REPUBLIC OF LEBANON
MINISTRY OF ENVIRONMENT

Climate Change

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Project Manager

REPUBLIC OF LEBANON
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Introduction

Project Background

In June 1992, in Rio de Janeiro, Brazil, Lebanon was among the 155 countries which signed a Framework Convention on Climate Change with the ultimate objective of achieving "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system", as describe in Article 2 of the convention.

Lebanon ratified the convention on December 15, 1994 and thus became a party to the convention, a Non Annex I party, i.e. a developing country as specified by the convention.

In accordance with decision 10 made in the second conference of the parties held in Geneva in July 1996, Lebanon is hereby presenting its first national communication under the United Nations Convention on Climate Change.

The National Communication has been developed by national team of experts working under the Climate change Enabling Activity, a project funded by UNDP/GEF implemented at the Ministry of Environment and aiming at building capacity in Lebanon to respond to the convention's obligations.

This present communication mainly contains a Greenhouse gas inventory developed according to the revised 1996 IPCC guidelines as decided upon in the COP 2.

The National Communication is accompanied by a technical annex comprising:

- A national greenhouse gas mitigation strategy.
- An assessment of Lebanon's vulnerability to climate change.

National Circumstances

LEBANON'S GEOGRAPHY[1]

Located on the eastern shore of the Mediterranean Sea between the North Latitudes 33° 03' 38" and 34° 41' 35" and East Longitude 35° 06' 22" and 36° 37' 22", Lebanon covers an area of 10,425 km^2, with an average width of 48 km and average length of 220 km.
In spite of its limited area, the Lebanese territory is dominated by two mountain ranges that run parallel to the sea (NNE-SSW) as well as to each other. The western range (Mount Lebanon) overlooks the narrow coastal plain and is separated from the eastern chain (the Anti-Lebanon) by the Bekaa Valley. This structure presents a variety of contrasting features, thus individualizing five major geomorphological regions with different ranges of altitude, slope and width.
The Coastal Zone including the shoreline, the coastal plain and the western chain foothills;
The Mount Lebanon middle and high elevation zones;
The Bekaa Plain (also called the Bekaa Valley);
The Anti-Lebanon (including Jabal Al-Sheikh, also called Mount Hermon);
The Southern Plateau (including Lebanese Upper Galilee and Jabal Amel).
Another component of the Lebanese physical environment is to be given a special attention: the river system. With the exception of the Litani and the Assi, the Lebanese rivers run perpendicular to the general direction of the above-mentioned mountains. Added to the steep relief and the local lithology, the result is the formation of deeply incised valleys with particular climate conditions and specific riverbank vegetation.

LEBANON'S CLIMATE

Characterized by a maximum rainfall during winter and an aestival period of drought, the Lebanese climate is classified as typically Mediterranean. It presents, however, some specific aspects resulting from the country's location and physiography. The general direction of the above-mentioned mountain ranges is perpendicular to the atmospheric circulation path from the core of the country. Added to the singular configuration of the relief, this results in the individualisation of six Bioclimatic levels: arid, semi-arid, sub-humid, humid, prehumid and oromediterranean, all the more remarkable by their variability over short distances.

LEBANON'S VEGETATION

Botanical and ecological approaches bring out the specificity of the Lebanese terrestrial ecosystems. The distribution of the Lebanese vegetation is characterized by: its general features (floristic ensembles), its geobotanical localization (vegetation levels), its floristic composition and its dynamics (series of vegetation). A special emphasis is to be laid on the territorial extensions of these subdivisions[2] . The Mediterranean Ensemble spreads all over

[1] [1] Abi-Saleh, B. & Safi, S. Liban-La rescherche phytoecologique: premiers resultats et perspectives. Ecologia Mediterranean, 1990, XVI: 365-370

[2] [2] Abi-Saleh, B. & Safi, S. Carte de la vegetation du Liban au 1/200 000 + Notice explicative. Ecologia Mediterranean, 1988, XVI (1/2): 123-142

the western part of Mount Lebanon, the eastern regions of the same chain to the south of the Beirut parallel, as well as the western face of the Hermon. On the other hand, the Presteppic Mediterranean Ensemble covers the eastern slopes of Mount Lebanon in its northern part, and the northern part of Anti-Lebanon. In terms of vegetation structure, the stage of evolution, the Lebanese terrestrial ecosystems are classified as forest, shrub land (garrigue) or grassland. The latest estimates of the Lebanese Ministry of Agriculture, concerning the distribution area of these ecosystems, give the following figures: 119,774 ha are occupied by forests (including woods) while 527,790 ha are stated as rangelands. These values represent, respectively, 11.46% and 50.5% of the total surface of the country.

POLITICAL REGIME OF LEBANON

Lebanon is a republic of democratic and parliamentary regime. The people form the source of authority and the power of sovereignty which are exercised through the state institutions. The Lebanese regime is organized on the basis of defined authority. Namely,
Separation of powers between the legislative, judicial and executive authorities
Coordination and cooperation between legislative and executive authorities, and
Accountability of the government before the parliament.
A brief summary on each of the legislative and executive authority is given below.

LEGISLATIVE AUTHORITY

Art. 16 of the Constitution enacts that legislative authority shall be vested in one sole corps comprising the House of Deputies. However, election of deputies, their number and legal terms are determined by an electoral law. Accordingly, the parliament consists of 128 deputies: that is 64 seats for Christians and 64 seats for Muslims. Seats in the parliament are further distributed geographically. Thus the Governate of Beirut has 19 seats, the Governate of the north 28 seats, Mount Lebanon 35 seats, Bekaa 23 seats and South Lebanon 23 seats.

EXECUTIVE AUTHORITY

The Executive Corps consists of the President of the Republic and the Council of Ministers.
President of the Republic: He is the Head of State symbolizing the unity of the nation. He is entrusted with such great tasks as seeing to the respect of the Constitution's enactment, the preservation of Lebanon's independence, its unity and the integrity of its territorial boundaries.
The Council of Ministers.
The cabinet consists of premier and Ministers and, constitutionally, religious denominations should be fairly represented in the formation of the cabinet. That is, it should be composed of an equal number of Christian Ministers and Moslem Ministers with due observance of the distribution of the main portfolios in a sort of equilibrium between the main sects.

ORGANIZATION OF PUBLIC DEPARTMENTS

At present, Lebanon enjoys the existence of 26 ministries. Namely, Ministries of Justice, Foreign Affairs, Interior, Finance, Public Works, National Defense, National Education,

Public Health, Economy and Trade, Agriculture, Posts and Telecommunications, Labor, Information, Hydraulic and Electric Resources, Tourism, Housing and Cooperatives, and Oils. As from 1993, the following ministries have been operation: Ministries of Emigrants, Displaced Citizens, Culture and Higher Education, Vocational and Technical Education, Transport and Traffic, Municipal and Rural Affairs, Social Affairs, Environment, Industry, and Ministry of State for Administrative Reforms.
The Ministry of Planning was deformed in 1977 and replaced by the Council of Development and Reconstruction (CDR) as a public institution enjoying the legal entity and financial and administrative autonomy. CDR is connected to the cabinet directly, and charged with the setup of plans for development and programs for reconstruction. Financing is ensured through internal and / or external funding.

INTERNAL ORGANIZATION OF MINISTRIES

The Minister is the Head of the Department who is supposed to ensure the application of laws and regulations and the preservation of the State's interest. Each ministry shall consist of one Directorate General or more, divisible into sections and services. The Director General is the direct supervisor of all the ministry's staff and he is supposed to administer the department with its various sections, divisions and services.
Public departments in Lebanon are subject to the control of various institutions like the Civil Service Board, Central Inspection Board, Disciplinary Board and the Cours de Comptabilite. This besides the overall control exercised by the Ministry of Finance in the course of controlling legality of financial transactions of all ministries and departments of State.

GREENHOUSE GAS INV ENTORY

I- INTRODUCTION

The structure of the present greenhouse gas inventory report follows the order established
-
which has identified six major economic sectors, as follows:

- Energy
- Industrial processes
- Solvent and other product use
- Agriculture
- Land use change and forestry
- Waste

These guidelines have considered the following greenhouse gases:

- CO_2: carbon dioxide
- CO: carbon monoxide
- No_x: nitrogen oxides
- N_2O: nitrous oxide
- SO_2: sulfur dioxide
- CH_4: Methane
- NMVOCs: non methane volatile organic compounds
- HFCs: Hydrofluorocarbons
- PFCs: Perfluorocarbons
- SF_6: sulfur hexafluoride

It should be noted that the protocol developed for the United Nations Framework Convention on Climate Change, in the Conference of Parties 3, held in Kyoto on December 10, 1997 has determined six greenhouse gases to be controlled, which are: CH_4, CO_2, N_2O, HFC, PFC, SF_6.

In this report, each section starts with an introduction presenting the state of each sector in Lebanon, followed by the methodology adopted in order to compute emissions of greenhouse gases by sources and removals by sinks, in accordance with IPCC guidelines. In addition, it is accompanied by exper
finallly by the IPCC Sectoral tables which present the results obtained in each sector.

This executive summary described in the IPCC summary tables 7A and 7B and table 8A, which shows the quality of estimates calculated, presents the main results obtained in each sector. In the last paragraph, the global warming potential of the greenhouse gases emitted

In order to provide a summary picture of all important results obtained by the National Inventory team, this executive summary hereby presents in table1:

- The emitted amount of each greenhouse gas by sector.
- The total emitted amount of all greenhouse gases in a sector.
- The total amount of each greenhouse gas in all sectors.
- The total quantity of greenhouse gases emitted in Lebanon, in gigagrams.

Following the summary table, charts 1-7 have been developed to show:

- The contribution of various sectors to total CO_2 emissions in Lebanon in 1994 (Fig.1).
- The contribution of various sectors to total CH_4 emissions in Lebanon in 1994 (Fig.2).
- The contribution of various sectors to total N_2O emissions in Lebanon in 1994 (Fig.3).
- The contribution of various sectors to total NO_x emissions in Lebanon in 1994 (Fig.4).
- The contribution of various sectors to total CO emissions in Lebanon in 1994 (Fig.5).
- The contribution of various sectors to total NMVOC emissions in Lebanon in 1994 (Fig.6).
- The contribution of various sectors to total SO_2 emissions in Lebanon in 1994 (Fig.7).

Table 1 Summary of Greenhouse Gas Emission Inventories for Lebanon (1994)

SECTOR	CO_2	CH_4	N_2O	NO_X	CO	NMV0C	SO_2
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
Energy	11678.694	1.3794	0.1157	54.0959	473.7119	87.3411	79.6036
Industry	1924.063	NO	NO	0.01112	0.0003	273.888	3.382

Solvents	NE	NE	NE	NE	NE	NE	NE
Agriculture		7.97862	3.0147	0.00146	0.04306		
Land-use Change & Forestry	200.4132	0.253	0.00168	0.06276	2.213		
Waste	0	42.804	0	0	0	0	0
Total	**13803.1702**	**52.41502**	**3.13208**	**54.17124**	**475.96826**	**361.2291**	**82.9852**

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II- ENERGY SECTOR

The following GHG are of interest in the energy sector: carbon dioxide CO_2, methane CH_4, nitrous oxide N_2O, oxides of nitrogen Nox, carbon monoxide CO, sulfur dioxide SO_2 and non-methane volatile organic compounds (NMVOCs). The inventory has focused on the following GHG related sources:

1. Electricity generation through the electric utility.
2. Private generation of electricity.

3. Manufacturing industries and construction.
4. Transport: road, domestic aviation, national navigation.
5. Energy use in the residential sector.
6. Energy use in the commercial/institutional sector.
7. Energy use in the agriculture/forestry/fishing sector.

The fuel types taken into consideration are: gasoline, jet kerosene, kerosene for household use, gas oil, diesel oil, fuel oil, LPG, lubricating oil, coal, wood and charcoal (under solid biomass). Care has been taken to eliminate the fuel used by international marine and aviation bunkers from the national inventory.

Finally, it is worth mentioning that both the reference approach and analysis by source categories have been carried out and are reported in this inventory.

The total amount of liquid secondary fuels that was imported to Lebanon in 1994 was 4,107,883 tons. The use of solid fuel and biomass fuel is minor and confined to the use of 160,000 tons of wood, 1,560 tons of charcoal and 180,000 tons of coking coal. Data on international bunkers in Lebanon were restricted to international aviation because the amount of fuel in international marine movement has never been documented and is believed to be minor. Domestic aviation is almost nonexistent in Lebanon and therefore all imported jet kerosene is used in international aviation except for 1,910 tons used by a few training planes.

Tables 2 to 5 provide information on fuels used and GHG emissions by fuel source, fuel type, sector and non-CO_2 emissions.

Table 2 Summary of CO_2 emissions by fuel source

FUEL TYPE	CONSUMPTION, TJ	CO_2 , Gg
Gasoline	55,694.55	3821.03
Jet Kerosine	85.166	6.0285
Kerosene	4.475	0.318
Gas/Diesel oil	35,449.23	2,599.35
Fuel Oil	56,708.65	4,343.48
LPG	6,907.26	431.261
Lubricants	12.053	0.437
Coking Coal	5,040	467.248
Municipal Solid Wastes	64.995	4.765
Charcoal	46.64	5.363
Wood (Solid Biomass)	2400	550.096
International Bunkers	6,420.96	454.507

Table 3 Summary of CO_2 Emissions by Fuel Type

FUEL TYPE	CONSUMPTION, TJ	CO_2 , Gg
Total liquid fuel	15,492,636	11206.68

(including LPG)		
Total solid fuel	5,040	467.248
Total biomass	2,446.64	263.221

Table 4 Summary of CO_2 Emissions by Energy Use of Sector

SECTOR	CO_2 , Gg
Energy Industries	3615.05
Manufacturing Industries and Construction	2774.09
Transport	3957.12
Commercial/Institutional	226.319
Residential	534.25
Agriculture/Forestry/Fishing	571.857
International Bunkers	454.507

Table 5 Summary of Non-CO_2 Emissions (Gg) by Energy Use of Sectors.

SECTOR	CH_4	N_2O	NO_X	CO	NMVOC	SO_2
Energy Industries	0.1418	0.0283	9.4584	0.7093	0.2364	45.021
Manufacturing Industries and Construction	0.11545	0.02517	7.6684	1.0862	0.2559	24.667
Transport						2.679
Road	1.1221	0.0344	34.824	447.193	83.8708	
Domestic Aviation	$4.2583x10^{-5}$	0.000170	0.0255	0.00856	0.00425	
Domestic Navigation	$9.11\ x10^{-5}$	$1.094x10^{-5}$	0.0273	0.01822	0.00364	
Commercial/Institutional	0.0284	0.001568	0.2844	0.08447	0.01594	1.130
Residential	1.4990	0.0214	1.0281	24.564	2.9153	2.579
Agriculture/Forestry/ Fishing	0.0779	0.00467	0.7798	0.1559	0.0389	3.528
Total	**2.9847**	**0.1157**	**54.0959**	**473.7119**	**87.3411**	**79.6036**
International Bunkers	0.0032105	0.0128419	1.926288	0.642096	0.321048	0.14134

III- INDUSTRIAL PROCESSES SECTOR:

In 1994, the Lebanese industry has emitted 1924.063 Gg (1,924,063 tons) of carbon dioxide, 0.0003 Gg (0.3 tons) of carbon monoxide, 0.01112 Gg of nitrogen oxide, 273.888 Gg (273,888 tons) of non-methane volatile organic compounds and 3.382 Gg (3,382 tons) of sulphur dioxide.

The cement industry is the major source of CO_2 emissions among the industrial processes in Lebanon. The cement industry is responsible for 77.2% of the total emissions followed by the iron and steel industry which produces 21.7% of the total CO_2 emissions from industrial processes. Fig. 8 shows the percentage distribution of various industrial sources contributions to CO_2 emissions in Lebanon.

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The NMVOC emissions are mainly produced by the use of asphalt for road paving (98.8% of total emissions by industry) followed by the food and beverage industry (1%). Fig. 9 shows the percentage distribution of various industrial sources contributions to NMVOC emissions in Lebanon.

The emissions of sulphur dioxide SO_2 come from three industrial sources. The first source is from the production of sulphuric acid (67% of total industrial emissions). The second from the cement industry (25% of total industrial emissions) and the third is from the iron and steel mills (8% of total industrial emissions). Fig. 10 shows the percentage distribution of various industrial sources contributions to SO_2 emissions in Lebanon.

Carbon monoxide emissions in the industrial sector are very small. The major source is iron and steel mills and the minor source is asphalt-roofing production.

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Uncertainties and limitations are associated with the estimated greenhouse gas emissions. The emissions reported for industrial processes in Lebanon reflect current best estimates. Thus the reported emissions inventory provides a foundation for the development of a more detailed and comprehensive Lebanese inventory in the future.

Specific limitations include:

(a) quantitative estimates for some sources of greenhouse gas emissions were not always based on data obtained from specific sources, but from bulk imports of certain products;

(b) and the accuracy of the inventory estimates relies heavily on emission factors available from the IPCC Guidelines . These factors are used in the Lebanese inventory and may differ for some local industrial processes because of differences in the raw material used.

IV- SOLVENT AND OTHER PRODUCT USE

This category covers mainly NMVOC emissions resulting from the use of solvents and other products containing volatile compounds. It also includes CO_2 and N_2O emissions from anaesthetic and propellant gases. The only relevant part to Lebanon in this sector is paint applications, degreasing and dry cleaning. However no estimation of GHG was made in this sector due to non availability of data and emission factors.

V- AGRICULTURE SECTOR

In Lebanon, emissions of greenhouse gases from agricultural activities occur through the following processes:

I- Enteric fermentation and manure management of the domestic livestock emits methane and nitrous oxide.

II- Agricultural burning of crop residues is of minor importance since field burning of crop residue is not a common practice in Lebanon.

III- Agricultural soils are a source of nitrous oxide directly from the soils and from animal production, and indirectly from the nitrogen added to the soils.

The following results were obtained for the inventory year 1994:

7.60955 Gg of methane, 3.01478 Gg of nitrous oxide, 0.00146 Gg of nitrogen oxides, and 0.04306 Gg of carbon monoxide.

VI- LAND USE CHANGE AND FORESTRY SECTOR:

The land use change and forestry considers the following sub-modules in calculating GHG emission by sources or removal by sinks:

I- Sub-module changes in forestry and other woody biomass stocks.

This sub-module has presented considerable difficulties in the data collection activity since no information or records are available at the institutional level. Therefore, the data derived represents a large degree of uncertainty.

The stocks of woody biomass, needed to calculate the carbon uptake or storage in Lebanon for 1994, were found to be made of:

a- 75,000 ha of forest trees (65,000 evergreen and 10,000 deciduous)

b- 50,280,000 non-forest trees which include:

49,794,000 farm and village trees (21,980,000 of evergreen fruit and olive trees and 27,814,000 of deciduous fruit trees) 486,000 urban trees (450,000 evergreen urban trees and 36,000 deciduous urban trees).

The total carbon uptake increment by these stocks of woody biomass is 169.800475kt.The loss of biomass from fuelwood consumption and from timber production is 4170298kt. As a result the change in woody biomass stocks is considered a source of CO2 emitting 142.4446kt of CO2.

II- Sub-module forest and grassland conversion-CO_2 from biomass:

Natural and man made fires are included in this sub- module. In 1994, around 1300 ha of woodland were affected by fires, and the resulting CO_2 released was 57.968625Gg.

Forests in 1994 constitute a minor source of CO_2 rather than a sink due to the loss of woody biomass stocks and to forest fires .

Co2 emission from land use change and forestry is 200.413225kt.

VII- WASTE SECTOR

The waste management section of this report deals with two sectors: land disposal of solid waste and wastewater treatment. It provides background information on the type of emissions that contribute to the greenhouse gases from these two sectors, presents both sectors' current status in Lebanon, describes the methodology followed to estimate the corresponding emissions, and presents the results obtained regarding greenhouse emissions.

The total methane emissions from solid waste disposal on land are 42.804Gg approximately. There are no emissions from wastewater and industrial handling systems because, for the target year 1994, there was no treatment facilities in Lebanon. The wastewater (municipal, commercial, and industrial) was directly discharged into the sea, rivers, ravines, or septic tanks which indicate that methane or nitrous oxide emissions are insignificant if not nonexistent. Note that this situation will change in the future as treatment plants are being constructed around the country and are expected to come into operation by the year 2000.

VIII-RELATIVE IMPACT OF GREENHOUSE GASES EFFECT: GLOBAL WARMING POTENTIAL (GWP)

The impact of a given quantity of gas in terms of weather warming is measured by its global warming potential (GWP). The GWP is defined as the cumulative radiating forcing between the present and some chosen future time horizon caused by a unit mass of gas emitted now, expressed relative to some reference gas (here CO_2 is used). The future global warming commitment of a greenhouse gas over the reference time horizon is the appropriate GWP multiplied by the amount of gas emitted. The GWP of a given gas depends mostly on the thermal efficiency of the gas, on various complex physical and chemical parameters and on its life span in the atmosphere as a direct or indirect greenhouse gas. As a rule, three possibilities of integration timespan are used: 20 years, 100 years and 500 years.

The 20 years possibility appears to be too brief for an assessment of high inertia phenomena such as those found in climatology. In addition, the life span of many greenhouse gases is much longer. A 500 years integration time span is very attractive, but gives highly uncertain projections on changes in the physical and chemical phenomena. The intermediate option, 100 years, leads to reasonable analysis and is the most commonly used option.

Table 6 presents the GWP time horizon referenced to the updated decay response for the carbon Cycle Model and future CO_2 atmospheric concentrations held constant at current level.

Table 6 Global Warming Potential Time Horizon of Greenhouse Gases

TYPE GAS	LIFE TIME	GLOBAL WARMING POTENTIAL* (TIME HORIZON)		
	(years)	20 years	100 years	500 years
CO_2		1	1	1
CH_4	12 ± 3	56	21	6.5
N_2O	120	280	310	170
HFC-134a	14.6	3400	1300	420

*Source: Climate Change 1995, the Science of Climate Change: Summary for Policy Makers and Technical Summary of Working Group I Report, pg. 26.

With the GWP, the global emissions of the country by sectors can be expressed in the same unit of CO_2 equivalent for the sake of aggregation or comparison. Accounting for the GWP of each greenhouse gas emitted, the CO_2 equivalent for each gas is calculated and the data are summarized in Table 7. Fig. 11 shows also the GWP of greenhouse gases emitted in Lebanon in 1994 for the three calculated time horizons.

The total GWP based on a 100 years life span for greenhouse gas emissions in Lebanon is 17665.997 $GgECO_2$ (17.666 $MTECO_2$). If this amount is divided by the Lebanese population for the year of 1994, then the GWP is 4.64 tons Equivalent of CO_2/capita/year.

Table 7 Global Warming Potential of Greenhouse Gases Emitted in Lebanon (1994)

TYPE OF GAS	GAS EMISSION	GWP (20 YEARS)	GWP (100 YEARS)	GWP (500 YEARS)
	(Gg)	Gg Equivalent of CO_2 ($GgECO_2$)		
CO_2	15,937.8538	15,937.8538	15,937.8538	15,937.8538
CH_4	64.7035	3,623.396	1,358.7735	420.7275
N_2O	4.05459	1135.2852	1,256.9229	689.28
HFC-134a	0.002	6.8	2.6	0.82
	Total GWP	**20,703.899**	**18,556.1502**	**17,048.6813**

Table 2.7A Sectoral Report For National Greenhouse Gas Inventories

(Sheet 1 of 3)

Sectoral Report for National Greenhouse Gas Inventories (Gg)

Green House Gas Source snd Sink Categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_X	CO	NMVOC	SO_2	HFCs		PFCs		SF_6	
									P	A	P	A	P	A
Total National Emissions and Removals	**16555.9**	**-600.6**	**22.989**	**3.216**	**49.88**	**448.35**	**135.93**	**83.33**	**0.002**	**0**	**0**	**0**	**0**	**0**
1 Energy	**11723.8**		**2.73**	**0.11**	**46.74**	**337.58**	**61.99**	**79.80**						
A Fuel Combustion														
1 Energy Industries	3904.00		0.16920	0.03380	11.2815	0.8461	0.2820	45.2160						
2 Man Ind. and Construction	2534.00		0.12180	0.02849	8.6579	0.3573	0.2794	24.6670						
3 Transport	3957.13		0.78363	0.02448	24.7105	311.661	58.4600	2.6780						
4 Other Sectors	1328.70		1.65230	0.02763	2.0924	24.7199	2.9703	7.2370						
5 Other (Specify)														
B Fugitive Emissions from Fuels	NO		NO	NO	NO	NO	NO	NO						
1 Solid Fuels	NO		NO	NO	NO	NO	NO	NO						
2 Oil and Natural Gas	NO		NO	NO	NO	NO	NO	NO						
2 Industrial Process	**1951.841**		**NO**	**NO**	**0.0111**	**0.3619**	**73.936**	**3.5346**	**0.002**	**0**	**0**	**0**	**0**	**0**
A Mineral Products	1506.921					0.0004	70.4656	0.894						
B Chemical Industry	NO	NO	NO	NO	NO	NO	NO	2.3625						
C Metal Production	444.92				0.0111	0.3615	0.0278	0.2781						
D Other Production (Food & Drink)							3.4428							
E Production of Halocarbons And Sulfur Hexafluoride									NO	NO	NO	NO	NO	NO
F Consumption of Halocarbons And Sulfur Hexafluoride									0.002	NE	0	NE	0	NE
G Other (Specify)														

Table 7A Sectoral Report For National Greenhouse Gas Inventories

(Sheet 2 of 3)

Sectoral Report for National Greenhouse Gas Inventories (Gg)														
Green House Gas Source snd Sink Categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_X	CO	NMVOC	SO_2	HFCs		PFCs		SF_6	
									P	A	P	A	P	A
3 Solvent and Other Product Use	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**						
4 Agriculture	**0**		**7.60955**	**3.01474**	**0.00146**	**0.4306**								
A Enteric Fermentation			6.7859											
B Manure Management			0.8216	0.4194										
C Rice Cultivation				0										
D Agricultural Soils				2.5953										
E Prescribed Burning of Savannas			0	0										
F Field Burning of Agricultural Residues			0.00205	0.00004	0.00146	0.4306								
G Other (specify)														
5 Land use Change and Forestry	**2880.281**	**-600.62**	**12.5685**	**0.08641**	**3.12305**	**109.974**	**0**	**0**						
A Changes in Forest and Other Woody Biomass Stock		-600.62												
B Forest and Grassland Conversion	2880.281		12.5685	0.08641	3.12305	109.974								
C Abandonment of Managed Lands														
D CO2 Emissions and Removals from Soil														
E Other(specify)														
6 Waste	**0**	**0**	**0.0837**	**0**	**0**	**0**	**0**	**0**						
A Solid Waste Disposal on Land	0	0	0.0837	0	0	0	0	0						
B Wastewater Handling	0	0	0	0	0	0	0	0						
C Waste Incineration	IE[1]	IE[1]	IE[1]	IE[1]	IE[1]	IE[1]	IE[1]	IE[1]						
D Other (specify)														
7 Other (specify)														

IE[2] Addressed in the Energy Sector

Table 7A Sectoral Report For National Greenhouse Gas Inventories

(Sheet 3 of 3)

Sectoral Report for National Greenhouse Gas Inventories (Gg)														
Green House Gas Source and Sink Categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_X	CO	NMVOC	SO_2	HFCs		PFCs		SF_6	
									P	A	P	A	P	A
Memo Items														
International Bunkers														
Aviation	454.507		0.00321	0.01284	1.926	0.642	0.321	0.14134						
Marine	NE		NE	NE	NE	NE	NE	NE						
CO_2 Emissions from Biomass	555.459													

Table 2.7B Short Summary For National Greenhouse Gas Inventories

Sectorial Report for National Greenhouse Gas Inventories (Gg)														
Green House Gas Source snd Sink Categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_X	CO	NMVOC	SO_2	HFCs		PFCs		SF_6	
									P	A	P	A	P	A
Total National Emissions and Removals	**15955.03**		**21.4974**	**4.05459**	**49.3995**	**448.048**	**129.634**	**83.3346**						
1 Energy Reference Approach	11723.62													
Sectoral Approach	11723.62	0	1.2356	0.9534	46.2639	337.669	59.1228	79.8						
A Fuel Combustion	11723.62	0	1.2356	0.9534	46.2639	337.669	59.1228	79.8						
B Fugitive Emissions from Fuels	0	0	0	0	0	0	0	0						
2 Industrial Processes	1951.841	0	NO	NO	0.01112	0.36188	70.5114	3.5346	0.002	NE	0	NE	0	NE
3 Solvent and Other Products	NE	0		NE			NE							
4 Agriculture	0	0	7.60955	3.01478	0.00146	0.04306								
5 Land-use Change and Forestry	2279.569	*	12.5685	0.08641	3.12305	109.974								
6 Waste	0	0	0.0837	0	0	0	0	0						
7 Other(specify)														
Memo Items														
International Bunkers														
Aviation	454.507	0	0.00321	0.01284	1.926	0.642	0.321	0.14134						
Marine	NE	NE	NE	NE	NE	NE	NE	NE						
CO_2 Emissions from Biomass	555.459													

P: Potential emissions based on Tier I Approach. A= Actual emissions based on Tier 2 Approach

* CO2 removals is included in the net CO2 emissions as a single number.

Table 2.8A Overview Table For National Greenhouse Gas Inventories

Overview Table

GreenHouse Gas Source And Sink Categories	CO_2		CH_4		N_2O		NO_X		CO		NMVOC		SO_2		HFCs		PFCs		SF_6	
	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality
Total National Emissions and Removals	**ALL**	**M**	**ALL**	**M**	**ALL**	**M**	**ALL**	**M**	**ALL**	**M**	**ALL**	**M**	**ALL**	**M**	**ALL**	**M**	**ALL**	**M**	**ALL**	**M**
1 Energy	ALL	M	ALL	M	ALL	M	ALL	M	ALL	M	ALL	M	ALL	M						
A Fuel Combustion Activities																				
Reference Approach	ALL	H	ALL	H	ALL	H	ALL	H	ALL	H	ALL	H	ALL	H						
Sectoral Approach	PART	M	PART	M	PART	M	PART	M	PART	M	PART	M	PART	M						
1 Energy Industries	ALL	H	ALL	H	ALL	H	ALL	H	ALL	H	ALL	H	ALL	H						
2 Manufacturng Industries and Construction	PART	M	PART	M	PART	M	PART	M	PART	M	PART	M	PART	M						
3 Transport	ALL	H	ALL	H	ALL	H	ALL	H	ALL	H	ALL	H	ALL	H						
4 Other Sectors	PART	M	PART	M	PART	M	PART	M	PART	M	PART	M	PART	M						
5 Other (specify)																				
B Fugitive emissions from Fuels	NO		NO		NO		NO		NO		NO		NO							
1 Solid Fuels	NO		NO		NO		NO		NO		NO		NO							
2 Oil and Natural Gas	NO		NO		NO		NO		NO		NO		NO							
2 Industrial Processes	**ALL**	**M**					**ALL**	**M**	**ALL**	**M**	**ALL**	**M**	**ALL**	**M**						
A Mineral Products	ALL	H					0		ALL	H	ALL	H	ALL	H						
B Chemical Industry	NO		NO		NO		NO		NO		NO		2.363	M						
C Metal Production	PART	M					PART	M	PART	M	PART	M	PART	M						
D Other Production	PART	M									PART	M								
E Production of Halocarbons and Sulphur Hexafluoride															NO		NO		NO	

Table 2.8A Overview Table For National Greenhouse Gas Inventories

Overview Table

GreenHouse Gas Source And Sink Categories		CO_2		CH_4		N_2O		NO_X		CO		NMVOC		SO_2		HFCs		PFCs		SF_6	
		Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality
Continued Industrial Processes																					
F. Consumption of Halocarbons and Sulphur Hexafluoride																					
	Potential															ALL	M	ALL	H	ALL	H
	Actual															NE		NE		NE	
G Other (specify)																					
3 Solvent and Other Product Use		**NE**				**NE**						**NE**									
4 Agriculture				**ALL**	**M**	**ALL**	**M**	**ALL**	**M**	**ALL**	**M**										
A Enteric Fermentation				**ALL**	**M**																
B Manure Management				**ALL**	**M**	**ALL**	**M**														
C Rice Cultivation																					
D Agricultural Soils						**ALL**	**M**														
E Prescribed Burning of Savannas																					
F Field Burning of Agricultural Residues				**ALL**	**M**	**ALL**	**M**	**ALL**	**M**	**ALL**	**M**	**ALL**	**M**	**ALL**	**M**						
G Other Specify																					
5 Land-use Change& Forestry		**ALL**	**M**	**ALL**	**M**	**ALL**	**M**	**ALL**	**M**	**ALL**	**M**										
A Changes in Forest and Other woody Biomass Stock		ALL	M																		
B Forest and Grassland Conversion		ALL	M	ALL	M	ALL	M	ALL	M	ALL	M										
C Abandonment of																					

Managed Lands																				
D CO_2 Emissions and Removals from Soil																				
E Other Specify																				

Table 2.8A Overview Table For National Greenhouse Gas Inventories

Overview Table

GreenHouse Gas Source And Sink Categories	CO_2		CH_4		N_2O		NO_X		CO		NMVOC		SO_2		HFCs		PFCs		SF_6	
	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality
6 Waste	0		ALL		0		0		0		0		0							
A Solid Waste Disposal on Land	ALL	M	ALL	M	ALL	M	ALL	M	ALL	M	ALL	M	ALL	M						
B Wastewater Handling	ALL	M	ALL	M	ALL	M	ALL	M	ALL	M	ALL	M	ALL	M						
C Waste Incineration																				
D Other Specify																				
7 Other (Specify)																				
Memo Items:																				
International Bunkers																				
Aviation	ALL	H	ALL	H	ALL	H	ALL	H	ALL	H	ALL	H	ALL	H						
Marine	NE		NE		NE		NE		NE		NE		NE							
CO_2 Emissions from Biomass	ALL	H																		

SECTOR 1
ENERGY

1.1 INTRODUCTION

The aim of this section is to report the results of the greenhouse gas (GHG) emission inventory for the year 1994. The following GHG are of interest in the energy sector: carbon dioxide CO_2, methane CH_4, nitrous oxide N_2O, oxides of nitrogen NO_X, carbon monoxide CO, sulphur dioxide SO_2 and non-methane volatile organic compounds (NMVOCs). The inventory has focused on the following GHG related sources:

1. Electricity generation through the electric utility.
2. Private generation of electricity.
3. Manufacturing industries and construction.
4. Transport: road, domestic aviation, and national navigation.
5. Energy use in the residential sector.
6. Energy use in the commercial/institutional sector.
7. Energy use in the agriculture/forestry/fishing sector.

The fuel types taken into consideration are: gasoline, jet kerosene, kerosene for household use, gas oil, diesel oil, fuel oil, LPG, lubricating oil, coal, wood and charcoal (solid biomass). Care has been taken to eliminate the fuel used by international marine and aviation bunkers from the national inventory.

The amount of GHG released to the atmosphere has been estimated using the IPCC methodology and emission factors [1,2]. Where national emission factors differed from those of IPCC, the factors are discussed. Complete documentation of compiled information and data sources are attached to this report in the Appendix.

Finally, it is worth mentioning that both the reference approach and analysis by source categories have been carried out and are reported in this inventory.

1.2 ENERGY STATUS IN 1994

The energy sector in Lebanon plays an important role in the overall development of the country. Apart from a modest amount of hydropower and traditional energy (wood and charcoal) which together represent less than 2 % of energy consumption, all energy in Lebanon is derived from imported petroleum products and some coal (180000 T used by two cement factories). Prior to the war, there were two refineries in operation, but both were badly damaged and are currently out of operation [3].

Total consumption of petroleum products in Lebanon in 1994 was of 3,830,628 Tons [3] covering the following types of fuel: gasoline, gas oil, jet kerosene, LPG, fuel oil, bitumen, kerosene for domestic use and lubricants.

A. THE PETROLEUM SECTOR

The petroleum and gas sector is the responsibility of the Ministry of Petroleum (MoP). The executing agency is the Directorate of Petroleum, responsible for licensing import activities, import and refining of crude oil, import of fuel oil, and setting prices for petroleum products. Until 1988, the government retained a monopoly over the petroleum market, but a number of private companies have subsequently been authorised to import and distribute petroleum. A total of 21 companies [3,8] are importing petroleum in addition to the government and large industries. In addition to importing companies, 84 private companies are involved in the distribution of petroleum products to 2022 gas stations, responsible for the distribution of petroleum products to end users.

B. THE ELECTRICITY SECTOR

Electricity is supplied through the electric utility EDL (Electricite du Liban), an autonomous state-owned entity under the jurisdiction of the Ministry of Hydraulic and Water Resources (MHWR). The electricity generating plants comprise the following units [4,8]:

- 15 hydro-electric plants having a combined capacity of 281 MW constituting 19% of the total nominal capacity. The Awali plant is the largest of these with 109.5 MW capacity.

- three major thermal plants with combined nominal capacity of about 1300 MW, comprising Zouk (61% of capacity), Jieh (26%) and Hrayshe (13%).

In 1994, electricity production was evaluated at 5184 GWh [4](taking into account network losses). Because EDL is unable to continuously provide electricity, many domestic, industrial and commercial users have supplemented EDL supplies with their own private generators. The share of electric generation in Lebanon in 1994 was: EDL:66%, Domestic and Commercial: 12% and Industry: 22% [4].

At present, the electricity sector in Lebanon is approaching the end of a major rehabilitation program which resulted in refurbishing all its physical components, and upgrading its generating capacity. EDL will be subjected to an extensive extension program whereby modern technologies, managerial skills and planning techniques will be introduced in order to improve the efficiency and quality of services.

C. THE TRANSPORT SECTOR

Since 1993 transport functions have been the responsibility of the Ministry of Transport (MoT) [8]. The Directorate General of Civil Aviation and the Directorate General of Land

and Marine Transport operate under the MoT. The Railways and Public Transport Authority (RPTA), which is an independent public authority also functions under the supervision of the MoT. The classified road network in Lebanon is made up of 6295 km of paved roads. This network includes 523 km of international highways, 1640 km of major roads, 1352 km of secondary roads and 2780 km of local roads. The size of the vehicle fleet in Lebanon is estimated at 1.1-1.2 million. The rail system is made up of 428 km but was badly damaged during the war. In 1994 the rail system was not functioning [3].

1.3 ESTIMATIONS OF EMITTED GREENHOUSE GASES USING THE REFERENCE APPROACH

The total amount of liquid secondary fuels that was imported to Lebanon in 1994 was 3,830,628 Tons, broken down as shown in Table 1-1:

Table 1-1. Fuel imports by type

Fuel Type	Imports, Tons
Gasoline [3,9,10]	1243182
Jet kerosene [3]	145910
Other kerosene [3]	100
Gas/Diesel oil [3,8,9]	818123
Fuel oil [3,8]	1411014
LPG [5,6]	146000
Bitumen [7]	66000
Lubricants [6,8]	299

The use of solid fuel and biomass fuel is minor and confined to the use of 160000 Tons of wood [11], 1560 Tons of charcoal [7] and 180000 Tons of coking coal [8]. The lubricants were estimated as follows [6,8]: 197 Tons used by EDL and 102 Tons used by private generators.

The conversion and carbon emission factors as well as the fraction of carbon oxidised and stored used for all fuel types are those recommended by the IPCC methodology.

Data on international bunkers in Lebanon were restricted to international aviation because the amount of fuel that goes on international marine has never been documented and is believed to be minor [10]. Domestic aviation is almost non existent in Lebanon and therefore all imported jet kerosene goes on international aviation except for 1910 Tons used by few training planes [9].

The actual CO_2 emissions as obtained from the reference approach are shown in Table 1-2.

Table 1-2. Actual CO_2 emissions from various fuels

Fuel Type	Emissions, Gg
Gasoline	3821.03
Jet kerosene	6.028
Other kerosene	0.318
Gas/Diesel oil	2599.35
Fuel oil	4343.48
LPG	431.26
Bitumen	0
Lubricants	0.436

1.4 ESTIMATIONS OF EMITTED GREENHOUSE GASES USING THE SECTORAL APPROACH

This section reports the greenhouse gases emitted from various sectors, namely, energy industries, manufacturing industries and construction, transport, residential, commercial/institutional, and agriculture/forestry/fishing. The conversion and carbon emission factors as well as the fraction of carbon oxidised and stored used for all fuel types are those recommended by the IPCC methodology.

A. ENERGY INDUSTRIES

In Lebanon, the term energy industries relates only to the electric utility EDL. In this sector, the types of fuel used are gas/diesel oil, fuel oil and lubricants as described by Table 1-3. Also Table 1-3 reports the CO_2 emissions from the energy industry sector.

Table 1-3. Fuel types used by EDL

Fuel Type	Quantity, Tons	CO_2 Emissions, Gg
Gas/diesel oil [3,4]	48650	154.571
Fuel oil [3,4]	1124070	3460.19
Lubricants [8,6]	197	0.288

B. MANUFACTURING INDUSTRIES AND CONSTRUCTION

Table 1-4 describes the fuels used by this category as well as the CO_2 emissions.

Table 1-4. Fuel types used by the manufacturing industries and construction

Fuel Type	Quantity, Tons	CO_2 Emissions, Gg
Gas/diesel oil [8,3]	425424	1351.66
Fuel oil [8,3]	286944	883.291
LPG [3,5]	21060	62.208
Coking coal [8]	180000	467.248
Lubricants [8,6]	102	0.1488

Municipal solid waste [12]	1500	4.7658

The gas/diesel oil used in this sector was estimated at 52% of the total fuel imported to the country [8]. The fuel oil is calculated as the total imported minus

the EDL consumption. The consumption of LPG by this sector is estimated as follows: The total import of LPG is 146000 Tons [5]. Out of this 110360 Tons are used by households and 14580 Tons are used by the commercial/institutional sectors. The remaining amount which is 21060 Tons is used in industry applications. Such estimations are based on the assumption that the consumption of LPG and electricity are similar. Figures for electricity consumption were taken from [6, 4].

The consumption of coking coal was taken from [8] and the lubricants consumption is, as mentioned in section 1.3, about 34% of total imported lubricants.

C. TRANSPORT

In this analysis, domestic aviation, road transport, national navigation and international bunkers are reported. The types of fuel used under this category are given in Table 1-5.

Table 1-5. Fuel types used by the transport sector

Fuel Type	Quantity, Tons	CO_2 Emissions, Gg
Gasoline (road) [3]	1242803.3	3819.872
Diesel oil (road) [3]	40906	129.967
Jet kerosene [3]	1910	6.0285
Gasoline (navigation) [10,13]	378.61	1.1636
Diesel oil (navigation) [10,13]	29.2	0.0927

Information on international bunkers is restricted to international aviation. The fuel used by the latter is 144000 Tons and the CO_2 emissions are 454.507 Gg.

The consumption of gas/diesel oil is estimated at:

- Road: 5% of total gas/diesel oil import based on reference [8].
- Navigation: 29.2 Tons based on a field survey covering the Saint George and Riviera Hotels [13].

The consumption of gasoline by national navigation is 378.612 Tons also obtained from the same field survey mentioned above. The consumption of gasoline by road transport is the total minus the amount used by national navigation.

D. COMMERCIAL/ INSTITUTIONAL SECTOR

Table 1-6 describes the fuels used by this category as well as the CO_2 emissions.

Table 1-6. Fuel types used by the commercial/institutional sector

Fuel Type	Quantity, Tons	CO_2 Emissions, Gg
Gas/diesel oil	57677	183.252
LPG	14580	43.067

In this table, the consumption of gas/diesel oil is mainly spent on space heating. This is estimated at 7.05% of total gas/diesel oil import based on reference [8,6]. The use of LPG in this sector is estimated at 9.986% of the total LPG import to the country.

E. RESIDENTIAL

Table 1-7 describes the fuels used by this category as well as the CO_2 emissions.

Table 1-7. Fuel types used by the residential sector

Fuel Type	Quantity used, Tons	CO_2 Emissions, Gg
Kerosene [3]	100	0.3183
Gas/diesel oil	65449	207.945
LPG	110360	325.986
Charcoal [7]	1560	5.363
Wood (solid biomass) [11]	160000	257.857

In this table, the consumption of gas/diesel oil is mainly spent on space heating. This is estimated at 8% of total gas/diesel oil import based on reference[8,6]. The use of LPG is estimated at 75.59% of the total LPG import to the country. The consumption of wood is based on the assumption that 5% of the existing 800,000 Lebanese families use wood at a rate of 4 Tons per year [11]

F. AGRICULTURE/FORESTRY/FISHING

In this sector, only gas/diesel fuel is used under the stationary category. This accounts for 22% of total gas/diesel oil import based on reference [8]. Table 1-8 describes the fuel consumption as well as the CO_2 emissions.

Table 1-8. Fuel types used by agriculture/forestry/fishing

Fuel Type	Quantities, Tons	CO_2 Emissions, Gg
Gas/diesel oil	179987	571.857

1.5 VERIFICATIONS

Since in this inventory two approaches are followed, there is a need to verify the results in order to be sure that they match. This can be confirmed by comparing the results of the sheets related to the reference approach with the results documented in the sheets entitled

1.6 SUMMARY OF INVENTORY RESULTS

As a summary, tables 1-9 to 1-13 provide information on fuels used and GHG emissions by fuel source, by fuel type, by sector and by non-CO_2 emissions.

Table 1-9. Summary of results by fuel source

FUEL TYPE	CONSUMPTION, TJ	CO_2 , Gg
Gasoline	55694.55	3821.03
Jet kerosine	85.166	6.0285
Kerosene	4.475	0.318
Gas/diesel oil	35449.23	2599.35
Fuel oil	56708.65	4343.48
LPG	6907.26	431.261
Lubricants	12.053	0.437
Coking coal	5040	467.248
Municipal solid wastes	64.995	4.765
Charcoal	46.64	5.363
Wood (Solid Biomass)	2400	257.85
International Bunkers	6420.96	454.507

Table 1-10. Summary of results by fuel type

FUEL TYPE	CONSUMPTION, TJ	CO_2 , Gg
Total liquid fuel (including LPG)	15492636	11206.68
Total solid fuel	5040	467.248
Total biomass	2446.64	263.221

Table 1-11. Summary of results by sector

SECTOR	CO_2 , Gg
Energy Industries	3615.05
Manufacturing Industries and Construction	2774.09
Transport	3957.12
Commercial/Institutional	226.319
Residential	534.25
Agriculture/Forestry/Fishing	571.857
International Bunkers	454.507

Figures 1.1 and 1.2 show the percentage contribution of CO_2 emissions by fuel sources and fuel types respectively. Figure 1.3 provides information on percentage contribution of various sectors to CO_2 emissions. The percentage contribution of various sectors to non-CO_2 emissions are shown in Figs. 1.4-1.9.

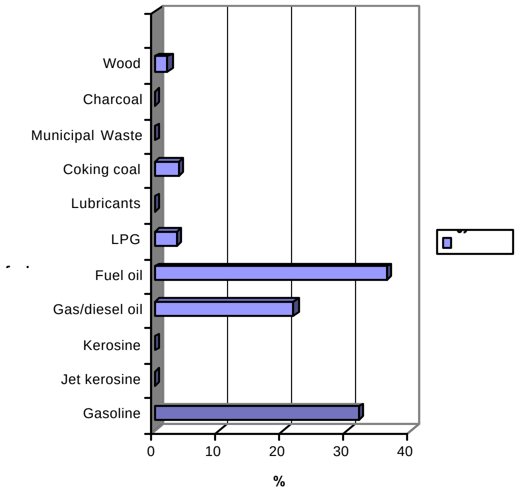

Fig. 1.1 Contribution of fuel sources to CO2 emissions

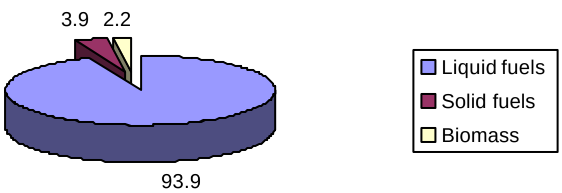

Fig. 1.2 Contribution of fuel types to CO_2 emissions

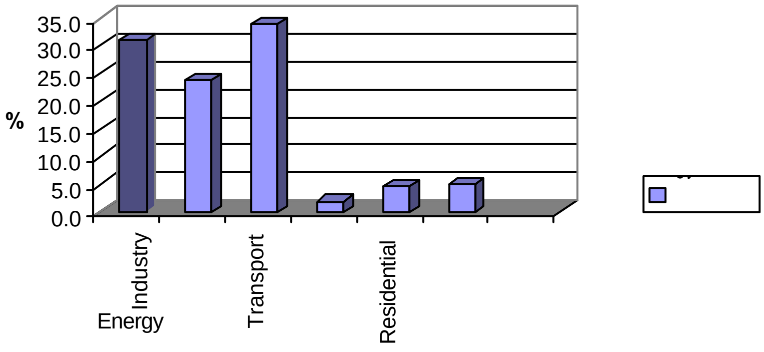

Fig. 1.3 Contribution of various sectors to CO_2 emissions.

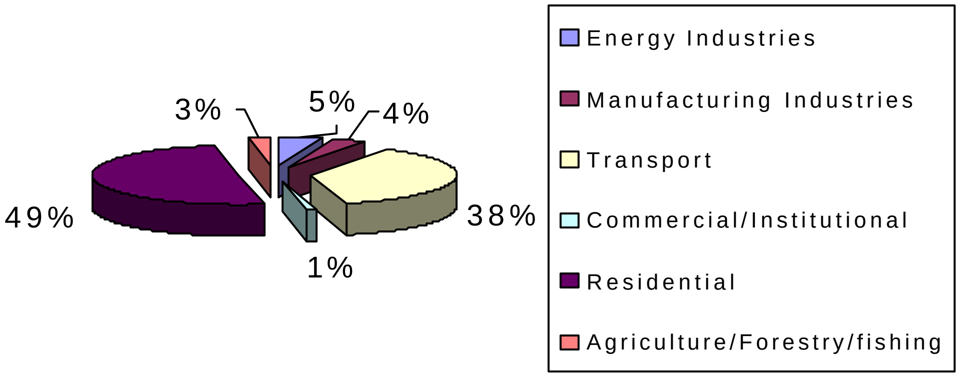

Fig. 1.4 Contribution of various sectors to CH4 emissions.

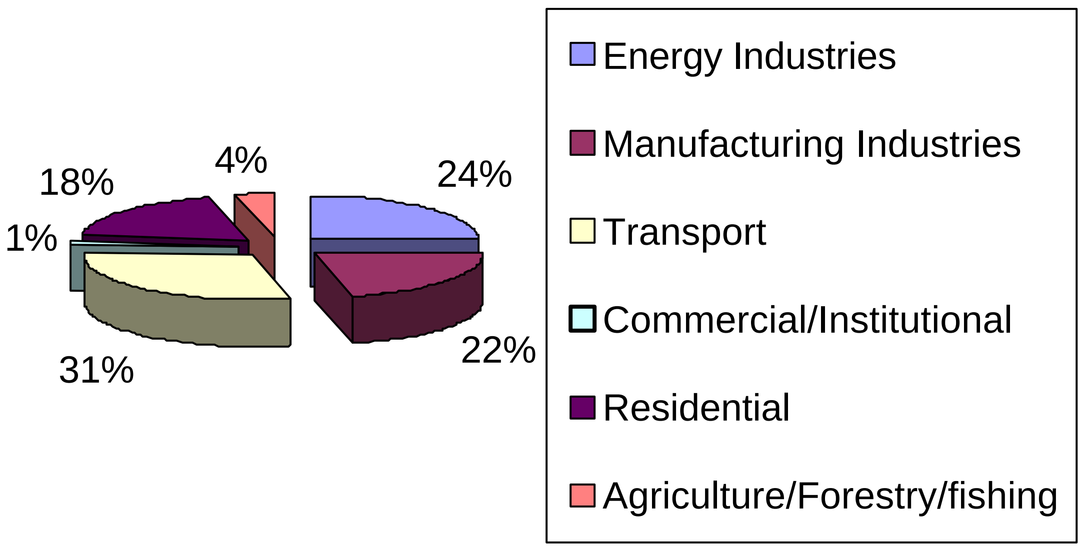

Fig.1.5 Contribution of various sectors to N2O emissions.

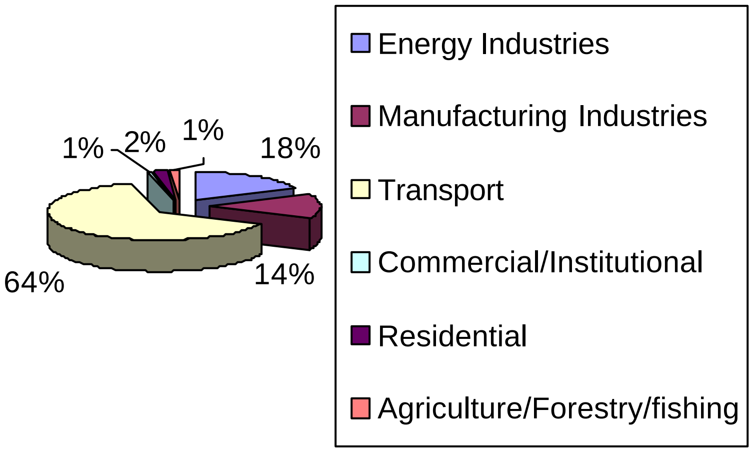

Fig. 1.6 Contribution of various sectors to NOx emissions.

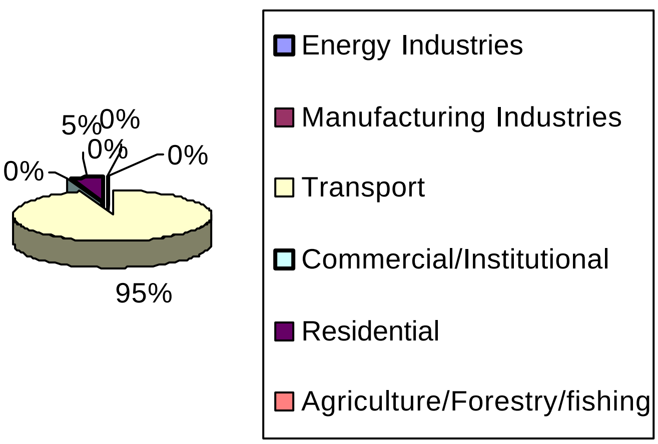

Fig. 1.7 Contribution of various sectors to CO emissions.

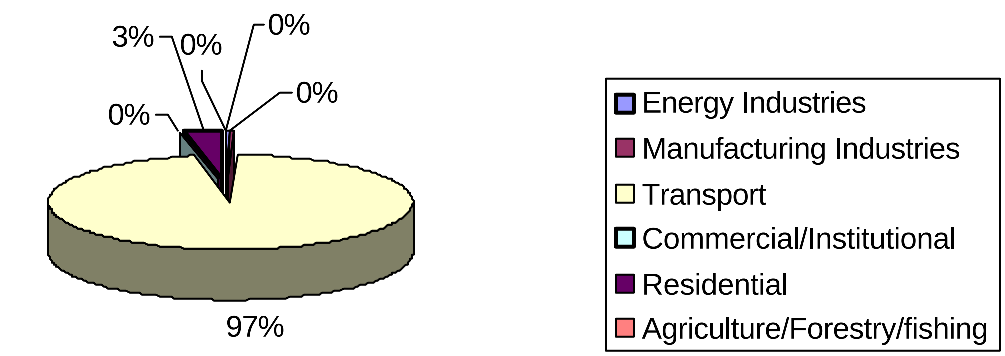

Fig. 1.8 Contribution of various sectors to NMVOC emissions.

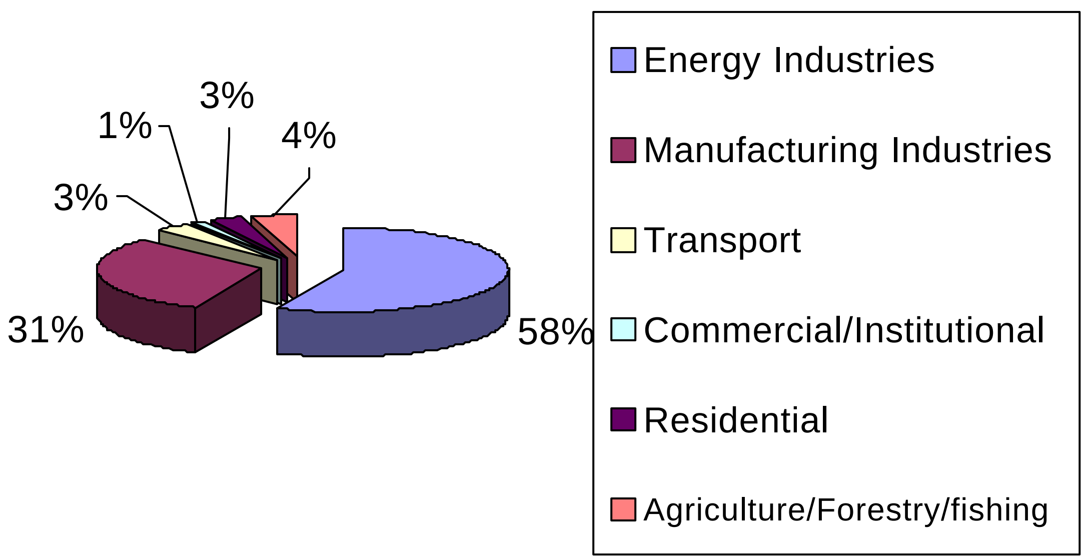

Table 1-12. Summary of results of non-CO_2 emissions, Gg

SECTOR	CH_4	N_2O	NO_X	CO	NMVOC
Energy Industries	0.1418	0.0283	9.4584	0.7093	0.2364
Manufacturing Industries and Construction	0.11545	0.02517	7.6684	1.0862	0.2559
Transport					
Road	1.122	0.0344	34.824	447.193	83.8708
Domestic Aviation	$4.2583 x 10^{-5}$	0.000170	0.0255	0.00856	0.00425
Domestic Navigation	$9.11 x 10^{-5}$	$1.094 x 10^{-5}$	0.0273	0.01822	0.00364
Commercial/Institutional	0.0284	0.001568	0.2844	0.08447	0.01594
Residential	1.4990	0.0214	1.0281	24.564	2.9153
Agriculture/Forestry/ Fishing	0.0779	0.00467	0.7798	0.1559	0.0389
Total	2.9817	0.1157	54.0959	473.711	87.3411
International Bunkers	0.0032105	0.0128419	1.926288	0.642096	0.321048

Table1-13. Summary of results of SO_2 emissions, Gg

SECTOR	SO_2
Energy Industries	45.021
Manufacturing Industries and Construction	24.667
Transport	2.679
Commercial/Institutional	1.130
Residential	2.579
Agriculture/Forestry/ Fishing	3.528
Total	79.603
International Bunkers	0.1411

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[12]. Communication with Mr. M. Sleiman, CDR.

[[13]. Communication with the Directors of Saint George and Riviera Hotels.

Table 2.22 Sectoral Report For Energy

Sheet (1 of 1)

Sectoral Report for National Greenhouse Gas Inventories (Gg)							
Green House Gas Source snd Sink Categories	CO_2	CH_4	N_2O	NO_X	CO	NMVOC	SO_2
Total Energy	**11723.6229**	**2.67993391**	**0.10698093**	**46.74144**	**337.56071**	**61.99289**	**79.798562**
A Fuel Combustion Activities (Sectoral Approach)							
1 Energy Industries	3903.996	0.1692	0.0338	11.2815	0.8461	0.282	45.216
a Public Electricity and Heat Production	3903.996	0.1692	0.0338	11.2815	0.8461	0.282	45.216
b Petroleum Refining	0	0	0	0	0	0	0
c Manufacture of Solid Fuels and Other Energy	NO	NO	NO	NO	NO	NO	NO
2 Manufacturing Industries and Construction	2533.805	0.1218	0.02849	8.6578	0.3572	0.2794	24.667
a Iron and Steel							
b Non-Ferrous Metals							
c Chemicals							
d Pulp, Paper, Print							
e Food Processing, Beverages and Tobacco							
f Other(please specify)							
3 Transport							
a Civil Aviation	6.02853	0.00004258	0.00017	0.0255	0.00851	0.00425	0.001872
b Road Transportation	3949.839	0.7835	0.0243	24.657	311.634	58.4535	2.67669
c Railways	0	0	0	0	0	0	0
d Navigation	1.2564	0.00009133	0.00001093	0.02734	0.0182	0.00364	0
e Other(please specify)							
4 Other Sectors							
a Commercial/Institutional	225.884	0.0284	0.00156	0.2844	0.0844	0.0159	1.13
b Residential	530.957	1.499	0.014	1.0281	24.4564	2.9153	2.579
c Agriculture/Forestry/Fishing	571.857	0.0779	0.00465	0.7798	0.1559	0.0389	3.528
5 Other (please specify)							
B Fugitive Emissions From Fuels	NO	NO	NO	NO	NO	NO	NO
1 Solid Fuels							
a Coal mining							
b Solid Fuel Transformation							
c Other(please specify)							
2 Oil and Natural Gas	NO	NO	NO	NO	NO	NO	NO
a Oil							
b Natural Gas							
c Venting and Flaring							

Memo Items							
International Bunkers							
Aviation	454.507	0.00321	0.01284	1.926	0.642	0.321	0.14134
Marine	NE	NE	NE	NE	NE	NE	NE
CO_2 Emissions from Biomass	555.459						

SECTOR 2.
INDUSTRIAL PROCESSES INVENTORY

2.1 INTRODUCTION:

Lebanon, in its recovery process from after the war has made efforts to actively participate in international forums related to the environment and the climate. Studies aimed at understanding the causes of environmental problems and their societal impact are now favourably supported by the Government of Lebanon, universities and non-profit groups. Industrial sector is one of the targeted sectors for survey and assessment study of its environmental implications through waste production and disposal. In 1994, industry in Lebanon accounted for 14% of the total GNP compared to agriculture accounting for 26% and the service sector accounting for 60%.

This work objective is to conduct a greenhouse gas emission inventory of the industrial processes in Lebanon for the year 1994. Six gases are known to be significant greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), nitrogen oxides (NOx), carbon monoxide (CO) and non-methane volatile organic compounds (NMVOCs). Industrial sources in Lebanon, which contribute to significant emission of these gases, are identified through IPCC guidelines (Intergovernmental Panel on Climate Change) and emission estimates are reported in Standard Tables format. Sulphur dioxide (SO_2) emission sources and emission estimates are also reported for Lebanon. Other gases that do not occur naturally are the Chlorofluorocarbon and halons, which are used in refrigeration, air-conditioning, foam and solvent production. These gases are already being phased out worldwide.

For 1994 the inventory of the industrial processes uses methodologies taken from IPCC Reference Manual on Guidelines for National Greenhouse Gas Inventories [1]. The sources of the compiled data have been obtained either from official governmental reports or directly from the concerned industries. The inventory has focused on the following relevant industries to greenhouse gas emissions in Lebanon:

- Cement production
- Lime production
- Road paving asphalt, and roofing asphalt
- Glass production
- Chemical compounds which include mainly sulphuric acid, fertilisers and plastics.
- Steel products where raw iron is imported.
- Aluminium shaping and extrusion factories.
- Paper & printing (raw material of dried pulp is imported).
- Food processing which includes processing of local crops for sugar and wine production. It also includes meat and poultry and margarine. For the processes of bread making and coffee roasting, the wheat and green coffee are mainly imported.

The amounts of greenhouse gases released to the atmosphere via the above-specified industrial processes have been estimated using the IPCC methodology and emission factors. Where national emission factors varied from those of IPCC, the factors are discussed.

2.2 THE INVENTORY PROCESS:

The inventory proceeded by identifying the process and emission greenhouse gases sources in the Lebanese industry. The industrial firms surveyed are: the cement production, lime, chemical products, asphalt roofing, paper and printing, cosmetics, foam and plastics, iron and steel, aluminium extrusion and food and drinks. A list of the industrial firms to be surveyed was prepared. Forms were sent to each specific industry requesting information about their production of relevant components of interest and the type and amount of fuel used in 1994 and the following years as available. Data was obtained from several sources for comparison with other industrial census and surveys conducted in Lebanon and reported by the Lebanese Government.

The first part of this sectoral report is concerned with emission estimations for each type of industry emitting greenhouse gases. The verification procedures used to check data are also reported. The completed set of inventory worksheets of IPCC on industrial processes is compiled in Appendix A2.

2.3 ESTIMATIONS OF EMITTED GREENHOUSE GASES FROM VARIOUS INDUSTRIAL PROCESSES IN LEBANON (1994):

A. CEMENT PRODUCTION (CO_2 & SO_2 EMISSIONS):

There are two Portland cement plants and one white cement plant in Lebanon. Data was available on the total production of cement in 1994 from the Administration of the Statistical Centre of the Council of Ministers [3]. The data inspected reported that the fraction of lime in the cement produced in Lebanon is between 0.6 and 0.65. The value of 0.635 is used in our calculations of the emission factor (t CO_2/ t cement produced). This is also the same default value reported in the IPCC guidelines for estimating emission factors of CO_2 from cement, [2].

Worksheets 2-1 of Appendix 2 give the estimated emissions of CO_2 and SO_2 due to cement production in Lebanon in 1994.

B. LIME PRODUCTION (CO_2 EMISSIONS):

The companies that produce lime in Lebanon are the Lebanese Lime & Plaster Factory and the Middle East White Cement Factory. Data on lime production for 1994 has been obtained directly from the Lime Factories as shown in Table 2-1.

Table 2-1 Lime Production Data in 1994

YEAR 1994	PRODUCTION OF LIME (TONS)	RAW MATERIAL LIMESTONE (TONS)	PRODUCTION CAPACITY (TONS)	ENERGY SOURCE FUEL OIL
Middle East White Cement Factory	13,813	22,100	*	1,657 ton of fuel oil
Lime & Plaster Factory	6,960	1,100	150,000	100 (LITRE/ TON OF LIME PRODUCED)

* Data not available

The lime produced in Lebanon uses a kiln-calcite feed which has an emission factor of 0.79 tons of CO_2 per ton of quicklime produced [2,pp2.5]. Worksheet 2-2 of Appendix 2 presents the data for CO_2 emissions due to quicklime production in Lebanon in 1994.

C. SODA ASH USE (CO_2 EMISSIONS)

Soda ash is not produced in Lebanon. It is imported and is mainly used in glass production. There are two major glass producers. One is located in Shuwaifat and the other in Shtura. The ratio of soda ash quantity used in tons per ton of glass produced was calculated as 0.169973, based on information provided by the factories. The details of the data are given in Table 2-2.

Table 2-2 Container Glass Production and Soda Ash Use in 1994

FACTORY NAME	CONTAINER GLASS PRODUCTION (1994) (TONS)	AMOUNT OF SODA ASH USED (1994) (TONS)	FUEL USED (1994)		
			Fuel Oil	Diesel	LPG
MALIBAN Manuf. Of Glass Containers Shtura	23,819	4,048.6	5,077 (10^3 Ltrs)	4,001 (10^3 Ltrs)	708.95 (Tons)
Shuwaifat Glass Factory	32,211	5,475	6,823 (Tons)	3,481 (Tons)	561 (Tons)

In 1994, the container glass production in the Shuwaifat factory was 32,211 tons and the soda ash used was 5,475. The Shtura factory produced 23,819 tons of container glass in 1994 and so the soda ash used is calculated as 4,048.6 tons.

The flat glass production was of 15,000 tons, which uses 2,549.595 tons of soda ash. So the total soda ash used in 1994 was 12,072.6 tons.

Worksheet 2-4 of Appendix 2 presents the data for CO_2 emissions due to soda ash production and use in Lebanon in 1994.

D. PRODUCTION & USE OF MISCELLANEOUS MINERAL PRODUCTS:

D.1 Asphalt Roofing Production (NMVOC & CO Emissions)

There is one asphalt-roofing plant in Lebanon (CMC Construction Material Company SAL). The company imports the material and provides no data. The emissions from asphalt roofing production are estimated from the national total imported mass of the product. The data is obtained by considering the amount of asphalt imported as raw material. It is reported that in 1993, 51,000 tons of asphalt were imported, 108,839 tons in 1996 and 87,585 tons in 1997 [4,5]. The amounts of asphalt used as raw material for road paving is obtained from the Ministry of Public Works given in Table 2-3, for the years of 1994 through to 1996. The South Council and the Council for Development and Construction (CDR) also use comparable amounts of asphalt for road paving. Since road paving has been a major activity in 1994, it is acceptable to assume that 80% of imported asphalt is used for road paving and 5% is used for asphalt roofing.

Table 2-3 Asphalt Production Data

	Total Estimated Road Paving Asphalt Production	Road Paving Asphalt Production (Ministry Of Public Work)	Imported Raw Asphalt	Amount Of Raw Asphalt Used In Road Paving (Ministry Of Public Work)	Asphalt Roofing Production
Year	**(Tons)**	**(Tons)**	**(Tons)**	**(Tons)**	**(Tons)**
1994	844,035	218,994	51,000	10,586	2,550
1995	**	209,092	**	10,598	**
1996	**	260,508	108,839	12,960	5,442
1997	**	335,885	87,585	16,518	4,379

** Data not available

According to IPCC guidelines it is possible to assume that all of the asphalt not used for road paving is blown [2]. The emission factor in kg NMVOC/ton asphalt roofing produced is taken as 2.4 for a no control blowing process, using table 2-3 of IPCC guidelines [2]. The emission factor for CO is taken for a blowing process as 0.0095 using Table 2-2 of the IPCC guidelines [2].

Worksheet 2-5 (1&2) of Appendix 2 present the data for NMVOC & CO emissions due to asphalt roofing production and use in Lebanon in 1994.

D.2 Road Paving With Asphalt (NMVOC Emissions)

The quantity of road paving material used in Lebanon by the Ministry of Public Work in 1994 has been 10586. There are two other major sources of road paving asphalt: the South Council and the Council for Development and Construction. The total quantity used in road paving is estimated from the amount of asphalt that was imported in 1994. The data is shown in Table 2-3. The emission factor of 0.023 kg of NMVOC per ton of paving material used in the asphalt plant, is obtained from IPCC guidelines reference volume [1]. The emission factor of 320 kg of NMVOC per ton of paving material used in the road surface, is obtained from the IPCC guidelines reference volume [1].

Worksheet 2-5 (3) of Appendix 2 presents the data for NMVOC emissions due to asphalt road paving in Lebanon in 1994.

D.3 Glass Production (NMVOC Emissions)

The total amount of container glass produced in Lebanon is already reported from the factories and is given in Table 2-2 of this report. The flat glass production amount is obtained using a maximum production capacity of 1.86 Million m^2/year of flat-glass, [5]. This is converted to tons using an average glass thickness of 5mm and an average density of 2700 kg/m^3 ,so that the estimated glass production in tons = 1.86 x thickness 0.005* density*1000. Assuming that the flat glass production is at 60% of its maximum value, then a final value is obtained for glass production in tons in 1994. The emission factor of 4.5 is obtained from the revised 1996 IPCC guidelines [1].

Worksheet 2-5(4) of Appendix 2 presents the data for NMVOC emissions based on total amount of glass produced in Lebanon in 1994.

E. PRODUCTION OF CHEMICALS

E.1 Production of Sulphuric Acid (SO_2 Emissions)

The only chemical produced in Lebanon that contributes to greenhouse gas emission is the sulphuric acid. The amount of sulphuric acid produced in Lebanon is reported to be 135,000 tons per year [6]. It was extremely difficult to get data directly from a list of 5 major chemical producing companies. The companies do not disclose such information so as not to be liable for pollution.

Worksheet 2-10 (5) presents the data for SO_2 emissions based on the total quantity of sulphuric acid produced in Lebanon in 1994.

F. IRON & STEEL PRODUCTION (CO_2, NO_X, NMVOC, CO& SO_2 EMISSIONS)

The total production capacity of steel mills in Lebanon is of 480,000 tons [5]. The total amount of raw iron imported to Lebanon was 273,965 tons in 1994, [3]. It is assumed that all imported raw material is used by the factories. The density of produced steel is about 98% of the raw iron due to the added carbon in the steel processing using rolling mills. One ton of raw iron produces on average about 1.015 tons of steel. So the total estimated steel production for 1994 is 278,074.5 tons. The emission factors used for green house gas production per ton of steel produced are obtained from tables 2-13 to 2-16 in the 1996 IPCC Guide Lines, [2].

Worksheet 2-11 (2&3) of Appendix 2 presents the data for CO_2 , NO_x, CO, NMVOC and SO_2 emissions based on the total quantity of steel produced in Lebanon in 1994.

G. PULP & PAPER INDUSTRIES:

Paper industry is one of the major industries in Lebanon. It does not involve the production of dried pulp. The pulp is imported from other countries.

H. FOOD & DRINK (NMVOC EMISSIONS):

H.1 Alcoholic Beverages:

Wine and beer are produced in Lebanon. Data has been obtained directly from the factories for the year 1994 and is shown in Table 2-4. Emission factors in kg NMVOC/ per hl beverage produced are obtained from table 2-25 in the 1996 IPCC Guidelines, [2]. Worksheet 2-13 (1) of Appendix 2 presents the data for NMVOC emissions based on the total quantity of alcoholic beverages produced in Lebanon in 1994.

Table 2-4 Alcoholic Beverages Production in 1994

NAME	QUANTITY OF WINE PRODUCED (1994) (LTRS/YEAR)	QUANTITY OF BEAR PRODUCED (1994) (LTRS/YEAR)
Chatou (Beirut)	941,770	111,215
Ksara (Beirut)	1,100,000	750,000
Total	2,041,770	861,215

H.2 Bread and Other Food Products:

Emission factors in kg NMVOC/ per ton of food produced are obtained from table 2-26 in the 1996 IPCC Guidelines, [2]. The main food processing industries in Lebanon include meat and poultry, margarine, biscuits and cakes, bread and coffee roasting.

Meat and Poultry production is obtained from the Arab Union of Food Industry Report, page 21, [7]. The production in 1991, 1992, and 1993 was 79,000, 80,000 and 80,000 tons respectively. It is also assumed to be the production of the year 1994.

Sugar production is obtained from two references, one is from the Arab Union of Food Industry Report,[7] and from the Trade Information Centre, Ministry of Economy and Trade.

Margarine production is obtained from the Arab Union of Food Industry Report, pages 14 & 48 in Tables 7 and 17 of Reference 7. The total production of olive oil in 1994 was 8000 tons. It is subtracted from the total production of margarine and oil which was 29,590 tons. This gave margarine production of Lebanon in 1994 as 21,590 tons.

Biscuits, cakes and bread are produced from wheat. The total amount of wheat imported and produced in Lebanon was 389,000 tons. Seventy five percent was used for bread production and 25% was used for cakes and biscuits. The amount of wheat used for bread making was multiplied by a factor of 1.2 based on the fact that each kg of wheat produces 1.2 kg of bread.

The amount of green coffee imported to Lebanon in 1994 is obtained from Reference 7, page 34.

The emissions of NMVOC are presented in worksheet 2-13 (2) of Appendix 2 based on the total quantities of various types of food produced in Lebanon in 1994.

I. EMISSIONS RELATED TO PRODUCTION OF HALOCARBONS AND SULPHUR HEXAFLOURIDE:

conditioning applications, in the aerosol, solvents and foam industry, and in the fire fighting sector. Those sectors are using the Ozone Depleting Substances. Lebanon has only recently ratified the Montreal Protocol on March 31, 1993. Since then Lebanon has been working in a country program for applying phase out measures on these substances. In 1994, the phase out process was not yet enforced. The ban on imports and use of the Ozone Depleting Substances started only in 1996. A chemical substitute of these substances such as HFC134a was imported in small amount (2 tons) to Lebanon in 1993, [8]. It is assumed that in 1994, also an equal quantity was imported.

years after the ratification of the Montreal Protocol (1993) and they have to be included in any future inventory. **In this report only the bulk potential halocarbon emissions is calculated based on the amount imported** [1,2]. This is summarised in Worksheet 2-15 (1-3) of Appendix 2. No information or data was available on product imports and exports of items containing halocarbons and sulphur hexaflouride for the year 1994. Actual emission estimates of these gases were not possible.

2.4 CLOSURE OF THE INDUSTRIAL PROCESSES INVENTORY:

In 1994, the Lebanese industry emitted 1924.063 Gg (1,924,063 Tons) of carbon dioxide, 0.0003 Gg (300 Tons) of carbon monoxide, 0.01112 Gg of nitrogen oxide, 273.888 Gg (273,888 Tons) of non-methane volatile organic compounds and 3.382 Gg (3382.6 Tons) of sulphur dioxide.

Uncertainties and limitations are associated with the estimated greenhouse gas emissions. The emissions reported for industrial processes in Lebanon reflect current best estimates. Thus the reported emissions inventory provides a foundation for the development of a more detailed and comprehensive Lebanese inventory in the future. Specific limitations include: a) Quantitative estimates for some sources of greenhouse gas emissions were not always based on data obtained from specific sources, but from bulk imports of certain products; and (b) the accuracy of the inventory estimates relies heavily on emissions factors available from the IPCC Guidelines [1,2]. These factors are used in the Lebanese inventory. These factors may differ for some local industrial processes because of differences in the raw material used.

2.5 REFERENCES:

1. The Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Reference Manual (Volume 3).

2. The Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Workbook (Volume 2).

3. Republique Lebanaise, Presidence Du Conseil Des Ministres, Administration

4. of Feb.2, 1998, pp.9. Tables 1 & 2 obtained from the Ministry of Oil.

5. Environmental Resource Management Report on the state of the environment in Lebanon. Funded by the World Bank and conducted by the EDL, pp. 112, table 7.3b, 1993.

6. Ministry of Environment Study report, Lebanon, Feb.13-15, 1996.

7. Submitted to the Ministry of Industry, 1993-1994.

8. Ministry of Environment, Report of the Country Program of the National Working Committee on Ozone Depleting Substances in Lebanon, March 1996.

Table 2.27 Sectoral Report For Industrial Processes

Sheat (1 of 2)

Sectoral Report for National Greenhouse Gas Inventories (Gg)													
Green House Gas Source snd Sink Categories	**CO_2**	**CH_4**	**N_2O**	**NO_X**	**CO**	**NMVOC**	**SO_2**	**HFCs**		**PFCs**		**SF_6**	
								P	A	P	A	P	A
Total Industrial Processes	**1951.80**			**0.01**	**0.36**	**70.511**	**6.977**	**0.02**		**0.00**		**0.00**	
A Mineral Products													
1 Cement Production	1485.50						0.894						
2 Lime Production	16.41												
3 Limestone and Dolomite use	0												
4 Soda Ash Production and Use	5.01												
5 Asphalt Roofing					0	0.097							
6 Road Paving						70.067							
7 Others (Glass Production)						0.320							
B Chemical Industry													
1 Ammonia Production	0				0	0	0						
2 Nitric Acid Production	0												
3 Adipic Acid Production	0												
4 Carbide Production	0												
5 Others (Sulpheric Acid)							2.3625						
C Metal Production													
1 Iron and Steel Production	444.92			0.0111	0.3615	0.0278	0.2781						
2 Ferroalloys Production	0			0	0		0						
3 Aluminum Production	0			0	0		0						
4 SF6 Used in Aluminum And Magnesium Foundries	0												
5 Others (please specify)	0												

Table 2.27 Sectorial Report For Industrial Processes

Sheat (2 of 2)

Sectorial Report for National Greenhouse Gas Inventories

(Gg)

Green House Gas Source snd Sink Categories	CO_2	CH_4	N_2O	NO_X	CO	NMVOC	SO_2	HFCs		PFCs		SF_6	
								P	A	P	A	P	A
D Other Production													
1 Pulp and Paper	NO	NO	NO	NO	NO	NO	NO						
2 Food and Drink						3.4428							
E Production of Halocarbons and Sulphur Hexafluoride													
1 By-Product Emissions								NO	NO	NO	NO	NO	NO
2 Fugitive Emissions								NO	NO	NO	NO	NO	NO
3 Other (specify)								NO	NO	NO	NO	NO	NO
F Consumption of Halocarbons and Sulphur Hexafluoride								0.002	NE	0	NE	0	NE
1 Refrigeration and Air Conditioning Equipment									NE		NE		NE
2 Foam Blowing									NE		NE		NE
3 Fire Extinguishers									NE		NE		NE
4 Aerosols									NE		NE		NE
5 Solvents									NE		NE		NE
6 Other (specify)													
G Other (please specify)													

P: Potential emissions based on Tier I Approach. A= Actual emissions based on Tier 2 Approach

SECTOR 3
SOLVENT AND OTHER PRODUCT USE

This category covers mainly NMVOC emissions resulting from the use of solvents and other products containing volatile compounds. It also includes CO_2 and N_2O emissions from anesthetic and propellant gases. The only relevant part to Lebanon in this sector is paint applications, degreasing and dry cleaning. In Lebanon the amount of paint used in 1994 is estimated as 669 tons, while the amount of degreasing and dry cleaning solvents is estimated as 2,706 tons in 1994, [1]. The IPCC 1996 guidelines for national greenhouse gas inventories [2], does not provide emission factors of the amount of greenhouse gas per ton of solvent which is necessary to calculate the emitted amounts of gases.

REFERENCES:

1.

2. The Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Reference Manual (Volume 3).

Table 2.28 Sectoral Report For Solvent and Other Product Use

Sectoral Report for National Greenhouse Gas Inventories (Gg)			
Green House Gas Source snd Sink Categories	CO_2	N_2O	NMVOC
Total Solvent and Other Product Use			NE
A Paint Application (Sectoral Approach)			NE
B Degreasing and Dry Cleaning			NE
C Chemical Products, Manufacture and Processing	NO	NO	NO
D Other (Please Specify)	NO	NO	NO

SECTOR 4
AGRICULTURAL

4.1 INTRODUCTION

The Lebanese topography is such that only about one-third of land area is arable, and cultivation is confined to around 22% (1). The agricultural sector employs about 11% (1) of the active population and contributes only in an estimated 10 %(1) of national income.

A. CROPS

The Bekaa valley is the dominant agricultural region where a wide range of crops mainly potatoes, tomatoes and sugar beet are grown . South Lebanon is a wheat growing region while the coastal zone from the north to the south supports an intensive agriculture, primarily citrus, fruits, bananas and vegetables. Cereals are largely produced in the north of Lebanon especially in Akkar .

B. LIVESTOCK

Livestock is particularly concentrated in Akkar and in the Bekaa area. Livestock production contributes only an estimated 15% (1) of the domestic market. Cattle and dairy farming are of minor importance; bovines of all kinds are vastly outnumbered by sheep and goats. Poultry farming is in increasing development. In summary, Lebanon has become a large-scale exporter of fruits, vegetables and poultry, but remains a net importer of animals, dairy products, cereals and poultry foodstuff.

4.2 DOMESTIC LIVESTOCK

This section deals with methane and nitrous oxide emission from two sources:

- Enteric fermentation
- Manure management

Enteric fermentation contributes to methane emission as a by-product of the digestive process.

Manure management leads, under different conditions, to the emission of methane and nitrous oxide.

For estimation purposes, the revised default methodology developed by the IPCC (2) was followed.

The data needed to estimate methane and nitrous oxide emissions are provided from the FAO production year book -1994 (3). The table 4-1 summarizes these data.

Table 4-1 Livestock Population

Livestock type	Number of animals (1000_s)			
	1992	1993	1994	average
Cattle	73	77	80	76.7
Dairy Cattle	45	47		46.0
Non-dairy Cattle	28	30		30.7
Sheep	240	250	258	249.3
Goats	465	450	456	457.0
Camels	1	1	1	1
Horses	11	12	13	12.0
Mules and Asses	30	31	33	31.3
Swine	42	40	41	41.0
Poultry	20000	24000	24000	22700.0

In the last column of table 4-1 each number is a three year average except that of dairy cattle which is a two year average. The number of non-dairy cattle is obtained by subtracting the two year average of the dairy cattle from the average of the total number of cattle .

A. METHANE EMISSION FROM DOMESTIC LIVESTOCK

To estimate the emission of methane from domestic livestock, emission factors are needed. These factors are not available, therefore default values of the emission factors presented in the IPCC Reference Manual (2) for enteric fermentation and manure management are used

B. NITROUS OXIDE EMISSIONS FROM DOMESTIC LIVESTOCK

-The default value (18%) presented in the IPCC- workbook (4), in the used fuel system for dairy and non-dairy cattle is not appropriate for Lebanon

-The default value (77%) presented in the IPCC workbook (4) , in Pasture Range and Paddock system for dairy and non- dairy cattle seems to be high for Lebanese cattle farming.

This can be justified by considering the following:

- Personal field survey and interviews with farmers showed that animal waste is not used as fuel in the Hariri farm for cattle and poultry, where there are about 1000 cattle and 4 million poultry. The supervisor (5) of the farm confirmed the following:
    1- Animal waste is not used as fuel. This confirmation comes from small, and large farms.
    2- Animal waste is stored in the form of dry lots in a small area.
    3- Successively half of the cattle go daily to pasture.

- A great number of cattle stay near the farmhouses and therefore animal waste is treated in the drylot system.
- Information from the president of the south farmers congregation (6) indicate the following:

  1- Animal waste burning as fuel is no more a Lebanese farmer's practice.

  2- On the farms, animal waste is managed in solid storage and drylot system.

- There are no natural pastures in Lebanon except for some farms where we found a small area used as pasture (5,6).

From this we can conclude that, for Lebanon, the default value 77% (4) for cattle in pasture range and paddock system is high and that the default values 3 and zero presented in solid storage and drylot system (4) for dairy and non-dairy cattle respectively are very low. Instead of these default values we estimate the following values:

- 50% of animal waste for dairy and non-dairy cattle are deposited in pasture range and paddock system. This value is used in the worksheet 4-1 (supplemental) Pasture Range and Paddock.
- 48% of animal waste for dairy cattle and 46% for non-dairy cattle are managed in solid storage and drylot system. These two values are used in the worksheet 4-1(supplemental) solid storage and drylot system.
- 0% of animal waste is used as fuel. This value is used in the worksheet 4-1(supplemental) used fuel.

4.3 FIELD BURNING OF AGRICULTURAL RESIDUES

Important quantities of residues are produced from agricultural crops. Several broad categories of crop residues can be distinguished:

- Cereal residues like wheat straw and maize stalks
- Residues from pulse
- Residues from tuber and root
- Residues from legumes

Burning of crop residues in the fields can lead to the emission of the following gases:

CO_2, CO, CH_4, N_2O and NO_x .

This section accounts for emission of the non-CO_2 gases. The data required for the estimation of the emission of the above mentioned gases from crop residues are provided from FAO production yearbook (3)-1994. This data is presented in table 4-2.

Table 4-2 Annual Production of Crops from which Some Residues are Burned

Crop	Annual Production (Gg Crop)

	1992	1993	1994	Average
Wheat	62	50	39	50.333
Barley	21	20	22	21.000
Oats	1	1	1	1.000

We have selected only these crops for the following reasons:

Field survey (7) in the Bekaa, information from the south farmers congregation (6) and interviews with experts (8) showed that in the Bekaa, south-Lebanon and Akkar, the most important agricultural centers, large quantities of crop residues provide an important source of animal feed and at least are collected for this purpose by farmers and stored for the animals.

The fraction of residues remaining in fields after harvest is also used as feed in the case of some cereals like wheat, barley and oats. Sometimes it is partly burned because of agricultural disease (8).

The residues of all other crops are collected and thrown as waste or left on fields.

From this we can conclude that field burning of agricultural residues is not a common practice in Lebanon therefore the fraction burned in fields is estimated to be 1%. This value is used in the worksheet 4-4 sheet 1 of 3 step 3. In work sheet 4-4 sheet 1 of 3 the residue to crop ratio used for oat is 1.3, the same as for wheat, because of similarity of oat to the wheat .

4.4 AGRICULTURAL SOIL

Agricultural soils emit N_2O from three sources:

- Direct emission from agricultural soils that results from the nitrification and denitrification processes. This is particularly observed in organic soils.
- Direct soil emissions from animal waste management systems. This type of N_2O emission results from dung and urine deposited by free-range grazing animals.
- Indirect N_2O emission from nitrogen used in agriculture and resulting from the use of fertilizer.

In order to estimate N_2O emission from agricultural soils, the following data is needed:

- Synthetic nitrogen fertilizer consumption. This is available from FAO fertilizer year book (9) - 1996. This data is presented in table 4-3.
- Crop production which is available from FAO production yearbook (3) -1994. Table 4-4 summarizes this data.
- Livestock population in table 4-1 section 4-2.

Table 4-3 Annual Consumption of N-Fertilizer

	1992	1993	1994	average

Annual Consumption of N-Fertilizer ton-N/yr	12400	14200	18000	14866.6

Table 4-4 Annual Production of Crops

Crop	Annual Crop Production 1000t/yr			
	1992	1993	1994	Average
Cereals (a)	116	103	96	104.9
Pulses (b)	62.1	64.0	67.5	64.5
Tubers and Roots (c)	512	519	555	528.6
Other (d)	715	724	773	737.3

a) Includes: wheat, coarse grain, barley, maize oats and sorghum.
b) Includes: dry beans, broad beans, peas, chick peas, lentils, green beans and green peas. The FAO data of green beans and green peas are multiplied by (1-0.15) to account for crop water content.
(c) Includes: Potatoes, sugar beet and carrots.
(d) Includes: Taro, groundnut, cottonseed, cabbage, artichoke, cauliflower, tomatoes, pumpkin, cucumbers, onion, garlic, watermelon, cantaloupe, sugar cane, and tobacco leaves.

A. In the worksheet 4-5 A (supplemental) sheet 1 of 1 :

F_{AW} is calculated by considering $Frac_{GRAZ} = 0.6$. This value is obtained from the following :

$$Frac_{GRAZ} = \frac{Nex_{GRAZ}}{Nex}$$

$$Frac_{GRAZ} = \frac{25421.1 \times 10^3}{42106.7 \times 10^3} = 0.6$$

F_{CR} is calculated by considering

$$Frac_{BURN} = \frac{\text{fraction burned in fields for all crops}}{crop_{BF} + crop_{0}}$$

$$Frac_{BURN} = \frac{0.717\ Gg}{(64.5 + 1370.8)\ Gg} = 5 \times 10^{-4}$$

This formula can be explained as follow:
The total quantity of crop residues results by subtracting the FAO crop production from total crop biomass production.
The total crop biomass is obtained by multiplying the FAO crop production by the factor 2 [4].

FAO crop production = Production of pulses + soy beans in country ($crop_{BF}$) + production of non-N fixing crops in country($crop_{0}$)

FAO crop production = $crop_{BF} + crop_{0}$
From the above mentioned explanation it can be concluded that:
Total quantity of crop residues = FAO crop production = $crop_{BF} + crop_{0}$
In Lebanon, some fraction only of wheat, barley and oats is burned in field. The estimated fraction burned, 1%, belongs specifically to wheat, barley and oats. From this value and the annual production of wheat, barley and oats, the quantity of crop residues

burned in field can be obtained.
Fraction burned for all crop residues results from the following:

$$Frac_{BURN} = \frac{\text{quantity of residue burned in field}}{\text{Total quantity of crop residues}}$$

$$Frac_{BURN} = \frac{\text{quantity of residue burned in field}}{Crop_{BF} + crop_{0}}$$

Where:
$Crop_{BF}$= production of pulses + soybeans in country (kg dry biomass / yr)
$Crop_{0}$ = production of non- N- fixing crops in country (kg dry biomass / yr)

Quantity of residue burned in field=71.7x 0.01=0.717 Gg (worksheet 4-4, sheet 1 of 3)
$Crop_{BF}$ = 64.5 Gg (table 4-4 Annual production of crops)
$Crop_{0}$ = 1370.8 Gg (table 4-4 Annual production of crops)

The value 1370.8 results from the sum of the annual production of cereals, tubers and roots and other (table 4-4 Annual production of crops)

$$Frac\ BURN = \frac{0.717}{1370.8 + 64.5} = 5 \times 10^{-4}$$

B. In the worksheet 4-5 sheet 2 of 5:

The value of Fos is estimated to be null. Information from experts (10) confirmed that there is no organic soil in Lebanon.

F_{aw} = manure nitrogen used as fertilizer in country, corrected for NH_3 and NO_x emissions and excluding manure produced during grazing (kg N/yr)

$Frac_{GRAZ}$ = fraction of livestock nitrogen excreted and deposited onto soil during grazing (kg N / kg N excreted).

Nex_{GRAZ} = nitrogen excretion during grazing (worksheet 4-1) (supplemental), Pasture Range and Paddock system (kg N/yr).

Nex = total nitrogen excretion by animals in country (kg N/yr).

$Frac_{BURN}$ = fraction of crop residue that is burned rather than left on field.

4.5 REFERENCES

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7. Nasser Chreif, Plant-expert, Yammouneh-Lebanon.

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Table 2.33 Sectoral Report For Agriculture

(Sheet 1 of 1)

Sectoral Report for National Greenhouse Gas Inventories (Gg)						
Green House Gas Source snd Sink Categories		CH_4	N_2O	NO_X	CO	NMVOC
Total Agriculture		**7.97862**	**3.01482**	**0.00146**	**0.04306**	
A Enteric Fermentation						
	1 Cattle	2.63840				
	2 Buffalo	0				
	3 Sheep	1.24650				
	4 Goats	2.28500				
	5 Camels and Lamas	0.04600				
	6 Horses	0.21600				
	7 Mules and Asses	0.31300				
	8 Swine	0.41000				
	9 Poultry	NE				
	10 Other (please specify)					
B Manure Management						
	1 Cattle	0.12270				
	2 Buffalo	0				
	3 Sheep	0.03990				
	4 Goats	0.07770				
	5 Camels and Lamas	0.00192				
	6 Horses	0.01968				
	7 Mules and Asses	0.02817				
	8 Swine	0.12300				
	9 Poultry	0.40860				
	10 Anaerobic		0			
	11 Liquid Systems		0.00054			
	12 Solid Storage and Dry Lot		0.38870			
	13 Other (please specify)		0.03020			
C Rice Cultivation			0			
	1 Irrigated					
	2 Rainfed					

	3 Deep Water					
	4 Other (please specify)					
D Agricultural Soils			2.59534			
E Prescribed Burning of Savannas			0			
F Field Burning of Agricultural Residues						
	1 Cereals	0.00205	0.00004	0.00146	0.04306	
	2 Pulse					
	3 Tuber and Root					
	4 Sugar Cane					
	5 Other (please specify)					
G Other (please specify)						

SECTOR 5

LAND USE CHANGE AND FORESTRY

5.1 INTRODUCTION

Forests in Lebanon are considered as important natural resources and contain a remarkable range of vegetation. This is most likely due to geographical, geological and climatic factors. The area covered by the forests is relatively low and constitutes around 7% of the total area of Lebanon.

Most of the basic knowledge about the forest cover of Lebanon originates from the FAO mapping of the Lebanese forests in 1966.

of Bsharre (North Lebanon), Barouk forest (Mount Lebanon) and Qammouaa forest (North Lebanon). The main widespread forest tree types in Lebanon are Oak (Quercus calliprinos , Quercus infectoria), Juniper (Juniperus excelca), Cedar (Cedrus libani), Fir (Abies silicica), Pines (Pinus pinea, Pinus halepensis, Pinus brutia) and Cypress. The bulk of the forest area consists of Oak and Pine stands and the most climatically favored zone in Lebanon is the western slope of Mount Lebanon. In addition, the Lebanese forests contain diversified species of aromatic, wild, and medicinal plants.

Forests were severely neglected, along with other natural resources during the period of the Lebanese civil war. Therefore, the woodland area of Lebanon has sharply decreased. Deforestation was and still is basically due to the following factors; urban expansion in the mountain areas, illegal tree cutting, unlawful grazing and overgrazing, forest fires and poor management and harvesting policies of the forests. Deforestation has weakened the soil structure, accelerated soil erosion and led to the general degradation of soil quality.

The Barouk Cedar Forest and Horch Ehden (North Lebanon) were designated protected areas by law in 1991 and 1992 respectively . The forest law issued in 1949 and still valid, defines the rules of the forest exploitation, while a recent law introduced in 1996, addresses the issue of forest protection. Currently, a law is under preparation at the MoAg, dealing with the prevision, the prevention and the protection of forest from fire but Lebanon still suffers from improper enforcement measures against natural and man made forest fires.

The Forestry and Natural Resources Service of the MoAg is the main body in charge of the management of the forestry in Lebanon, with the support of various agencies acting under the jurisdiction of the MoAg. Efforts are now underway to restore and protect the forest cover. Several programs on reforestation and afforestation were implemented by the MoAg and several NGOs. The MoE is currently implementing a UNDP-funded GEF project on Protected Areas (started in 1996).This includes the management and by the ONF France, and is expected to be achieved in 1999.

5.2 CHANGES IN FOREST AND OTHER WOODY BIOMASS STOCKS

A. INTRODUCTION

The woody biomass stocks in Lebanon are made up of:

1- forest trees;

2- non-forest trees, which include:

  a- farm and village trees (mainly fruit and olive)

  b- urban trees.

An overview of the Lebanese forestry has been mentioned in the above section.

The fruit crops grown in Lebanon include both the temperate zone fruits and the subtropical fruits. Citrus, olives, apples, grapes (not considered as farm or village tree) and stone fruits are the main fruit crops, constituting about 90% of the fruit production area and accounting for 80% of the total Lebanese fruit production. Citrus trees are mainly grown in the south and the north of the coastal plain. Olive trees are mostly spread in the medium elevation mountains and are almost entirely rainfed. Bananas are essentially grown in the south coastal area and more recently in greenhouses using tissue-cultured plants. 75% of apples are grown in the medium and high elevation mountains. The total fruit production has increased during the last decades by about three folds to reach 1.5 million tons in 1994 (1).

Although cutting trees is forbidden by law , some commercial harvest for timber production (charcoal and industrial wood) occurred in 1994. Concerning the data on wood removed from forest clearing, extensive investigation has been made with no results both by the governmental and non-governmental institutions. The loss of woodland area in this submodule includes only the fuelwood consumed and the domestic timber product in Lebanon. The fuelwood energy, considered as a traditional one, represent with the hydropower energy only 1.7% of total energy consumed in Lebanon and it mainly occurs in some mountain villages for heating in the winter season (2). The loss of woody biomass stocks by natural and man made woodland fires has been taken into account on the submodule of forest and grassland conversion.

B. BIOMASS INCREMENT

a. Forest area

Primarily it must be pointed out, that the data related to the forests in Lebanon is more uncertain than in any other field. No comprehensive study of the forest has been conducted during the last decade.

The only available data on the national level are the following:

1- Coniferous forest area 29250,2 ha (around 40% of the total forest area) broadleaf forest area: 43215,2 ha (around 60% of the total forest area)

Total forest area: 72465 ha (3). These data could be considered for 1987 since the most recent of the used satellite images date back to the summer of that year.

2- Rough estimates on type forest/species for 1994 (4), (Table 5.1).

Table 5.1 Rough Estimates on Forest Cover

Type of forest/species	Area (ha)[(1)]
Oak	38 000
Pinus Pinea	14 000
Pinus Halpensis & Pinus Brutia	10 000
Juniper	9 000
Cedar	2 500
Cypress	2 000
Fir	1 500
Ripisylve	1 000
Total	**78 000**

The Table 5.1 estimates on forest types have been broken down into two subdivisions according to criteria provided by experts:

1- Evergreen Forest and Deciduous Forest.

The Oak in Lebanon is mainly made up of an evergreen species, the quercus calliprinosy (around three-quarter of the oak area or 28500 ha), and a deciduous species, the quercus infectoria (around the quarter of the oak area or 9500 ha). In addition, all the Ripisylve (around 1000 ha) are deciduous, while all the other types are evergreen (around 39000 ha) (5,6).

Therefore the **deciduous forest area is estimated at 10500 ha (around 13.5% of the total forest area) and the evergreen forest area at 67500 ha (around 86.5% of the total forest area).**

2- Coniferous Forest and Broadleaf Forest.

The oak and the ripisylve are broadleaf forest [6], while all the other types are coniferous forest [6].Broadleaf forest covers around 39,000ha and coniferous forest covers approximately the same surface (table 5.1). Therefore, around 50% of the total forest area are made up of broadleaf forest and 50% of coniferous.

The first subdivision (deciduous and evergreen) has been adopted in this module since the annual growth rate of dry matter necessary to compute the increment of biomass are available for this subdivision only. Nevertheless, the second subdivision, the same as in the FAO source, (coniferous and broadleaf) has been selected later in the forest and grassland conversion submodule since the default values of dry matter in above ground biomass is necessary to compute the quantity of biomass burned and is available only for this subdivision.

Although, the data of the two sources were collected in two different years (1987 and 1994) and by two different methodologies (one by satellite image processing, and the other by field work), and since the data of Mr. Akl is a rough estimation, the average of the data **(75,000 ha)** has been used. The estimate of the total forest area constitutes around 7% of the total area of Lebanon.

Therefore, the following figures are used in the worksheet **5-1 (sheet 1 of 3)** to compute the total carbon uptake increment by forest:

- **Evergreen forest area: 65000 ha (86.5% of 75000 ha the estimated total forest area)**
- **Deciduous forest area: 10,000 ha (13.5% of 75,000 ha the estimated total forest area)**
- **Annual growth rate for Evergreen forests: 2.5 tdm/ha [6]**
- **Annual growth rate for Deciduous forests: 1.5 tdm/ha [6]**
- **Default value of carbon fraction of dry matter: 0.5**

b. Non-Forest Trees

c. Farm and Village Trees

The farm and village trees are made up as mentioned before in section 5.2. A of fruit and olive trees. The data available are the areas of fruit and olive trees for 1993 (7) and for 1996 (8).

For baseline year 1994, the area data was estimated as follows:

i- dividing fruit and olive trees into evergreen trees and deciduous trees.

ii- calculation of the difference (increase or decrease) between the 1996 and 1993 data, occurring during three years.

iii- division of this difference by three, assuming that the results reflects the difference for one year.

iv - application of the difference (increase or decrease) calculated in step (iii) on 1993 data. **(Table 5.2).**

Finally, the number of trees for each species was computed from 1994 data using estimates of the number of trees/ha provided by expert judgment (9**) (Table 5.3)**.

Table 5.2 Evergreen Fruit & Olive Trees

Evergreen Trees	Area 1993[(7)] (ha)	Area 1996[(8)] (ha)	Increase(+)/ Decrease(-) per year (ha)	Estimated Area (1994) (ha)	Trees/ha[(9)]	Trees
Banana	3353.5	3005	-116.16	3237.34	2000	6474680
Citrus	12728.8	14087	+452.73	13181.53	450	5931688
Olive	42608	51552	+2981.33	45589.33	210	9573760

Total				62008.2		21980128

Table 5.3 Deciduous Fruit Trees

Deciduous Trees	Area 1993[7] (ha)	Area 1996[8] (ha)	Increase(+)/ Decrease(-) per year (ha)	Estimated Area (1994) (ha)	Trees/ha[9]	Trees
Apple and Others	38798.6	55910	+5703.8	**44502.4**	625	**27814000**

Since no studies on annual growth rate for fruit trees have been carried out in Lebanon, it was estimated that the annual growth rate per fruit tree is the three quarter of that per forest tree for both deciduous and evergreen trees [6].

According to expert judgement the cover rate of all forest types in Lebanon is estimated to be around 450 trees /ha[6]. Therefore, this value (450 trees/ha and the values of annual growth rate for both evergreen forest (2.5tdm/ha) and deciduous forest (1.5 tdm/ha) were used to compute the annual growth rate per forest tree (tdm/tree).

- The annual growth rate /evergreen forest tree is:

  $\frac{2.5 tdm/ha}{450 trees/ha} = 0.0055 tdm/$ evergreen forest tree

- The annual growth rate / deciduous forest tree is :

  $\frac{1.5 tdm/ha}{450 trees/ha} = 0.0033 tdm/$ deciduous forest tree

- The annual growth rate / evergreen fruit tree is :

- The annual growth rate / deciduous fruit tree is:

Therefore, the following figures are used in the worksheet 5-1 **(sheet 1 of 3)** to compute the total carbon uptake increment by farm and village trees:

- **Evergreen fruit and olive trees: 21980 thousand trees**
- **Annual growth rate for 1000 evergreen trees: 0.004125 ktdm**
- **Deciduous fruit and olive trees: 27814 thousand trees**
- **Annual growth rate for 1000 Deciduous fruit and olive trees: 0.002475 ktdm**

d. Urban Trees

The only official data for urban trees are the number of trees in municipal Beirut and the city surface (10). Although several responsibles in different public line organizations

(MoPW and several municipalities) have been interviewed, no data related to urban trees in Lebanon could be found. Rough estimates on urban trees were reached by a rapid field assessment conducted by the working team.

It must be pointed out that the coastal zone and few inland cities where the Lebanese population is mainly concentrated are considered as the area of concern in this field assessment. Therefore the number of urban trees was estimated as the following:

i- The urban coastal zone is assumed to have one cover rate of urban trees (trees/ha) while the inland cities were divided into two categories, one (including Aley, Beit-Meiri-Broumana-Baabdat, Bhamdoun Chtoura-Taalabaya-Jlala, Zahle, and Jezzine) is assumed to have a cover rate higher than the other (including Nabatiyeh and Baalback only).

ii- Five cities were selected as representative of the urban area : Tripoli, Beirut and Saida have been chosen from the coastal zone. Zahle was assumed to represent inland cities with a higher cover rate, while Nabatiyeh those with a lower cover rate.

iii- The areas of the urban coastal zone and the inland cities mentioned in (i) have been estimated at the NCRS by image processing using SPOT image 1992, assuming that the urban growth between 1992 and 1994 has mostly occurred within the urban area.

iv- Representative streets have been chosen within each of the selected cities. The number of trees was counted in the chosen streets. The length and the width of the streets were also field-assessed. This allowed us to estimate the streets cover rate of each of the selected cities. **(Table 5.4)**

v- It was assumed that trees in urban zone exist in the streets and squares only. According to the law 25% of urban areas are dedicated to the roads and squares. Therefore, the streets cover rate represent four times the cover rate of the city.

vi- The number of trees in inland cities has been calculated by multiplying the surface of each city as computed at the NCRS by the respective cover rate of the city as calculated in (v)..

vii- The number of trees in the urban coastal zone has been calculated by multiplying the surface of the urban coastal zone as computed at the NCRS by the average cover rate of Beirut, Tripoli and Saida (total number of trees divided by the total surface) **Table 5.5**.

viii- It was assumed that in the coastal zone all trees are evergreen, while some inland cities have deciduous trees only. **(Tables 5.5, 5.6, 5.7)**

Table 5-4 Streets Cover Rate of Selected Cities

Selected City	Street Area (ha)	Trees	Streets Cover Rate (Trees/ha)
	3.61	210	

Nabatiyeh	1.2 2.7	132 66	55
Total	**7.51**	**408**	
Saida	2.185 4.48 2.97 3.84	180 200 460 60	67
Total	**13.475**	**900**	
Tripoli	4.65	1600	344
Zahle	8	889	111

The following Tables show the data on urban trees as estimated by the working team on Land use change and Forestry:

Table 5-5 Estimated Evergreen Urban Trees in the Coastal Zone

Urban Zone	Cover Rate in the City/Urban Zone (Trees/ha)	Urban Area (ha)	Total Evergreen Trees in Urban Area
Beirut	11	3600(10)	40020(10)
Saida	17	320	5440
Tripoli	86	2690	231340
Total (Beirut, Saida and Tripoli)		6 610	276800
Coastal Zone	42	**9 418**	**395556**

Table 5-6 Estimated Evergreen Urban Trees in Inland Cities

Urban Zone	Cover Rate in the City/Urban Zone (Trees/ha)	Urban Area (ha)	Total Trees in Urban Area
Aley	28	465	13020
Beit-Meri, Broumana, Baabdat	28	1125	31500
Bhamdoun	28	187	5236
Jezzine	28	58	1624
Total		**1835**	**51380**

Table 5-7 Estimated Deciduous Urban Trees in Inland Cities

Urban Zone	Cover Rate in the City/Urban Zone (Trees/ha)	Urban Area (ha)	Total Trees in Urban Area
Baalback	14	873	12222

Chtoura, Taalabaya, Jlala	28	514	14392
Nabatiyeh	14	155.5	2177
Zahleh	28	248	6944
Total		**1790.5**	**35735**

- The total evergreen urban trees as estimated by our working team is:

  total evergreen trees in the coastal zone **(Table 5-5)** + total evergreen trees in inland cities **(Table 5-6)**

  395556 + 51380= 446936 trees or roughly 450000 trees

- The total evergreen urban area is:

  coastal zone area **(Table 5-5)** + total inland cities area which contains evergreen trees **(Table 5-6)**

  9 418 + 1835 = 11253 ha

- The evergreen urban cover rate is:

  450000 trees / 11253ha = 40 trees/ha

- The total deciduous urban trees as estimated by our working team is:

  35,735 trees or roughly 36,000 trees **(Table 5-7)**

- The total deciduous urban area is: 1790.5ha **(Table 5-7)**

- The deciduous urban cover rate is: 36000 trees/1790.5ha = 20 trees/ha

Since no studies on annual growth rate for urban trees have been carried out in Lebanon, it was assumed that the annual growth rate per forest tree is the same as for urban tree (0.005 tdm/ evergreen tree, 0.0033 tdm/ deciduous tree) .

Therefore, the following figures are used in the worksheet 5-1 (sheet 1 of 3):

Evergreen urban trees: 450,000 trees

Annual growth rate for 1000 evergreen urban trees: 0.0055 ktdm

Deciduous urban trees: 36,000 trees

Annual growth rate for 1000 evergreen urban trees: 0.0033 ktdm

As a result **the total carbon uptake increment by forest trees and non-forest trees** (farm and village trees, and urban trees) **is 1690800475 kt C worksheet 5-1 (sheet 1 of 3).**

(Recommendation by team member: Photogrametry technique is an accurate method for future collection of data related to forest trees and non-forest trees using aerial photos scale: 1/10000).

C. BIOMASS LOSS

As required in worksheet 5-1 (sheet 2 of 3), the biomass loss was computed from data on :

i- Fuelwood consumed collected from two sources:

1- 200-250kt for 1994[4]

2- 200 kt /y [11]

The value 200 kt/ y has been selected for 1994.

ii- Domestic timber production for 1994 [7]

Charcoal: 1.535 kt

Industrial wood: 147.344 kt

Worked wood: 68.419 kt

Therefore the following figures are used in the worksheet 5-1 (sheet 2 of 3):

Fuelwood consumed: 200 kt dm

Total other wood used (total domestic production): **217.298 kt dm**

The total biomass consumption from stocks for 1994 is 417.298kt dm

As a result of section 5.2 CO2 annual emission (-) or removal (+) by the sub-module changes in forest and other woody biomass stocks has been calculated in the **worksheet 5-1 (sheet 3of 3).For 1994, change in forest and other woody biomass stocks was a minor source of CO2 and the annual CO2 emission for that year was 142.4446 of CO2.**

5.3 FOREST AND GRASSLAND CONVERSION

A. INTRODUCTION

Forest and grassland conversion to permanent cropland is not an activity in Lebanon. Clearing forest for cropland may take place on a limited scale, but this practice when it occurs is illegal. Requested data on that issue are not available (4). Consequently, calculation of estimates of CO_2 emissions due to forest/grassland conversion is limited to the carbon dioxide emitted by burning aboveground biomass on-site (immediate emissions in 1994) which occurs from natural and man made woodland fires. The carbon dioxide released from soil is taken into account in section 5.5. Burning biomass on-site is also a significant source of non-CO_2 trace gases (CH_4, N_2O, CO and NO_x) and their emission estimates were calculated in this submodule. It must be noticed that the net CO_2 emissions from fuelwood consumption appears as a loss of biomass stocks in **section 5.2.C**, and non-CO_2 trace gases from fuelwood consumption were considered in the energy module.

B. CARBON RELEASED BY BURNING ABOVEGROUND BIOMASS ON-SITE

The woodland area in Lebanon is mainly affected by natural and man made forest fires. Data for forest fires in 1994 are not reliable. According to expert judgement, the range of forest fires in Lebanon in 1994 could be assimilated to that of 1995[6]. The later is estimated by the MoAg to be around 1300ha.

As required in worksheet 5-2, sheet 2 of 5, forests were subdivided into coniferous and broadleaf. Sources revealed two slightly different results, as following:

- Coniferous: around 40% of the total forest area.
  Broadleaf: around 605 of the total forest area [3]

- Coniferous: around 50% of the total forest area
  Broadleaf: around 50% of the total forest area[4]

The average of these two sources was used. Therefore, the forest area was assumed to be made up of **45% of coniferous and 55% of broadleaf** and the areas affected by fires were 585 ha for coniferous and 715 ha for broadleaf.

The value of this affected area (mostly forest area) was converted to tons of dry matter. The total dry matter is obtained by multiplying the area of each category by respective dry matter per hectare in aboveground biomass. The values of dry matter in aboveground 257.5 tdm /ha (average of the default value of coniferous temperate forests) and 35 tdm/ha (for broadleaf coppice) [6] have been respectively used for coniferous and broadleaf forests.

Total biomass in coniferous forests affected by fires :

0.2565 ktdm/ha x 585ha = 150.6375 ktdm

Total biomass in deciduous forest affected by fires is:

0.035 ktdm/ ha x 715 ha = 25.025 ktdm

The biomass burned on site was assumed to constitute around 20% of total biomass [6]. Therefore, the quantity of biomass burned is 30.1275 ktdm for coniferous forests and 5.005 ktdm for broadleaf forest.

The following figures are used in **worksheet 5-2 (sheet 2 of 5).**

- **Quantity of biomass burned on site for coniferous : 30.1275 ktdm**
- **Quantity of biomass burned on site for deciduous : 5.005 ktdm**
- **Default value of fraction of biomass oxidised on site : 0.9**
- **Default value of carbon fraction of aboveground biomass (burned on site): 0.5**

As a result , **the quantity of carbon released from biomass burned (forest fires) worksheet 5-2 (sheet 2 of 5) is : 15.809625 kt**

Worksheet 5-2 (sheet 5 of 5) converts the C released emission into CO2. The **CO2 emitted from forest fires is 57.968625 Gg.**

5.4 ON SITE BURNING OF FOREST: EMISSION OF NON-CO2 TRACE GASES

The non-CO_2 trace gases emissions from on-site burning of forests (forest fires) are calculated in **worksheet 5-3 (sheet 1 of 1)**.

CH_4 and CO are estimated as ratios to the carbon flux (15.809625 kt C) emitted during forest fires worksheet 5-2 (sheet 2 of 5). Total nitrogen content is estimated based on the nitrogen-carbon ratio (0.01). N_2O and NO_X are estimated as ratios to total nitrogen.

As a result, **Trace gas emissions from forest fires are:**

0.253 Gg of CH_4

2.213 Gg of CO

0.00168 Gg of N_2O

0.06276 Gg of NO_X

5.5 ABANDONMENT OF MANAGED LANDS

Different socio-economic factors, namely migration (external and internal), war and the generally low income from agriculture have been the main agents to abandonment of the ancient terraced lands in Lebanon, particularly in Mount Lebanon. It is estimated that there are about 90,000 ha of terraces in Lebanon, of which about 40% (36,000 ha) are either not being maintained or have been abandoned (12).

Nevertheless, some of the abandoned land may have been managed again or may have re-grown towards a natural state, but there is no quantitative data on the issue (4).

In the basic calculation of net CO_2 removals in biomass accumulation resulting from the abandonment of managed land, only abandoned lands which are regrowing towards a natural state should be included. Lands that do not regrow or degrade should be ignored in this calculation. Consequently there are no items to be taken into account in this submodule.

5.6 CO_2 EMISSIONS AND UPTAKE BY SOILS FROM LAND USE CHANGE AND MANAGEMENT

A. INTRODUCTION

The soils in Lebanon are typically Mediterranean in character, exhibiting similarities related to climate, exposure, slope, lithology and vegetation. Most of the soils are calcareous, except for the sandy soils formed on the basal Cretaceous strata. The most widely represented soils are the Terra-Rossa, the Inceptisols and the Rendzinas. On the steep landscapes of Lebanon and Anti-Lebanon, where water erosion can be extreme, the fersiallitic soils (Terra-Rossa) often develop into Lithosols (3).

According to several experts' judgments (13,14,15,16), organic soils in Lebanon are extremely rare. Consequently, conversion of organic soils to agriculture or plantation forestry is merely occurring in Lebanon. And since most of the soils in Lebanon are calcareous (basic soils), liming is not used in Lebanon. Therefore, the calculation of CO_2 emissions or uptake by soil in this submodule is limited to changes in carbon stored in soil and litter of mineral soils due to changes in agricultural land-use practices.

B. CHANGES IN MINERAL SOIL CARBON STOCKS

The net carbon fluxes must be calculated on the basis of changes in soil carbon stocks over a twenty-year period. In this context, the needed data relate to 1994 (the inventory year), and 1974 (for twenty years prior to the current inventory year).They must include for these two years:

- Agricultural land-use practices in Lebanon;
- The distribution (areas) of different soil type according to each agricultural land-use practices:

A lot of effort has been placed on that issue and several experts have been interviewed, namely Dr. Khoury W. (9), and Dr. Baalbaki R. (17) in addition to the experts mentioned in section **5.5.A**. They all agree that the agricultural land use practices could be estimated only for 1994, while the distribution (areas) of different soil type according to agricultural land use practices could not be established neither for 1994, nor for 1974.

Therefore, the data collected and related to the present module are the following:

- Estimates on soil type for selected areas in Lebanon (13,14).
- The extent of irrigation practice as a part of total cultivated land (8).
- Estimates of current agricultural land-use practices in Lebanon (9).
- Estimates on areas for 1974 and 1994 of different soil type by land-use classes based on the FAO land-use map, 1991 (3).
- Unified soil map of Lebanon (scale 1/50000) with database on soil in

  LNCSR with the cooperation of GORS (Syria) and the Lebanese University, started 1997, expected to be achieved 1999).

The above mentioned sources could be useful for updating purposes, but all data available to date are not sufficient for the calculation of net carbon fluxes on the basis of changes in soil carbon stocks in this submodule.

5.7 SUMMARY OF THE LAND USE CHANGE FORESTRY INVENTORY RESULTS

For 1994 , the change in woody biomass stocks is a source of CO_2 and emit

142.4446 kt of CO_2 due to the fuelwood consumed and to the timber production while the emission of CO_2 from forest fires is 57.968625 kt.

As a result, forest for 1994 are not a sink of CO_2 as they should be, but they are a minor source of CO_2 and release 200.413225 kt of CO_2. Change in woody biomass stocks contributes by 71% in the emission, and forest fires by 29%.

5.8 REFERENCES

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Table 2.41 Sectoral Report For Land-Use Change and Forestry

Sectoral Report for National Greenhouse Gas Inventories (Gg)						
Green House Gas Source snd Sink Categories	$CO_{2\ Emiss}$	CO_{2Remov}	CH_4	N_2O	NO_X	CO
Total Land-Use Change and Forestry	2880.2813	-600.62442	12.5685	0.0864083	3.1230477	109.97437
A Changes in Forest and Other Woody Biomass Stock						
1 Tropical Forests						
2 Temperate Forests		-600.62442				
3 Boreal Forests						
4 Graslass/ Tundra						
5 Other(please specify)						
B Forest and Grassland Conversion						
1 Tropical Forests						
2 Temperate Forests	2880.2813		12.5685	0.0864083	3.1230477	109.97437
3 Boreal Forests						
4 Graslass/ Tundra						
5 Other(please specify)						
C Abandonment of Managed Lands						
1 Tropical Forests						
2 Temperate Forests						
3 Boreal Forests						
4 Graslass/ Tundra						
5 Other(please specify)						
D CO_2 Emissions and Removals from Soil						
E Other(please specify)						

SECTOR 6
WASTE MANAGEMENT

6.1 INTRODUCTION

The waste management section of this report deals with two sectors: land disposal of solid waste and wastewater treatment. It provides background information on the type of emissions that contribute to the greenhouse gases from these two sectors, presents the current status in Lebanon of both sectors, describes the methodology followed to estimate the corresponding emissions, and presents the results obtained regarding greenhouse emissions which will be evaluated in the context of their potential contribution to the global warming effect. This section does not estimate emissions from solid waste incineration which is addressed in the energy sector.

6.2 BACKGROUND INFORMATION

Solid waste including municipal, commercial and industrial wastes, as well as municipal wastewater contains a large percentage of organic materials which can decompose under appropriate environmental conditions. In the absence of oxygen (anaerobic conditions), the decomposition process produces primarily methane (CH_4) and carbon dioxide (CO_2) and insignificant quantities of other gases. This process is carried to completion through a series of microbial populations the most important of which are referred to as methanogens or methane producing bacteria. These latter are sensitive to the waste composition and several environmental factors such as temperature, pH, and availability of nutrients. Assuming that favourable conditions for methane production persist, the objective of the present work is to estimate the amount and type of emissions from solid waste disposal and wastewater treatment.

6.3 SECTOR STATUS IN LEBANON

A. SOLID WASTE

Until recently, a comprehensive approach to solid waste management in Lebanon has been virtually absent. For the project year 1994, slow burning and uncontrolled dumping on hillsides and on seashores were still the common methods practised for solid waste disposal. In urban areas, uncontrolled open dumps became quite large particularly along the coastal front (The Normandy and Burj Hammoud sites in Beirut, and the Nahr Abu Ali site in Tripoli, etc.). Incineration was also practised at two relatively old facilities (Karantina and Amrousiyeh). Certainly the trend is changing and there is a great deal of effort to develop integrated solid waste management systems for most areas in Lebanon, particularly large urban areas. These efforts centre on the construction of many well-controlled sanitary landfills in combination with sorting, recycling, and composting facilities.

As such, data on solid waste disposal quantities for the target year of 1994 are relatively unreliable because of the uncontrolled nature of waste disposal and the general absence of weighing scales at disposal facilities. Therefore, the total daily quantity of waste generated has been generally expressed as a daily per capita generation rate multiplied by the number of population. Often these rates account for solid waste from commercial and industrial sources since the latter are not separated from regular household waste.

Following this approach, several survey studies have been conducted to estimate waste generation rates by examining small daily samples from a large number of communities of different sizes. The most relevant of these studies with respect to the 1994 target year, is a survey conducted by the American University of Beirut (1, 2). Table 6-1 presents generation rates for different localities (Caza) in Lebanon as reported in this study.

Table 6-1 Solid Waste Generation Rates for Different Cazas

Caza		Generation Rate kg/capita/day
Aley		0.78
Baabda		0.86
Beirut		0.74
Chouf		0.64
Kesrouan		0.77
Metn		0.70
Tripoli		0.64
Zahle		0.95
Other Communities	Highest Lowest	1.61 0.35

For estimation purposes, a rate of 0.8 kg/capita/day has been commonly used (3). Using this rate coupled with numbers on population estimates for the target year 1994, the total quantity of solid waste produced in different localities (Mohafazat) of Lebanon are calculated as presented in Table 6-2.

Table 6-2 Total Quantity of Solid Waste Generation for Different Mohafazats

Mohafazat	1994 Population	1994 Solid Waste
Greater Beirut Area	1,165	340.1
Mount Lebanon	695	202.9
Bekaa	460	134.3
North Lebanon	770	224.8
South Lebanon	635	185.4
Total Lebanon	3,725	1087.7

The composition of the solid waste quantities reported above vary substantially with socio-economic conditions, location, season, waste collection and disposal methods, sampling and sorting procedures, and many other factors. Table 6-3 presents average composition of unsorted municipal solid waste from the Beirut area. Despite the variability in its composition, solid waste in Lebanon as in most developing countries can be characterised by a high percentage of total organic content with relatively elevated moisture content.

Table 6-3 Composition of Unsorted MSW (1, 2)

Waste Category	Average Composition % by Weight
Paper/Cardboard	11.3
Food Waste	62.4
Diapers/Garments	4.2
Plastics	11.0
Glass/Brick	5.6
Metals	2.9
Other (wood)	2.6

B. WASTEWATER

Similar to solid waste, municipal wastewater management in Lebanon has been absent particularly during the many years of civil unrest during which existing treatment plants were destroyed and/or put out of operation. The general trend for wastewater management in urban areas along the seashores where the greater majority of the population resides has been limited to a deteriorated wastewater collection system that typically discharges into the sea. In other urban as well as rural areas, untreated wastewater is directly dumped into rivers, irrigation channels, valleys, and ravines as well as septic systems and then land disposal.

While numerous projects are underway to construct treatment plants around the country, for the target year 1994 and today, there are virtually no operational wastewater treatment plants in Lebanon.

Data on wastewater quantities for the target year of 1994 are typically estimated using a daily per capita average wastewater generation rate multiplied by the number of population. The daily per capita average rate can vary with location and season. For estimation purposes, a rate of 120 litre/capita/day has been reportedly commonly used for Lebanon (3, 4).

Wastewater is typically characterised in terms of several parameters such as Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and nitrates amongst other parameters. Table 6-4 summarises available information on wastewater characteristics in Lebanon (4).

Table 6-4 Typical Wastewater Characteristics in Lebanon

Parameter	Range (mg/l)	Average (mg/l)
BOD	30-230	128
COD	250-820	630
Nitrate-N	30-160	100

Using average per capita wastewater generation rate and average wastewater characteristics with the population estimates mentioned above, the total yearly quantity and quality of wastewater generated during the target year 1994, are summarised in Table 6-5 for different localities (Mohafazat) in Lebanon.

Table 6-5 Total Quantity of Wastewater Generation for Different Mohafazats

Mohafazat	1994 Population 00	1994 Wastewater ^{3}/year	1994 BOD	1994 COD	1994 N
Greater Beirut Area	1,165	51.0	6.5	32.0	5.1
Mount Lebanon	695	30.4	3.9	19.2	3.0
Bekaa	460	20.1	2.6	12.8	2.0
North Lebanon	770	33.7	4.3	21.2	3.4
South Lebanon	635	27.8	3.5	17.2	2.7
Total Lebanon	3,725	163.0	20.8	102.4	16.2

6.4 METHODOLOGY FOR EMISSION ESTIMATION

A. SOLID WASTE

The revised default methodology developed by the Intergovernmental Panel on Climate Change (IPCC) was followed in order to estimate emissions from solid waste disposal on land (5). The method follows a mass balance approach that involves estimating the degradable organic carbon (DOC) content of the solid waste to calculate the amount of CH_4 that can be generated by the waste.

Note that degradation processes will typically generate an approximately equivalent percent by volume of CO_2. However, the IPCC methodology assumes that the decomposition of organic material derived from biomass sources (e.g. crops, forests) which are re-grown on an annual basis is the primary source of CO_2 released from waste. Hence, CO_2 emissions from land disposal of solid waste are not treated as net emissions from waste in the IPCC methodology. They are rather reported under the Agriculture and Land Use Change and Forestry if biomass raw materials are not being sustainably produced.

The IPCC methodology is performed in four steps that are:

Step 1. Estimation of total MSW generated and disposed of in solid waste disposal sites.

The total MSW generated for the target year 1994 was estimated at 1087.7 $x10^3$ tonnes (Table 6-2). In Lebanon, about 70 percent of the population reside in urban areas. Waste generated from these areas is typically deposited in open dumps or incinerated thus accounting for about $761x10^3$ tonnes. Incineration at Amrousiyeh and Karantina accounted for about 400 tons/day (6), which are equivalent to $146x10^3$ tonnes per year. Therefore, the total amount of MSW disposed of in open dumps in the year 1994 is $615x10^3$ tonnes (615 Gg).

Step 2. Determination of the methane correction factor.

As indicated above, a good percentage of MSW is disposed of in open dumps. These dumps are unmanaged and have reached a depth far in excess of 5 meters. According to the IPCC guidelines, this corresponds to a methane correction factor of 0.8 (see attached IPCC sheet).

Step 3. Estimation of methane production rate per unit of waste.

The methane production rate per unit of waste is a direct function of the waste composition, which is presented in Table 6-3. The data in this table were used as described in the IPCC guidelines.

Step 4. Estimation of the total net annual methane emissions.

The total net annual methane emissions were calculated assuming a zero value for the methane oxidation correction factor which is a reasonable assumption given the fact that solid waste is deposited in open dumps with no potential gas entrapment at the surface of the dump. Gas will be emitted unobstructed into the atmosphere leaving no time for oxidation to occur.

B. WASTEWATER

Similar to solid waste, the revised default methodology developed by the IPCC can be followed in order to estimate emissions from wastewater and industrial waste treatment (5). The amount of methane that can be emitted is a direct function of the BOD and COD annual loading that are provided in Table 6-5. This information coupled with the type of treatment system utilised is required in order to estimate emissions.

6.5 RESULTS OF EMISSION ESTIMATION

A. SOLID WASTE

The total methane emissions from solid waste disposal on land are 42,804 tonnes (42.804 Gg) approximately. Methane emission estimates are summarised in Table 6 about Sectoral Report for Waste and the attached IPCC sheets.

B. WASTEWATER

There are no emissions from wastewater and industrial waste handling systems because for the target year 1994, there was no treatment facilities in Lebanon. The wastewater (municipal, commercial, and industrial) was directly discharged into the sea, rivers, ravines, or septic tanks which indicate that methane or nitrous oxide emissions are insignificant if not non-existent. Note that this situation will change in the future as treatment plants are being constructed around the country and are expected to come into operation by the year 2,000.

6.6 REFERENCES

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Table 6-6 Sectorial Report for Waste

(Sheet 1 of 1)

Sectorial Report for National Greenhouse Gas Inventories (Gg)						
Greenhouse Gas Source and Sink Categories	CO_2[1]	CH_4	N_2O	NO_x	CO	MNVOC
Total Waste		0.0837				
A. Solid Waste Disposal on Land						
1. Managed Waste Disposal on Land	0	0	0	0	0	0
2. Unmanaged Waste Disposal Sites	IE[1]	0.0837	0	0	0	0
3. Other (please specify)	0	0	0	0	0	0
B. Wastewater Handling						
1. ndustrial Wastewater	0	0	0	0	0	0
2. Domestic and Commercial Wastewater	0	0	0	0	0	0
3. Other (please specify)	0	0	0	0	0	0
C. Waste Incineration	IE[2]	IE[2]	IE[2]	IE[2]	IE[2]	IE[2]
D. Other (please specify)	0	0	0	0	0	0

[1] Note that CO_2 from waste disposal and incineration should only be included if it stems from non-biological or inorganic waste sources
IE[1] Addressed in the Agriculture Sector
IE[2] Addressed in the Energy Sector

Table 2.47 Sectoral Report For Waste

Sectoral Report for National Greenhouse Gas Inventories (Gg)						
Green House Gas Source snd Sink Categories	CO_2[1]	CH_4	N_2O	NO_X	CO	NMVOC
Total Waste	0	0.0837	0	0	0	0
A Solid Waste Disposal on Land						
1 Managed Waste Disposal on Land	0	0	0	0	0	0
2 Unmanaged Waste Disposal Sites	IE[1]	0.0837	0	0	0	0
3 Other (specify)						
B Waste Water Handling						
1 Industrial Wastewater	0	0	0	0	0	0
2 Domestic and Commercial Wastewater	0	0	0	0	0	0
3 Other (specify)	0	0	0	0	0	0
C Waste Incineration	IE[2]	IE[2]	IE[2]	IE[2]	IE[2]	IE[2]
D Other(please specify)	0	0	0	0	0	0

[1] Note that CO_2 from waste disposal and incineration should only be included if it stems from non-biological or inorganic waste sources

IE[1] Addressed in the Agriculture sector

IE[2] Addressed in the Energy Sector

3.3 SUMMARY OF BASELINE SCENARIOS

3.3.1 ELECTRICITY SECTOR

The electric power supply in Lebanon is a State monopoly by law. The public agency entrusted with electricity generation, transmission and distribution is the autonomous "Electricite Du Liban" (EDL) which is responsible to the Ministry of Hydraulic and Electric Resources. Lebanon imports almost all needed resources to generate electricity (with the exception of very little contribution from the hydro power plants). These resources are fuel oil, diesel oil and natural gas in the future.

The power sector in Lebanon has been going since 1993 through a major rehabilitation program in order to cope with the consequences of 17 years of civil war. Such a program was launched by the Lebanese Council for Development and Reconstruction (CDR) in October 1993. The budget of this program is estimated at US$1.7 billion from national and foreign funding. From the preliminary assessment and forecast of future electricity supply-demand balances, made on the basis of the prevailing rehabilitation and expansion program, the following observations can be made:

- Even with the rehabilitated facilities and all expansion capacities, the total production capacity would hardly cover the peak load estimates of the years 2000 onwards. However, since the expansion of the transmission network will not be ready before 2002, it only makes sense then to install extra units starting 2002 onwards.
- A sufficient spinning reserve should be considered to provide continuos electricity supply capable of responding to preventive maintenance and unit failures needs.
- A gradual withdrawal of rehabilitated facilities has to be considered from the year 2000 onwards.
- Major available and planned options depend on imported fuels.

THE BASELINE SCENARIO

The baseline scenario provides all the necessary information on activities that took place since 1994 (base line year) as well as the most likely developments that are planned for the future. Two plans have been distinguished; a short term plan extending from 1994 till 2005, and a long term plan extending from 2005 till 2040.

The supply system projections are closely linked to already announced government policy and priorities. In particular, the already announced policy of the government on the following matters:

- Commitment to full restoration of the generation, transmission and distribution networks.
- Commitment to continuously increase the capacity in the future to meet the expected increase in demand.

Lebanon's demand is divided into 2 parts:

1. Industrial.
2. Residential, commercial and others including schools, hospitals, governmental buildings, and electricity needs for agriculture, and concessions.

The growth in demand for the years 1994-1998 has been officially recorded by EDL; however, future demand on electricity is a function of income, prices, efficiency of energy conversion and government policy. In this study, the forecast of electricity demand growth for the years 1994-2004 was made to follow the GDP trend, but for the years 2005-2040 was based on the assumptions that by that time all the necessary infrastructure projects will be over and Lebanon will become a good place to attract foreign investments. Hence, the following 3 scenarios, which are consistent with the projected economic growth of 3-6%, are proposed to accommodate possible demand growth. These are a low growth scenario: 4% annually, a medium growth scenario: 6% annually, and a high growth scenario: 8% annually. Table 3.1 shows the energy balance for the 4% demand growth rate.

Table 3.1. Energy Balance (GWh)

	94	**2000**	**2005**	**2015**	**2040**
Total Generation	5000	7570	12400	18360	48930
Total Demand	6800	10190	12400	18360	48930
EDL shortfall	2550	2630	0	0	0

The data provided in this Table may not tie very well with the data used by the building and industrial sectors. This is due to the energy loss, energy used in the power plants and electricity used in the agriculture which were not accounted for elsewhere.

Shortages in electricity supply are to be expected at least until the year 2002 because of the unfinished works in the transmission network. Later, there is a need that every five years, necessary extra units are installed to satisfy the demand over the next five years (Table 3.2).

Under the assumed demand growth of 4% and technical losses of 15%, the supply of electricity with no shortages will require the yearly addition of the following capacity.

Table 3.2. Required yearly expansion of generation capacity

Years	2006-2010	2011-2015	2016-2020	2021-2025	2026-2030	2031-2035	2036-2040
Capacity, MW	130	154	181	222	271	332	491

The generation of electric energy in Lebanon is done mainly through thermal units operating on fuel and diesel oils and through very little of hydro power. In 1996, two combined cycle power plants were installed but they are expected to continue operating on diesel oil until 2005. At that time natural gas is expected to become available and the combined cycle units will fully operate on natural gas. However, because the future availability of natural gas is highly uncertain, the increase in demand will be satisfied in the baseline scenario by the continuous addition of thermal units operating on fuel oil.

Using projections on future demand and generation, the total emissions for the years 1994-2040 are calculated as shown in Table 3.3.

Table 3.3. Total emissions for 2005-2040 (Gg)

	1994-2004	2005-2040		
		4%	6%	8%
Carbon Dioxide	39644	741450	1200870	1952920
Carbon Monoxide	8.76	180	275	430
Nitrogen	117	2074	3343	5421
Sulfur	557	8459	14492	24362

Transmission and distribution losses in Lebanon can be classified as technical and non-technical losses. Non-technical losses (very high in the last years reaching at some time 60%) result from theft of electricity through unauthorized connections and tempering with meter readings. Recently, these losses have been reduced significantly and will continue to reduce in the future. In this analysis, such losses were not considered. Technical losses, on the other hand, were estimated at 15% in the baseline scenario, and it is assumed that after the rehabilitation is over and normal operation goes back to the system, losses can be significantly reduce. Table 3.4 shows the environmental benefit that will take place if EDL succeeds in bringing its technical losses down to 10%.

Table 4. baseline scenario emissions reduction due to loss reduction

Losses (%)	Growth (%)	Discount rate (%)	Average yearly emissions reduction, Gg/year			
			CO2	CO	NOX	SOX
10	4	10	624	0.13	1.7	8
10	6	10	1028	0.21	2.8	13.5
10	8	10	1758	0.36	4.9	23

CONCLUDING REMARKS

From the baseline scenario of the electricity supply sector in Lebanon, the following conclusions can be drawn based on the results obtained:

- Shortages in electricity supply are to be expected at least until the year 2002. This is mainly due to the unfinished works in the transmission network. Between 2002-2005, the situation will depend on the availability of funds to install extra units of about 475MW. Later, there is a need that every five years, necessary extra units are installed to satisfy the demand over the next five years.
- The contribution of hydro power stations is on the decrease as there are no government plans neither to increase the capacity of the existing plants nor to build new hydro power plants. Also, the water resources in Lebanon are not expected to contribute more in the future.
- Natural gas will not be available in the market before 2005. Therefore, the new combined cycle's power plants will continue to operate on diesel oil. A matter that defies their purpose as clean and efficient technologies. The reason for this fact is that natural gas is not available in Lebanon and the construction of pipes that will bring it from Syria has not been finished yet.
- When some thermal units are retired, the replacement will be done with units operating on fuel oil.

3.3.3 TRANSPORTATION

The transport sector of Lebanon constitutes a fleet of over one million registered vehicles and can be characterized as being relatively old and poorly maintained. Moreover, the car ownership rate in Lebanon (3 persons for every car) is amongst the highest in the world. In the baseline and mitigation assessment, the data used in the comprehensive evaluation of national, social and economic development frameworks for climate change mitigation process included base year statistics as well as common data for short- and long- term projections.

Base Year Conditions

The Lebanese transport sector in 1994 could be characterized by the poor status and the lack of a regular vehicle inspection program on a regular basis. The cumulative total of vehicles registered in Lebanon reached close to 1.4 million at the end of 1996, however, the actual number may not exceed 1 million vehicles. The average age of private vehicles is around 14 years.

The number of red- plat vehicles has undergone a significant change from around 10 thousand vehicles in 1994 up to around 32 thousands. Two bus services are operated, one publicly owned and one privately owned, the latter being more efficient. This sector has witnessed a significant improvement in the bus fleet size but with a disproportionate increase in ridership.

In the rail sector, studies have been conducted for the rehabilitation and upgrading of the 170 km of railway along the coast. However, in light of the concerns raised about the potential impact of such an upgraded railway on the coastal area, consideration is being given to the possibility of looking at the feasibility of an alternative alignment.

Baseline Scenario Projection

It is expected that fuel prices will keep fluctuating around a price of about $16/barrel for crude oil. Prices of fuel used for transport in Lebanon have been increased due to additional taxation. These increases, however, had small impact on fuel consumption due to the lack of alternative means for transport and due to low fuel prices compared to other countries and compared to average income.

The statistics of imported fuel for transport indicate that the amount of fuel will be slightly dropping in the short term due to the improvement in the status of the fleet caused by the ban on import of cars older than 8 years.

In the baseline scenario, it is assumed that the number of vehicles will have an annual increase of around 1.5%. The fleet condition is expected to improve so that by year 2005, the average age of the fleet will drop to around 10-12 years compared to the 14- years average of 1994. Transport management would eventually lead to some consumption reduction. Inside GBA, however, most of the measures are within the scope of traffic control rather than traffic jams reduction.

In providing short- and long- term projections, the following factors are taken into consideration:

- Private cars: 1.5% annual increase throughout.
- Taxis and microbuses: 30,000 by 1997 and an annual increase of 1% for later years.
- Buses: 4000 by 1996, and 1% increase from then on.
- Trucks and others: 96000 by 1996, and 1% annual increase from then on.

The annual distance travelled is expected to increase to 16000 Km by 2005, and to 18000 Km by 2040. Moreover, it is expected that the consumption rate for all vehicles will drop by 10% by year 2005 due to the drop in the average age of the fleet. The projection of the demand for gasoline, diesel, and jet fuel is shown in Fig.3.1

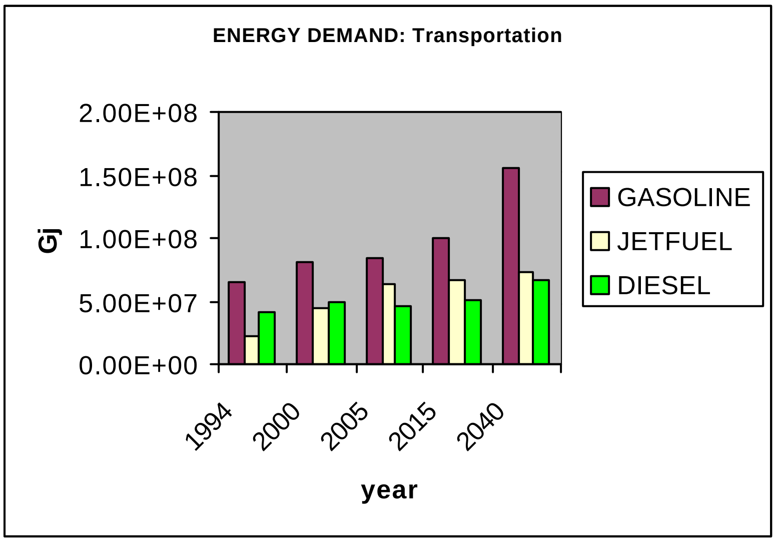


Fig.3.1 Transport fuel projection in the base line scenario.

The rehabilitation and extension project of Beirut International Airport would increase the capacity to around 6 million passengers annually. Plans are being developed to use the airport as a center for delivery and distribution of air cargo, served by feeder activity. For seaport and marinas activities, it is assumed that fuel consumed for sea transport is restricted to that used by local marinas and sports clubs. In the base line scenario and in the absence of any statistics or plans, the data are set taking into consideration the new marina projects being planned and built along the Lebanese coast.

Table 3.7. Transport data

	Number of Vehicles				
Device	1994	2000	2005	2015	2040
CARS & JEEPS	914000	999000	1077000	1249000	1813000
TAXIS & MICROBUSES	9000	30909	32486	35884	46019
BIG BUSES	4000	4566	4799	5301	6798
TRUCKS & OTHERS	85000	99846	104939	115918	148657
	Number of boats				
SMALL BOATS	280	738	1200	1440	2400
	Number of Flights				
PASSANGER JETPLANES	19450	38878	61220	63791	70220
FREIGHT JETPLANES	1500	2517	4000	4200	4700

Table 3.8: Consumption rates in the base line projection

Vehicle Type	Consumption (Gj/vehicle) = (Gj/veh/km)* (km)				
	1994	2000	2005	2015	2040
CARS & JEEPS	70.065	75.525	72.066	74.638	81.075
TAXIS & MICROBUSES	202.409	202.409	182.168	182.168	182.168
BIG BUSES	369.750	369.750	332.775	332.775	332.775
TRUCKS & OTHERS	475.393	475.393	427.854	427.854	427.854
ELEC-GASO-VEH.	35.032	37.762	36.033	37.319	40.537
ELEC.TRAINS	12600	12600	12600	12600	12600
	Consumption (Gj /flight)				

P-JETPLANES	1080	1080	972	972	972
F-JETPLANES	1080	1080	972	972	972
Consumption (Gj / boat)					
SMALL BOATS	36.975	36.975	33.278	33.278	33.278

A summary of the data used for the baseline scenario is shown in Table 3.7. Table 3.8 presents the consumption rate of various elements of the transportation sector.

Concluding Remarks

Gasoline will still be the major source of fuel for the transport sector and consequently, transport sector in Lebanon will still be regarded as the major source of greenhouse gases, namely carbon dioxide. The annual distance traveled would increase from 14000 km in 1994 only to 18000 km by 2040. The increase in the number of cars in accordance with the population growth would lead to a fleet size of 1.8 vehicles in 2040, compared to 0.914 million in 1994. The Lebanese fleet will be modernized to a certain extent, leading to consumption and emission reductions. The overall result is almost a doubling in the amount of GHG emitted, from around 4160 tons of CO_2 in 1994 up to 9150 tons in 2040. Buses used for private and public transport will increase due to the intention of the Government to implement public transport in the whole country in the foreseeable future.

3.3.5 BUILDING SECTOR

3.3.5.a Electricity Consumption in the Residential and Commercial Sectors

The residential and commercial sectors consumed, in 1994, 30% of the final energy consumption, which is 30 x 10^6 Gj, and in turn produced 1737 Gg of CO2.

Detailed analysis of electricity consumption in both the residential and commercial sectors was achieved by introducing necessary modifications to the previous studies done in 1992 by EDF.

Table 3.14 shows the structure of electricity demand in the residential and commercial sectors.

Table 3.14. Structure of low voltage electricity demand for household equipment Residential and commercial 1994*

Equipment	Residentail			Commercial			Sum		Total CO2 emissions in Gg
	Number in thousand	Unit consumps in Kwh	Total consump in Tj	Number in thousand	Unit consumps in Kwh	Total consump in Tj	In Tj	In %	
Lighting	720.8	371.5	964.0	201.4	432.0	313.2	1277.2	8.5	78.1
Refrigerator	720.8	342.1	887.7	201.4	51.8	37.6	935.5	6.2	56.6
Freezer	720.8	77.8	201.9	201.4	36.3	26.3	228.2	1.5	13.9
Iron	720.8	205.2	532.5	201.4	0.0	0.0	532.3	3.6	32.5
Extractor	720.8	34.2	88.7	201.4	27.0	19.6	108.4	0.7	6.6
Electric Oven	720.8	54.0	140.1	201.4	36.0	26.1	166.4	1.1	10.2
Electric Boiler	720.8	29.7	77.1	201.4	27.0	19.6	96.5	0.6	5.9
Laundry Washer	720.8	97.2	252.2	201.4	27.0	19.6	271.7	1.8	16.6
Hair Dryer	720.8	8.1	21.0	201.4	0.0	0.0	21.0	0.1	1.3
Radio	720.8	18.6	48.3	201.4	4.3	3.1	51.5	0.3	3.1
TV B/W	720.8	17.6	45.7	201.4	2.9	2.1	47.7	0.3	2.9
TV Color	720.8	103.7	269.1	201.4	17.3	12.5	281.6	1.9	17.2
Table Fan	720.8	18.6	48.3	201.4	43.2	31.3	79.4	0.5	4.9
Roof Fan	720.8	10.5	27.2	201.4	16.2	11.7	38.9	0.3	2.4

A/C	720.8	540.0	1401.2	201.4	810.0	587.3	1988.5	13.3	121.5
DHW**	720.8	1166.4	3026.7	201.4	324.0	234.9	3261.5	21.8	199.3
Electric Heater	720.8	1296.0	3363.0	201.4	1800.0	1305.1	4668.1	31.2	285.3
Other Household	720.8	0.0	0.0	201.4	1296.0	939.7	939.5	6.3	57.4
TOTAL	720.8	4391.2	11394.6	201.4	4951.0	3589.7	14984.3	100.0	915.7

* Note that ALME estimated this data based on the 1991 data with a 2% yearly increase in the number of households
** DHW: Domestic Hot Water used for sanitary purposes in residential & commercial sectors

By analyzing the electricity structure and consumption for both residential and commercial sectors, we found out that the most consuming equipment which represent 80% of the total electricity consumption are:

- Electric heaters for space heating 31%
- Electric hot water for sanitary purposes: 22%
- Air conditioning: 13%
- Lighting: 8,5%
- Refrigerator: 6%

Since there are no specific policies for the management of demand in Lebanon, the energy efficiency in the residential and commercial sectors is slightly and slowly improved by the introduction of some efficient equipment due to the dynamic of the market but with different payback times, penetration rate and incremental costs.

Table 3.15 Electricity demand for the residential and commercial sectors Base case (business as ususl)

YEAR	1994	2000	2005	2015	2040
LOW Scenarios, 10^6 Gj					
RESIDENTIAL	10.88	22.16	27.22	33.07	46.20
COMMERCIAL	3.32	6.94	10.32	17.47	41.38
TOTAL LOW	14.20	29.10	37.54	50.54	87.58

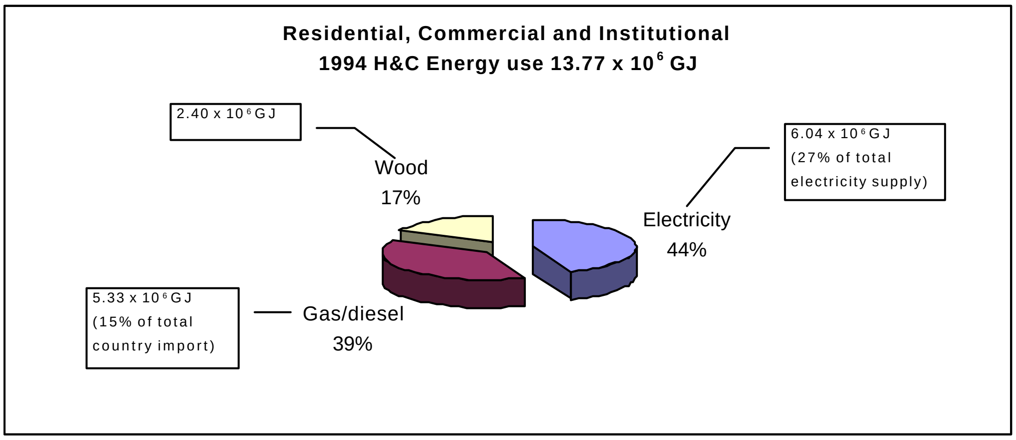
YEAR	1994	2000	2005	2015	2040
HIGH Scenarios, 10^6 Gj					
RESIDENTIAL	10.88	24.14	29.29	35.03	53.20
COMMERCIAL	3.32	7.56	12.98	30.25	142.21
TOTAL LOW	14.20	31.70	42.27	65.28	195.41

3.3.5.b Building Envelops

Background

The energy consumed by the residential, commercial and institutional sector for space heating and cooling amounted to 13.77 x 10^6 GJ in 1994. As shown in Fig.3.2, this energy was derived from three sources: electricity, gas/diesel oil and wood. Where by the amount of electricity used corresponded to 27% of total country electricity-supply, and the amount of gas/diesel oil used corresponded to 15% of total country imports of gas/diesel oil.

Fig. 3.2: 1994 Heating and cooling energy demand.



Building envelopes, and depending on their thermal characteristics play a key role in determining the amount of energy used for the provision of occupant thermal comfort. Although this is the case, the Lebanese building law has so far lacked any reference to the thermal performance of building envelopes.

Nevertheless there has been a recent governmental commissioning of a study concerned with the upgrading of the thermal performance of building envelopes in Lebanon. The specified upgrading suggestions are expected to bring about a 25% energy reduction on space heating and cooling needs.

This study, once approved, is intended to serve as a voluntary "guideline" only, given the numerous prevalent barriers that hinder its adoption and application. This in turn limits the possibilities of national energy reduction benefits.

Sector Description

Climate:

Although Lebanon can be said to exhibit a typical mild Mediterranean climate, the marked variety of its topography, in addition to the variety of wind regimes to which it is exposed give rise to several geo-climatic regions, documented in the "Atlas Climatique du Liban". For the purpose of this analysis, four geo-climatic zones have been considered: coastal, mid-mountainous, high-mountainous and inland.

Building Stock:

In order to determine the composition of the prevalent building stock in terms of age, use and geo-climatic distribution, the analysis relied on the 1996 building survey conducted by the Lebanese "Administration Centrale de la Statistique". From this survey, one can determine that the existing number of buildings until the base year 1994, was in the order of 480 000 buildings representing some 1.34 million building units. (75% of these building units are for residential use)

In terms of geo-climatic distribution, around 52% of these buildings was located in the coastal zone where the dominant energy requirement for thermal comfort is for cooling, and around 40% is located in the mid and high mountainous zones where the predominant energy requirement is for space heating.

Envelop Thermal Characteristics:

The thermal characteristics of the prevalent building envelop construction was found to be between 2.5 and 5.5 $W/m^2.K$. The current construction practice leads to a waste of energy, and the potential for improving the thermal integrity of building envelopes is considerable.

Regulations and Initiatives:

The Lebanese Building Law has so far lacked any reference to the thermal performance of buildings, and as a result, has lacked any consideration for the energy consumption of buildings.

In 1995 however, a study on summer and winter thermal comfort in buildings has been commissioned. The study entitled "Guide de L'isolation Thermique et du Comfort D'ete des Batiments au Liban" is intended for voluntary application. At present, there exists numerous market, institutional, information and human capacity barriers that impede the adoption and application of the thermal building guidelines.

The proposed thermal building guidelines can lead to an estimated 25% energy reduction for heating and cooling per household. In light of these barriers, there are no governmental plans to transform these guidelines into building standards, nor to activate market demand in order to increase the voluntary application of these guidelines.

Environment and Energy:

The energy consumed by the building sector in 1994 for space heating and cooling can be seen in the following table:

Table 3.16: 1994 energy consumption for the provision of thermal comfort.

		1994 10^6 GJ	**1994** Gg CO_2
RESIDENTIAL	Electricity	4.33	263
	Gas/diesel oil	2.82	208
	Wood	2.40	258
	Sub-total	*9.55*	*729*
COMMERCIAL & INSTITUTIONAL	Electricity	1.71	104
	Gas/diesel oil	2.51	183
	Sub-total	*4.22*	*287*
TOTAL		**13.77**	**1016**

Baseline Forecast

Based on a series of input data and assumptions, two baseline scenarios have been considered (fig.2). The forecast results for the period 1994 – 2040 revealed the following:

- Under a low baseline scenario of 3% energy growth rate for space heating and cooling, the associated total energy consumption between 1994 and 2040 will be 1339 x 10^6 GJ, and will result in the emissions of 208 750 Gg of CO_2. Where as the yearly average energy demand will be 28.48 x 10^6 GJ/yr, and will result in the emission of 4 442 Gg of CO_2/yr.

- Under a high baseline scenario of 4% energy growth rate for space heating and cooling, the associated total energy consumption between 1994 and 2040 will be 1771 x 10^6 GJ, and will result in the emissions of 276 236 Gg of CO_2. Where as the yearly average energy demand will be 37.68 x 10^6 GJ/yr, and will result in the emission of 5877 Gg of CO_2/yr.

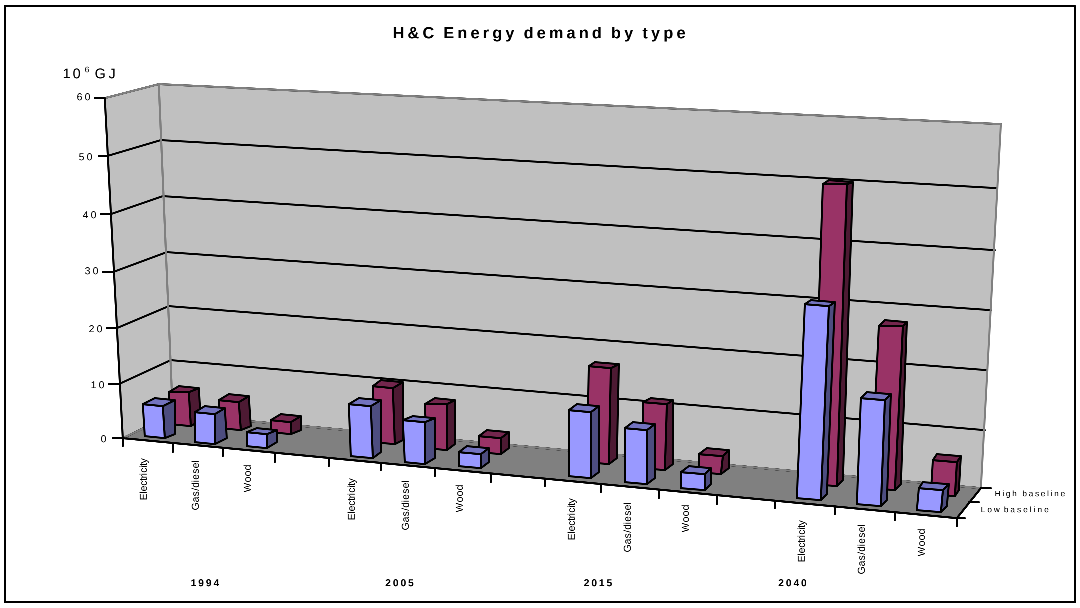


Fig. 3.3: Forecast of heating and cooling energy demand by type.

Results

Both under a low and high baseline scenarios of energy demand growth, the most likely chain of events, in terms of application of “guidelines”, will result in 3.2% energy reduction for heating and cooling. Moreover, under both baseline scenarios, the greatest share of growth in energy demand for heating and cooling is from electricity. This means that the environmental implications in terms of CO2 emissions will be dependant on the form of electricity production.

3.3.4 WASTE SECTOR

Waste management covers two major activities:

- Land disposal of solid waste; and
- Wastewater treatment (domestic, commercial, and industrial).

Depending of the method of waste disposal and the wastewater treatment technology, these two activities can result in greenhouse gas (GHG) emissions which include primarily the following gases:

- Methane (CH_4);
- Carbon dioxide (CO_2); and
- Nitrous Oxide (N_2O).

In this report, the years 1994, 2005, 2015 and 2040 were selected as short term and long term baseline scenarios.

Population Projections

Population projections for Lebanon have been conducted and reported [1] Table 3.9 presents a set of projected population estimates based on an average growth rate of 1.5%. The overall population will increase from 3.7 million in 1994 to about 7.4 million in 2040. While these projections are tentative estimates, they can serve as the basis for analysis of trends in mitigating GHG emissions.

Table 3.9. Projected population for Lebanon

MOHAFAZA	***1994 ('000 persons)***	***2005 ('000 persons)***	***2015 ('000 persons)***	***2040 ('000 persons)***
Beirut	1165	1372	1593	2311
Mount Lebanon	695	819	950	1378
Bekaa	460	542	629	912
North Lebanon	770	907	1053	1527
South Lebanon	635	750	868	1260
Total	3725	4390	5092	7388

Methods of Solid Waste Disposal

Until recently, a comprehensive approach to solid waste management in Lebanon has been virtually absent. Slow burning and uncontrolled dumping on hillsides and on sea shores were still the common methods practiced for solid waste disposal. In urban areas, uncontrolled open dumps became quite large particularly along the coastal front (The Normandy and Burj Hammoud sites in Beirut, and the Nahr Abu Ali site in Tripoli, etc.). Incineration was also practiced at two relatively old facilities (Karantina and Amrousiyeh).

Certainly the trend is changing and there is a great deal of efforts to develop integrated solid waste management systems for most areas in Lebanon, particularly large urban areas. These efforts center around the construction of many well controlled sanitary landfills in combination with sorting, recycling, and composting facilities.

Based on experience to date at the Naameh controlled landfill site (which serves the City of Beirut and its surroundings and accounts for about 50% of the total solid waste generated in Lebanon) and the plans reported by the Council for Development and Reconstruction (CDR) [2], it is expected that upwards of 80% of the solid waste generated in Lebanon will be disposed of in relatively large size controlled sanitary landfills by the year 2005. This value is likely to exceed 90% by the year 2040.

Solid Waste Composition

As for other countries worldwide, the composition of the solid waste in Lebanon vary substantially with socio-economic conditions, location, season, waste collection and disposal methods, sampling and sorting procedures, and many other factors. Table A6-2 presents average composition of unsorted municipal solid waste from the Beirut area. Despite the variability in its composition, solid waste in Lebanon as in most developing countries can be characterized by a high percentage of total organic content with relatively elevated moisture content.

Table 3.10. Composition of unsorted municipal solid waste in Lebanon [3, 4]

Waste Category	***Average Composition % by weight***
Paper/cardboard	11.3
Food waste	62.4
Diapers/garments	4.2
Plastics	11.0
Glass/Brick	5.6
Metals	2.9
Other (wood)	2.6

Solid Waste Generation Rates

Several survey studies have been conducted to estimate waste generation rates by examining small daily samples from a large number of communities of different sizes. The most relevant of these studies with respect to the 1994 target year, is a survey conducted by the American University of Beirut [3, 4]. Table 3.11 presents generation rates for different localities (Caza) in Lebanon as reported in this study.

Table 3.11. Solid waste generation rates for different Cazas

Caza	***Generation Rate kg/capita/day***
Aley	0.78
Baabda	0.86
Beirut	0.74
Chouf	0.64
Kesrouan	0.77
Metn	0.70
Tripoli	0.64
Zahle	0.95
Other Communities (Lowest-Highest)	0.35-1.61

For estimation purposes, a rate of 0.8 kg/capita/day has been commonly used [1, 5] for present conditions. Under normal growth conditions, it is expected that this rate will increase. For the baseline scenario, it is assumed that the generation rate will increase by 1.5% annually to reach an average of 1.6 kg/capita/day for the year 2040, respectively. It is likely that this rate will stabilize in the future and perhaps decrease as witnessed in industrial countries. Using these average per capita wastewater generation rate and population estimates mentioned above, the total yearly quantity of solid waste generated for the baseline scenario are summarized in Tables 3.12 for different localities (Mohafaza) in Lebanon.

Table 3.12. Solid waste generation in Lebanon

	1994)	***2005***	***2015***	***2040***
Generation Rate (kg/capita/day	0.8	0.94	1.12	1.6
Mohafaza	*('000 ton)*			
Beirut	340	471	651	1350
Mount Lebanon	203	281	388	805
Bekaa	134	186	257	533
North Lebanon	225	311	430	892
South Lebanon	185	257	355	736
Total Amount Generated	1087	1506	2082	4315

Methods of Wastewater Treatment

Similar to solid waste, municipal wastewater management in Lebanon has been absent particularly during the many years of civil unrest during which existing treatment plants were destroyed and/or put out of operation. The general trend for wastewater management in urban areas along the seashores where the greater majority of the population resides, has been limited to a deteriorated wastewater collection system that typically discharges into the sea. In other urban as well as rural areas, untreated wastewater is directly dumped into rivers, irrigation channels, valleys, and ravines as well as septic systems and then land disposal. This method of treatment has been practiced for all types of wastewater including domestic, commercial, and industrial.

Numerous projects are underway to construct treatment plants around the country and for the short term baseline year of 2005 it is expected that about 70% of the domestic and commercial wastewater generated in Lebanon will be collected and treated at a wastewater treatment facility before final disposal. This value is likely to reach 90% by the year 2040. While the type and level of treatment will vary depending on the location, the majority of these facilities involve aerobic processes which are typically associated with little to no methane emissions. At some facilities, anaerobic processes may be introduced in a hybrid fashion with aerobic ones. The methane emitted from such processes will be flared or used as an energy resources at the facility itself. Therefore, it is not appropriate to include the amount of methane emissions from wastewater treatment as a baseline source.

As such it is assumed in this report that aerobic processes will be adopted for wastewater treatment. This assumption along with the actual usage methane from potential anaerobic processes (if adopted) must be verified in the future as facilities come into operation. Note also that wastewater treatment are planned for primarily domestic and commercial wastewater.

While a national industrial wastewater action plan has been prepared [6], no provisions have been made to date for the treatment of industrial wastewater. However, illegal dumping into sewer lines will not be surprising in which case the wastewater from the industry will find its way to the treatment facilities planned for commercial and domestic wastewater. While in such an event the treatment process at these facilities may get adversely affected, it is not possible to estimate whether and how much methane can be generated from illegal dumping.

At this stage, it was assumed that industrial wastewater management will be monitored and proper enforcement to prevent illegal dumping will be implemented. Industrial wastes are assumed to be handled at the source and no GHG emissions as methane will be generated from this sector since industrial wates are treated primarily through aerobic processes. This assumption must be checked in the future as plans for industrial waste management becomes more available and ready for implementation. In the event anaerobic processes are adopted, methane emissions should be accounted for.

Wastewater Characteristics

Wastewater is typically characterized in terms of several parameters such as Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and nitrates as nitrogen (N) amongst other parameters. Table 3.13 summarizes available information on wastewater characteristics in Lebanon [6].

Table 3.13. Wastewater characteristics in Lebanon

Parameter	*Range (mg/l)*	*Average (mg/l)*
BOD	30-230	128
COD	250-820	630
Nitrate-N	30-160	100

Note that Table 3.13 represents domestic and commercial wastewater characteristics. Industrial wastewater characteristics is highly variable and depends on the type of industry as well as the industrial process itself. While attempts at characterizing and quantifying industrial wastewater in Lebanon have been conducted [1], the reported results have not been accepted particularly by the industry itself. Therefore, at this stage these results are not reported until a consensus is reached regarding this matter. For this purpose, industry cooperation in providing accurate data is essential.

3.3.6 FORESTRY

The forestry sector in Lebanon provides opportunities for mitigating climate change through:

1) Reducing emissions of GHG by maintaining existing carbon sinks through conservation and protection of forests; and improvement of management practices.

2) Sequestering carbon by expanding forest cover and increasing carbon storage in forest, soils and in long-term products.

The Lebanese government forestry orientations aim at the conservation of the environment and bio-diversity, the protection of soil and water and the provision of social services through:

- Protection and conservation of natural forests and improvement of forest management.
- Expansion of the forest area from 75,000 hectares to 200,000 hectares as a low target and up to 282,000 hectares as a high target through reforestation, agro-forestry, and urban forestry.

Table 3.17 shows the land use pattern in Lebanon in year 1994 (base year) and the most likely trends (Baseline scenario) in land use change in years 2000, 2005, 2015 and 2040 respectively.

Table 3.17. Land use pattern, Baseline scenario (Area x 1000 hectares)

		1994[1]	2000	2005	2015	2040
1	Forest land:					
	> 40% crown cover	32	32	39	54	93
	10 - 40% crown cover	43	43	39	34	20
	< 10% crown cover: Woodlands	60	60	57	47	22
	Range lands	147	147	147	147	147
	Sub-total	282	282	282	282	282
2	Protected land[2]		(6)	(12)	(20)	(36)
3	Grass land (pasture)	316	316	308	293	253
4	Crop land	297	297	305	320	360
5	Other	126	126	126	126	126
	Total	1021	1021	1021	1021	1021

[1]Sources: Bio-diversity Country Study (1996) and agriculture census (1998), Ministry of agriculture. Trends of land change are based on officials and experts' estimation since no official statistics are available.
[2]For the record, this area is already included in forestland.

Forest protection and management

The total carbon pool sequestered by forest protection is:

- In the Baseline scenario: t.c: 14,587,500
- In the Mitigation scenario: t.c: 20,175,000, and
- The incremental carbon sequestered: t.c: 5,587,000

The protection of 75,000 ha of natural forest from the year 2000 up to 2040 will produce the results shown in Table 3.18: (Discount rate used is 10%)

Table 3.18. Cost-effectiveness indicators

Incremental C. sequestered		Equivalent Co_2 reduced		Total cost
Total t.c	Initial cost $/t.c	t. Co_2	Cost $/t. Co_2	In $
5,587,500	0.403	20,450,250	0.110	2,251,726

Expansion of carbon sinks by reforestation

To expand the stock of carbon in biomass, soil, and wood products, it was assumed that carbon will need to be stored in perpetuity and so the amount of stored carbon on a given area needs to be estimated over an infinite number of rotations. Thus the options will be based on:

- the amount of reforested area taken as 125,000 ha (first scenario) and 207,000ha (second scenario) and
- the length of the rotation age taken as 75, 100 and 125 years in each scenario

STRATEGY / RECOMMANDATIONS

The main polices that aim to maintain carbon stocks and expand carbon sinks should include the following:

Forest protection and conservation policies

To preserve existing forests in a sustainable fashion, the following measures have to be taken:

- Undertaking a new-forest inventory and mapping (the first one was done in 1966) including a descriptive structure and composition of forests stands.
- Developing forest management systems that improve the long-term productivity and ecological integrity of the forests.
- Developing sound methods of fighting fire, insects, and diseases.

Reforestation

- Long rotation periods adapted to species characteristics will increase carbon stock periods and reduce the cost per reforested unit area as well as the cost of the carbon sequestered.
- Quality of wood produced should permit its use for long life products; thus more carbon will be stored away. Quality of wood depends on forest species and management systems.
- Research on species and seeds provenance and on appropriate techniques for harvesting and regeneration of forests.

Other measures

- Amendment of the forest laws to allow various parties to participate in implementing reforestation programs and forest management plans.
- A comprehensive land use planning and zoning through which appropriate land is spread for agriculture, forestry and pasture.
- Grazing, in forests and reforested lands should be managed to avoid damages that goats and sheep could cause to regeneration of old forest stands or to the growth and development of young forest and new reforested lands. Serious prejudices will affect any forestry development plan if grazing problems are not solved.

3.4 BIO-CLIMATIC BASELINE SCENARIO

3.4.1 BIOCLIMATIC ZONES

The purpose of constructing the bioclimatic baseline scenario is not only to show the current climate but also to identify, in the absence of global warming, its possible variations for the period defined by the time frame.

The adopted baseline scenario is based on the analysis of the climatic parameters' varlues shown in our records (see Appendix in the technical annex). The climatic projects for the period defined by the time frame are considered as a perpetuation of the current climate. This assumption is based on the following:

- All climatic parameters are expressed as mean values calculated, for the majority of the stations, for a period of thirty years (i.e. climatic normals)
- In the absence of global warming it is suggested that the mentioned factors would fluctuate around these calculated normals. They can be, therefore, assumed to reflect the natural climatic changes
- Models adapted to simulate such "natural" fluctuations are, to the best of our knowledge, unavailable. Furthermore, temporal, technical and budget restrictions would not allow us to explore if such methodology could be applied.

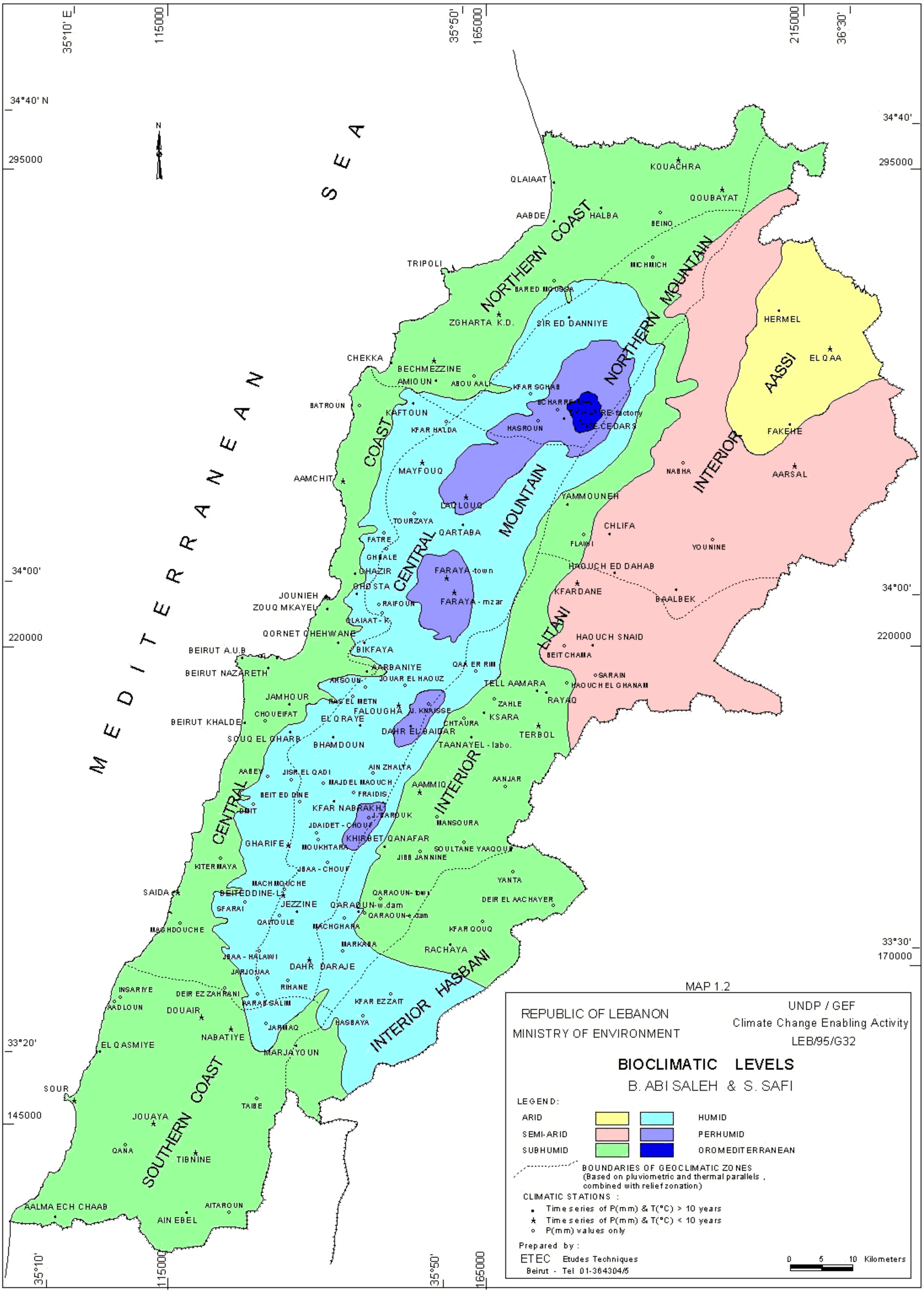
- **The map entitled 'bioclimatic levels' shows the distribution of bioclimatic levels under the baseline conditions (without climate change).**

3.4.1.1 *Water Resources*

There is no better way to project the future then to depend on existing trends and plans assuming they will carry on as they are. This is what Table 3.19 and Fig. 3.4 show.

It must be borne in mind that time and space resolution, for the different sectoral uses of water in Lebanon, is not that flexible as data is not abundant and verifiable within the available means. The wide ranges in values shown in Table 3.19, plus the fact that they are estimates, is proof of the above. Even though lots of experts work in Lebanon's water domain, the technical, professional and financial resources available to them are minimal. This is why the data is to be taken with caution.

Precipitation (supply) data is relatively more accurate than others, i.e. water quality or desertification. However, what is used here does support the picture emerging from precipitation curves, namely, that the current trend is towards more arid conditions. In fact, in a recent conference on observing and monitoring the Mediterranean Basin by satellites, several workers on the southern and eastern part indicate a similar picture to the above, i.e. precipitation is decreasing, evaporation is increasing with a net "export" of water. More focused, this is saying that water deficit in Lebanon is coming within less than two decades (Fig. 3.4).



MAP 1.2
REPUBLIC OF LEBANON
MINISTRY OF ENVIRONMENT
UNDP / GEF
Climate Change Enabling Activity
LEB/95/G32
BIOCLIMATIC LEVELS
B. ABI SALEH & S. SAFI
LEGEND:
ARID
SEMI-ARID
SUBHUMID
HUMID
PERHUMID
OROMEDITERRANEAN
BOUNDARIES OF GEOCLIMATIC ZONES
(Based on pluviometric and thermal parallels, combined with relief zonation)
CLIMATIC STATIONS :
Time series of P(mm) & T(°C) > 10 years
Time series of P(mm) & T(°C) < 10 years
P(mm) values only
Prepared by :
ETEC Etudes Techniques
Beirut - Tel 01-364304/5
0 5 10 Kilometers
MEDITERRANEAN SEA
NORTHERN COAST
NORTHERN MOUNTAIN
COAST
CENTRAL MOUNTAIN
CENTRAL COAST
SOUTHERN COAST
INTERIOR
AASSI
LITANI
INTERIOR
INTERIOR HASBANI
35°10' E
115000
35°50'
165000
215000
36°30'
34°40' N
295000
34°00'
220000
33°30'
170000
33°20'
145000
N
KOUACHRA
QOUBAYAT
QLAIAAT
AABDE
HALBA
BEINO
TRIPOLI
MICHMICH
BARED MOUSSA
ZGHARTA K.D.
SIR ED DANNIYE
HERMEL
EL QAA
CHEKKA
BECHMEZZINE
AMIOUN
ABOU AALI
KFAR SGHAB
BCHARRE
CEDARS
HASROUN
BATROUN
KAFTOUN
KFAR HALDA
FAKEHE
AARSAL
NABHA
MAYFOUQ
AAMCHIT
LAQLOUQ
YAMMOUNEH
TOURZAYA
QARTABA
CHLIFA
FLAWI
YOUNINE
FATRE
GHALE
GHAZIR
FARAYA-town
HAOUCH ED DAHAB
JOUNIEH
GHOSTA
KFARDANE
ZOUQ MKAYEL
RAIFOUN
FARAYA - mzar
BAALBEK
QLAIAAT - K.
QORNET CHEHWANE
HAOUCH SNAID
BEIRUT A.U.B.
BIKFAYA
BEIT CHAMA
AARBANIYE
QAA ER RIM
SARAIN
BEIRUT NAZARETH
ARSOUN
JOUAR EL HAOUZ
TELL AAMARA
HAOUCH EL GHANAM
JAMHOUR
RAS EL METN
ZAHLE
RAYAQ
FALOUGHA
J. KNAISSE
KSARA
CHOUEIFAT
EL QRAYE
CHTAURA
BEIRUT KHALDE
DAHR EL BAIDAR
TERBOL
SOUQ EL GHARB
BHAMDOUN
TAANAYEL - labo.
AIN ZHALTA
AABEY
JISR EL QADI
MAJDEL MAOUCH
AANJAR
AAMMIQ
BEIT ED DINE
FRAIDIS
KFAR NABRAKH
BMIT
J. BAROUK
JDAIDET - CHOUF
MANSOURA
KHIRBET QANAFAR
GHARIFE
MOUKHTARA
SOULTANE YAAQOUB
JIBB JANNINE
JBAA - CHOUF
KITERMAYA
YANTA
MACHMOUCHE
SAIDA
BEITEDDINE-L.
QARAOUN-town
JEZZINE
DEIR EL AACHAYER
SFARAI
QARAOUN-u.dam
QARAOUN-d.dam
QAITOULE
MACHGHARA
MAGHDOUCHE
KFAR QOUQ
MARKABA
RACHAYA
JBAA - HALAWI
DAHR DARAJE
JARJOUAA
INSARIYE
RIHANE
DEIR EZ ZAHRANI
AADLOUN
ARAB SALIM
KFAR EZZAIT
DOUAIR
JARMAQ
HASBAYA
NABATIYE
EL QASMIYE
MARJAYOUN
SOUR
TAIBE
JOUAYA
QANA
TIBNINE
AALMA ECH CHAAB
AITAROUN
AIN EBEL

The associated uncertainties have to be clarified. To begin with, even though available data are not up to international standards, yet the resultant baseline Fig. 3.4 is fairly acceptable. The margin of error affects only the actual values, such as in Table 3.19, but does not change the indicated trend. To overcome this issue, higher values are used to represent a "High Scenario" baseline, while lower values are used to represent a "Low Scenario" baseline. This is critical for water demand, and is shown in Fig. 3.4. The projected increase and decrease in precipitation and demand at 1.11% and 3.52%, respectively, are critically higher than can be accepted by this author. Instead, the more realistic values of a <u>maximum</u> of 0.9% and 2.0%, respectively, make the projection a little smoother, yet still with a steep increase in demand.

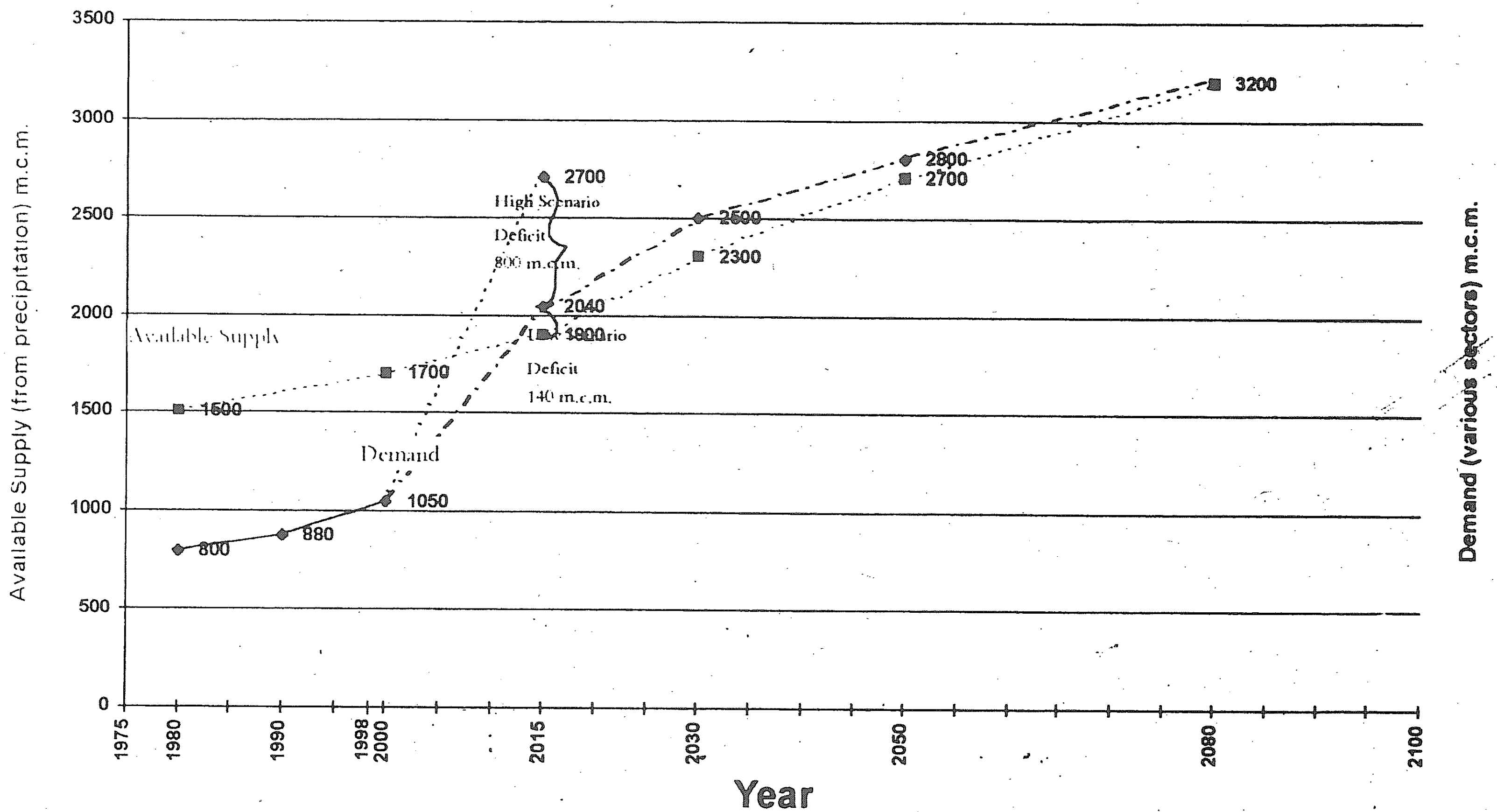


Figure 3.4. Baseline Projection, Water Supply - Demand

Table 3.19. Ranges of estimated data on sectoral use of water resources, and supply-demand, (Khawlie, 1997-different sources)*

<table>
<tr><td colspan="3">Total Precipitation (Supply)
(+ snow)
b.c.m.
8.6-9.7</td><td colspan="4">Total Demand
(major uses)
m.c.m.
900-1460</td></tr>
<tr><td rowspan="2">Surface water
1.4-4.2</td><td rowspan="2">subsurface water
0.6-3.8</td><td rowspan="2">lost out
2.3-3.0</td><td rowspan="2">agriculture
(irrigation)
670-890</td><td colspan="2">Residential
(80-420)
per capita
l/d</td><td rowspan="2">industrial
50-150</td></tr>
<tr><td>Urban
250-300</td><td>rural
150-200</td></tr>
<tr><td colspan="3">Projected average annual decrease in precipitation = 1.11% ** (max 0.9%)</td><td colspan="4">projected annual increase in water needs = 3.52 % ** (2.0%)</td></tr>
<tr><td colspan="3">An integrated estimate (b.c.m.):
(Maksoud, personal communication)</td><td colspan="4">- total supply 8.60
- beneficial consumption 3.30
- to sea &/or out 2.31
- unutilized surface flow 2.99</td></tr>
<tr><td colspan="3">Estimated projections of available water:
(UNDP, 1997)</td><td colspan="4">- 1995 = 1.46 b.c.m. → 2015 = 2.70 b.c.m.
- Deficit in 2015 = 800 m.c.m.</td></tr>
</table>

* As can be obviously seen in the Table, there is a wide range in the estimated values of supply, demand and projections. This, unfortunately, makes arriving at an accurate baseline questionable.

** These two projections sound rather high. The regression lines of Beirut 100 years precipitation do not indicate a decrease exceeding maximum 0.9%. As for increase in water needs, several workers put it more realistically at about 2.0% maximum. This is because of water conservation and other environment-friendly practices that would be expectedly employed in the near future.

3.4.1.2 Agriculture

Lebanon imports more than 70% of its needs in grain and meat and more than 75% of food. Agriculture does not fall among the primary economic concerns of the government, since the budget of the Ministry of Agriculture is less than 2% of the total Government's budget. Moreover, the Ministry depends, for funding agricultural projects, on foreign resources, like long term loans and donations from regional and international agencies.

The direct losses that hit the agricultural sector during the war from 1975 until 1990 were mainly destruction of orchards and irrigation canalizations, the loss of agricultural lands and the agricultural equipment (pumps, generators, and green houses...). In addition, the agricultural lands were neglected due to forced emigration. Consequently, we lost the export markets, specially the Gulf markets that used to import 90% of our produce.

The subsidizing policy, the attempts to limit internal emigration towards cities, and to abolish the cultivation of forbidden crops, the adoption of the agricultural calendar, and some administrative policies to protect the local production, all these help in protecting and promoting certain vegetables and fruits.
The general trend in agricultural areas and production nowadays as shown in Table 3.19 can be described as follows:

- A remarkable decrease in areas planted with grains like wheat, and barley. These crops are not irrigated. However, the quantity of production of these crops is not reduced due to the adoption of new hybrid varieties and better cultural practices.

- An increase in the areas planted with legumes, various vegetables, fruit trees and industrial crops mainly sugar beet and tobacco . It is noted also that the average production of these crops per unit area has increased.
  Based on the following indicators: the demographic pressure, the state stability, and the government's agricultural policy, and regardless of any predicted climate change, the agricultural lands in the coastal plain are subject to a strong reduction at the end of the coming century. The hills overlooking the coastal plain, starting from a height of 300m above sea level, will constitute a certain substitute for the tropical plants after constructing terraces and soil reclamation. This will provide an appropriate environment for planting bananas and citrus fruits. The policy of subsidies will allow expanding the areas of tobacco and sugar beet plantations in the Bekaa region as well as the protection of other agricultural products like olives in the central mountainous area.

Table 3.20. Comparison of agricultural areas and production in Lebanon

Species	1979(*)		1996(**)		Differences %	
	Crop Area (1000ha)	Production (1000hk)	Crop area (1000ha)	Production (1000mt)	Crop area %	Production %
Wheat	66.5	67.8	23.6	58.3	-60	-14
Barley	13.4	15.8	11.2	28.4	-16.4	+79.7
Corn	3.0	5.2	2.03	4.7	-32.3	-9.6
Grain legumes	13.8	29.2	20.5	83.6	+48.5	+186.3
Vegetables	30.5	348.0	81.9	1676.7	+170	+382.0
Fruits	74.6	650.0	130.1	1354.5	+74.4	+108
Industrial crops	13.2	n.a.	54.4	365.6	+312	n.a

(*) Faculty of Agricultural and Food Sciences, 1979,Agricultural development in Lebanon. AUB Number 62
(**) Agricultural Statistics, 1996. Department of statistics and research. Lebanese Ministry of Agriculture, 1997

3.4.1.3 Terrestrial Ecosystems

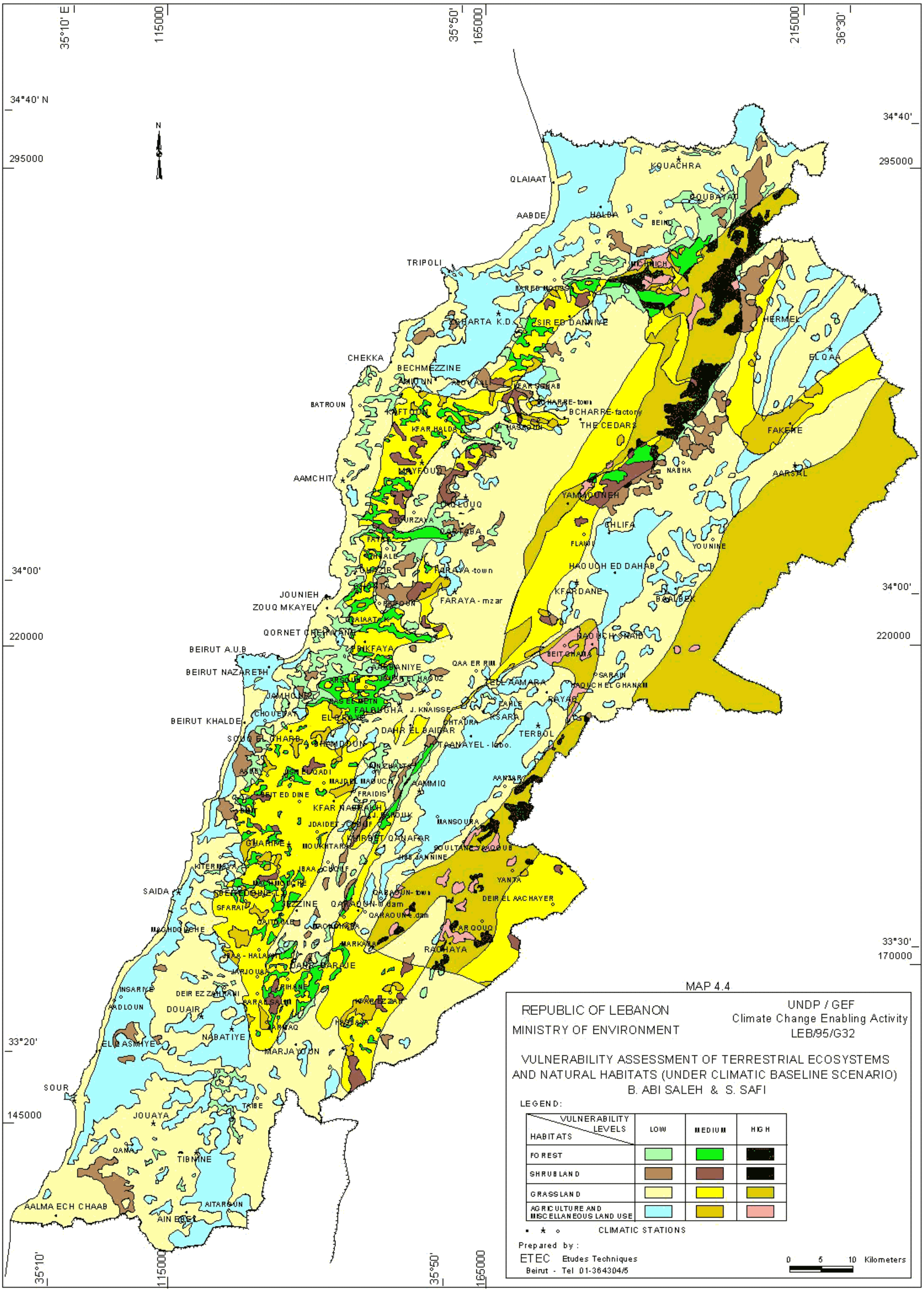
The map entitled 'Vulnerability assessment of terrestrial ecosystems and natural habitats (under climatic baseline scenario) represents, for these natural habitats, the future no-climate-change baseline scenario.

The Mediterranean Ensemble spreads over the western part of Mount Lebanon and its eastern slopes to the south of the Beirut parallel, as well as the western slopes of the Hermon. On the other hand, the Pre-steppic Mediterranean Ensemble covers the eastern slopes of Mount Lebanon in its northern part, and the northern part of Anti-Lebanon. Based on altitudinal and climatic characteristics we distinguish, within the first ensemble, the following vegetation zones: Thermomediterranean, Eumediterranean, Supramediterranean, Mountainous mediterranean and Oromediterranean. Whereas the second ensemble encompasses the Presteppic mediterranean, Presteppic supramediterranean, Presteppic mountainous Mediterranean and Presteppic oromediterranean vegetation zones. The structure of the vegetation reflects the ecological evolutionary stage that a given formation has reached.

The Lebanese Ministry of Agriculture estimates the area of rangelands to be about 527,790 ha which constitute 50.5% of the total land area of the country. Forests, on the other hand occupy approximately 119,774 ha, representing 11.46% of Lebanon's total land area. Other estimates suggest that woodlands, composed mainly of oak, pine, juniper, cedar, beech and cypress, cover some 60,000 hectares representing 5.7% of the area of Lebanon. The actual total woodland area may be somewhere between the two figures. Only about a quarter of these woodlands are privately owned, while the rest is state-owned or public land. The decline in woodland area since 1975 is estimated to be about 25 percent while the reforestation rate is about 5 to 7%.

The main non-climatic disturbances that are currently affecting natural habitats are:

i. **Chaotic urbanization at the expense of forests and woodlands.**
ii. **Pollution of various sources, air, water and soil.**
iii. **Fires that seem to be increasing in frequency with the lengthening of the dry season.**


MAP 4.4
REPUBLIC OF LEBANON
MINISTRY OF ENVIRONMENT
UNDP / GEF
Climate Change Enabling Activity
LEB/95/G32
VULNERABILITY ASSESSMENT OF TERRESTRIAL ECOSYSTEMS
AND NATURAL HABITATS (UNDER CLIMATIC BASELINE SCENARIO)
B. ABI SALEH & S. SAFI
LEGEND:
VULNERABILITY LEVELS
HABITATS
LOW
MEDIUM
HIGH
FOREST
SHRUBLAND
GRASSLAND
AGRICULTURE AND MISCELLANEOUS LAND USE
CLIMATIC STATIONS
Prepared by:
ETEC Etudes Techniques
Beirut - Tel 01-364304/5
0 5 10 Kilometers
N
35°10' E
115000
35°50'
165000
215000
36°30'
34°40' N
34°40'
295000
295000
34°00'
34°00'
220000
220000
33°30'
170000
33°20'
145000
35°10'
115000
35°50'
165000
QLAIAAT
KOUACHRA
QOUBAYAT
AABDE
HALBA
TRIPOLI
HERMEL
CHEKKA
BECHMEZZINE
EL QAA
BATROUN
BCHARRE-factory
THE CEDARS
FAKEHE
AAMCHIT
AARSAL
NABHA
YAMMOUNEH
CHLIFA
FLAWI
YOUNINE
HAOUCH ED DAHAB
FARAYA-town
FARAYA - mzar
JOUNIEH
ZOUQ MKAYEL
KFARDANE
BAALBEK
QORNET CHEHWANE
HAOUCH SNAID
BEIRUT A.U.B
BEITCHAMA
BEIRUT NAZARETH
QAA ER RIM
TELL AAMARA
BEIRUT KHALDE
ZAHLE
KSARA
RAYAQ
TERBOL
DAHR EL BAIDAR
TAANAYEL - labo.
AAMMIQ
MANSOURA
KFAR NABRAKH
KHIRBET QANAFAR
JDAIDET
KITERMAYA
SAIDA
YANTA
DEIR EL AACHAYER
JEZZINE
RACHAYA
MARJAYOUN
INSARIYE
DEIR EZ ZAHRANI
DOUAIR
NABATIYE
EL QASMIYE
SOUR
JOUAYA
TIBNINE
QANA
AALMA ECH CHAAB
AITAROUN
AIN EBEL
TAIBE

iv. **Changes in the water table due to excessive water exploitation for domestic and agricultural use.**
v. **Quarrying activity, which is also affecting the water table.**
vi. **Overgrazing.**
vii. **Fragmentation by one or more of the above factors.**

Despite the increased environmental awareness and the protection of some areas and due to growing human population size and economic pressures it does not seem likely that any of the above factors may show major reductions. In the absence of any present quantitative data, we are unable to make any definite projections under either baseline or climate change scenarios. Nonetheless, any intensive or extensive increase in any of these factors will lead to a degradation of the natural habitats that will be further exasperated by climatic changes.

3.4.1.4 The Coastal System

The Physical Component

Table 3.21 on coastal storms and Fig. 3.5 on Baseline Projection reflect existing trends. The emphasis on probability of storms and, therefore, coastal flooding financial losses as the baseline is because it can be quantified more accurately. The probability approach also assumes a certain maximum, and different options, or scenarios, can be assumed to project the future.

The scope of assessment considers the frequency and effects of coastal flooding plus management to reduce its impacts. The frequency has to do with the nature of torrential episodes that characterize semi-arid to arid environments. While the effects have to reflect on flooding of economically important coastal stretches, denudation of sandy or other soft beaches, and deterioration of coastal water quality which, added together, imply large damages and economic losses.

Of course, the Baseline Projection can be considered a scenario, i.e. it can attain high and low options. This will depend not only on the actual flooding itself, but also on the extent of real damage. The crucial issue is economic loss. The following example explains that: If there is a large flood along a coastal segment X, but there is nothing to be damaged there, i.e. no human activity, the economic loss is most likely minimal, or the real damage is minimal. This explains the probability approach followed in trying to project the Baseline in the (inset) of Fig.3.5. There could be options of very high losses, i.e. the high scenario where the baseline trend increases and then levels off towards 2050 and 2080, but still at a high probability of flooding with real damage. Or, it could follow the low scenario case with a slight increase and then leveling off at lower rates of loss.

Event & Year	Coastal Location	Direct Impacts: Social	Direct Impacts: Physical destruction	Direct Impacts: Economic losses estimates mil. $	Indirect Impact	Management
Tempest, floods 1975	Beirut	- 4 people dead - stressed coastal community - disruption of functions	- structural failure - ships/boats - water pollution - agricultural produce - electricity & phones	15	- capital expenditure	local/national As obvious throughout this table, and in spite of the annual recurrence of these destructive episodes, not much in terms of proper management has been done, except construct some local marinas for fishing boats whose stand against huge coastal storms is speculative
Torrents, floods 1977	Akkar, Antelias, Dbayie, Beirut, Tripoli	ditto	ditto	5	- populace well-being & safety	
Torrents, floods 1978	Dbayie, Akkar, Batroun	ditto	- huge soil erosion - derailed coastal train ditto	8	- disruption life functions	
Sea storms 1979	Akkar, Beirut, Tripoli	ditto	ditto	12	- loss of resources	
Sea storms 1980	many coastal segments & Refinery (N. Tripoli)	ditto	- landslides - seaports - communications ditto	20		
Sea storms 1983	all coastal cities	- 90 people dead - 3000 cattle deceased ditto	- bridges, roads, ships, houses, seaports ditto	90	- hit progress of coastal agri-sector	
Tempests 1984	Sour	ditto	- soil erosion - coastal agriculture	1		
Sea storms with huge waves 1986	all coastal segments	ditto	- ports, ships ditto	31	- hit progress of fishing community	
Tempest, floods, Sea storm & huge waves 1987	all coastal segments	- 5 persons dead ditto	ditto	46		
Floods 1988	Saida, Tripoli, Dbaiye	- 4 people dead ditto	ditto	11		
Floods 1991	Coastal cities	ditto	ditto	13		

Table 3.21. Continue

Event & Year	Coastal Location	Direct Impacts: Social	Direct Impacts: Physical destruction	Direct Impacts: Economic losses estimates mil. $	Indirect Impact	Management
Torrents, floods avalanche 1992	Akkar, Sour, Beirut	- 5 people dead	- soil erosion - coastal agriculture - road damages and cut - rivers level rises	29	- disruption of life functions	No proper management done
Torrents, floods, storms 1993	Sour, Tripoli, Saida	- Unidentified number of cattle deceased	- road damage - landslides - soil and rock drifting	11	- isolation of 1500 persons	Attempts to conduct the isolated people
Torrents, flood, storms tempest 1994	All coastal cities	- 1 person deceased	- landslides - road destruction - soil drifting - bridges destruction	29	- roads cut isolated most of the coastal cities - hit progress of life functions	Only local aids were reported
Torrents, floods 1995	Beirut and most of the coastal area	- stressed coastal community	- soil and rock drifting - road destruction	8	- disruption of functions	Management has been done after certain time
Torrents, floods, storm 1996	Jbail	- 1 person deceased	- road damage - road collapse - landslides	10	- electricity destruction - hit progress of coastal agri-sector	No proper management done
Torrents, floods, storm 1997	Jbail, Beirut, Akkar	- stressed coastal community	- rock failure - landslides - soil erosion - construction damage - water intrusion into houses - disruption of life functions due to traffic problems	17		ditto
Torrents, storm 1998	Beirut, all coastal stretch	ditto	- soil erosion - water intrusion into houses - sewage overflow - huge damages in all vital projects	42		ditto

INCREASING PROBABILITY OF COASTAL FLOODING, AND IMPLIED ECONOMIC LOSSES

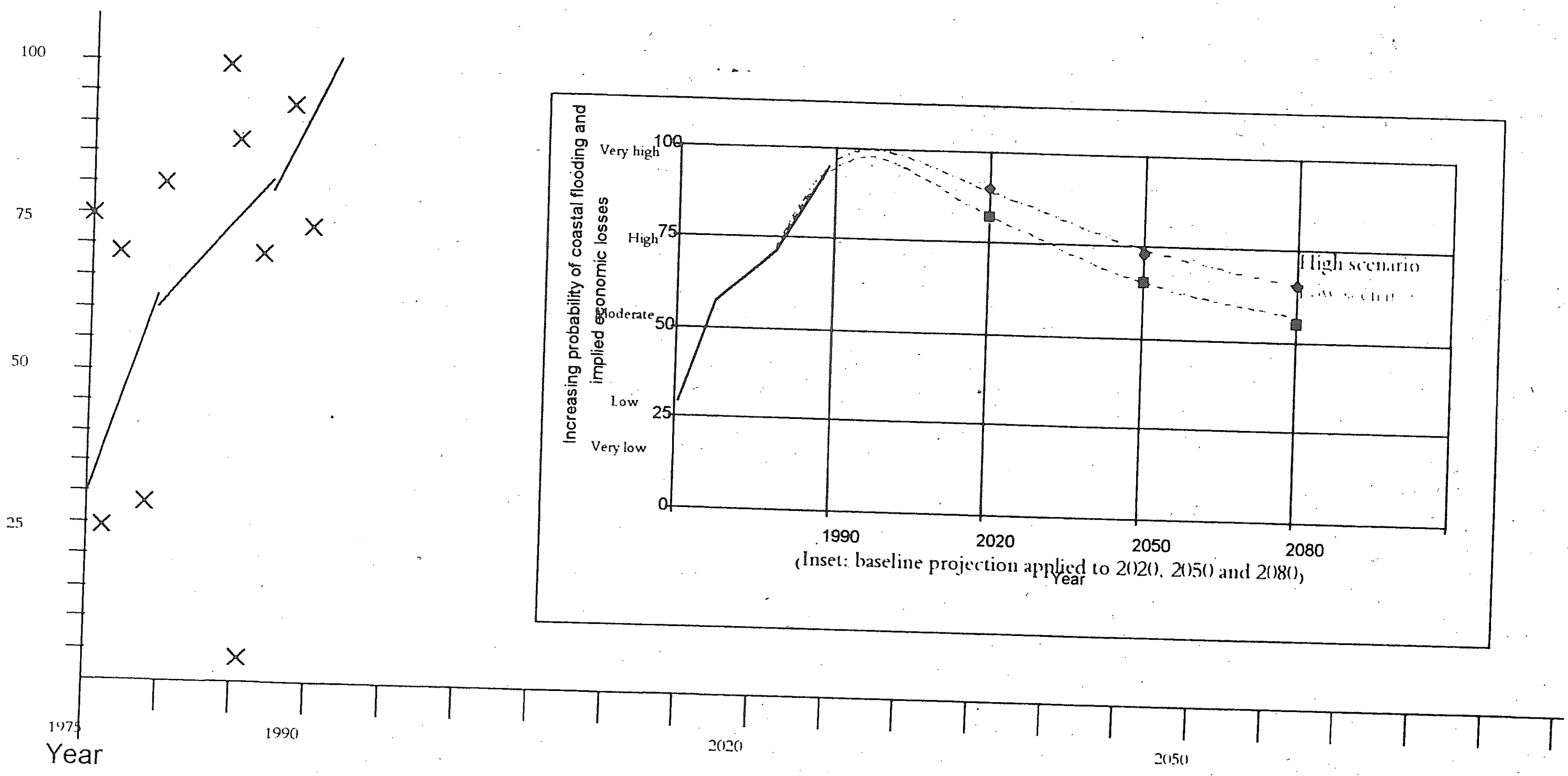


Figure 3.5. Baseline projection, probability of coastal flooding and implied increase in financial losses

3.4.1.5 The Marine Ecosystems

Baseline in Jounieh Bay: Figure 3.6 shows the baseline of water temperature (average of available data between 1979 and 1998).
Figure 3.7 shows the baseline for phytoplankton populations for the same period. We expected that these populations would be directly affected by water temperature rise, which in turn is affected by air temperature; also inundation and salinity decrease can also affect these populations.
Fish populations particularly clupoidae will be affected by these populations because they constitute their aliments. For these reasons we did the baseline of clupeidae (Fig. 3.9) and for total catch of fish in Lebanon (Fig. 3.10).
Baseline in Batroun Bay: only water temperature is available for this baseline (Fig. 3.8).
In Batroun Bay, it is important to study the benthic ecosystem because of the presence of terraces. Based on a sketch map of Lebanon's coastline showing geoidal elevation (G.E.) and geographic distribution of risk potential areas, we conclude that the region of Batroun Bay is situated in the category of less critical zone (geoidal elevation >2.5m) and G.E. is 3.8m in this region.

3.4.1.6 Socio-Economic Aspects

Disparity in income induces a strong rural-urban migration and a high rate of urbanization (87% in 1994 and 93% in 2015). Annual population growth rate is steadily decreasing.

The economy is liberal dominated by the service sector. The share of industry in the GDP is 19%, and that of agriculture 7%. The imbalance is corrected by invisible earning (tourism, overseas Lebanese remittances...). Post war reconstruction implies high expenditures leading to a budget deficit. Nevertheless GDP continues to increase reaching 4800$ per capita in 1998. Unemployment rate is only 14% despite more than 1 million foreign workers. Economy will continue to rely on services and invisible earnings. This general view masks the severity of the problem in the agricultural remote areas where low income and unemployment will lead to migration. Tourism assured 20% of GDP before 1975. This sector is able to regain importance and consequently to contribute to the development of some regions, some other economical sectors and employment.

Coastal activities show very limited fisheries and an over urbanization. Average annual losses due to natural events are 35 millions dollars in 1983, particularly in the low-lying coastline settlements.

Water problems affect agriculture and health by means of quantity or quality. The deficit will remain in 2020 even if adequate measures are taken. Quality of water is also a matter of concern (contamination of aquifers and networks by sewage, salt intrusion, secondary to over pumping, fertilizers, and lack of treatment and filtering, old network...).

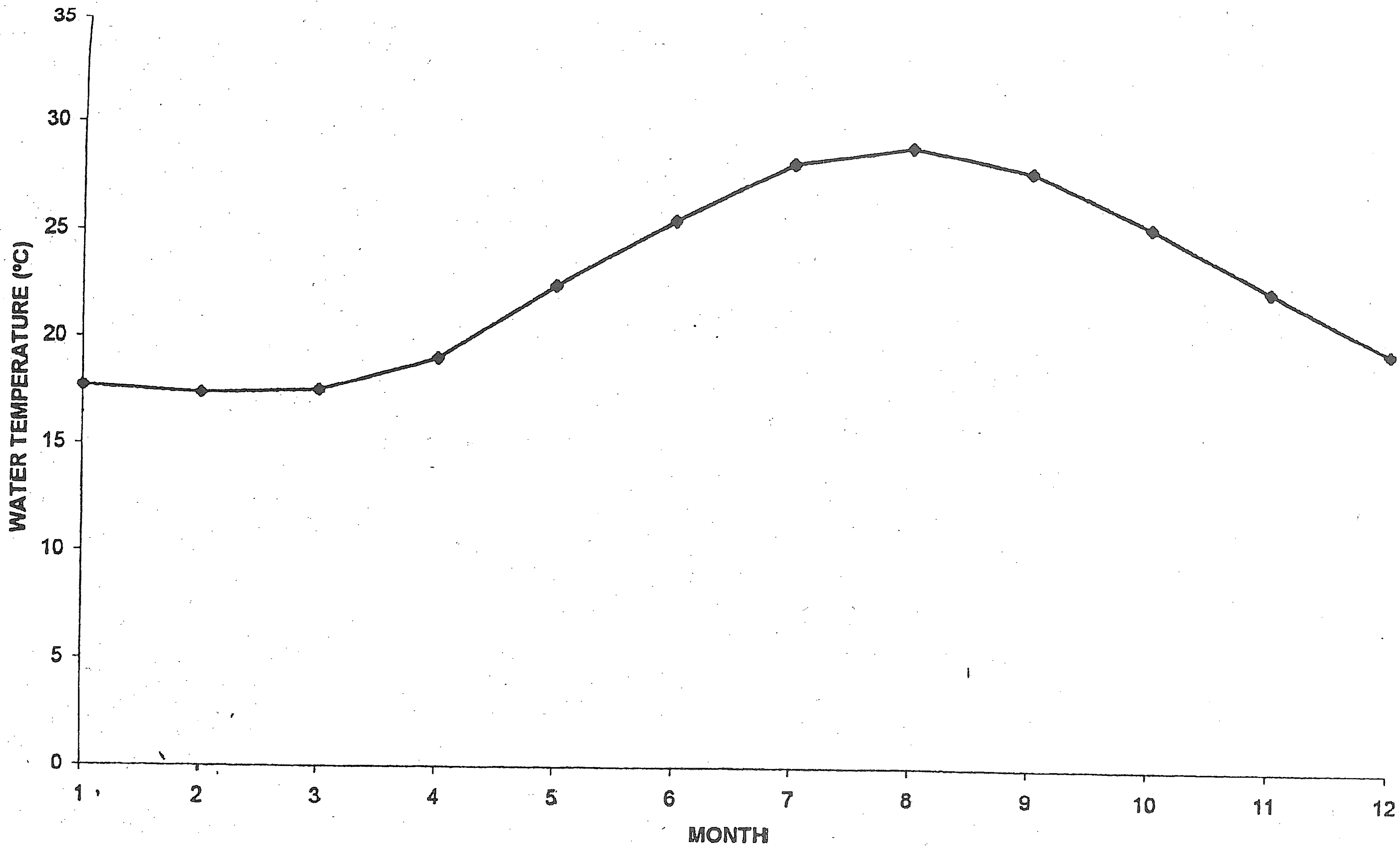


Fig 3.6 : Jounieh monthly average water temperature (%C) (1979-1998)

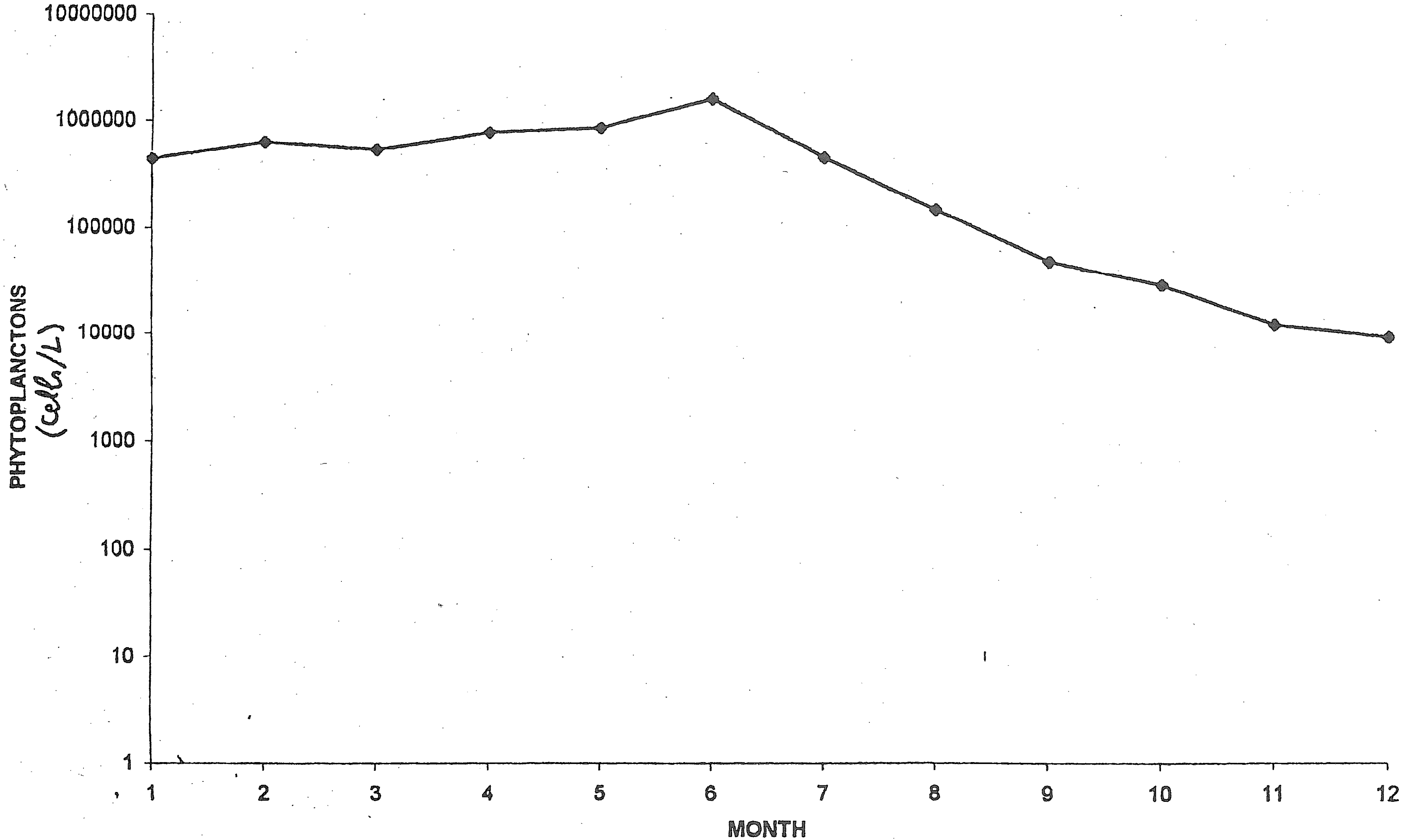


Fig 3.7 : Phytoplanctonic population in Jounieh (1979-1998)

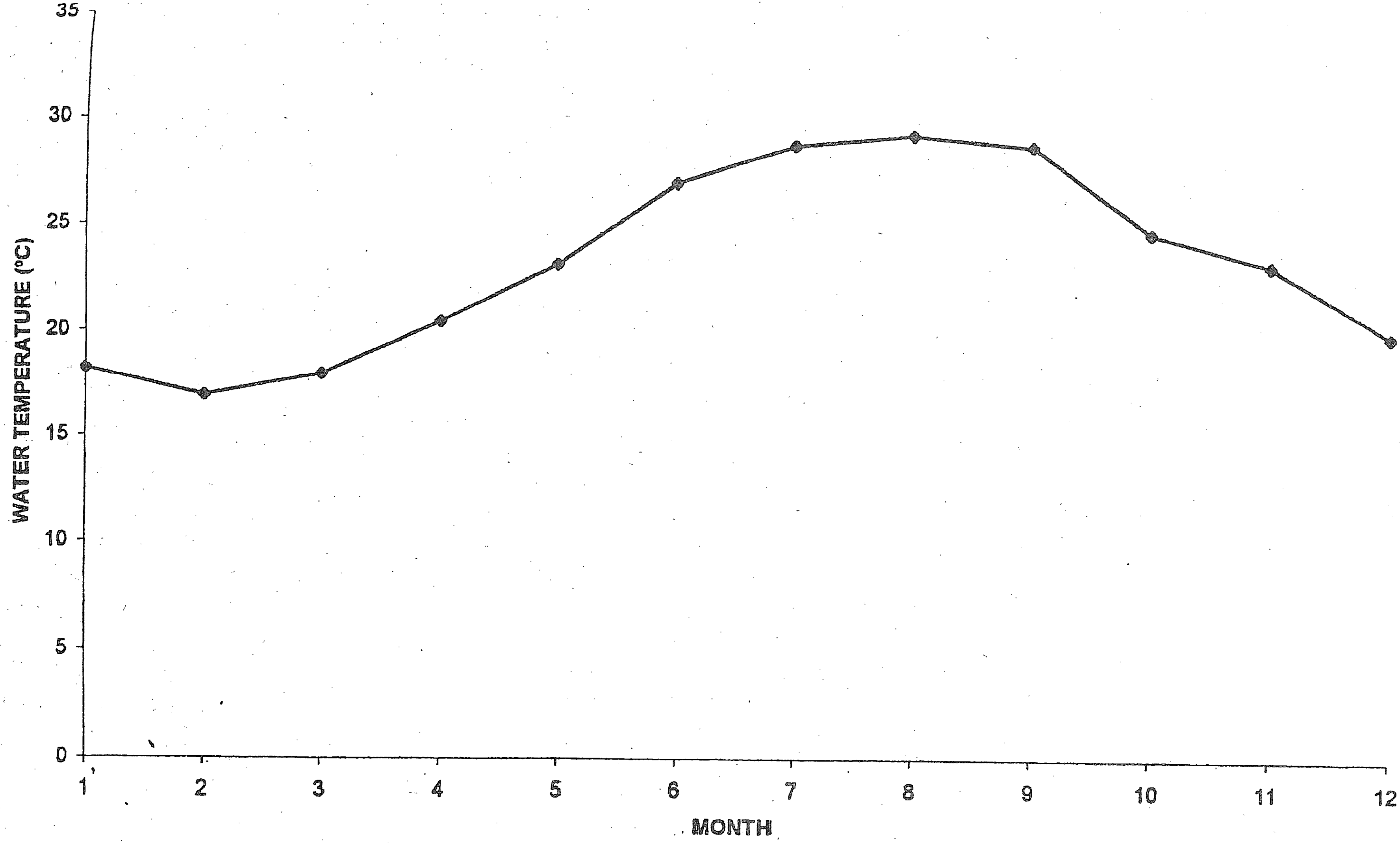


Fig 3.8 : Batroun monthly average water temperature (% C) (1996-1998)

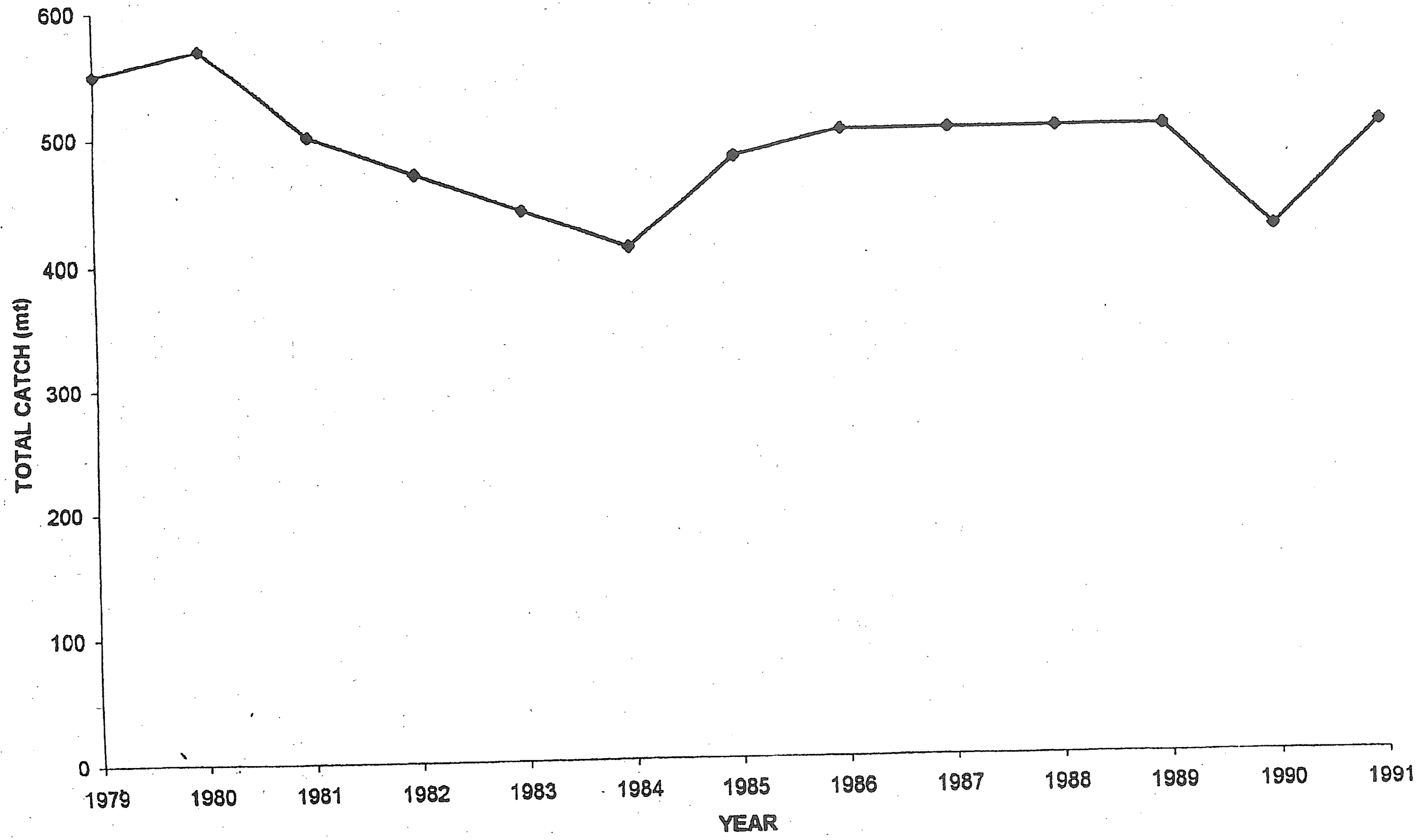


Fig 3.9 : Clupeoids catch in Lebanon (1979-1991) (FAO, 1993)

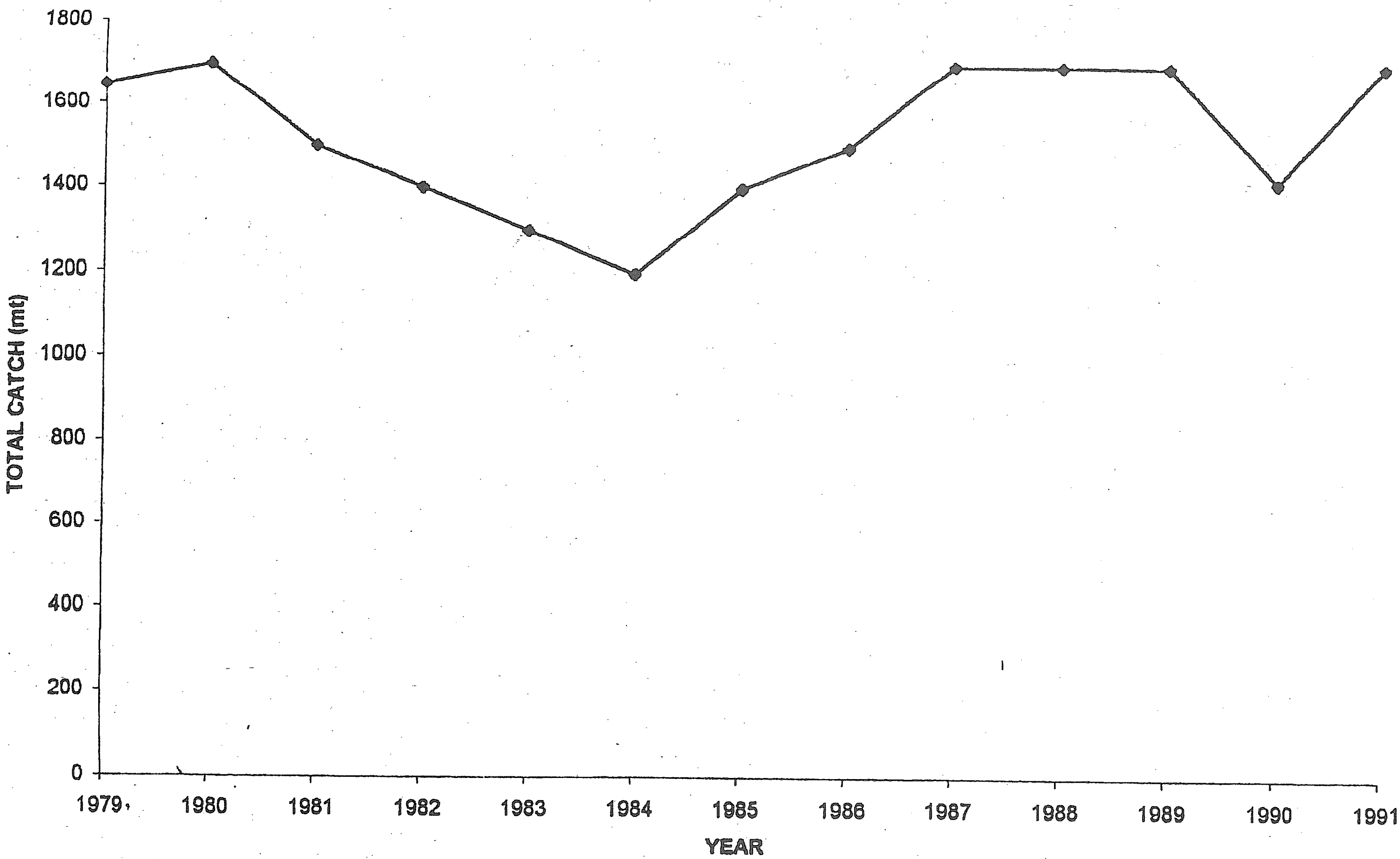


Fig 3.10 : Total catch in Lebanon (1979-1991) (FAO, 1993)

Agriculture represents now 10% of GDP, 7.8% of labor force, 12% of population and 19% of exportation, but Lebanon still imports 80 % of food. Already in bad shape, agriculture will continue to decline and is going to be less and less competitive, even in the local market. Despite its slight share in the economy, it will hit severely the rural areas, mainly due to the fact that they are not able to shift towards other activities, because of their unskilled labor force. This will lead to more poverty, more exodus to the poor suburbs of the big cities.

In the same way, health services are unequally distributed with consequent disparities in the unsatisfied basic needs index and unemployment, which are the highest in the peripheral areas and the suburbs of Beirut. Vicious circle of poverty is closed with high household size (6,5 to 7), low income and unskilled young people. The cost of health care is one of the highest in the world. It is insured mainly by the private sector and reached 11.8% of the GDP in 1995. The preventive component is very weak. Disparities are evident. Most vulnerable groups to diseases are infants, children, elderly, malnourished and non-immunized. Three categories of diseases are relevant: Water borne diseases (diarrhea, typhoid and hepatitis-A are a real problem), Vector borne diseases (conditions of outbreak of Malaria are still present), Acute respiratory illnesses which is one of the most common causes of infant mortality. In addition to vaccinations' annual campaign, MOH launched recently a program to prevent and treat diarrhea and respiratory illness. Water shortage, pollution and poverty will lead to an increase in these diseases.

3.4.2 GOVERNMENT BASELINE RESPONSE TO CLIMATE CHANGE

The signing and ratification of several international conventions and protocols is among the important steps taken along by Lebanon as a response and contribution to Global Change. One can group the Lebanese Government's efforts in response to climate change, under two labels: First, the direct efforts such as the UN Climate Change program being managed nationally through the Ministry of Environment; Second, the indirect efforts which include a variety of programs or projects relating mostly to Rio 1992 Earth Summit themes and topics. The latter could have been initiated by some government decrees, or by some individual ministry, or by some specialized agency of the government, e.g. the National Council for Scientific Research.

The Climate Change Program is the document at hand, so one needs not expand on it as it talks for itself.

Concerning the indirect efforts, they can be further subdivided into those emanating from the UN programs, and non-UN programs, such as follows:

Major UN Programs

- ***Capacity Building***
  - **Capacity 21** relating to environmental laws, EIA, coastal zone management, and enhancing environmental NGOs
  - **SDNP** working on promoting networking, access to environmental information, and participatory approaches

+ **LIFE** helping municipalities' CBOs and NGOs in developing environment-protection projects, public awareness, workshops notably on the urban environment, and assist in securing funds
+ **UMP** has helped initiate national studies on solid waste, participation of women, environmental mass media, urban poverty alleviation and participatory governance

- ***Energy Conservation***
  + **GEF Climate Change Enabling Activity** (of which this document is a major output)
  + **Energy Efficiency Regional Project in the Arab States** aims at improving the management of the energy sector in the Region, especially promoting energy end-use efficiency and integrated resource planning to reduce high energy intensity of Arab economies.

- ***Biodiversity Conservation***
  + **GEF Protected Areas Project** for management of three demonstration areas, institutional strengthening and government agencies capacity building, and education-awareness campaigns.
  + **GEF Biodiversity Enabling Activity** to follow up on the biodiversity country study and develop action plan for biodiversity conservation.

- ***Combating Desertification Project***

+ It strengthens institutional framework (both GOs and NGOs), undertakes preparatory surveys, motivates stakeholders, prepares the National Action Program and ensures availability of resources

- ***Agro-Biodiversity***

+ Like the biodiversity above but geared more specifically to agro-production, genetics and preservation of potentially valuable species.

B. Major Non-UN Programs

- ***Regional Program for Solid Waste Management***

+ It aims to reduce the effects of uncontrolled open and burning dumping of SW especially in urban areas, to create productive activities especially involving women, disseminate knowledge and encourage practices for the re-use and re-cycling, and public awareness

- ***Mediterranean Network for Biodiversity Conservation in Hot Areas***

+ Establish an action plan for environmentally stressed areas (hot) to ameliorate their environmental conditions, assure enacting economically productive activities (e.g. bees breeding), institutional capacities and public awareness, plus training of experts.

- ***Strengthening Industrial Control and Monitoring***

+ To support efforts geared to reduce industrial pollution especially through upgrading relevant legislation, EIA and strengthening management.

- ***Rehabilitating the climatic gauging stations, modernizing equipment and training personnel***

- ***GLOBE***

+ This is an agreement with the American National Ocean-Atmosphere Administration, to enhance educational environmental awareness and more effective participation in and contribution to earth-environment programs.

+ At the National Council for Scientific Research several relevant components exist:
  - *SOCSS* - Survey of Operating Climatic and Solar Stations project
  - *NCMS* - National Center for Marine Studies
  - *NCRE* - National Center for Renewable Energy
  - *NCRS* - National Center for Remote Sensing
  - *DANP* - Database of Air and Noise Pollution
  - *CWDD* - Center for Water studies, Documentation and Database
  - *USOCM* - Unified Soil Classification Maps of Lebanon
  - ATSUWS - Airborne Thermal Scanning of Unconventional Water Sources
  - *ERes Man MedK* - Environmental Resources Management in Mediterranean Karstic areas
  - *EPEPF* - Evaluating Plant Ecosystems in Pine Forest
  - *FFRAPP* - Forest Fire Risk Assessment and Prevention Plan

There are many other steps that have been taken variably by Ministries and could indirectly contribute to a response mechanism. Examples include projects on sustainable development of rural areas, reforestation, rehabilitating the water sector, enforcing relevant environmental legislation, banning CFCs, introducing unleaded fuel (benzene), increasing prices of fuel, enhancing re-use and recycling, reduce solid waste incineration ... etc.

Obviously, all the above mentioned projects or practices are crucially significant, must be encouraged to continue and to expand. What is lacking, however, and that could undermine the long-term continuity, is the need for following elements: 1. coordination, 2. integration, 3. availing information, and 4. standardization. Unless a well-defined coherent plan in the various relevant sectors is devised that incorporates these 4 elements, a long-term and efficient climate change response strategy would not be achieved.

4 EXPECTED IMPACTS OF CLIMATE CHANGE AND ADAPTATION MEASURES

4.1 BIOCLIMATIC ZONES

A. Impacts

The parameters that characterize the climate change are numerous: precipitation, temperature, atmospheric humidity, winds, intensity and length of the drought period, potential evaporation etc ...

The chosen model/scenario for the Lebanese case study for Vulnerability Assessment to Climate Change is HadCM2/HHGGax, according to which CO_2 emissions will continue to increase with an annual rate of 1%, leading to a doubling of the 1990 CO_2 level by the year 2060. Based on this model/ scenario, the expected changes in the principal climatic factors (e.g. precipitation, temperature ...) are shown in Table 4.1.

These changes are bound to reflect directly upon the dstribution of the current bioclimatic levels. The modifications, in terms of area percentage of the Lebanese territory covered by each of the identified bioclimatic levels, are summarized in Table 4.2, whereas the chronology of these changes is shown on the enclosed map.

B. Vulnerability and Adaptation

In our case, i.e. the Mediterranean climate, the evaluation of the degree of vulnerability can be based on the study of the two principal limiting factors: period of droughts and risk of frost. The vulnerability to climatic modifications becomes greater when these factors increase in value or in intensity.

At this point of the study we can say that the most bioclimatic vulnerable zones are the levels that are the most humid and cold ones, the areas that lay under severe drought conditions and also the regions where a "climatic warming" would occur within the high altitudinal ranges, i.e.>1500m.

On the other hand, a medium degree of vulnerability can be given to the areas submitted to changes that will induce their crossing to the closest level, especially in the medium altitudinal ranges, i.e. from 500m up to 1000-1500m.

All other areas would be classified under a low vulnerability degree, particularly where no changes in the distribution of the bioclimatic levels have occurred.

As a result of this study, we can make the following comments:

- The predicted changes in climatic parameters, i.e. decrease in precipitation amounts combined with an increase in temperature values, reflect clearly on the spatial distribution of the bioclimatic levels.

- The decrease in area coverage, for a given bioclimatic level, is frequently accompanied by a fragmentation of the initial area. On the other hand, an increase in such coverage results in joining separate regions under one geographic and bioclimatic zone
- Another relevant fact consists in the individualization, in year 2080, of a new bioclimatic level extreme arid, characterized by a twelve-month period of drought, and in the disappearing of the Oromediterranean level along milestone-years 2050 and 2080.
- Variations are also observed through the latitudinal and longitudinal shifting of the boundaries of these bioclimatic levels.

Table 4.1. Values of predicted temperature and precipitation changes for the years 2020, 2050 and 2080 (source IPCC, Model HadCM2/HHGGax)

PARAMETER	MINIMUM TEMPERATURE						MAXIMUM TEMPERATURE						AVERAGE TEMPERATURE						PRECIPITATION*					
GRIDBOX	2123			2219			2123			2219			2123			2219			2123			2219		
YEAR / MONTH	2020	2050	2080	2020	2050	2080	2020	2050	2080	2020	2050	2080	2020	2050	2080	2020	2050	2080	2020	2050	2080	2020	2050	2080
JAN	1.16	1.61	2.51	1.22	1.86	2.77	1.37	2.1	3.57	1.57	2.28	3.77	1.23	1.8	2.88	1.39	2.09	3.25	-3.1	-7.75	-17.98	-4	-4.34	-10.23
FEB	1.16	2.06	3.05	1.31	2.24	3.28	1.75	2.69	4.23	1.94	2.84	4.25	1.39	2.29	3.55	1.62	2.52	3.76	-8.12	-9.8	-13.72	-7.28	-5.88	-8.68
MAR	1.63	2.43	3.54	1.88	2.62	3.66	1.99	2.92	4.45	2.08	2.89	3.99	1.8	2.67	4.01	1.95	2.72	3.8	-3.72	-4.65	-10.85	-3.41	-3.72	-3.41
APR	1.58	2.23	3.58	1.51	2.2	3.37	1.86	2.45	4.16	1.67	2.45	3.76	1.73	2.34	3.89	1.59	2.31	3.53	-3	-1.8	-7.5	-2.7	-3.6	-6.6
MAY	1.77	2.6	3.99	1.59	2.36	3.6	1.75	2.73	4.14	1.66	2.54	3.89	1.74	2.65	4.02	1.62	2.43	3.7	-3.1	-4.03	-8.06	-0.93	-2.17	-4.96
JUN	1.72	3.17	4.83	1.66	3.06	4.67	1.56	3.31	5.3	1.54	3.37	5.24	1.62	3.23	5.06	1.58	3.22	4.97	-0.3	-0.6	-2.1	-0.3	-0.3	-0.9
JUL	1.89	3.11	4.7	1.81	3.19	4.97	1.92	3.54	5.83	1.88	3.57	5.95	1.88	3.34	5.32	1.86	3.41	5.52	0	0	-0.31	0	0	0
AUG	1.99	3.11	4.48	1.71	2.69	4.12	1.7	2.66	4.27	1.55	2.42	4.11	1.81	2.84	4.33	1.63	2.54	4.12	0.31	0	0	0	0	0
SEPT	2.04	3.67	5.46	1.92	3.47	5.23	1.99	3.66	5.68	2.01	3.74	5.82	2.01	3.63	5.53	1.98	3.61	5.55	-0.3	-0.3	-0.9	0	0.3	-0.3
OCT	2.12	3.72	5.2	2.09	3.78	5.44	2.1	3.34	4.34	2.14	3.37	4.58	2.1	3.5	4.79	2.09	3.55	5	-2.48	-0.93	-2.48	-3.1	-1.55	-3.41
NOV	1.57	2.37	3.17	1.64	2.48	3.46	1.61	2.12	3.15	1.73	2.25	3.19	1.59	2.27	3.21	1.7	2.41	3.4	-4.5	-4.5	-12.3	-6.3	-0.75	-11.7
DEC	0.8	1.47	2.39	0.97	1.76	2.59	1.44	2.17	3.57	1.52	2.22	3.62	1.05	1.78	2.86	1.24	2	3.09	-10.85	-13.95	-22.94	-5.89	-6.2	-11.16
YEARLY AVE. OR TOTAL	1.61	2.62	3.9	1.6	2.64	3.93	1.75	2.8	4.39	1.77	2.82	4.34	1.66	2.69	4.12	1.68	2.73	4.14	-39.16	-48.31	-99.14	-33.61	-28.21	-61.35

*Monthly precipitation results were calculated from daily change values

Table 4.2. Area percentage for the bioclimatic levels, along the different milestone years

Bioclimatic level	Baseline scenario	Climate change scenario		
		Year 2020	Year 2050	Year 2080
Extreme arid	—	—	—	2.762
Arid	4.856	4.919	4.920	13.270
Semi-arid	19.321	23.838	23.871	15.223
Subhumid	45.166	49.575	50.652	60.757
Humid	25.903	19.728	19.442	7.470
Perhumid	4.522	1.765	1.115	0.518
Oromediterranean	0.232	0.175	—	—

4.2 WATER RESOURCES

A. Impacts

The exposure units used in the study to reflect on impacts of baseline and climate scenarios are the water resources where the quantity of water, the quality of groundwater and environmental impact on soil productivity will be subjected to increasing natural and human-induced stresses rendering them very fragile.

- Water quantity would be reduced as the total amount of precipitation would be less, evaporation rate would increase, therefore, springs water yield and rivers flow would decrease as well. Because population is increasing and social attitude is becoming more consumptive, demand for water would also increase.
- Reduced water amounts and increased exploitation of less available water would affect by further deterioration in water quality. This is especially applicable to groundwater where springs would give water that is more concentrated in certain undesirable metals and contaminants than before. Salinity increase would become inevitable.
- Increased stresses on water resources through the fact that precipitation is less, evaporation is more, vegetation cover is reduced, and increased water demand for various utilities, will lead to reduced soil moisture and enhanced desertification thus affecting agricultural productivity.

B. Vulnerability and Adaptation

Water is the most vital resource necessary for all forms of life, when it is vulnerable, all those forms and their activities are vulnerable. And depending on the characteristics of the locality, i.e. geographically (how much rain or snow does it receive), geologically (how adequate are the lithologies to transmit or to store water) and socio-economically (what kind of water-demanding activities are there), will determine whether it is highly vulnerable, medium or low. It turns out that the highest vulnerability is, in addition to availing enough water (quantity) and being of acceptable standards (quality), the economic productivity and living standards. These will be highly affected and may lead to social instability.

There are many and varied adaptation measures that could be taken to ameliorate the above. They should be implemented at different levels, i.e. the strategic, the population and the individual. Some approach solutions through toleration of loss, sharing, changing use or through quality control. They are many and can be summarized as follows:

- a modernized water pipes network that considerably reduces losses and leaks
- a new and independent network to drain excessive rain water for possible future use
- a more efficient taxation and service system that would force people to reduce excesses
- a modernized monitoring system to better quantify and control the quality of water
- apply a diversity of ways for treating wastewater and reusing it
- implementing surface water harvesting projects such as mountain lakes and dams, and a better exploitation of subsurface water through a well-studied network of water wells
- at the community level implement a series of water resource management procedures for better utilization, conservation, and availability as well as better quality

4.3 AGRICULTURE

A. Impacts

The expected changes in the Lebanese agricultural sector irrelevant to the climate change during the next century are dictated by three main factors:

1. A reduction of agricultural areas due to the urban expansion in the coastal zone leading to a shift of land toward more elevated mountainous areas
2. An intensification of the agricultural production using new more advanced technologies
3. An adaptation of a support policy (subsidization) for some agronomic products

B. Vulnerability and Adaptation

Based on these e

precipitation decrease between 61 and 99mm, accompanied by a doubling of atmospheric CO_2 concentration, will affect the growth and the production of the major agricultural crops.

This study was limited only to 4 more expanded crops that are: citrus, olive, apple and sugar beet. Each crop is well representing an appropriate agro-climatic zone: citrus for thermo-Mediterranean, olive for Eu-Mediterranean, apple for supra-Mediterranean and sugar beet for the pre-steppic Mediterranean zone. The impacts of climate change during the coming century on the above named crops, as well as the adaptation measures are demonstrated in a table form as follows:

	Impacts	**Adaptation Measures**
Citrus	• Urban expansion reinforce the displacement of citrus plantation toward hilly calcareous soils induce citrus chlorosis • Recurrence of cold weather and wind ravages on the gardens situated on hills • Water shortage coupled with deterioration of water quality	• Terraces building and transportation of non-calcareous, well structured soil, or substitution of citrus by other tropical trees tolerating calcareous soils such as loquate and avocado • Planting of wind breakers around new planted orchards and cultivation of banana in greenhouses • Digging deeper artesian wells and re-launch some governmental irrigation projects previously planned

Olive	• Thermal increase at the flowering time will decrease the number of flower formation • Low precipitation rate will affect the non-irrigated olive plantation during October and November • The concentration increasing level of CO_2 will enhance the photosynthesis rate. The decrease in the relative humidity in the mountains will limit the spread of fungal diseases (positive effect)	• Expansion of olive plantation toward higher altitude, accompanied by terraces building • Supplemental irrigation is needed to increase fruit size: water harvesting through reservoir construction
Apples	• The shortage of annual precipitation rate and the decrease of the amount of cold degree-days will negatively affect the fruit sitting	• Reclamation of new lands in higher colder mountainous areas, plantation of new varieties (spur types) and construction of reservoirs (lac collinaires)
Sugar beet	• The temperature rises in parallel with increasing CO_2 concentration have a positive impact on the photosynthetic activity • The sugar beet transpiration coefficient that is the lowest compared to other crops, and its high capability to grow in saline soil, encourages its expansion in this zone in the coming time	• Keeping the governmental subsidization policy to encourage farmers to abandon the illicit crop cultivation and to remain in their land instead of leaving it to the city

4.4 TERRESTRIAL ECOSYSTEMS

A. Impacts

The expected changes in the distribution of vegetation communities may lead to the disappearance of certain vegetation associations and their replacement by others. For example, a forest may regress into a shrubland or even grassland depending on the intensity of the modification.

Two forests in protected areas, namely Horj Ehden in the North and Arz Al-Shouf in the Barouk Mountain are characterized by great floral diversity of herbaceous and arborescent plants containing many endemic, rare and endangered species some of which are at the southernmost edge of their distribution. The distribution of *Cedrus libani which* normally falls within the precipitation range of 500-1300 mm with mean winter temperatures between 2 and 5^oC may become increasingly under stress with the upward shift in bioclimatic zones. For a 3^oC temperature increase, for example, an upward shift in vegetation belts of around 545m would be expected. Climatic factors, however, are not the only factors that may affect the success of cedars but there is a clear preference for humid atmospheres and moist well-drained soil.

According to the climatic scenario used here, there may be a 300m upward shift in the year 2020, 486m in 2050 and more than 700 meters in the year 2080. This would push the tree line in the year 2080 in both reserves to around 2500m. Considerable stress will begin to be felt as early as the year 2020. This makes both protected areas highly vulnerable. Furthermore, the rate of change may be faster than the species ability to adapt. Montane vegetation as found in the two above-mentioned reserves may face considerable threat of serious decline and even disappearance.

Other factors, however, such as the increased water efficiency due to CO_2 increase may enhance its ability to withstand the new drought conditions. It is also uncertain to what extent and how soon there may be a change in soil characteristics affecting the vegetation.

In the main wetland area in Lebanon, the Ammiq ephemeral marshes intensive water pumping for the irrigation of several cultivated lands in the surrounding areas has reduced the area and shortened its seasonal span. It is expected that, in the absence of climate change and due to the lack of management plans, these marshes will be affected by:

- Change in land use in the surrounding areas, where more land will be reclaimed for cultivation,
- Increased water demand for the irrigation of these and other nearby cultivated lands.

The effect of climate change on the marshes may take two forms:

1. Spatial: leading to reduction in the total area of the marshes
2. Temporal: shortening of the duration in which the marshes exist during each year. This may mean, for example, that there may be no marshland left for the birds in their autumn return migration.

It is estimated that the total area of the marshes may undergo a decline at the rate of about 6% per year. At this rate, without climate change, the marshes may practically disappear in less than two decades and without climate change. This will be obviously exasperated under climate change.

The Tyr sandy beach, the only remaining significant sand dune habitat in Lebanon for many plants and animals that are unable to thrive except on sandy substrates. The main pressures on the sandy beach in the foreseeable future, without climate change, is land reclamation and tourist development. Increased population density and the demand for more agricultural land will place more pressure on the whole zone. It is considered to be highly vulnerable to sea

The establishment of a nature reserve in the Ras El-Ain area may not be enough to protect sufficient sandy areas. There is a risk that the sandy beach narrow or even disappear with its indigenous fauna and flora.

The Palm Islands Nature Reserve, composed of three islets, will be subjected to inundation under a climate-change scenario.

The main problems facing the Lebanese wildlife today are the same as those listed above for natural areas. Populations of many species may be subjected to extirpation (local extinction) due to the great fragmentation affecting their habitats. This fragmentation is likely to continue and perhaps accelerate due to increased urbanization.

B. Vulnerability and Adaptation

The species most vulnerable to climate change may be those that are endemic, endangered, at the edge of their geographic distribution, montane, coastal and those which may be replaced by potential competitors from other zones. Some such species have been named in this report as facing decline or extinction.

In Lebanon, the known endangered forest tree species are found in degraded, heavily grazed areas. The extent to which they face threat is directly related to the continuing human pressures through felling and grazing. No study has quantified these two aspects. Under climate change, some their areas of distribution may shift bioclimatically putting more stresses on these species.

Adaptations that may reduce the climate change impact may include the following:

1. Natural adaptation where the vegetation and wildlife may acclimatize where the climate change may srtill be within their tolerance range. Some may adapt (in the evolutionary sense) if containing enough genetic diversity.
2. Natural adaptation may have to be assisted by exploring and cultivating certain drought-tolerant ecotypes. It may be also be enhanced by reducing habitat fragmentation and thus allowing the natural genetic variation to lead to suitable adaptations.
3. Habitat fragmentation can be reduced by establishing corridors and connections between the isolated habitat types.
4. Intensive studies on species and ecosystems have to be devoted to assess the degree of vulnerability an to discern the above aspects.
5. Water use and change in land use have to be rationalized to protect wetlands and riparian habitats.
6. The area and the number of protected areas need to be expanded to include more of the sensitive habitat types and/or more vegetation and bioclimatic zones.
7. Buffer zones need to be established around protected areas to reduce the human impacts and those of climate change.

8. Adaptation measures have to be adopted within the next two decades.
9. Because of the international importance of some protected area it may be possible to seek international a

   and maintenance of protected areas and nature reserves.

4.5 THE COASTAL SYSTEM: THE PHYSICAL COMPONENT

A. Impacts

The exposure units used in the study to reflect on impacts of baseline scenario and climate scenarios are the coastal lands where low-lying coastlines, beach stability and coastal waters will be subjected to increasing natural and human-induced stresses rendering them very fragile.

- Low-lying segments between 2.5 and 1.5m geoidal elevation would be critical due to relative rise in sea level. Sandy stretches would be under increasing threat of erosion
- A higher frequency of inundation would mean more aggressive attack on coastal stretches inducing land loss
- A rising sea level would lead, together with the presence of karstic coastal water regime and continuously increasing human excesses on the fresh ground water resource, to furthering salt-water intrusion. This means, therefore, less water is available and of worse quality.

B. Vulnerability and Adaptation

Obviously, any natural or human-operated activity on the coastal stretch is vulnerable. But depending on the specific site, i.e. whether critically low-lying or not, sandy or rocky, rich in resources or not, what kind of land-use is it- urban, agricultural, tourism, services, utilities ... etc., will determine whether it is highly vulnerable, medium or low. It turns out that the highest vulnerability is where land would be lost, where instability of beaches increases, where modification of the coast is imminent, where water quality is affected most, and where some economic activities would have to be eliminated or reduced.

There are many and varied adaptation measures that could be taken to ameliorate the above. They should be implemented at different levels, i.e. the strategic, the population and the individual. Some approach solutions through toleration of loss, sharing, changing use or through quality control. They are many and can be summarized as follows:

- reduce infringement on coastlines, on beach and in the nearshore
- control coastal land-use in a way appropriate with reducing excesses on the coastal regime
- allow only low-economic cost activities at sites of very critical and critical risk potential coastlines
- take forceful preventive measures for on-going activities deleterious to the coastline
- devise economic and social incentives
- design and implement soft and hard protective barriers where most appropriately applicable

4.6 THE MARINE ECOSYSTEM

A. Impacts

The exposure units in the coastal zone can be divided in two parts:

- Benthic: - sandy coast
  - rocky coast
- Pelagic: - plankton, primary production ...
  - nekton, fisheries ...

By global warming, the former will be affected particularly by sea level rise and the latter by water temperature increasing

Concerning Benthic ecosystem, coastal systems in the country are under high potential threat from development. This development includes large cities (>100.000 people), major ports, touristic complexes, all of which contribute to pollution in coastal areas, resulting in the deterioration of benthic populations. Coastal pollution is a major problem in Lebanon. Also oil spills from ships and pipeline, as well as land-based pollution discharges-all of which lead to the deterioration of coastal areas particularly the benthic populations in absence of regular and ecological data. The major pressures on coastal zones will be related to development rather than the direct result of climate change. In Batroun Bay for example, basing in a sketch map of Lebanon's coastline showing geoidal elevation (G.E.) and geographic distribution of risk potential areas, we conclude that the region of Batroun Bay is situated in the category of less critical zone (geoidal elevation >2.5m) and G.E. is 3.8m in this region. Terraces, which are partially submerged will be gradually emerged. Algae will receive different qualitative and quantitative light and this will affect their distribution.

Concerning pelagic ecosystem, the major parameters used in trying to estimate the effect of climate change are:

- Water temperature
- Phytoplankton populations
- Total product of fish and total product of Clupeidae

The increase of water temperature is based on the increase of air temperature after GCM.

20.67 in 2080.

The phytoplankton populations in Jounieh Bay, species responsible for bloom at late winter and at the beginning of spring like *Skeletonema costatum, Nitzschia spp., Leptocylindrus denicus and L. minimus* and others could start earlier, because features of temperature marine planktonic ecosystems are not only sensitive to annual variations in weather, but also any trends that might result from greenhouse warming or other factors that affect the climate system. Both density and timing of spring blooms will be altered in some regions. The taxonomic composition of the phyto- and zooplanktaton may change influenced by the change of ocean structure.

Clupeidae which is very sensitive to the gradient of temperature will reproduce also earlier in our country. Concerning species, maybe thermophile species will increase in density replacing the biota of other species preferring cooler waters. Changes in plankton productivity associated with greater temperature and greater stratification of the water column may favor pelagic as opposed to demersal fish communities.

B. Vulnerability and Adaptation

The following measures and recommendations can be drawn:

1. Coastal systems in the country are under high potential threat from chaotic development and urgently need a coastal management for a sustainable development
2. Most data concerning coastal zone are not sufficient and should be completed for a better understanding of marine ecosystems
3. Appropriate programs and selected marine environmental factors should start properly on a regular basis and for a long term to help the determination of trend of climate change
4. Studies concerning benthic and pelagic ecosystems should focus on the studies of species not only groups or families

4.7 SOCIO-ECONOMIC ASPECTS

A. Impacts

Socio-economic climate change impacts in Lebanon will vary among economical sectors and regions.

As a whole, economy will mildly suffer, since it relies mainly on services not on agriculture. Tourism will improve positively. Coastal activities show artisanal fisheries and an over-urbanization, expected to double in 2020. Losses on human settlement due to climate change will be noticed if deliberate adaptive measures are not applied. But agriculture and public health will be the most vulnerable sectors.

Climate change impact on agriculture will have moderate consequences over the economy, because of the weak share of this activity in the GDP. Even though there is no big natural catastrophe, many geoclimatic regions and alternative crops, rural low-income regions relying on agriculture will particularly suffer. Agriculture is already weakened by many factors: small parcels, inadequate technique, and high production cost, absence of marketing policy and over-urbanization of the fertile coastal plains. Thus, products are non competitive even in their local market. This leads to a progressive rural exodus towards the suburbs searching for a more lucrative job.

B. Vulnerability and Adaptation

The climate change will affect this sector by three means at least:

- Water shortage secondary to diminishing precipitation will induce the use of high cost drip methods
- Deterioration of water quality either by pollution or aquifers or by salination due to over-pumping and sea level rise
- Shift of cultivation to more favorable altitudes, necessitating new investments

The poor populations of rural regions cannot afford easily such investments, and it is expected to witness a worsening of their economical activities, exacerbating a rural exodus to suburbs, of which the inhabitants have also their economical difficulties and are unable to face a new situation caused by climate change.

These groups (rural and suburbs) have the highest index of unsatisfied basic needs. Vicious circle is closed with household size (6.5 to 7), low-income, unskilled people and high rate of unemployment.

The cost of health care is one of the highest in the world (11.8% of GDP), preventive component is very weak; disparities are evident. Most vulnerable groups to diseases are infants, children, elderly, malnourished and non-immunized. Three categories of diseases are relevant:

- Water-borne diseases (diarrhea, typhoid and hepatitis A)
- Vector-borne diseases (conditions of outbreak of malaria are still present)
- Acute respiratory illnesses, which are the first cause of infant mortality despite WHO's program recently launched

Human health will be affected in the same under-served area by climate change. All above mentioned diseases will find a favorable physical and sociological medium. Increase in temperature and humidity will allow anopheles to bread and malaria parasites to mature. Diminishing of precipitation will increase air pollution and consequent respiratory effects mainly in the suburbs.

Adaptive measures are needed to reduce socio-economic impact of climate change. The most important one must be to implement an integrated development in rural regions and suburbs. In this order:

- Familial planning aiming to reduce household size is mandatory
- Rational use of water and preservation of its quality (prevention of pollution and treatment for potable water)
- Widespread of vaccination and preventive medicine
- Facilitate access to health care and education (especially technical)
- More job opportunities in the rural regions by mean of development of alternative sectors: exotic fruits, green tourism, food processing and light industry.

5. PROJECT PROPOSALS AND RECOMMENDATIONS FOR FUTURE WORK

5.1 ELECTRICITY SUPPLY SECTOR

The two options that have been identified for the electricity supply sector in Lebanon are solar and wind energy generating units, and combined cycle plants operating on natural gas. As for natural gas, the unavailability of such a resource in Lebanon is currently being addressed. The Lebanese government has already negotiated the issue of natural gas with the Syrian authorities and as a result natural gas is expected to be available around 2005. In addition, to address the situation when Syria would not be capable of satisfying the whole Lebanese market, the USTDA (United States Trade and Development Agency) has sponsored a study to check the feasibility of importing gas from Europe and doing all the necessary treatment here in Lebanon to make it satisfy the required specifications. Additional feasibility studies have to be conducted in this area.

With regard to renewable energy, a lot of work has to be done to drastically change the situation into one favoring a significant penetration of renewable on both the generation and demand sides. The following are the barriers that the project should address at present.

<u>Information Barriers</u>

- Lack of accurate wind and solar resource assessment. Shortage of data on patterns of end-use energy consumption in all sectors of the economy prevents practical evaluation of supply-side and demand-side management programs based on solar and wind energy.
- Lack of documentation regarding the economic, environmental and social implications of existing supply-side energy technology.

<u>Awareness Barriers</u>

- Decision makers are not familiar with the social, environmental and economic benefits, resulting from the introduction of renewable energy.

<u>Economic and Financial Barriers</u>

- There are no dedicated financing schemes or special incentives to promote renewable energy systems especially that such systems have very high capital investment costs.

<u>Institutional Barriers</u>

- No policy that favors renewable energy, nor there are laws that permit private electricity generation in the country.

<u>Capacity Barriers</u>

- There are very few people who are familiar with the installation, operation and control of solar and wind energy systems.

5.2 BUILDING SECTOR

The two main barriers for the quick development of the previously mentioned options in Lebanon are :

1. The high prices of the equipment on the local market.
2. The relatively low cost of the electricity.

These two main barriers lead often to high payback times (8 years for the solar domestic hot water system, 15 years for the efficient refrigerator, etc..).

Consequently, steps to be adopted for accelerating the diffusion of options in question are :

At short and medium terms :

1) Adjustment of the electricity prices to reflect the real production cost .
2) Establishment of a quality control system such as certificates and labels of quality in order to better guide the consumer.
3) Training of technicians on energy saving issues and especially in the solar domestic hot water equipment.
4) Development of new customs policies and laws in favor of the performing equipment instead of the consuming one.
5) Awareness campaigns .

At long term :

1) Establishment of quality norms.
2) Development of local industries especially solar domestic hot water and efficient refrigerators.
3) Development of a loan system for credit sales on energy performing equipment at low rates for the industrials, contractors and consumers.
4) Establishment of regulations in the residential and commercial sectors for installing solar domestic hot water systems.
5) Integration in the energy pricing the notion of the “environmental cost”.

5.3 BUILDING ENVELOPS

The recently developed Thermal Building Guideline which aims at enhancing the thermal performance of building envelopes, and thus of reducing the energy consumed for space heating and cooling, faces numerous barriers that hinder its adoption and application. The main barriers are the following:

- ***Information and Know-how barrier:*** **Unfamiliarity with subject matter among professionals, policy makers and consumers; Uncertainty about the effectiveness of the new technology (Energy reduction versus new problems of construction details or space overheating)**
- ***Economic barrier:*** **Uncertainty with economic and environmental implications; Initial incremental cost of conservation measure.**
- ***Institutional barrier:*** **Lack of trained personnel; Lack of adequate verification mechanism.**

Consequently, there seems to be two main projects needed in this sector:

➢ **Capacity Building project** aimed at providing the needed foundation of supportive policy makers, informed consumers, skilled professionals, and trained personnel.

- **Market based program** aimed at overcoming the initial incremental cost and at activating market demand.

Recommendations for future work

- The analysis has been performed based on the assumption of 25% reduction on heating and cooling energy needs per building unit. A detailed simulation of study cases is needed for the various climatic zones in order to determine more accurately the potential of energy reduction.
- The specifications of the Thermal building guideline were recommended based on historical precedent in other countries. Further work is needed to update the specifications based on an economic cost-effective approach.
- The analysis has considered the potential of static building envelope conservation measures. A further multi-parameter assessment that looks at the overall potential of passive heating and cooling techniques for the Lebanese climate is needed.
- Assessment of the potential of microclimatic interventions such as increasing green cover along the coastal zone as a means of reducing the urban heat island effect, and thus reducing cooling energy needs.
- This analysis has assumed that both the residential and commercial uses will rely on partial heating and cooling. Further data refinement in terms of differentiating between residential and commercial energy uses and energy growth rates is needed.
- The analysis did not account for additional energy reductions due to the natural improvement of the efficiency of HVAC equipment.
- The cost-benefit assessment of this analysis looked at the national level; a further assessment of the consumer pay back period is needed.

5.4 INDUSTRIAL SECTOR

Motor Drive System Improvement and Replacement

Motor-driven systems are the backbone of industrial operations such as fluid handling and movement, and material processing and fabrication. These systems account for more than 70% of all electricity used by the industrial sector in Lebanon. Improvements in the efficiency of these electric motor systems can translate directly into enhanced productivity, competitiveness and environmental performance. Electric motors are generally regarded as very efficient, with first law efficiencies of order of 90%. Yet, in the aggregate, losses are considerable. In Lebanon, a large number of motor drive systems are relatively old, or second-hand. Replacing old motors with new ones represents a great opportunity for improving the system efficiency. But this has to go hand in hand with motor control improvements, particularly for variable frequency drives of induction motors, which can cut internal losses by a factor of 2, at least. In order to carry an accurate analysis, data should be available on the number of current motors in use by the industrial sector in Lebanon, their power rating, years of operation and efficiency. Such data were not available, so a few assumptions have to be made in order to arrive at a reasonable model for this mitigation option. Two scenarios for electric motor replacement are considered. The first scenario “M1A” considers replacement of old electric motors with new efficient ones. The second scenario “M1B” considers that the new standard motors added to the industry each year are replaced by new efficient motors.

The replacement of old electric motors by new energy efficient ones is proposed according to the following schedule: year 2000: 10 % of old motors is replaced by new ones, year 2005: 25% of old motors is replaced by new ones, year 2015: 50% of old motors is replaced by new ones, year 2040: 100% of old motors is replaced by new ones. The replacement of added new standard motors by efficient ones will be considered done for all new imported motors starting year 2000.

The average implementation current cost of the new energy-efficient motor is estimated as $66/HP for the 20-50 HP range and $61/HP for the 50-100 HP range. The motor rewind cost has an average value of $16/HP, and the average standard motor cost is estimated as $56/HP for the 20-50 HP range and $61/HP for the 50-100 HP range. Industries in Lebanon use motors for periods of time that are far beyond the motor lifetime and rewind old motors once they breakdown. For the first motor scenario, the modified annualized life cycle cost is then based on the incremental cost of the new electric motor of which the motor rewind cost is subtracted rather than incremental cost between an energy efficient new motor and a standard base-case new motor. The calculated life cycle cost is then equal to $50/HP for the 20-50 HP range and $45/HP for the 50-100 HP range. In the second motor replacement scenario where the new standard motors are replaced by energy efficient ones, the modified annualized life cycle cost is then based on the incremental cost between an energy efficient new motor and a standard base-case new motor. The calculated life cycle cost difference is then equal to $10/HP for the 20-50 HP range and $12/HP for the 50-100 HP range. The energy savings are calculated based on 3600 hours of operation of the motors per year.

The costs and benefits of the proposed mitigation options for electric motors are shown in Table 5.1, where the cost in Million of real 1994 $ is given over selected years and the discounted cost over the selected study period are presented. The expected carbon dioxide emission reductions over the study interval (1994-2040) are shown in Table 5.2.

Table 5.1: Electric Motor Improvement and Replacement Project Costs and Benefits

MITIGATION OPTION	Cost Million Real 1994 $ (2000)	Cost Million Real 1994 $ (2005)	Cost Million Real 1994 $ (2015)	Cost Million Real 1994 $ (2040)	Costs Discounted To 1994 $ At 10% Dr (1994-2040)	Benefits Discounted To 1994 $ At 10% Dr (1994-2040)	Benefit To Cost Ratio
Scenarios associated with low economic growth Baseline BA							
M1A Costs	0.26	1.04	2.91	12.75	12.42	84.51	6.8
M1B Costs	46.42	55.87	81.86	214.46	99.42	599.33	6.03
Scenarios associated with high economic growth Baseline CA							
M1A Costs	0.31	1.42	5.32	47.76	25.52	216.36	8.47
M1B Costs	55.15	76.6	149.5	803	168.91	1027	6.3

Table 5.2: Emission Reductions of Electric Motor Improvement and Replacement Project

Mitigation Option	CO_2 Reduction (Gg) (2000)	CO_2 Reduction (Gg) (2005)	CO_2 Reduction (Gg) (2015)	CO_2 Reduction (Gg) (2040)	Total CO_2 Reduction (Gg) (1994-2040)
Reductions from Baseline BA					
M1A	2.59	8.5	345.1	1055	20,633
M1B	29.45	46.77	79.39	219.52	4,640
Reductions from Baseline CA					
M1A	2.61	9.45	192	3625	57,822
M1B	33.95	62.14	134.56	754.34	12,512

Boilers and Furnaces Improvements in Efficiency by Replacement and Fuel Switching Options:

The burning of fossil fuels in boilers, to raise high temperature and high-pressure steam that have been used for various heating and power generation processes, produces a problem source of carbon dioxide and other green house gases. Efforts to increase the efficiency of industrial processes should also focus on improving the efficiency of boilers and furnaces. Many industrial processes involve the use of direct thermal heating either from steam or using electricity directly. Examples vary from food processing industries, chemicals, plastics, glass and steel manufacturing. Conventional boilers used in industry are mostly operated using fuel oil followed by gas oil and a small percentage of LPG. Heating furnaces are also operated using fuel oil. Accurate data on age distribution and age-efficiency of boilers used in the industrial sector in Lebanon are not available. The current state of boiler equipment in industry is similar to that of electric motors, where the average age of boilers would easily exceed 20 to 30 years. In absence of an energy code for boiler-efficiency standards, engineering estimation and sizing of boilers to the respective application is not properly administered. The mitigation option of replacing old boilers in the industrial sector with cleaner and more efficient systems, these options are divided into two main categories. The first category considers only improvement in boiler efficiency where old boilers are replaced with new efficient ones operating on the same fuel type. The second category considers replacing inefficient industrial boilers with efficient ones that operate on a cleaner fuel such as LPG or natural gas.

- Replacement of old boilers by new energy efficient according to the following schedule:
  Year 2000: 10 % of old boilers is replaced by new ones.
  Year 2005: 25% of old boilers is replaced by new ones.
  Year 2015: 50% of old boilers is replaced by new ones.
  Year 2040: 100% of old boilers is replaced by new ones.

- Fuel switching from fuel oil and from diesel to natural gas and LPG is according to the following schedule for boilers and furnaces:
  Year 2000: 10 % of old boilers are replaced by new ones.
  Year 2005: 20% of old boilers is replaced by new ones.
  Year 2015: 40% of old boilers is replaced by new ones.
  Year 2040: 60% of old boilers is replaced by new ones.

The costs and benefits of the proposed mitigation options for boilers and furnaces are shown in Table 5.3, where the cost in Million of real 1994 $ is given over selected years and the discounted cost over the selected study period are presented. The expected carbon dioxide emission reductions over the study interval (1994-2040) are shown in Table 5.4.

Table 5.3: Boilers and Furnaces Improvement and Replacement Project Costs and Benefits

MITIGATION OPTION	COST Million Real 1994 $ (2000)	COST Million Real 1994 $ (2005)	COST Million Real 1994 $ (2015)	COST Million Real 1994 $ (2040)	COSTS Discounted To 1994 $ AT 10% DR (1994-2040)	BENEFITS Discounted To 1994 $ AT 10% DR (1994-2040)	Benefit To Cost Ratio
Scenarios associated with low economic growth Baseline BA							
M4 Costs	0.2	0.8	2.41	9.76	9.87	84	8.5
MB Costs	.07	0.24	0.77	1.92	2.86	30	10.3

M8 Costs	.35	1.17	3.1	47	111.41	66	1.68
M9 Costs	1.14	3.73	12.5	30.24	69.38	75	1.09
Scenarios associated with high economic growth Baseline CA							
M4 Costs	0.24	1.09	4.41	36.56	20.25	173	8.54
MB Costs	.07	0.24	0.77	1.92	2.86	30	10.3
M8 Costs	.42	0.161	5.4	175	233.85	185	0.79
M9 Costs	0.6	2.06	8.3	64.67	144.95	151	1.04

Table 5.4: Boilers & Furnaces Improvement and Replacement Emission Reductions

MITIGATION OPTION	CO_2 Reduction (Gg) (2000)	CO_2 Reduction (Gg) (2005)	CO_2 Reduction (Gg) (2015)	CO_2 Reduction (Gg) (2040)	Total CO2 Reduction (Gg) (1994-2040)
Reductions from Baseline BA					
M4	40	150	400	1270	24473.84
MB	10	60	150	290	6913.8
M8	40	110	300	900	17552.22
M9	30	80	210	630	12416.32
Reductions from Baseline CA					
M4	40	210	740	4780	75265.66
MB	10	60	150	290	6912.88
M8	60	250	890	5580	88475.48
M9	20	100	390	380	37913.66

Cement Mitigation Option

The cement industry is the single largest source of Lebanese process CO_2 emissions and a major energy user. Energy related CO_2 emissions are of similar magnitude depending on the cement kiln technology. Of the process emissions, about 60% of the direct emissions are from calcination of lime stone and the other 40% are from combustion products of fossil fuels that directly or indirectly supply the energy for calcination. Grinding is the other major energy consumer in the manufacturer, which is usually a low efficiency process. According to the baseline scenario on cement demand, 38% of 1994-cement production is coming from an old technology while 62% of the production is already producing cement with retrofit and new plants.

The proposed mitigation option includes conservation and preheating in the pyroprocessing, which can save 10% in fuel energy, and include improvements in the grinding process, which is reported to have made small but significant gains through use of mill liners, grinding media and the use of more complex grinding circuits. Implementing such an improvement would save at least 5% of the electric energy use.

The costs and benefits of the proposed mitigation options for boilers and furnaces are shown in Table 5.5, where the cost in Million of real 1994 $ is given over selected years and the discounted cost over the selected study period are presented. The expected carbon dioxide emission reductions over the study interval (1994-2040) are shown in Table 5.6.

Table 5.5: Cement Production Improvement Project Costs and Benefits

MITIGATION OPTION	COST Million Real 1994 $ (2000)	COST Million Real 1994 $ (2005)	COST Million Real 1994 $ (2015)	COST Million Real 1994 $ (2040)	COSTS Discounted To 1994 $ AT 10% DR (1994-2040)	BENEFITS Discounted To 1994 $ AT 10% DR (1994-2040)	Benefit To Cost Ratio
Scenarios associated with low economic growth Baseline BA							
C2 Costs	.07	10.11	14.92	27.8	61.38	42.01	0.688
Scenarios associated with high economic growth Baseline CA							
C2 Costs	1.84	13.9	27.14	69.62	113.22	74	0.65

Table 5.6: Emission Reductions of Cement Production Improvement Project

MITIGATION OPTION	CO_2 Reduction (Gg) (2000)	CO_2 Reduction (Gg) (2005)	CO_2 Reduction (Gg) (2015)	CO_2 Reduction (Gg) (2040)	Total CO2 Reduction (Gg) (1994-2040)
Reductions from Baseline BA					
C2	20	210	270	390	11331.64
Reductions from Baseline CA					
C2	40	290	500	980	23626.98

Recommendations For Future Work

The mitigation efforts in industry should focus on long term support for energy efficiency measures and fuel switching in boilers and furnaces to cleaner types. A comprehensive energy audit for the industrial sector is a first step. Subsidy support should enable companies even those with limited financial resources to afford comprehensive efficiency measures, given the lack of resources to invest in new equipment by manufacturers. Policies should focus on increasing the speed with which technology is replaced. Standards for energy efficiency for equipment should be mandatory along with a mechanism for monitoring energy use and CO_2 emissions. More accurate data are needed to assess the industrial sector for each type of product or process. Training should be provided to managers and professionals to increases their awareness about GHG emissions and benefits associated with energy savings and measures taken to reduce these emissions. For technologies where natural gas is to be used, the government must insure uninterrupted supply.

Although the proposed mitigation projects suggest a substantial reduction in CO2 emissions associated with manufacturing activities, it would require a strong, well-designed policy package involving a political will.

5.5 TRANSPORT

Most of the emissions' reduction comes from small and light- duty vehicles that form the vast majority of the fleet. Switching to electric vehicles can be effective only if the electricity used for charging the batteries is generated from a clean energy source such as hydropower, or eventually renewable energy resources. Use of electricity generated from natural gas for batteries charging could lead to around 30% reduction in GHG emissions. Batteries are still expensive and currently electric cars cost almost twice as much as petrol- driven ones and the drive- per- charge range is still less than 100 km. These limitations still make electric vehicles a less attractive option related to conventional vehicles for wide- spread use.

Another new vehicle technology is the hybrid electric vehicle (HEV) with high- energy efficiency and a much lower GHG emission rate. HEV could have a consumption rate almost 60% of that of equivalent conventional fuel-driven car but with a unit price almost 25% more. Two scenarios have been developed. The first lacks any governmental incentives and assumes merely a 1% share for HEV of imported vehicles by year 2015, and double this value by 2040. In the second scenario, car registration waver is to be introduced by the government, and this is expected to increase the share of HEV to 10% of the imported cars by 2015 and again by twice this value by 2040. This scenario would lead to emission reduction rate is around 10% and would be profitable in the long run due to savings in fuel consumption.

Advances in diesel fuel and engines' technologies made diesel cars more competitive to the gasoline ones. Diesel engines, with higher energy content, are more environment- friendly in some aspects such as carbon monoxide, oxides of nitrogen, and hydrocarbons emissions. On the other hand, diesel fuel has higher carbon content and more Btu per unit volume. As a result, the overall reduction in energy consumption and CO_2 emissions would not reach 1%. Diesel fuel would still be an attractive alternative for personal travel since its cost is almost 60% that of gasoline. Their use should, however, be accompanied by a strict tail pipe smoke and emissions control.

Other feasible alternatives with great potential to reduce GHG emissions are different biomass-derived gases. It has been reported recently that ethanol can reduce CO_2 emissions by around 90%. This technology, however, is still in the stages of research and development in car-manufacturing nations and hence its pricing is still very difficult to set. Similar analysis would apply to options to improve the vehicle design such the aerodynamics, reduce vehicle weight, reduce engine size and improve the combustion efficiency.

Measures to shift towards travel modes with lower emissions include promoting public transport and freight railway systems. Rail freight systems have the greatest benefit- to- cost ratio and the greatest relative emissions reduction. Subsidies to public transport would lead to a reduction in fares compared to personal travel, mainly for longer-distance trips. Deployment of rail systems for freight is the most promising alternative in term of consumption and emissions reduction. Adopting a rail system of six lines results in a 67% modal share for small vehicles (private autos and taxis) in 2015. This reduction is expected to translate into a 10% reduction in automobile-related trip making at the national level. The increase in speed on the GBA from 18 km/hr to 22 km/hr is translated into an increase in fuel efficiency and consumption rate close to 30 km/20 liters.

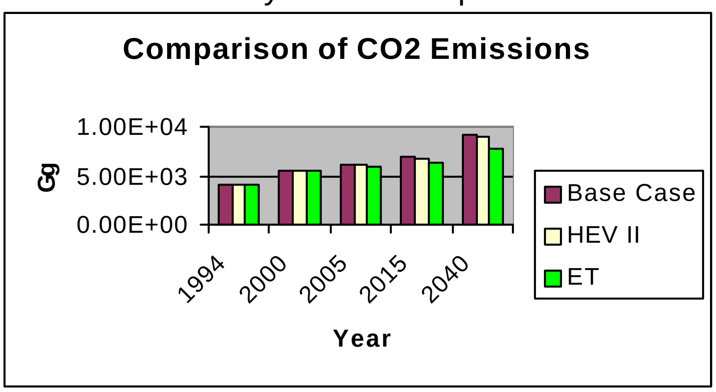


Fig.5.1: Comparison of CO_2 emissions.

A comparison of the CO_2 and CO emissions in the base line, the HEV with incentive, and the electric trains scenarios are illustrated in Figure 5.1

Measures for improving system efficiency are highlighted. These include improving traffic flow by implementing computerized signal timing, increasing vehicle occupancy rate by ride sharing, and reducing trips lengths via decentralization.

Development in the aviation technologies, worldwide, is expected to lead to better energy conversion efficiency. These developments, when realized, would lead to significant reductions in GHG emissions in countries that would acquire these new generations of planes, including Lebanon.

Technologies used in aviation as well as in other transport sectors have a great potential for reducing GHG emissions. Their impact may, however, take some time before it is felt. Meanwhile, new policies and legislation have to be set to provide incentives for shifting towards technologies and measures that would eventually lead to GHG reduction in the country.

5.6 WASTE

Landfilling with Gas Recovery and Flaring (LF+F)

In this alternative, all the waste is landfilled and the methane emissions are recovered and flared. Table 5.7a lists specific design parameters for this alternative. Table 5.7b presents the economic assessment results pertaining to this alternative. Note that results are presented with one ton of waste as the base unit of waste deposited per year.

Table 5.7a. Landfilling with gas recovery and flaring – Design parameters

Parameter	*Value*
Mass of waste managed	40 tons
Mass of methane emitted	2.78 tons
Mass of CH_4 emission reduction	2.51 tons
Equivalent mass of CO_2 reduced	52.62 tons
Thermal energy potential of recovered CH_4	874.94 $kW\text{-}hr_{th}$
Energy potential of recovered CH_4	437.37 $kW\text{-}hr_{mix}$/ton
Power potential of recovered CH_4	0.01 kW_{mix} *[1]*
Gas recovery flaring capital costs	$3.5/ton
Operation and maintenance costs	0.175 to 0.7 $/ton/year
Revenues	None

1. 437.472/(5 years × 365 days × 24 hours)

Table 5.18A. Landfilling with gas recovery and flaring – Economic results

Operation and Maintenance Cost [2] (%)	*Interest Rate (%)*	*Net Present Value ($)*	*CH_4 Reduction Cost ($/ton)*	*Equivalent CO_2 Reduction Cost ($/ton)*
5	5	- 73.06	29.11	1.39
	10	- 40.71	16.22	0.77
	15	- 27.14	10.81	0.51

10	5	- 86.06	34.29	1.63
	10	- 47.20	18.80	0.90
	15	- 31.04	12.37	0.59
20	5	- 112.06	44.65	2.13
	10	- 60.18	23.98	1.14
	15	- 38.83	15.47	0.74

2. *Percent of flaring capital cost*

Landfilling with Gas Utilization (LF+U)

This alternative is similar to the landfilling with gas flaring alternative except that the gas recovered is used as a fuel to generate electrical and thermal energy. This would certainly increase the capital cost however; it capitalizes on the benefits of selling this energy at competitive prices. Table 5.8a lists specific design parameters of this alternative. The economic results are presented in Table 5.8b.

Table 5.8a. Landfilling with gas recovery and utilization – Design parameters

Parameter	*Value*
Mass of waste managed	40 tons
Mass of methane emitted	2.78 tons
Mass of CH_4 emission reduction	2.51 tons
Equivalent mass of CO_2 reduced	52.62 tons
Thermal energy potential of recovered CH_4	874.94 $kW\text{-}hr_{th}$
Energy potential of recovered CH_4	437.37 $kW\text{-}hr_{mix}$/ton
Power potential of recovered CH_4	0.01 kW_{mix}
Gas recovery and utilization capital costs	$10/ton *[3]*
Operation and maintenance costs	0.5 to 2.0 $/ton/year
Revenues	1 to 6 $/ton/year

3. *$1000 × 0.01*

Table 5.8b. Landfilling with gas utilization – Economic results

Operation and Maintenance Cost [4] (%)	*Revenues [5] (%)*	*Interest Rate (%)*	*Net Present Value ($)*	*CH_4 Reduction Cost ($/ton)*	*Equivalent CO_2 Reduction Cost ($/ton)*
5	10	5	- 134.45	53.57	2.55
		10	- 79.26	31.58	1.50
		15	- 55.29	22.03	1.05
	30	5	+ 14.13	-5.63	-0.27

		10	- 5.11	2.04	0.10
		15	- 10.76	4.29	0.20
	60	5	+ 237.00	-94.42	-4.50
		10	+ 106.10	-42.27	-2.01
		15	+ 56.04	-22.33	-1.06
10	10	5	- 171.59	68.36	3.26
		10	- 97.79	38.96	1.86
		15	- 66.42	26.46	1.26
	30	5	- 57.33	22.84	1.09
		10	- 43.21	17.22	0.82
		15	- 35.17	14.01	0.67
	60	5	+ 199.86	-79.63	-3.79
		10	+ 87.56	-34.88	-1.66
		15	+ 44.9	-17.89	-0.85
20	10	5	- 245.88	97.96	4.66
		10	- 134.86	53.73	2.56
		15	- 88.68	35.33	1.68
	30	5	- 97.30	38.76	1.85
		10	- 60.72	24.19	1.15
		15	- 44.15	17.59	0.84
	60	5	+ 125.57	-50.03	-2.38
		10	+ 50.49	-20.12	-0.96
		15	+ 22.64	-9.02	-0.43

4. *Percent of flaring capital cost*
5. *Percent of gas recovery capital costs*

Composting and Landfilling with Gas Recovery and Flaring (C+LF+F)

In this alternative, 50 percent of the organic portion of the waste stream (or 37 percent of total weight of solid waste) will be composted and the remaining portion will be landfilled (63 percent of the total weight of solid waste). The composted portion of the waste composted will cost an additional $20/ton as compared to landfilling option. The amount of waste to be landfilled will have an organic fraction of 58 percent by weight compared to 73.7 percent organics in the original waste stream. Therefore, the methane conversion factor of 0.0696g/g waste as obtained using the IPCC method is corrected by a factor of 0.787 *[6]* thus yielding a new methane conversion factor of 0.055g/g waste. This alternative has the benefit of saving landfill space thus increasing the service life of the landfill. This amounts to $5.55/ton *[7]* waste. Table 5.9a lists the specific design parameters for this alternative. Economic results are presented in Table 5.9b.

Table 5.9a. Composting and landfilling with gas recovery and flaring – Design parameters

Parameter	*Value*
Mass of waste managed	40 tons
Mass of waste landfilled	25.2 tons
Mass of waste composted	14.8 tons
Mass of CH_4 emitted	1.24 tons
Mass of CH_4 emission reduction	2.51 tons
Equivalent mass of CO_2 reduced	52.62 tons
Thermal energy potential of recovered CH_4	433.71kW-hr_{th}
Energy potential of recovered CH_4	216.86kW-hr_{mix}/ton
Power potential of recovered CH_4	0.005 kW_{mix} *[8]*
Incremental waste management capital cost	$7.4/ton *[9]*
Waste management benefits	$5.55/ton
Gas recovery and utilization capital costs	$1.73/ton *[10]*
Operation and maintenance costs	0.086 to 0.346 $/ton/year
Revenues	None

6. *58/73.7 = 0.787*
7. *0.37 × $15*
8. *216.86/(5 years × 365 days × 24 hours)*
9. *$20/ton × 0.37 tons*
10. *$350/$kW_{mix}$ × 0.005 kW_{mix}*

Table 5.9b Composting and landfilling with gas flaring – Economic results

Operation and Maintenance Cost [11] (%)	*Interest Rate (%)*	*Net Present Value ($)*	*CH_4 Reduction Cost ($/ton)*	*Equivalent CO_2 Reduction Cost ($/ton)*
5	5	- 72.49	28.88	1.38
	10	- 40.86	16.28	0.78
	15	- 27.50	10.96	0.52
10	5	- 78.91	31.44	1.50
	10	- 44.06	17.55	0.84
	15	- 29.42	11.72	0.56
20	5	- 91.77	36.56	1.74
	10	- 50.48	20.11	0.96
	15	- 33.27	13.25	0.63

11. Percent of flaring capital cost

Composting and Landfilling with Gas Recovery and Utilization (C+LF+U)

This alternative is similar to that of composting and landfilling with gas flaring with the exception that gas recovered is utilized as fuel to produce energy that can be sold at competitive prices. Table 5.10a lists the design parameters of this alternative. Economic results are presented in Table 5.10b.

Table 5.10a. Composting and landfilling with gas recovery and utilization – Design parameters

Parameter	*Value*
Mass of waste managed	40 tons
Mass of waste landfilled	25.2 tons
Mass of waste composted	14.8 tons
Mass of CH_4 emitted	1.24 tons
Mass of CH_4 emission reduction	2.51 tons
Equivalent mass of CO_2 reduced	52.62 tons
Thermal energy potential of recovered CH_4	433.71kW-hr_{th}
Energy potential of recovered CH_4	216.86kW-hr_{mix}/ton
Power potential of recovered CH_4	0.005 kW_{mix}
Incremental waste management costs	$7.4/ton
Waste management benefits	$5.55/ton
Gas utilization capital costs	$5.0/ton *[12]*
Operation and maintenance costs	0.25 to 1.0 $/ton/year
Revenues	0.5 to 3.0 $/ton/year

12. $1000 $\times$ 0.005

Table 5.10b. Composting and landfilling with gas utilization alternative – Economic results

Operation and Maintenance Cost [13] (%)	*Revenues [14] (%)*	*Interest Rate (%)*	*Net Present Value ($)*	*CH_4 Reduction Cost ($/ton)*	*Equivalent CO_2 Reduction Cost ($/ton)*
5	10	5	- 98.97	39.43	1.88
		10	- 57.72	23.00	1.10
		15	- 39.93	15.91	0.76
	30	5	- 24.68	9.83	0.47
		10	- 20.65	8.23	0.39
		15	- 17.67	7.04	0.34
	60	5	+ 86.76	-34.57	-1.65

		10	+ 34.96	-13.93	-0.66
		15	+ 15.73	-6.27	-0.30
10	10	5	- 117.54	46.83	2.23
		10	- 66.99	26.69	1.27
		15	- 45.50	18.13	0.86
	30	5	- 43.25	17.23	0.82
		10	- 29.92	11.92	0.57
		15	- 23.23	9.25	0.44
	60	5	+ 68.18	-27.16	-1.29
		10	+ 25.69	-10.24	-0.49
		15	+ 10.16	-4.05	-0.19
20	10	5	- 154.68	61.63	2.93
		10	- 85.52	34.07	1.62
		15	- 56.63	22.56	1.07
	30	5	- 80.39	32.03	1.53
		10	- 48.45	19.30	0.92
		15	- 34.36	13.69	0.65
	60	5	+ 31.04	-12.37	-0.59
		10	+ 7.15	-2.85	-0.14
		15	- 0.97	0.39	0.02

13. Percent of flaring capital cost
14. Percent of gas recovery capital costs

Comparison of Mitigation Alternatives

Comparison of alternatives was conducted using the following criteria:

- Operations & maintenance costs = 10 percent of gas flaring/utilization capital cost
- Revenues = 30 percent of gas utilization capital cost *(Sales would constitute 38% if sold at the current average price of $0.065/kW-hr)*
- Discount rate = 10 percent

Based on these criteria the composting and landfilling with gas recovery and utilization ranked first among selected mitigation options. The remaining three alternatives were relatively similar (Fig. 5.2).

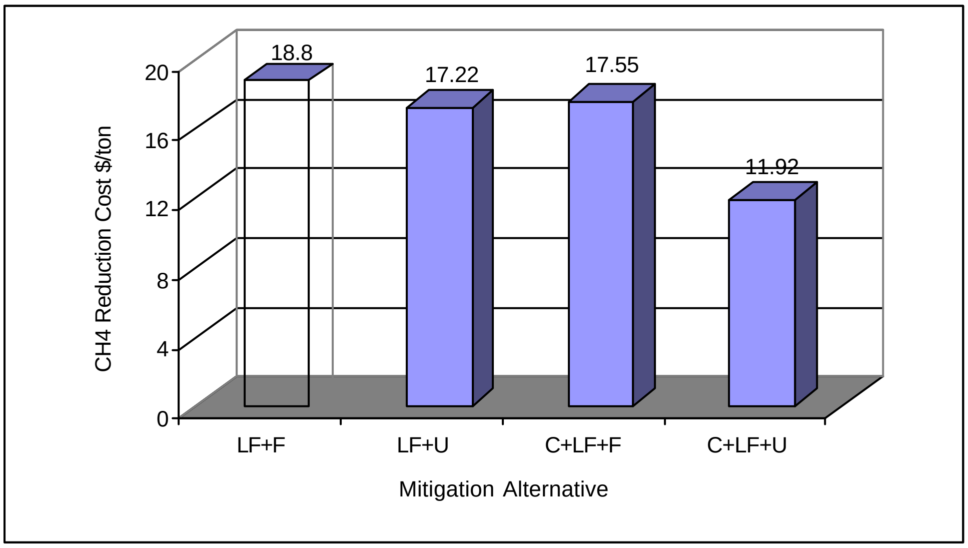


Fig. 5.2. Comparison of selected mitigation alternatives

Methane Emission Reduction

Emission reduction of The amount of methane and equivalent carbon dioxide (at 90% reduction rate) over the lifetime of the facility is presented in appendix 6-A. The amount of methane reduction for the years (2000, 2005, 2015, and 2040) is depicted in Fig. 5.3.

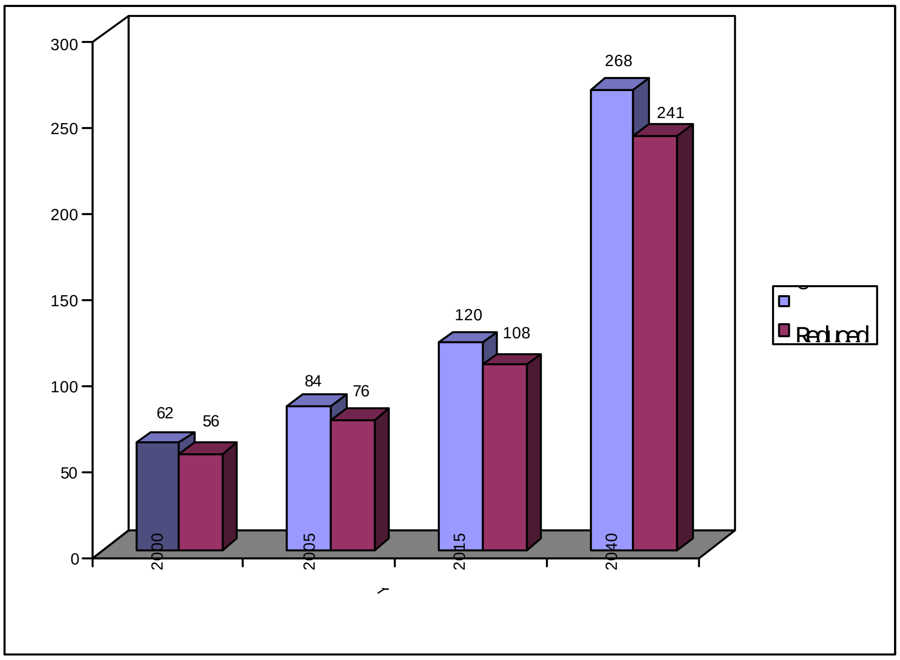


Fig. 5.3. Methane generation and reduction

5.7 BIOCLIMATIC ZONES

In order to conduct a more accurate analysis of the Lebanese climate as well as the distribution of the bioclimatic levels, but also to apply any simulation that is necessary, we would recommend:

- the rehabilitation of the climatic station network
- an increase in the number of such stations, especially in remote areas and in the mountain ranges
- a continuous monitoring of the records, leading to their updating and to the creation of a databank
- the acquisition of specific software, particularly for the processing of such data and their transcription into digitised maps. In this way, it will be easier to link them to the related sectors of interest and, therefore, to make them more accessible for the decision-makers.

5.7.1 WATER RESOURCES

See Table below

Proposal concepts on selected themes relating to the water sector

Theme	Justification	**Methodology, Workplan and Duration**	**Budget $**
1. Pilot study: A management model for a selective watershed in Lebanon	Water mismanagement is a major cause of resource wastage. A typical river watershed along the coast (where stress is maximum) can be studied to identify and assess sources and sinks in an integrated approach, and come up with a sustainable environmental resource management system	(times for Phases are overlapping) Phase I: 1-2 months • Documentation • Preparation • Pilot area • Stake holders Phase II: 10-12 months • Remote sensing data • Sources and sinks • Geo-environmental stresses • Institutional capacities Phase III: 4-6 months • Field verification • Data screening/analysis • Control mechanisms • Feedback Phase IV: 4-6 months • Model construction • Model validation • Reporting & dissemination	85000
2. A participatory simple technologies approach in facing water shortage during a natural disaster	Torrential rain & floods, mass movements, and droughts are very frequent in Lebanon often incurring disastrous conditions where water availability could become crucial. Unless popular participation occurs & simple water harvesting technologies are followed, the classical high tech- large scale options are proving ineffective	Phase I: 1-2 months • Documentation • Preparation • Pilot area • Stake holders Phase II: 4-6 months • Remote sensing data • Water harvesting alternatives • Potential natural disasters • Institutional capacities Phase III: 2-4 months • Field verification • Data screening/analysis • Participatory approach Phase IV: 1-2 months	40000

		• Demonstration • Reporting & dissemination	
3. Policies and incentives to enhance changing patterns of water use	Lifestyle dictates our means and levels of consumption. In many instances the water resource is wasted due to excessiveness, non-regulatory practices, malfunctions, unbalanced pricing and other aspects. If these are well identified and regulated through a mix of policies, incentives and call for changing water use, it could reduce a lot of wasted water and make it available	Phase I: 4 months • Documentation • Preparation • Pilot area • Stake holders Phase II: 6 months • Wasted vs available water • Direct controls • Indirect controls • Sectoral optimization Phase III: 2 months • Reporting & dissemination	35000

5.7.2 AGRICULTURE

In order to mitigate the expected negative impact of climate change, some research studies and executive projects can be proposed

- In terms of capacity building: land suitability evaluation studies are recommended for selected crops using crop growth simulation models (Van Keulen & Wolf, 1986; IBSNAT/ICASA ...) these models are using plant phyisological response curves to environmental factors to predict crop growth and yield
- In terms of research project: elaborating an integrated watershed management plan having the following topics: Development of land and water information system; assessment if changes in agriculture practices; forest fire risk assessment; introducing small scale wastewater treatment plants of irrigation; pollution of water by agricultural practices (pesticides, herbicides ...); use of models of soil erosion; urbanization effect on water and land resources, evaluation of socio-economic impacts
- In terms of executive project: elaboration of a unified national plan for agricultural land conservation accompanied by an executive plan for rehabilitating rural areas.

5.7.3 TERRESTRIAL ECOSYSTEMS

The main theme of any project to be proposed in this field is try to fill some gaps in the knowledge of the Lebanese flora and fauna with a new perspective related particularly to climate change. Studies dealing with impact of climate change are lacking in Lebanon. There is a need, therefore, to initiate work in this field that will be within the following framework:

- Conduct baseline studies of some ecosystems and species under current climatic conditions.
- Estimate and monitor ecological impacts of climate changes on living organisms both in controlled experiments and in the field.
- Incorporate data into models that can predict multivariate ecological changes.
- Provide perspectives that would guide policy-makers and stakeholders in issues related to the above aspects namely:

In Lebanon, habitats that may be vulnerable to the impacts of climate change can be found in inland terrestrial ecosystems, namely, forests, shrubland, and grassland. Certain species or habitats can serve as indicators for such changes. Of particular interest and special sensitivity to climate changes are:

1. High altitude forests and rangelends where altitudinal shifts in distribution may occur pushing some species towards their altitude limits.
2. Coastal zones including small islands and beaches that have already been reduced in size by anthropogenic impacts including chaotic urbanization, other

These areas are expected to shrink further by sea level rise.

3. Aquatic ecosystems including rivers (plus riverbank vegetation), and wetlands that are considered by experts to be highly vulnerable to precipitation changes whether in total amount or in frequency irregularity that may lead to flash floods.

A preliminary 2-year work plan is summarized below:

Year 1: General assessment to identify the main ecosystems and species that may be most vulnerable to climate change and the nature of the potential effects; purchase, set-up and calibration of equipment. Initiation of the Year 2 plan, below, by starting some field surveys etc.

Year 2 : Field surveys, field and laboratory experiments, model construction and application; data analysis; workshops, final report; Defining objectives for next years.

BUDGET

The following represents rough itemized estimates of the cost

CATEGORY	DETAILS	ESTIMATED COST (US$)
Major equipment **(Cost >$1000 per unit)**	e.g. Infrared gas analyser, Dobson spectrophotometer, scintillation counter, incubation chambers, ozone cuvettes, Multipurpose off road vehicle or field van, weather stations, GIS facilities, remote sensing services,computer system, greenhouse space	**50000**
Minor Equipment (cost <$1000 per unit)	e.g. portable weather stations, GPS equipment, cages, nets, animal traps, incubation chambers, plant growth chambers, thermometers, hygrometers, pH meters etc	**20,000**
Supplies	Chemicals, glassware, various cosumables etc.	**15,000**
Personnel	Research assistants, casual and local field assistance.	**30,000**
Travel	Local for field work and international for workshops training, conferences etc.	**10,000**
Publication cost	e.g. papers, educational leaflets and booklets etc.	**3,000**
Misc	e.g. museum-work bench fees	**4,000**
Total		**132,000**

5.7.4 The Coastal System

The Physical Component (See Table below)

Proposal concepts on selected themes relating to the physical component of the coastal system

Theme	Justification	Methodology, Workplan and Duration	Budget $
4. Assessing environmental indicators at "very critical" low-lying shorelines in Lebanon for coastal protection	Heavy financial losses will be incurred as studies have indicated an estimated 4mm of coastal land subsidence, a land loss varying between 7 & 16mm annually, and the presence of low-lying shorelines. With expected relative rise in sea level due to climate change, those losses will increase	Phase I: 1-2 months • Documentation • Preparation • Pilot area • Stake holders Phase II: 8-10 months • Shoreline parameters • Defining climate coastal regime • Defining human interference • Geoenvironmental stresses • Satellite-borne data Phase III: 6-8 months • Monitoring parameters-indicators • Data analysis including GIS • Defining control mechanisms • Protection measures Phase IV: 4-6 months • Projected limits and constraints • Optimum protection parameters • Feedback testing • Reporting & dissemination	85000
5. Effects of sea level rise on salt-water intrusion along selected coastal segments	As sea water is expected to rise, and because the land is karstic and/or fractured with sea water intrusion occurring, this intrusion will increase and affect further the quality of coastal fresh groundwater	Phase I: 1-2 months • Documentation • Preparation • Pilot area • Stake holders Phase II: 10-12 months • Geological delineation • Hydrological regime • Human interference and water use • Relative rise in sea level Phase III: 8-10 months • Monitoring coastal regime • Monitoring groundwater • Data analysis including GIS • Defining intrusion boundaries Phase IV: 4-6 months • Model construction • Model validation • Reporting & dissemination	145000

5.7.5 MARINE ECOSYSTEMS

Objectives

The project aims to study a special area of Lebanese coastal waters (hydrogeological and hydrobiological parameters) in intertidal zone and populations (benthic and planktonic fauna and flora); this region is directly affected by sea level rise and temperature change.

Place of Research
National Center for Marine Sciences/NCSR

Period of Research
3 years

Frequency of Sampling
Monthly for hydrological and hydrobiological parameters, planktonic populations, and seasonally for benthic populations

Stations
In rocky and sandy coast, protected and unprotected area, polluted and clear waters ...

Parameters
Hydrology: temperature, salinity, pH
Hydrobiology: nutrients (PO_4, NO_3, NO_2)
Phytoplankton populations: density and taxonomy of species
Zooplankton populations: density and taxonomy of species
Benthos: study of macroalgae (biomass and taxonomy)
study of fauna (biomass and taxonomy)

Budget
- Equipment: pH meter, oxygen meter, STD probe, thermometers, kit for nutrients, etc ...
- Chemicals
- Glassware
- 3 researchers
- 4 research assistants
- Transport, others, ...

Total ***US$ 50 000***

5.7.6 SOCIO-ECONOMIC FRAMEWORK

- Reduce vulnerability of under served areas by integrated rural development, especially: planning familial, sanitation, health services, support of farmers (mainly technical assistance).
- Make strategic economic choices and policies, favoring alternative sectors less vulnerable to climate change as tourism.
- Reactivation of Directorate of Statistics in order to have unified and standardized reliable data.
- ***Establish monitoring system on evolution of critical health indicators: socio-economic indicators, demographic and epidemiological data, data related to the delivery of the health services, indicators of quality of care.***

6 CONSTRAINTS FACING CLIMATE CHANGE STUDIES

Aside from those constraints related to external factors, i.e. from outside Lebanon, such as the GCM itself, the short time allowed for the National Communication, the little honoraria given to experts ... there are aspects inherent to the current status in Lebanon that all experts preparing this document felt hindered their work. These relate to the inherent weakness or lack of many and varied components that can be grouped as follows (see sketch).

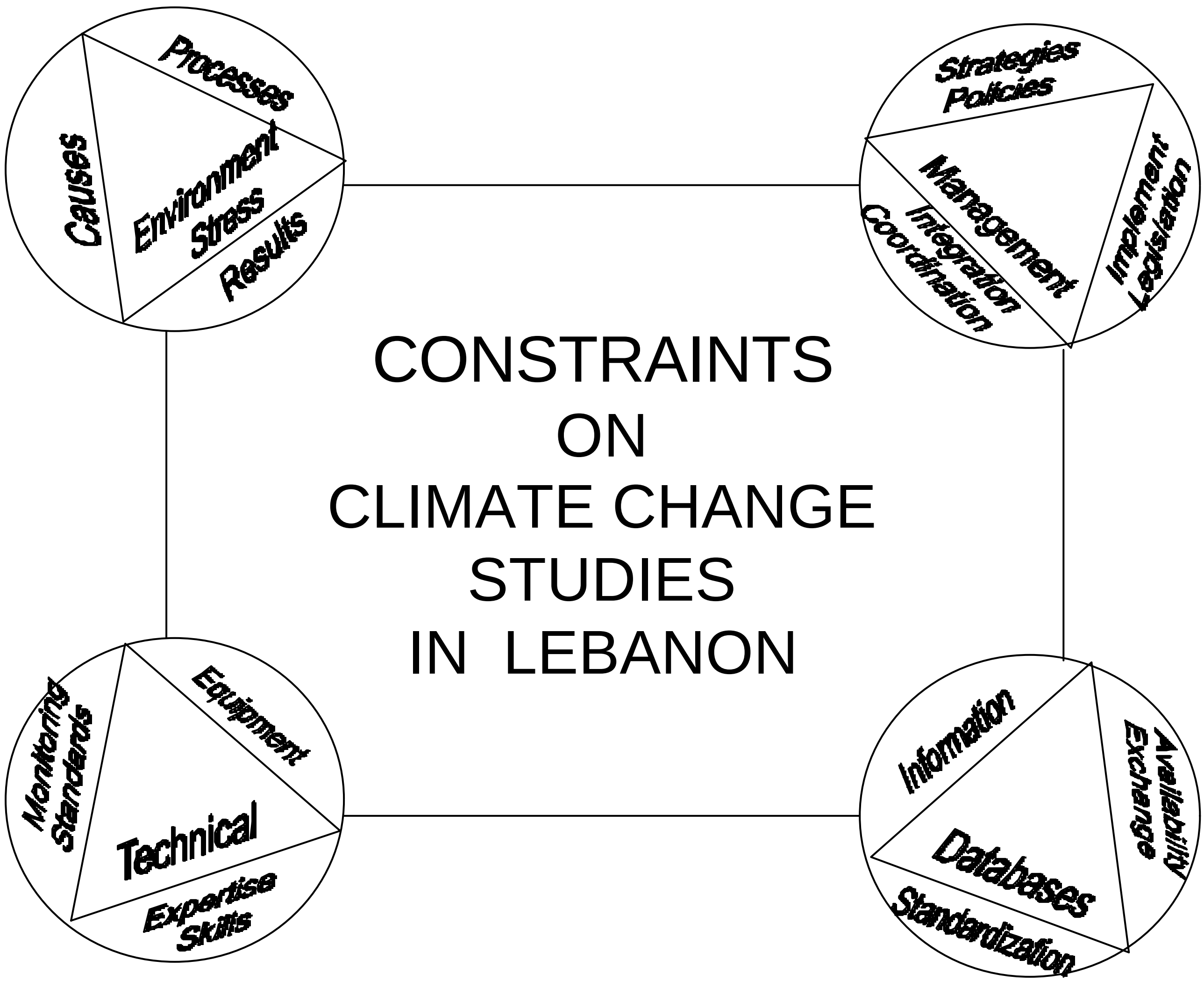
Concerning management, there is a general lack of well defined sectoral strategies and policies, as well as a very weak integration and coordination between different government agencies, plus the fact that implementing legislation needs a great push.

When it comes to environmental stresses, and what has recently become popular, i.e. using the terms "Hot Spot" and "Sensitive Area", it is observed that under several circumstances there is no distinct differentiation between approaches separating causes of environmental deterioration from processes taking place that further this deterioration, and from results themselves. This is why approaches followed are often partial solutions and, hence, deliverables are short-term only.

The technical aspects are pretty straight forward. There is a notable lack of expertise and skilled manpower, monitoring plans are almost non-existent, standards are not yet ratified and updated-upgraded equipment is lacking.

Finally, in general existing databases are, to begin with, chaotic, dispersed, inaccurate, sometimes old and, therefore, can not be used as a reliable source of specific information. If and when good information is there, government agencies may not make them available and even difficult to exchange. The data/information are mostly unstandardized posing, therefore, a problem of making good use of them.

Obviously, all the above constraints must be removed. This is necessary in order to be able to achieve good results of problem analysis. It is of utmost importance to do studies, investigate and evaluate the proper requirements to face a national and international problem as serious as climate change. Lebanon must play a role and contribute to human sustainability.



Sketch showing the major essential components whose weakness or lack in Lebanon is a constraint that should be eliminated

List of Symbols

A	AUB	American University of Beirut
B	BOD	Biochemical Oxygen Demand
C	C	Carbon
	CDR	Council for Development and Reconstruction
	CH4	Methane
	CHP	Combined Heat and Power
	CO	Carbon Monoxide
	CO_2	Carbon Dioxide
	COD	Chemical Oxygen Demand
	COMAP	Comprehensive Mitigation Assessment Process
	CSE	Cost of Saved Energy
D	Dm	Dry Matter
	DOC	Degradable Organic Carbon
	DSM	Demand-Side Management
E	EDF	Electricite du France (The French electric utility)
	EDL	Electricite du Liban
	EIE_{steel}	Energy Intensity for Electricity Use in Steel Industry
	EI_{steel}	Energy Intensity for steel
	ERM	Environmental Resources Management
	EU	European Union
F	FAO	Food and Agriculture Organization of the United Nations
G	g	Gram
	GDP	Gross Domestic Product
	GEF	Global Environment Facility
	Gg	Giga-gram = 1000 tons
	GHG	Greenhouse Gases
	GIS	Geographic Information System
	GJ	Giga-Joule
	GNP	Gross National Product
	GORS	General Organization for Remote Sensing (Syria)
	GWH	Giga-Watt-hour
	GW-hrel	Giga-Watt hour electric
	GW-hrth	Giga-Watt hour thermal

H	Ha	Hectare
	HFC & PFC	Halocarbons
	HP	Horsepower
I	ICRAF	international Center for Research and Agro-Forestry
	IPCC	Intergovernmental Panel on Climate Change
	IRP	Integrated Resource Planning
	IRR	Internal ate of Return
J	j	joule
K	kg	Kilogram
	KWel	Kilo Watt electric
	KW-hr	Kilo Watt hour
	KWmix	Kilo Watt mixed
	KWth	Kilo Watt thermal
L	l	Liter
	LARS	Lebanese Agriculture Research Strategy
	LFG	Landfill Gas
M	m	Meter
	m3	Cubic Meter
	METAP	Mediterranean Environment Technical Assistant Program
	MHWR	Ministry of Hydraulic and Water Resources
	mm	Millimeter
	MoAg	Ministry of Agriculture
	MoE	Ministry of Environment
	MoPW	Ministry of Public Work
	MoT	Ministry of Transport
	MSW	Municipal Solid Waste
	MWH	Mega-Watt-hour
N	N	Nitrogen
	N_2O	Nitrous Oxide
	NCSR	National Council for Scientific Research
	NG	Natural Gas
	NGO	Non Government Organization
	Nm3	Normal Cubic Meter
	NMVOC	Non-Methane Volatile Organic Compounds
	NO_x	Oxides of Nitrogen
	NPV	Net Present Value
O	OM	Operation & Maintenance
	ONF	Office National des Forets
R	RPTA	Railways and Public Transport Authority
S	SO_2	Sulfur Dioxides
	SOTER	Soil Terrain
T	t	Ton
U	UNDP	United Nations Development Programme
	UNEP	United Nations Environmental Programme

REPUBLIC OF LEBANON
MINISTRY OF ENVIRONMENT

Climate Change

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