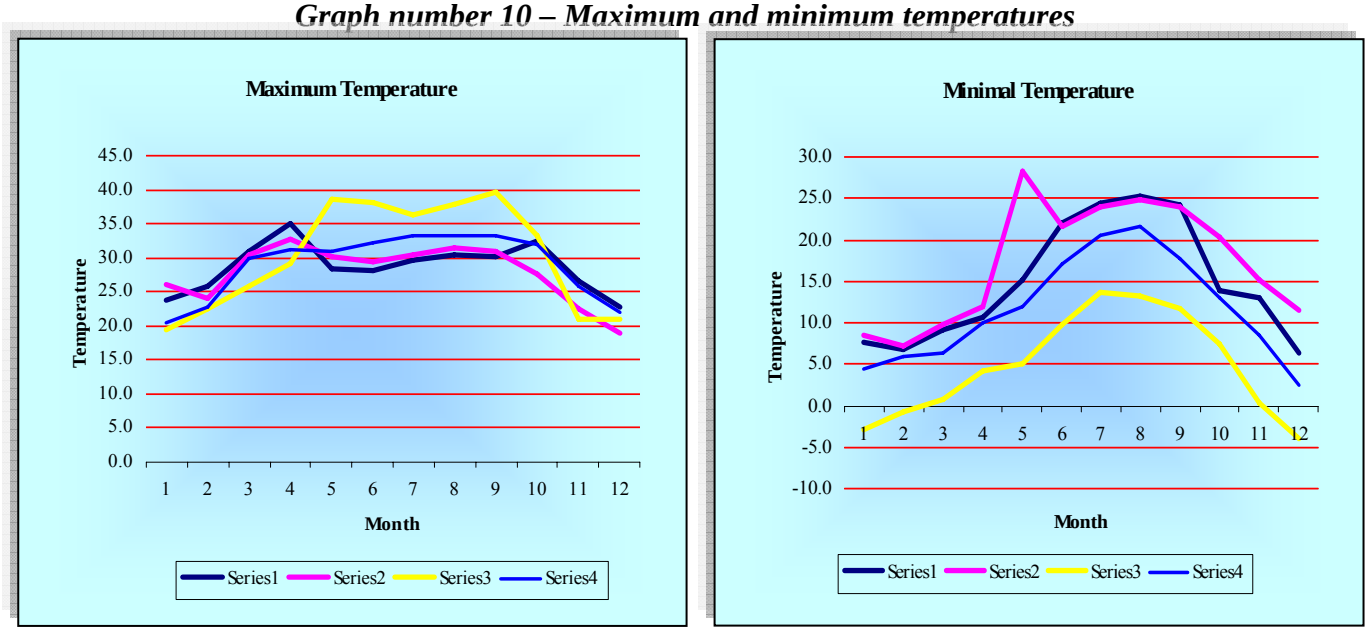
- the narrowest plain of 3 m wide that goes along the shore is when the mountains come close to the sea. The coastal plain is larger in the north near the Syrian frontier;
- the continuous Mount-Lebanon chain from north to south, is a calcareous mountain mass culminating at 3 083 m at Qornet es-Saouda. Deep crams interrupt the peaks made of high plateaus ;
- the interior plain of Bekaa is a syncline. This agricultural region has an elevation of 1 000 m, draws a corridor of width varying between 5 to 20 Km;
- Anti-Lebanon chain is less high; at its south-east, rises the Mount-Hermon rising to 2 814 m above southern Bekaa.

A river system goes along Lebanon and Anti-Lebanon (CDR, 2004 and SEMIDE, 2005).
Lebanon morphology influences its Mediterranean climate which has two prominent seasons. Prevailing in the West a Mediterranean climate with a moderate rainy winter and a dry and hot summer; autumn and spring are too short. Prevails at the East a hot and dry climate of the Arab peninsula. Nevertheless, snow is too scarce on the coast; but it covers during winter Lebanon and Anti-Lebanon mountain chains. Therefore, snow is a main source of Lebanese water wealth.

2.1 Temperature

In general, in January, February and December, the temperature is very low; while it is very high in July and August.

Graph number 10 – Maximum and minimum temperatures



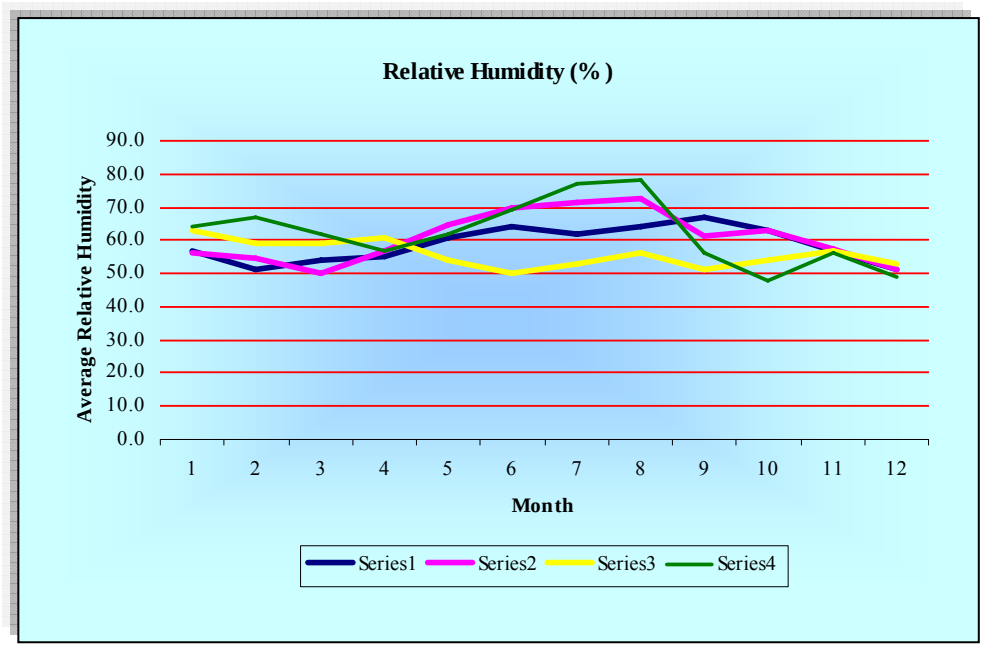
Series 1: Rafic Hariri International Airport
Series 2: Beirut – Golf
Series 3: Zahleh
Series 4: Tripoli

- In the coastal zone:
  - In Beirut:
    - According to Rafic Hariri International Airport: the minimum temperature (6.3 degrees) is registered in December and the highest temperature is registered exceptionally in April (35.1 degrees) and then in October (32.5 degrees);
    - According to Beirut-Golf: the minimum temperature is registered in February (7.1) degrees and the maximum temperature is registered exceptionally in April (32.7 degrees) followed by August (3.1.5 degrees);
    - According to Tripoli (North Lebanon): the minimum temperature (2.4 degrees) is registered in December and the maximum temperature is registered in July (33.3 degrees);
- In the mainland zone:
  - Zahleh (Bekaa): the minimum temperature (-4.0 degrees) is registered in December and the highest temperature is registered in September (39.7 degrees).

2.2 Humidity

High humidity characterizes the country climate. Its monthly averages vary between 48.0% (October) and 78.0% (August) in the coastal zone because of the sea influence.

Graph number 11 –Average relative humidity



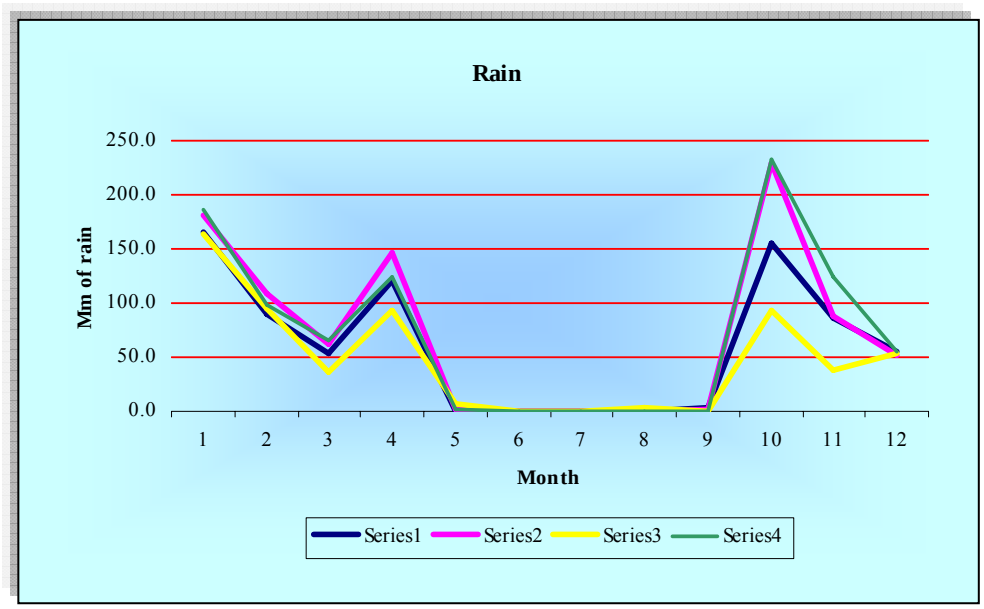
Series 1: Rafic Hariri International Airport *Series 2: Beirut – Golf*
Series 3: Zahleh *Series 4: Tripoli*

- In the coastal zone:
  - In Beirut:
    - According to Rafic Hariri International Airport: the average relative minimum humidity (51.0%) is registered in February and in December and the average relative maximum humidity (67.0%) is registered in September;
    - According to Beirut-Golf: the average relative minimum humidity (50.0%) is registered in March and December and the average relative maximum humidity (72.5%) is registered in August;
    - According to Tripoli (North Lebanon): the average relative minimum humidity (48.0%) is registered in October and the average relative maximum humidity (78.0%) is registered in August (the pic in Lebanon for the year 2006);
- In the mainland zone:
  - Zahleh (Bekaa): the average relative minimum humidity (50.0%) is registered in June and December and the average relative maximum humidity (63.0%) is registered in January. The humidity in Zahleh is not high since it is located in the mainland far from the sea.

2.3 Rain

Climates difference, temperature, relative humidity, wind speed and number id sunny days influence the evapotranspiration in Lebanon which varies between 1 300 mm and 1 400 mm per year (SEMIDE, 2005). Moreover, rain total annual general quantity varied in 2006 between 583.6 mm and 888.7 mm.

Graph number 12 – Rain



Series 1: Rafic Hariri International Airport *Series 2: Beirut – Golf*
Series 3: Zahleh *Series 4: Tripoli*

- In the coastal zone:
  - In Beirut:
    - According to Rafic Hariri International Airport: the total rain quantity is equal to 713.8 mm. January registered the highest rain quantity (166.0 mm);
    - According to Beirut-Golfe : the total rain quantity is equal to 870.1 mm. October registered the highest rain quantity (228.9 mm);
  - According to Tripoli (North Lebanon): the total rain quantity is equal to 888.7 mm (the highest in Lebanon). October registered the highest rain quantity (233.4 mm) ;
- In the mainland:
  - Zahleh (Bekaa): the total rain quantity is equal to 583.6 mm (the lowest in Lebanon). January registered the highest rain quantity (164.4 mm) (General Directorate of Civil Aviation, Climate Department, 2006).

3 Water and sea bottom

Water is becoming scarcer in Lebanon because of its ill management and because of the quick deforestation caused by crushing plants and fires. In the absence of a solution, UNESCO considers that Lebanon will suffer from dryness by the 2050. Actually, rivers are polluted because of the unorganized dumping of liquid and solid waste. The precise state of groundwater is unknown because of the karstic soil of Lebanon; which facilitates the infiltration of untreated used water and liquid waste.

3.1 Water balance

Mediterranean climate gives Lebanon its rain and snow. Its groundwater is permanent, nourishes its rivers and rises to the surface or flows into the sea due to karst. Most of its waters are lost by evapotranspiration, sub ground infiltration and outflow to the sea. The water balance displays a general overview over resources and uses of water in order to optimize its management and exploitation. Unfortunately war destroyed 75% of the 80 measuring stations founded during the 1960s. Hence, water monographs of elementary basins were reduced and the water balance is not

precise. Nowadays, 41 measuring stations, affiliated to the Water Resources Service which depends of the Litani National Office, measure the hydrometric network. Lebanon enjoys 2000 springs, 40 rivers of which 17 are permanent and 23 are seasonal. The total length of rivers is equal to 730 Km. Surface and groundwater quantity is equal to 2.6 billions m^3, whereas 2 billions are effectively exploitable (SEMIDE, 2005).

3.2 Water exploitation

Lebanon exploits an annual average of 1 billion m^3 of water through the Water and Used Water Establishments and 250 millions m^3 through private drillings. Annual water demand is distributed over domestic consumption (195-405 millions m^3), irrigation (670-875 millions m^3), and industry (35-65 millions de m^3) (CDR, 2004).

However, 75.6% of the population are connected to the public water network, but only 60% of the population have access to tap water (CAS and Al., 2006); whereas, the percentage of irrigated water is equal to 30.9% (MEW and al., 2004).

3.3 Water quality

Water quality in Lebanon is questionable. Groundwater suffers from the pollutants infiltration (wastewater, industrial waste, decomposing solid waste, etc.), demographic growth, uncontrolled multiple drillings (33 410 individual wells (CAS, 2004) and the absence of water treatment in the zones of water vulnerability. Hence, surface waters are polluted. The lack of an efficient measure network gives an incomplete observation of water chemical composition. Consequently, the following quantities are unknown:

- the dissolved oxygen – necessary to fauna and flora diversity, oxygen saturation, oxygen biochemical demand (OBD)and the oxygen chemical demand (OCD) for organic pollution;
- the nitrate and phosphorus for the fertilizers pollution;
- the metals concentration for industrial pollution.

Table number 9 – Some rivers water quality

Item	Unit	Litani	Oronte	Awali	Damour	Beirut
Acidity	pH	8.21	8.01	7.95	8.2	7.74
OBD (20°C, 5d)	mg O_2/l	71	42	0.6	10	47
OCD ($K_2Cr_2O_7$)	mg O_2/l	6 151	12 898	68.96	19.6	117.6
Dissolved substances	mg/l	207	220	334	266	309
Nitrogen	mg N/l	1.4	0.7	0.28	4.2	7.17
Phosphorus	mg P/l	1.35	1.77	2.74	0.258	3.87
Copper	mg Cu/l	- 0.005	440	- 0.005		- 0.005

Ministry of Environment (1996)

According to the observation of these 5 samples, the oxygen demand is very high in Damour, Awali, Beirut, Oronte and Litani rivers. However, the nitrogen demand is important in Damour and Awali rivers. By the way, Awali river requests phosphorus on the contrary to Beirut and Litani rivers.

3.4 Coastal zone

The characteristics of the Lebanese coastline are physical (beach, fjord, estuary, etc.), ecological, and human (presence of big and dense agglomerations). Polluted surface and groundwater go directly to the sea without treatment and thus they pollute the sea bottom. The total of collected domestic used water was equal to 683 000 m^3/day (MedPol and Ministry of Environment, 2003).

River pollution can be measured by the pollutant charge which is expressed by the quantity of pollutants by day or by year.

Table number 10 – Nautical pollution marine coming from rivers

Polluting load				
River flow	Unit	Litani	El-Kelb	Awali
OBD	1 000 Kg O_2/day	6 222	18	69.76
Total nitrogen	1 000 Kg N/ day	1.4	3.5	0.023
Total Phosphorus	1 000 Kg P/ day	1.35	0.45	2.74
Total Cadmium	1 000 Kg year			0.02
Total Copper	1 000 Kg year	< 0.005		< 0.005
Total Mercury	1 000 Kg year	600		100
Total Zinc	1 000 Kg year	< 0.004		< 0.004

Ministry of Environment (1996)

OBD is relatively high in Awali, Litani, and al-Kalb rivers. The phosphorus rate is very low in Awali river but is very high in Litani river. The nitrogen is almost absent in Awali and Litani rivers but is very high in Litani river; which means that there is disequilibrium in the constituents quantity of the river waters.

4 Air and air pollution

Industrial, transportation means and heating equipment emissions reduce oxygen quality and harm ecosystems. Intra and extra muros air pollution causes bronchitis, respiratory disorders, cancer, etc. and kills 350 people by year in Beirut and Tripoli. Air pollution components are lead, sulphide, oxidized nitrogen particles, etc. (Sarraf and al., 2004).

4.1 Transmissions

The combustion of fossil energy and of certain industrial productions are the main sources of carbon dioxide (CO_2). The main pollutants are oxidize suffers (SO_2), carbon dioxyd (CO_2), methane (CH_4), oxidized nitrogen (NOX), carbon monoxide (CO) and the volatile organic component (non methane or NMVOC) (Ministry of Environment, 2001).

Table number 11 – Air pollutants transmissions

(1000 tonnes)	SO_2	CO_2	CH_4	NOx	CO	NMVOC
Mobile sources	*2.6786*	*3 957.1239*	*1.221*	*34.8786*	*447.2197*	*83,8787*
Of which land transport	2.6767	3 949.3890	1.1220	34.8240	447.1930	83.8708
Of which other mobile sources	0.0019	7.7349	0.0001	0.0528	0.0267	0.0079
Fixed sources	*80.30666*	*9 645.6330*	*1.8626*	*19.2302*	*26.4925*	*277.3524*
Of which several power stations	45.0210	3 615.0540	0.1418	9.4584	0.7093	0.2364
Of which fuel industrial burnings	24.6670	2 774.0900	0.155	7.6684	1.0862	0.2559
Of which industrial processes	3.3820	1 924.0630		0.0111	0.0003	273.8900
Of which other fixed sources	7.2366	1 332.4260	1.6053	2.0923	24.6967	2.9701
Total of transmissions resulting from human activities	***82.98526***	***13 602.7569***	***2.9847***	***54.1070***	***473.4122***	***361.2311***

Ministry of Environment (1996)

4.2 Air pollution

The air receives the pollutants incoming from industries and engine vehicles; so the preservation and the restoration of its quality are a must.

Table number 12 – Air pollutants concentration

Pollutant	Beirut	Chekka
SO_2		0.45-0.7 µg
Hanging particles	200 µg	67-316 µg
NOx	1 000 µg	6.4-10.11 ppm
CO	30 µg	0.33 ppm
Lead	14 µg	

Ministry of Environment (1996)

The air quality in the cities is measured in terms of pollutants concentration, which requires an efficient measure network. The dry climate characterizing Lebanon in summer is the result of high levels of dust in the air.

Hanging particles rate differs of 166 micrograms between Beirut and Chekka. The concentration of produced anthropic transmissions are very high because of the movement of vehicles on dusty roads and because of the projects of construction which contribute with other activities to generate dispersed particles in the air in Beirut; the presence of Chekka National Cement Manufactory increases these particles in North Lebanon.

Nitrogen oxide is equal 1 000 micrograms in Beirut but it varies between 6.4 and 10.11 ppm at Chekka. Carbon monoxide is very high because if the vehicle movement density in Beirut. 14 micrograms of lead are measured in Beirut (Ministry of Environment, 2001 and CDR, 2004). The Ministry of Environment reduced these toxic transmissions and the total of methyl/brome, a substance degrading the ozone quality, is stabilized to 483.4 tons yearly (Ozone Office, 2004).

5 Waste

There are three types of waste: solid, liquid and hazardous. Solid waste consists of household and municipal waste, etc. Liquid waste takes the shape of waste water, oils, etc. As for hazardous waste, they come from hospitals and industrial, and nuclear activities. The waste annual production by inhabitant was equal to 336 Kg in 2001, a growing quantity; it growth rate was equal to 30% during the 1994-2001 period with an annual average rhythm was equal to 4%. The experience of industrialised countries shows that this growth is not an infinite one (CDR, 2004).

Table number 13 – Municipal waste composition

Composition in 1998	**%**
Paper, cardboard	17
Textiles	3
Plastic	10
Glass	9
Metal	3
Food, garden and similar material waste	51
Other waste	7
Total percentage	***100***

Sources: Ministry of Environment (2001) and CDR (2004)

As for the treatment, elimination and movements of municipal waste, they were of four types in 2001 which are: mechanical sorting, recycling, compost, and discharging.

Table number 14 – Municipal waste treatment, elimination and movement in 2001

Operation	Tons
Mechanical sorting	676 399
Total operations of treatment and reprocessing	158 081
Recycling	48 216
Compost	109 856
Final elimination – discharging	599 596

Sources : Ministry of the Environment (2001) and CDR (2004)

Beirut releases the highest quality of solid waste per inhabitant (1.1 Kg/inhabitant/day in 2001). North Lebanon is in the first place regarding the daily tons of solid waste (1 526) and of thousands of daily cubic meters of wastewater (257).

Table number 15 – Estimation of solid and liquid waste generated by Mohafaza in 2001

Mohafaza	Solid waste rate (Kg/inhabitant/day)	Solid waste (Tons/day)	Waste water (1 000 m^3/day)
Beirut	1.1	473	68.8
Mount-Lebanon	0.95	1 526	257.0
North Lebanon	0.85	731	137.6
Bekaa	0.85	488	92.0
South Lebanon	0.95	473	80.5
Nabatiyeh	0.85	249	47.0
Total	**0.92**	**3 940**	**683**

Source : Ministry of Environment (2001)