Prospects of Efficient Wastewater Management and Water Reuse in Lebanon

Country Study Lebanon

Prepared within the Framework of the EMWater Project

“Efficient Management of Wastewater, its Treatment and Reuse in the Mediterranean Countries”

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Executive Summary

Since the end of the war in 1990, Lebanon's principle challenge has been to rebuild its infrastructure and economy. The Lebanese economy is oriented towards the services sector, including banking, tourism, and transit. The country still suffers from a severe debt burden, economic stagnation and unemployment.

Compared to other countries in the Middle East, Lebanon has a relatively favorable position regarding water resources, but it is forecasted that Lebanon will also face a water deficit within the next 10-15 years. Therefore, the improvement of **water resource management** is of essential importance. An integrated water resource management plan is still lacking, and there is no comprehensive environmental law securing the protection of water resources. Limit values to regulate the quality of drinking water and the discharge of wastewater exist, but are not fully enforced yet. Standards for irrigation water or guidelines for water reuse do not exist so far.

The improvement of **wastewater management** is among the greatest challenges Lebanon is facing. Most towns and villages have no wastewater infrastructure except for the traditional household sanitary pits or inhabitants drain wastewater into boreholes in bedrock, which easily pollutes the groundwater. Particularly rural systems in Lebanon are mainly limited to cesspools and septic tanks. Some rural communities do not use any treatment and simply release raw sewage into the environment. Additionally, the water quality is adversely affected by industrial and agricultural wastewaters. Pesticides and fertilizers from agriculture cause ground and surface water pollution. Industrial activities release a wide range of chemical effluents into watercourses, in particular affecting surface and coastal waters. The prevalence of fissured limestone formations in Lebanon facilitates the infiltration of liquid wastes into groundwater, and many groundwater resources are already contaminated with fecal matter. Moreover, the entire central coastline and the regions around the major cities in the North and South (with few exceptional areas) have lost their recreational potential because they are continuously receiving municipal and industrial wastewater.

After two decades of civil war, first priority was given to restoring basic infrastructure facilities, like water and power supply and transport. The construction of sanitation systems focused on sewerage networks for collecting and transporting wastewaters out of towns and villages. The treatment of collected wastewaters has now become more relevant. At present only one large-scale **wastewater treatment** plant is operating south of Beirut. After primary treatment the effluent is piped 2 km offshore and released into the Mediterranean Sea. There are plans to connect nearly 80 % of the population to major sewage treatment plants by 2020. Seven wastewater treatment plants are currently under construction; 18 projects have secured funding and are under preparation, while 10 have secured no funding to date. According to the Lebanese government, lack of funds hinders the efficient implementation of wastewater treatment. The government has been advocating private sector participation in the water sector, but many factors obstruct this participation, such as the absence of written policies and action plans, an inadequate legal framework, and unclear procedures for creating and sustaining public-private partnerships.

In Lebanon the municipalities are responsible for building and maintaining sanitation systems and for providing wastewater treatment facilities. Some municipalities and local communities have started to invest in wastewater collection and treatment. In recent years projects promoting **small-scale, decentralized wastewater treatment** in rural areas have been implemented and several of these small-scale wastewater treatment plants provide secondary treatment resulting in water that is suitable for irrigation. However, most municipalities still lack the human and financial resources, environmental awareness, management capabilities, and/or political commitment necessary to implement wastewater management in an environmentally sound manner.

The **reuse of reclaimed wastewater** for irrigation is common in many Mediterranean countries. However, in Lebanon water reuse technology is currently not applied on a large scale. The reuse of treated wastewater in agriculture is not encouraged and there is no cultural acceptance of this practice. On the other hand, agriculture is by far the largest consumer of water with around 70 % of water usage, and the demand for irrigation water is growing constantly. While the total land area under cultivation has remained fairly constant during the past decades, the area of irrigated land has more than doubled in the last 40 years, reflecting the intensification of agricultural practices, and increasing the pressure on limited water resources.

In Lebanon, **public awareness** of the necessity of proper water and wastewater management must be enhanced. Effective wastewater treatment is essential for protecting water resources and restoring water quality. Considering the predicted water deficit, the efficiency of water use has to be improved, and alternative water resources, such as treated wastewater, must be considered as an option for satisfying the increasing demand for irrigation. To obtain cultural acceptance for water reuse, the public has to be fully informed about advantages and disadvantages.

The EMWater Project contributes to efficient management of wastewater in Lebanon by formulating wastewater treatment and reuse guidelines, demonstrating proper wastewater treatment and reuse, and by informing and educating the population through training courses and awareness campaigns.

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Abbreviations and Acronyms

AOX	Adsorbable organic halogens
BOD	Biochemical oxygen demand
CAS	Central Administration for Statistics
CCF	Country Cooperation Framework
CDR	Council for Development and Reconstruction
COD	Chemical oxygen demand
CPCP	Coastal Pollution Control Program
DAI	Development Alternatives Inc.
EC	European Commission
EEC	European Economic Community
EIA	Environmental Impact Assessment
EIB	European Investment Bank
ELV	Environmental Limit Values
EMWater	Efficient Management of Wastewater, its Treatment and Reuse in the Mediterranean Countries
ESCWA	United Nations Economic and Social Commission for Western Asia
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GP	Green Plan
IBRD	International Bank for Reconstruction and Development
IDB	Islamic Development Bank
IDRC	The International Development Research Program Canada,
IWRM	Integrated Water Resources Management
LBP	Lebanese Pounds
LEDO	the Lebanese Environment and Development Observatory
MECTAT	Middle East Center for the Transfer of Appropriate Technology
MEDA programme	Principal financial instrument of the European Union for the implementation of the Euro-Mediterranean Partnership
MEW	Ministry of Energy and Water Resources
MoA	Ministry of Agriculture
MoE	Ministry of Environment
MoPH	Ministry of Public Health
NCRS	National Center for Remote Sensing
NCSR	National Council for Scientific Research
NERP	National Emergency Rehabilitation Program
NGO	Non-governmental organization
SMAP	Short and Medium-Term Priority Environmental Action Program
SOER	State of Environment Report
UNDP	United Nations Development Program
UNFPA	United Nations Population Fund
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
WHO	World Health Organization
WRPP	Water Resources Protection Program
WWT	Wastewater treatment
WWTP	Wastewater treatment plant
YMCA	Young Men’s Christians Association

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1 Introduction

Water shortage is currently one of the biggest concerns of people worldwide and it becomes a global problem that seriously affects the lives of high numbers of the world's population. According to estimates of the 2003 Kyoto summit, two billion people will not have access to safe drinking water supplies in the year 2015. The Mediterranean countries are a part of the most affected region in the world. Water is a scarce and precious resource in the Middle East. Population growth, rising standards of living and urbanization increase pressure on the resource, thus leading to increasing costs of water supply. Physical and commercial losses are also high. Water is often supplied only for a few hours per day or even per week. At the same time little effort has been made to involve water users in low-income settlements to provide them with the most appropriate types of affordable water and sanitation services. In addition, tariffs are low so that the operation and maintenance costs of the utilities are often not recovered Furthermore, in most cases, wastewater is not adequately treated, leading to environmental and health hazards.

The aim of the **EMWater Project** "Efficient Management of Wastewater, its Treatment and Reuse in the Mediterranean Countries" is to create public awareness of innovative solutions in wastewater treatment and its reuse and support the installation of new technologies of wastewater management in the targeted countries Turkey, Jordan, Palestine and Lebanon. The project also aims at strengthening capacity building through local and regional training programs, the development of regional policy guidelines for wastewater treatment and reuse in the region. The improvement of the security and safety of water supply in the Mediterranean countries is the best recipe for social, economic and political stability in the region and is, thus, the foremost goal of the project.

As baseline document of the EMWater Project a **country study** is prepared for each participating Mediterranean partner country. The objective of the studies is to analyze the present state of water and wastewater management and reuse in each country. Therefore, relevant data are collected in different fields, such as

- national institutions, policies, guidelines and standards in the water sector,
- situation of the water resources (quantity, quality, demand, consumption)
- rural and urban water distribution systems,
- wastewater quantity and composition, and disposal systems
- status of wastewater treatment and reuse, existing wastewater treatment facilities

This study provides an insight into the situation of the water sector in **Lebanon** and gives an overview of possible partners and contact persons in the countries. If available, detailed information on the Lebanese **target areas** of the EMWater Project, **Jbeil** and **Koura**, is presented. The study will comprise one of the baseline documents of the EMWater Project for all further activities, like the development and construction of pilot plants, the formulation of wastewater treatment and reuse guidelines and the implementation of different training programs.

Compared to other countries in the Middle East, Lebanon has a relatively favorable position with regard to rainfall and water resources, but it is forecasted that Lebanon will have to face a water deficit within the next 10-15 years due to a lack of water management schemes. As a country still recovering from two decades of civil war, Lebanon faces deficiencies in the water supply and wastewater sector. Sanitation and environmental problems result from the lack of appropriate infrastructures related to wastewater treatment and integrated management. Almost half of all water produced is unaccounted for because of losses and billing deficiencies, while leaking or overflowing wastewater collection systems are affecting sanitary conditions and contaminating surface and groundwater resources.

2 Country Profile

2.1 Geography

The Republic of Lebanon is situated on the eastern coast of the Mediterranean Sea with a total area of 10,452 km², most of it consisting of mountainous regions. The width of the country from east to west averages only 50 km, with its widest point measuring 85 km; at the same time, the coastline stretches over 225 km from north to south. It is bordered by Syria in the north and east and by Israel in the south.

Lebanon is characterized by the presence of two mountain chains positioned parallel to the coast, "Mount Lebanon" to the west and "Anti-Lebanon" at the Syrian border. Thus topographically, Lebanon can be divided from west to east into four parallel parts:

1. A flat, narrow coastal plain parallel to the sea; reaching a maximum of 3 km, its width is annulled in certain places where the mountain dips directly into the sea. In the north, this coastal plain widens near the Syrian border.
2. The "Mount Lebanon" mountain chain is continuous from the north to the south with the highest crest in the country, Qornet es-Saouda (3,080 m) covered by snow for most of the year.
3. At a height of around 900 meters, the fertile Bekaa Valley forms a passage whose width varies from 5 to 20 km. The plain is devoted mainly to agricultural activities.
4. The "Anti-Lebanon" mountain chain in the east runs along the Syrian border and has a lower elevation than "Mount Lebanon." In the southeast, the Hermon summit rises above the south Bekaa and the Syrian Golan and reaches an altitude of 2,814 m.

2.2 Climate

Lebanon has a **Mediterranean climate** with long, dry, summers and mild winters with heavy rains; the spring and autumn seasons are short. However, Lebanon's climatic conditions are determined by its geography. The influences of the Mediterranean Sea, the topographic features, as well as the Syrian Desert in the north create **a variety of micro-climates** within the country with contrasting temperatures and rainfall distribution. Conditions vary from a typical Mediterranean climate along the coastal plain and in the middle mountain range to a sub-alpine or mountain Mediterranean climate on the highest slopes, which are covered by snow during most of the year. In some of the northern plains, the climate reaches sub-desert conditions and is almost too dry for agriculture.

The average annual **temperature** at sea level ranges between 19 °C and 22 °C. As the elevation increases, the average annual temperature decreases: at 1,000 m above sea level the average annual temperature is about 15 °C, and at 2,000 m above sea level it is 9 °C. The highest monthly temperatures are recorded during the months of July and August, and the lowest felt in December and January. On the Coast, while average temperatures vary between 7° C in winter and 27° C in summer. In the Central Bekaa, average temperatures range between 5.5 °C and 24 °C. Bekaa Valley summers are very hot and dry with temperatures reaching the high 30's though the nights are cool. The Lebanese winters are cold, wet and windy. Whereas frost is unknown on the Coast, it occurs frequently in the Bekaa.

Lebanon has about 260 days of sunshine per year. Average annual **precipitation** in Lebanon is estimated at around 840 mm/year. Rainfall occurs on eighty to ninety days a year, mainly between October and April. However, altitude and physiography account for important differences in rainfall throughout the country. The western part receives a good amount of rain due to the "Mount Lebanon" chain which stops the humid air masses coming from the Mediterranean Sea so that the precipitation varies from 600 to 900 mm along the coastal zones. The amount of rainfall can reach up to 1,500 mm in the high mountains. Snowfall occurs starting a 1,600 m and above 2,000 m precipitation consists predominantly of snow. In the Bekaa valley rainfall decreases from 800 mm in the south to 250 mm in the north-east so that climate turns nearly dry in the north of the Bekaa.

2.3 Administration

The Republic of Lebanon is divided into six administrative regions, called **Mohafaza** or provinces. Each Mohafaza is divided into districts, called **Caza**, excluding Beirut (see Table 2.1). In total there are 25 Cazas. Each Caza is divided into cadastral zones, called Manateq Ikarieh. Overall, there are 1,492 cadastral zones. The Bekaa is the largest Mohafaza (4,161 km^2), followed by the North (2,025 km^2) and Mount Lebanon (1,968 km^2).

Table 2.1: Administrative regions and localities at Mohafaza level

Administrative Regions and Localities at Mohafaza Level

Mohafaza	*Number of Cazas*	*Number of Cadastral Zones*	*Surface Area (km²)*
Beirut	-	12	19.6
Mount Lebanon	6	495	1,968.3
North	7	387	2,024.8
South	3	227	929.6
Nabatiyeh	4	147	1,098.0
Bekaa	5	224	4,160.9
TOTAL	**25**	**1,492**	**10,201.2**

Source: Data on surface areas supplied to ECODIT by the National Center for Remote Sensing

2.4 Demography

The **population** of Lebanon in 2001 was 4.4 million [27][1]. Around 1.5 million people live in the region known as Greater Beirut, of which 400,000 reside in the administrative Beirut, capital of Lebanon. Other major cities are Tripoli, which lies 91 km north of Beirut and has about 250,000 inhabitants; Saida (Sidon) 41 km south of Beirut, with about 80,000 inhabitants; Tyre (Sour) 79 km south of Beirut, with about 30,000 inhabitants and Zahle, 47 km east of Beirut with about 80,000 inhabitants.

Targeted Areas Jbeil and Koura: The population of Jbeil is 62,407 people and the population of Koura is 47,540 people.

The population distribution by Mohafaza in 1997 is shown in Table 2.2 below.

Table 2.2: Distribution of population by Mohafaza (1997)

Mohafaza	Population	Percent [%]	Surface Area [km²]	Population Density
Beirut	403,337	10 %	20	20,167
Beirut Suburbs	899,792	22 %	233	3,862
Rest of Mount Lebanon	607,767	15 %	1,735	350
North	807,204	20 %	2,025	399
South	472,105	12 %	930	508
Nabatieh	275,372	7 %	1,098	251
Bekaa	539,448	13 %	4,161	130
Total	**4,005,025**	**100 %**	**10,202**	**393**

The **average annual growth rate** of the Lebanese population was 1.3 % in 2001 and 1.5 % as an average between 1995 and 2001. This rate varies by Mohafaza.

The Lebanese population consists of the following **ethnic groups**: 95 % of the Lebanese are Arabs, 4 % are Armenians and 1 % belongs to other ethnic groups like Kurds or Jews. The **official language** in Lebanon is Arab, but French and English are spoken widely. The **literacy rate** is 87.4 % of the total population (male: 93.1 %, female: 82.2 %) [2].

[1] Estimates of the CIA's World Factbook for July 2003: 3.7 million people

2.5 Religion

An estimated 70 % of Lebanese are Muslims, while most of the remaining 30 % are Christians. At the time of Lebanon's independence in the 1940s, there were more Christians than Muslims. In the following years, many Muslims immigrated to Lebanon and had a higher birth-rate than the Christians As a result, Muslims became the majority group in Lebanon. Today the government recognizes 17 distinct religious sects: 5 Muslim sects (Shia, Sunni, Druze, Ismailite, and Alawite), 11 Christian sects (4 Orthodox, 6 Catholic, and 1 Protestant), and Judaism. The government policy of confessionalism, or the grouping of people by religion, plays a critical role in Lebanon's political and social life and has given rise to Lebanon's most persistent and bitter conflicts.

2.6 Economic Situation

Since the end of the war in 1990, Lebanon's principle challenge has been to rebuild its economy. The country suffers from a severe debt burden, economic stagnation and unemployment. The GDP for 2001 was $16.7 billion (US) with an average annual growth rate of 1.3 %. In 2000 the growth rate was negative (-0.5 %), but is expected to rise to 2.6 % from 2001-2005 [27]. The Lebanese economy is oriented towards the service sector including banking, tourism, and transit. The GDP (Gross Domestic Product) is divided among the economic sectors as follows (data from 2000):

- Services and Tourism: 66 %
- Industry: 22 %
- Agriculture: 12 %

The service sector is the most productive and is heavily backed by government policies. The agricultural sector is given less priority by the government. This renders Lebanon a major food importer with the local food production satisfying only 20 % of the demand.

Lebanon's three major coastal cities, Beirut, Saida and Tripoli, are engaged predominantly in commerce due to their location on the seafront and the presence of seaports. The economies of the Mohafazas, Bekaa, the North, and the South, are mostly agricultural with a few light industries. The main core of Lebanese industry is located in Mount-Lebanon as well as in the cities of Beirut and Tripoli. Moreover, several industries are located on the coastal strip in North-Lebanon.

Lebanese Industry

Most industries in Lebanon are light manufacturing plants. There are 23 industrial branches in Lebanon (not including water, power and construction activities). Almost 90 % of the industries belong to the following eight branches:

- food and beverages (20 % of total),
- fabricated metal products (16 %),
- non-metallic mineral products (12 %),
- furniture (11 %),
- clothes and dyeing fur (10 %),
- wood products (10 %),
- leather products (6 %), and
- textiles (4 %).

The industry sector has a permanent workforce of 114,000 people plus about 40,000 seasonal workers. More than 90 % of all industries employs fewer than 10 people. Only 47 industrial establishments employ more than 100 people and 20 employ more than 250 people.

There are about 973 high-risk facilities (Class I industries[2]) in Lebanon, including tanneries, cement, paper (from pulp), fertilizer, ammunition production plants and gas products. They employ 4,650 people and generate an estimated $104 million (US) in added value per year. Industries that manufacture cement lime and plaster account for 68 % of the total added value of Class I industries.

[2] In 2001 Decree 5243 (5/4/2001) introduced five industrial classes (Class I to V). This new classification system relied on several environmental criteria (e.g., impact on water, air and soil, environmental risk, odor, and noise) to define the degree of environmental threat. To date, several obstacles prevent the application of Decree 5243/01.

3 Legal and Institutional Framework

3.1 National Policies in the Water and Wastewater Sector

A number of laws, decrees, and ministerial decisions govern environmental management in Lebanon. Chief among them are the laws and decrees establishing the Ministry of Environment, defining its mandate and organizing the ministry. Other legal instruments - existing or pending - define environmental policies, procedures, standards, and other requirements for specific economic sectors or environmental media.

There is no comprehensive environmental law, but specific issues are addressed in sector laws and regulations. These laws include the protection of natural sites, forestry, archaeological and tourist sites, drinking water, as well as the control of sewage, marine pollution, air pollution, industry, hunting, fishing, urban development, mining, food control, municipal and hazardous waste disposal.

The Ministry of Environment has drafted an Environmental Framework Law, a Framework Law for Protected Areas and a Decree for Environmental Impact Assessment (EIA).

3.1.1 Water Quality Standards

In Lebanon, minimum standards exist to assure the quality of drinking water and environmental limit values for regulating the discharge of wastewater. Standards for the water used or reused for irrigation do not exist yet. **Standards Values for Drinking Water** are listed in Annex B. The **Environmental Limit Values (ELV) for Wastewater** for three different discharge options (discharge into the sea, discharge into surface water and discharge into sewer systems) are listed in Annex C.

3.1.2 Governmental Water Programs

In 1995, a Damage Assessment Report was prepared to formulate a policy framework for the wastewater sector [4]. Implemented over three phases, the resulting National Emergency Rehabilitation Program (NERP) launched two major programs:

- **Coastal Pollution Control Program (CPCP)**: The CPCP represents Lebanon's commitment to fulfilling the requirements of the Barcelona Convention and its protocols.
- **Water Resources Protection Program (WRPP)**: Works under the WRPP include the rehabilitation of water treatment plants and water sources (springs and wells), as well as the rehabilitation and construction of transmission and distribution networks.

3.2 International Environmental Conventions

Lebanon signed several conventions and agreements for the protection of the Mediterranean Sea from pollution, which include the Barcelona Convention and the Genoa Declaration. These agreements underlined the necessity of treating wastewater before discharging it to the sea in cities and towns with populations that exceed 100,000.

Table 3.1: Relevant international conventions, treaties and protocols signed or ratified by Lebanon

2001	Stockholm Convention on Persistent Organic pollutants for adoption by the conference of plenipotentiaries. Signature: 22/5/2001
1999	Convention on Wetlands of International Importance especially as Waterfowl Habitat.-Ramsar. Accession: 1/3/1999 by the law number 23
1995	**Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean. Amendments to the Barcelona Convention**
1994	United Nations Convention to Combat Desertification.-Paris. Ratification: 21/12/1994 by the law number 469
1992	United Nations Framework Convention on Climate Change.-Rio de Janeiro. Ratification: 11/8/1994 by the law number 359
1992	Convention on Biological Diversity.-Rio de Janeiro. Ratification: 11/8/1994 by the law number 360
1992	Amendment to the Montreal Protocol on Substances that deplete the Ozone Layer.-Copenhagen. Accession: 3/11/1999 by the law number 120
1990	Amendment to the Montreal Protocol on Substances that deplete the Ozone Layer.-London. Accession: 31/3/1993 by the law number 253
1989	Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal.-Basel. Ratification: 21/12/1994 by the law number 387
1987	Montreal Protocol on Substances that deplete the Ozone Layer.-Montreal. Accession: 31/3/1993 by the law number 253
1985	Vienna Convention for the Protection of the Ozone Layer.-Vienna. Accession: 30/3/1993 by the law number 253
1985	**Genoa Declaration on the Second Decade of the Mediterranean Action Plan**
1982	Protocol Concerning Mediterranean Specially Protected Areas. Accession: 27/12/1994
1980	Protocol for the Protection of the Mediterranean Sea against Pollution from Land-based Sources.-Athens. Signature: 17/5/1980_ Accession: 27/12/1994
1976	Convention on the Prohibition of Military or any other hostile use of Environmental Modification Techniques.-Geneva. Signature: 18/5/1977
1976	Protocol Concerning Co-operation in Combating Pollution of the Mediterranean Sea by Oil and Other Harmful Substances in Cases of Emergency.-Barcelona. Signature: 16/2/1976_ Accession: 30/6/1977 by the decree law number 126
1976	**Convention for the Protection of the Mediterranean Sea against Pollution.-Barcelona**. Signature: 16/2/1976_ Accession: 30/6/1977 by the decree law number 126
1976	Protocol for the Prevention and Elimination of Pollution of the Mediterranean Sea by Dumping from Ships and Aircraft.-Barcelona. Signature: 16/2/1976_ Accession: 30/6/1977 by the decree law number 126
1973	International Convention for the Prevention of Pollution from Ships.-London. Accession: 24/11/1993
1972	Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter.-London-Mexico city-Moscow-Washington. Signature: 15/5/1973
1971	Treaty on the Prohibition of the Emplacement of Nuclear Weapons and other Weapons of Mass Destruction on the Seabed and the Ocean floor and in the Subsoil.-London-Moscow-Washington. Ratification: 7/10/1974 by the decree number 9133
1969	International Convention relating to Intervention on the High Seas in cases of Oil Pollution Casualties.-Brussels. Ratification: 12/10/1974 by the decree number 9226
1969	International Convention on Civil Liability for Oil Pollution Damage.-Brussels. Ratification: 12/10/1973 by the law number 28/73
1954	International Convention for the Prevention of Pollution of the Sea by Oil.-London. Accession: 16/11/1966 by the law number 68/66

3.3 National Bodies Responsible for the Water and Wastewater Sector

In the following section, the important bodies responsible for the water and wastewater sector in Lebanon are listed. The private sector, research institutions, NGOs and international organizations are assisting the governmental bodies by providing technical and financial support to specific projects.

3.3.1 Ministry of Energy and Water (MEW)

The Ministry of Energy and Water Resources (MEW) oversees all activities related to water. Two of its three General Directions are dealing with water issues:

- General Direction of Hydraulic and Electric Resources: Its functions are to plan and study hydraulic projects, to carry them out and supervise the execution as well as to apply the laws and regulations relative to the protection of public water and its exploitation.
- General Direction of Exploitation: Its functions are to exercise the power of tutelage on the public establishments working in the water sector - mainly the **Water Authorities** and the **Litani National Authority** - to ensure the administrative and financial control of these organizations, to attend to the application of tender documents and specifications relative to the exploitation of water, and to study the complaints and measurements necessary to regulate the infringements committed by the organizations working in the water sector.

The Water Authorities

The 21 Lebanese Water Authorities are semi-autonomous public institutions with the responsibility of providing drinking water. They are responsible for the water networks and the equipment, as well as for the maintenance and the renewal of these.

The Authorities are placed under the tutelage of the MEW from a technical and administrative point of view. It is the responsibility of the Water Authorities to fix the price for drinking water. This price covers the costs for the maintenance and renewal of the existing network and equipment, but it does not take into account the initial or future investment costs for the extension of the network and the resources.

The jurisdictions of the Water Authorities are not linked to the administrative division of the country into Mohafaza and Caza: the same Water Authority can provide drinking water to several Cazas (for instance, the Water Authority of Barouk provides water to the two Cazas of Aley and the Chouf). In the same way, several Water Authorities can exploit the same water resource (for instance the water of the Jéïta Cave is exploited by three Authorities which are those of Beirut, Kesrouane and Metn).

Since the year 2000, the water sector has been reorganized and four regional independent **Water Establishments** were created, these are:

- Water Establishment of Beirut and the Mount of Lebanon (head office: Beirut),
- Water Establishment of North Lebanon (head office: Tripoli),
- Water Establishment of the Bekaa (head office: Zahleh),
- Water Establishment of South Lebanon (head office: Saida).

However, as long as the four new establishments are not operational, the former water authorities continue to safeguard their role.

In the reorganization of the water sector the responsibility of the wastewater treatment sector is presently being transferred from the Ministry of Interior to the Ministry of Energy and Water; this sector is entrusted to the four new establishments.

The Litani National Authority

The Litani National Authority is a public establishment, which is under the tutelage of the Ministry of Energy and Water and has the following duties:

- Preliminary studies and the construction of dams,
- Exploitation of the hydroelectric power plants,
- Big works of irrigation and their exploitation,
- Management of the water resources (surface and underground resources).

The name "Litani National Authority" often leads to confusion, because Litani National Authority is not only a Water Authority for the management of the Litani River but its action also extends over the whole Lebanese territory, especially in the domain of the gauging of rivers and springs.

The Water Resources Service

The Water Resources Service is part of the Direction of Studies in the Litani National Authority. The functions of this service are the gauging of all important rivers and springs in Lebanon and the study of underground water resources in South Lebanon and South Bekaa. The Water Resources Service has four regional offices (Beirut, Tripoli, Chtaura and Saida).

In the sixties, the Lebanese hydrometric network had an excellent extension. During the civil war, the equipment of the Water Resources Service suffered greatly: 75 % of the field equipment was destroyed, and gauging measurements were significantly reduced. Since 1990, the service has gradually recovered its activities. Presently, the Lebanese hydrometric network includes 41 stations, 35 of which are equipped with a limnigraph, and thus covers the entire country relatively sufficiently. Unfortunately, the qualified technical staff belonging to this service decreases year by year due to migration or retirement, and is not being sufficiently replaced.

3.3.2 Council for Development and Reconstruction (CDR)

The Council for Development and Reconstruction (CDR) is a public authority that was established in 1977, partially to replace the Ministry of Planning, to be the governmental unit responsible for reconstruction and development. The CDR was granted unprecedented power to avoid any administrative routine that could delay the reconstruction process, especially in the financial field. The main tasks of the CDR can be summarized as follows:

- Preparing general plans for the country, investment and implementation programs for reconstruction and development projects,
- Mobilizing external financing for priority projects within the investment plans,

- Implementing projects by appointment from the Council for Ministers and
- Taking action in rehabilitating the public administration and reconstruction of the infrastructure and negotiating foreign financing agreements.

Since 1991, with the recovery of security and peace, CDR has become more and more active. It has prepared and is currently updating the "Horizon 2000" Plan, which calls for $18 billion (US) of public investment through 2007 in coordination with all involved ministries. It has mobilized over $3 billion (US) of external financing, mostly from Arab countries, Europe and the World Bank, and is increasingly involved in monitoring, tendering and implementing priority reconstruction and development projects in basic infrastructure, social and productive sectors. Projects budgeted with more than $3 billion (US) have been awarded until now, primarily in sectors including power, health, education, **water supply and wastewater**, solid waste treatment, telecommunications, transportation, roads and highways.

The tendering procedure and award of contracts takes place according to bidding procedures of the Lebanese Government, taking into consideration procurement conditions of foreign funding agencies and bilateral governmental agreements.

3.3.3 Ministry of Environment (MoE)

The State Ministry of Environmental Affairs was first created in May 1981 with the aim of controlling all forms of pollution, the use of pesticides, deforestation and forest fires, solid waste disposal, protection of fauna and flora, and urbanization.

In April 1993, the Ministry of Environment (MoE) was established by the Law 216, thus replacing the State Ministry of Environmental Affairs and marking a significant step forward in the management of environmental affairs. However, until today the tasks of the MoE in the water and wastewater sector are mainly limited to monitoring.

3.3.4 Ministry of Agriculture (MoA)

The MoA’s mandate is to develop the agricultural sector including **irrigation** and to protect and manage natural resources. Before the establishment of the MoE, the MoA was in charge of the preparation and implementation of laws and legislation related to natural resources. After its founding, the MoE was responsible for the preparation and implementation of legislation on many of the issues related to natural resources. The MoA has the mandate to undertake reforestation projects, to protect, supervise and manage the natural resources and to provide assistance whenever necessary.

The **Green Plan** (GP), an independent authority established in 1963 which works under the hospices of the MoA, has the mandate to study and execute land rehabilitation and land development projects. All civil works in the GP activities are mainly designed and always executed by local consultants/contractors. The GP operates on a demand-driven basis, which does not always imply equity in providing services. However, priority is given to the farmers most in need and deprived areas.

3.3.5 Ministry of Public Health (MoPH)

The MoPH is responsible for the psychological and physical safety of people. As a result of recent developments in the field of prevention, cure and care, the MoPH has experienced a significant increase in its administration, competency and programs. This evolution has been accompanied by changes in the laws and regulations that define its role and intervention. It consists of the following Directorates:

- The Directorate of Health Prevention undertakes among other things the task of enhancing the role of **sanitary engineering**.
- The Directorate of Public Health Laboratories carries out activities that consist mainly of drug quality control, food control, **ensuring water safety**, active participation in the epidemiological surveillance operations in order to fight against intoxication cases or food contamination.

3.3.6 Municipalities

Municipalities in Lebanon are responsible by law for building and maintaining certain infrastructure (**sanitation**, local roads, and sidewalks) and providing basic services (solid waste management, **wastewater treatment**, construction permitting, etc.).

Unfortunately, most municipalities still lack the human and financial resources, environmental awareness, management capabilities, and/or political commitment necessary to discharge their mission in an environmentally sound manner. Training of municipal decision-makers and professionals will be required to improve the overall effectiveness and environmental performance of Lebanese municipalities.

3.3.7 Environmental NGOs

The number of Lebanese NGOs and international NGOs active in Lebanon has increased strongly in the last years. In July 2001, 112 environmental NGOs were registered with the Ministry of Interior and Municipalities and listed in the records of the MoE. There are no reliable, comprehensive data on the size and activities of NGOs. Most of the NGOs are small (a handful of members) working at the grassroots level. About a dozen have demonstrated the ability to raise funds, both nationally and internationally, and implement environmental projects at the local and national levels. Only a handful of NGOs have paid employees, on a part-time or full-time basis, and operate as a professional organization.

The two main associations or forums for NGOs are the **Lebanese Environmental Forum** and the **Green Forum**. The forums provide a co-ordination framework for Lebanese NGOs acting in various social, health, natural resources and educational sectors and create dialogue with governmental institutions within the framework of complementarities between governmental and non-governmental sectors.

Among those NGOs active in the field of wastewater treatment and reuse are YMCA and MECTAT (Middle East Center for the Transfer of Appropriate Technology).

3.3.8 Research Institutions and Universities

The **National Council for Scientific Research** is the umbrella public research institution in Lebanon. It has cooperative relationships with local, regional and international agencies. Locally it works with several ministries and public agencies and private research institutions. One of the three main centers of the National Council for Scientific Research is the **National Center for Remote Sensing**, which is currently undertaking several projects relating to the use of databases for analyzing environmental issues by means of remote sensing and GIS. The projects cover different topics including natural resources, geo-environmental hazards, and land use and impacts. The National Center for Remote Sensing is working on the **mapping of all water springs and all the coastal area showing all water run-offs into the sea**. It is also working on several issues related to monitoring and combating desertification, mapping erosion processes, forest fires, as well as other related activities.

Universities also play a major role in environmental research and education in Lebanon. They are increasingly offering environmental courses. The extent and depth of environmental education is variable. Some universities offer full-fledged multi-disciplinary environmental programs, while others provide environmental courses only for non-environmental majors. Some environment programs are geared towards natural sciences (i.e., ecosystem, ecology, water) while others are more focused on engineering (i.e., solid waste, air pollution control, cleaner production, wastewater).

With regard to the water sector, various universities are involved in research projects dealing with monitoring, managing and assessing water resources, with wastewater management and with irrigation issues.

3.4 International Organizations Active in the Water and Wastewater Sector

International donor agencies are playing an important role in financing environmental project activities. Projects cover a wide range of issues and areas of intervention, including institutional strengthening, resource management and conservation, biodiversity, and (re)building of the public infrastructure, like water supply, wastewater treatment and energy. The international organizations are working in Lebanon using capacity building, project implementation and technical assistance. Some countries are also providing support by means of bilateral arrangements. The most important international organizations are listed in the following section.

3.4.1 World Bank

The International Bank for Reconstruction and Development (generally known as the “World Bank”) was established in 1945 and is an International Organization affiliated with the United Nations. Lebanon joined the World Bank in 1947 and until today has received over $980 million (US) in World Bank loans. At the request of the Government of Lebanon, the World Bank opened a Country Office in Beirut in January 2000.

The current Bank portfolio in Lebanon consists of 13 projects with a total commitment amount of $529.44 million (US) in the areas of municipal development and infrastructure, revenue enhancement, agriculture infrastructure, irrigation, solid waste and environment, vocational and technical education, general education, health, roads, water, cultural heritage and community development.

The World Bank Office in Beirut aims to establish and develop a broad and effective set of partnerships with other donors, the private sector, and civil society.

3.4.2 United Nations Development Program (UNDP)

The United Nations Development Program (UNDP) was founded in 1965 to eradicate poverty through sustainable human development and has operated technical cooperation programs in Lebanon ever since. Activities were restricted during the war period, but resumed fully in 1992.

UNDP's cooperation with Lebanon aims to support the people and institutions by means of programs that focus on balanced regional development, sound environmental management, institution building, and strengthening human development. UNDP Lebanon works in partnership with the Council for Development and Reconstruction (CDR) and with different ministries, and develops collaborative action with civil society and with other UN organizations.

The mainstreaming of environmentally sound strategies within the sectoral ministries is considered one of the priority objectives of the UNDP **Environmental Management and Sustainable Development Program** in Lebanon. This process began with the ministries of Agriculture, Energy and Water and Public Works and will be further expanded to reach other key planning and operational bodies. The program focuses on national capacity building in terms of policy advice, updating environmental legislation, promotion of national capacities through training of stakeholders and establishment of integrated systems.

Sound environmental practices and policies are promoted through strategic pilot initiatives. Projects in the fields of desertification, biodiversity, climate change, and ozone depletion have been initiated. A national action plan for environmental education and increasing public awareness has also been started. However, so far UNDP-Lebanon has no programs or initiatives with a special focus on water or wastewater. As a foundation for dealing with the subject of water the United Nations Economic and Social Commission for Western Asia (ESCWA), in joint collaboration with UNDP, held a workshop in January 2003 on “Groundwater Legislation Review and Water Tariff Analysis in Lebanon” (see text box below).

The UNDP-ESCWA project entitled: **“National Policy Framework for Water Resources Management in Lebanon”** addresses two water priority issues: capacity building in groundwater legislation, and water tariffs. Its main objectives are to assess the overall water resources situation in Lebanon and to review the existing water policies and programs. It will review groundwater legislation and water tariffs in view of recommending appropriate measures for their effective implementation as part of building-up the institutional and technical capacity of water experts and ministry personnel in Lebanon in these areas.

The workshop on **“Groundwater Legislation Review and Water Tariff Analysis in Lebanon”** comprised five working sessions which focused on a number of issues, namely: the review of the evolution of legislation, the utilization and management of groundwater sources in

Lebanon; the identification of the basic components of a modern groundwater code relevant to the Lebanese context; suggestions of measures to update the existing legislation including their enforcement; and review of the different tariff structures applied in Lebanon in the domestic, industrial and agricultural sectors, identification of the basic components of an appropriate water tariff system and suggestion of measures to improve the existing water tariff schemes by proposing various tariff designs.

3.4.3 World Health Organization (WHO)

The World Health Organization, the United Nations specialized agency for health, was established in 1948. Lebanon has been an active member of the WHO since 1949. The Lebanon WHO Country Office works closely with the national authorities for formulation and implementation of adapted health policies and strategies and coordinates international health work. The WHO has been very active in raising public awareness on matters of health.

Tasks of the WHO Lebanon office in the sector of water are supporting the national wastewater management plan, risk assessment of environmental health factors with focuses on water quality and sanitation, surveys and training for water quality assessment and workshops, conferences and trainings in basic water supply and sanitation. In addition, the WHO Lebanon office is currently developing guidelines on health aspects and irrigation themes of water supply and sanitation. The team hopes to establish a national plan for water surveying early in 2004.

3.4.4 European Union (EU)

The European Community has increased its technical and financial cooperation with Lebanon since the signature of the Economic, Technical and Financial Cooperation Agreement between the European Economic Community (EEC) and Lebanon in 1977. In 1979 a Delegation of the European Commission was established in Lebanon and in spite of the war it never closed its doors. In 1995 relations between the European Union and Lebanon entered a new phase with the signing of the Final Declaration of the Barcelona Conference that established the **Euro-Mediterranean Partnership** between the 15 Members of the European Union and 12 Mediterranean Partners.

The main priorities of EU co-operation with Lebanon, as defined in the Country Strategy Paper 2000-2006, are support for the economic reform process, sustainable development, environmental protection, the development of human resources and the improvement of human rights. Environment is one of the priorities of the cooperation between the EU and Lebanon as it has a social and economic dimension and an impact on the population's health. The objective in this field is to preserve the natural resources, to optimize their utilization, and to reduce industrial pollution as well as pollution linked to solid waste and wastewater. The projects focus considerably on public awareness in the field of environment and on environmental requirements in local and national policies.

MEDA Program

The MEDA Program is the principal financial instrument of the European Union for the implementation of the Euro-Mediterranean Partnership. The program supports the establishment of a Euro-Mediterranean area of peace and stability and helps to prepare the establishment of a free-trade area to be set up by 2010. It offers technical and financial support focusing on economic reforms, on social and poverty alleviation issues, environmental protection, human rights and civil society, and human resource development. Under the MEDA Program, Lebanon has been granted for the period 1995 - 2002 a total amount of €194 million.

LIFE-Third Countries Program

Lebanon also benefits from the LIFE-Third Countries Program. LIFE, introduced in 1992, is the financial instrument that supports the environmental policy of the EU. Part of the LIFE budget is dedicated to LIFE-Third Countries Program, which finances activities implemented in third countries bordering on the Mediterranean and the Baltic Sea other than central and east European accession candidate countries.

The objective of LIFE-Third Countries Program is to contribute to the establishment of capacities and administrative structures needed in the environmental sector and in the development of environmental policy and action programs. Projects focus on the reduction of industrial pollution, coastal management and forest protection.

Short and Medium-Term Priority Environmental Action Program (SMAP)

At the level of regional cooperation SMAP is a framework program of action for the protection of the Mediterranean environment under the Euro-Mediterranean Partnership. Priority fields of action are **integrated water management**; integrated waste management; hot spots (polluted areas and threatened components of biodiversity); integrated coastal zone management; and combating desertification.

Lebanese Environment and Development Observatory (LEDO)

Funded by the European Commissions' Life-Third Countries Program, with the assistance of UNDP, the Ministry of Environment (MoE) hosted and executed a project named Lebanese Environment and Development Observatory (LEDO) between 1999 and 2002. LEDO was one of a group of observatories launched along the Mediterranean countries by an initiative of the Blue Plan Office. The scope of LEDO activities varied from the simple collection and publication of existing environmental information to gathering, collecting, analyzing and publishing well defined environmental-related development data and indicators. Although environment and development data are gradually becoming more available in Lebanon, significant information gaps continue to exist in key environment (e.g., air and water pollution levels, industrial wastewater discharges) and development areas (e.g., costs of environmental degradation). LEDO worked with other ministries, agencies, and academic institutions to agree on a limited number of environment and development indicators, find out who is collecting what type of information necessary to estimate those indicators, and agree on who was collecting the missing information to evaluate all selected indicators.

LEDO finalized the calculation of 60 indicators out of the 90 specified for Lebanon. The project produced a handbook on developed indicators, their significance and interpretation, and followed up on the preparation of the State of the Environment Report. The environment and development indicators related to water, wastewater or irrigation published by LEDO are listed in Annex D.

3.4.5 United States Agency for International Development (USAID)

USAID is the principal agency of the United States for assisting foreign countries recovering from disaster, trying to escape poverty, and engaging in democratic reforms. It is an independent federal government agency, which was founded in 1961. In Lebanon USAID is working on expanding economic opportunities, strengthening foundations for governance and improving environmental policies and practices. In the water management and sanitation sector USAID is involved in projects to support planning, conservation and strengthening of the water infrastructure, to regulate water prices and distribution, and projects on wastewater management. In communities where water resource management and agricultural productivity constitute serious challenges, USAID activities focus on working with diverse stakeholders by introducing collaborative planning techniques and developing mechanisms for resolving disputes over water. USAID activities aim at involving the private sector in water management endeavors, such as water distribution and pricing policies.

4 Water Sector

4.1 Water Resources

Lebanon has a relatively favorable position as far as its rainfall and water resources are concerned, but its development is constrained by the limited water availability during the dry summer months. The rain, which mainly falls in the winter season, is leading to the rise of 40 major streams and rivers (including 17 perennial rivers) and more than 2,000 springs.

Nevertheless, Lebanon is poised to experience a water deficit within 10-15 years as will be shown below, unless new water management policies are developed and put in action.

4.1.1 Annual Water Balance

The fact that Lebanon is at a higher elevation than its neighbors means that it has practically no incoming surface water flow.[3] The only renewable water resource in Lebanon is precipitation. It is estimated that the yearly precipitation in Lebanon results in an average flow of 8,600 million m^3/year.

Several studies were conducted to estimate the annual water balance in Lebanon. Although these studies contain certain inconsistencies, it is generally accepted that approximately 50 % of the average yearly flow of 8,600 million m^3 is lost through evapotranspiration. Additional losses include:

- Surface water flows to neighboring countries (8 %): Surface water flow to Syria is estimated at 510 million m^3/year[4]. Surface water flow to Israel is estimated at 160 million m^3/year.
- Groundwater seepage (12 %): Annual groundwater outflow is estimated at 1,030 million m^3, of which 130 million m^3 flow to Syria, 180 million m^3 to Israel and 720 million m^3 to the sea.

This leaves 2,600 million m^3 of surface and groundwater that is potentially available, of which 2,000 million m^3 is regarded exploitable (see Table 4.1).

The net exploitable surface and groundwater represent the total quantity of water that Lebanon can realistically recover during average rainfall years. It includes water that may be too polluted to use for domestic consumption (high treatment costs).

[3] A contribution of an estimated 74 million m^3/year to the El Kebir River in the north is generated by the 707 km^2 that border Syrian catchment areas. There might also be some groundwater inflow from these areas, but no figures on quantities are available.
[4] A recent (informal) agreement between Lebanon and Syria on the El Aassi River has led to an allocated share of 80 million m^3/year for Lebanon and the remainder for Syria.

Table 4.1: Approximate Annual Water Balance

Description	Yearly average flows [million m³]	
Precipitation		8,600
Evapotranspiration	4,300	
Surface water flow to neighboring countries • Flow to Syria • Flow to Israel	 510 160	
Groundwater seepage	1,030	
Net potential surface and groundwater available		2,600
Net exploitable surface and groundwater		2,000

Source: Various, including Jaber; Al Hajjart, 1997; Comair, 1998; El-Fadel and Zeinati, 2000; Note: Precipitation estimated from isohyetal maps, and flows to Syria from National Litani Organization

4.1.2 Precipitation and Evaporation

The average annual precipitation in Lebanon is estimated at about 840 mm/year resulting in the estimated average yearly precipitation flow of 8,600 million m^3. This abundance of rainfall is vital since precipitation is the only renewable water resource in Lebanon. The use of this water, however, is limited by temporal and spatial disparities. Temporally, precipitation occurs during a short period (about 80 to 90 rainy days between September and May). Spatially, it is not evenly distributed, thus creating sharp regional disparities whereby the annual precipitation varies from a low of 200 mm/year in the northern inland extremes of the Bekaa Plain to more than 1,500 mm/year in the peaks of Mount Lebanon. This uneven distribution is due to the geomorphologic nature of Lebanon. Despite its small surface area, Lebanon exhibits contrasting physiographic features and well-differentiated geomorphologic regions.

The precipitation in Lebanon is distributed as follows:

- 600 to 1,000 mm in the coastal areas;
- 1,000 to 1,500 mm in the mountain areas near the coast;
- 200 to 600 mm in the inland areas of the north and central regions;
- 600 to 1,000 mm in the inland areas of the south; and
- 600 to 1,000 mm in the Anti-Lebanon chain.

The Agricultural Research Institute has taken field measurements of potential **evaporation** in different locations. On the coast the measured annual values are 1,300 to 1,350 mm and the mean daily value is 7 mm. In the Bekaa valley the evaporation is slightly higher; the measured annual values are 1,330 to 1,400 mm and the mean daily value is 11 mm.

4.1.3 Groundwater

The underground water resources of Lebanon are mainly related to the development of a very important karstic network in the Jurassic and cretaceous limestone layers. Lebanon's limestone formations have many fissures and fractures. This increases the amount of percolation and infiltration of rainwater and snowmelt into the ground to feed the aquifers. Lebanon is strewed with numerous karstic springs, some of which have been tapped for thousands of years: Springs of Baalbeck, Salomon Fountains at Ras el Aïn, south of Tyre.

The country is divided into two major and distinct hydro-geological provinces:

- The Interior Province comprises the eastern flanks of the Lebanon range, the Bekaa valley, and the western flanks of Anti-Lebanon.
- The Mediterranean Province comprises the western flanks of the Lebanon range, which extend down to the sea.

The groundwater quantity available for exploitation in Lebanon is estimated to range from 400 to 1,000 million m^3/year, (about 12 % of the average yearly flow, 8,600 million m^3/year). Rainwater and snowmelt are the main sources of groundwater. The water infiltrates deep into the ground and is stored in underground aquifers. It can be divided as follows:

- The water remains stored in aquifers; some may be accessed by means of wells while others remain untapped below deep layers.
- At lower elevations the water reappears as surface water in the form of seasonal fresh water springs (nearly 2,000) that feed into various streams (nearly 40).
- The water forms about 60 submarine springs, 15 of which are offshore while the rest are littoral springs.
- The water remains unexploited deep in underground aquifers and reappears in neighboring countries.

The 1,000 million m^3/year of exploitable groundwater remain to be regulated and exploited properly. The characterization of Lebanon's groundwater resources is essential for determining the extent, hydrologic associations, storage capacity, quality, and retention time of each aquifer.

4.1.4 Surface Water

Lebanon has about 40 major streams: 17 perennial rivers, all originating from karstic springs, and about 23 seasonal streams. The combined length of the streams is about 730 km and their total average annual flow is about 3,900 million m^3.

Based on the hydrographical system, shown in Figure 4.1, the country can be divided into five regions:

1. The **El Kebir River** in the north: The El Kebir River flows west and is shared with Syria. The river itself forms part of the border between the two countries before flowing into the Mediterranean Sea.
2. The **El Assi (Orontes) River** in the north: The El Assi flows into Syria in the north east of the country, draining the northern Bekaa Plain.
3. The **Litani River** in the east and south: The Litani River flows from north to south entirely on Lebanese territory, drains the southern Bekaa Plain, crosses the southern periphery of the Mount Lebanon range and discharges into the sea in the

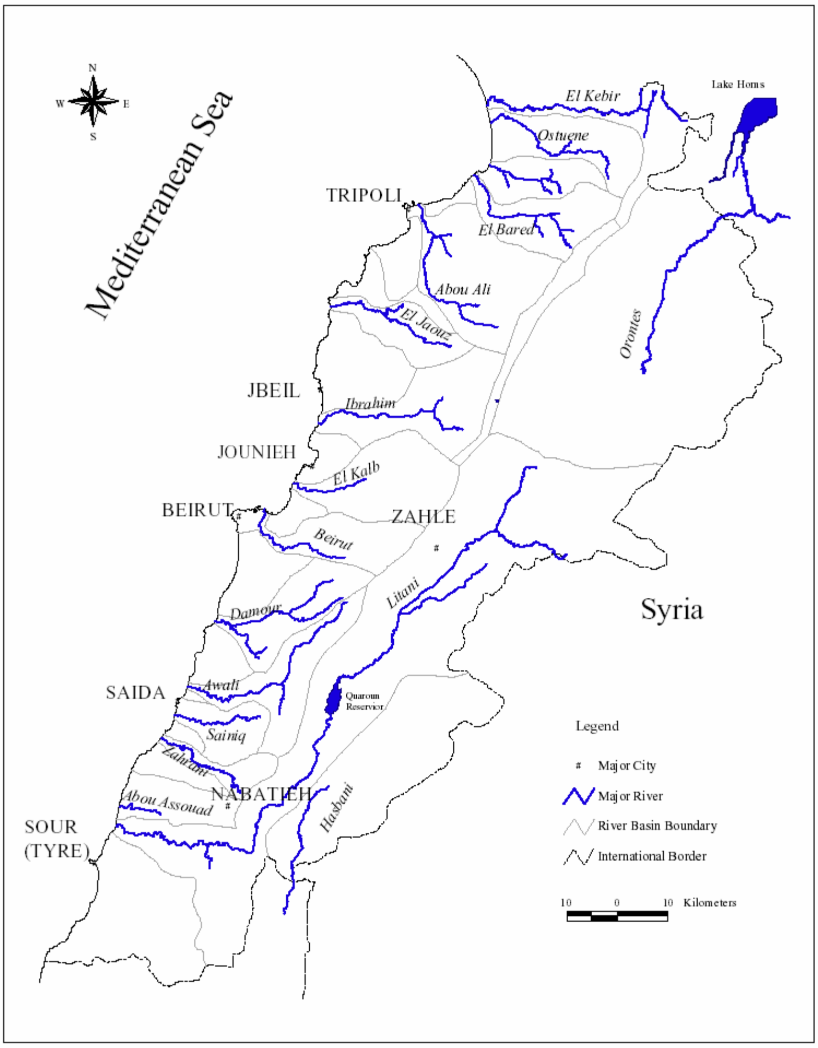
south west of the country in the north of Tyre. It presents significant possibilities for irrigation.

4. The **Hasbani River** in the south-east: The Hasbani River springs up in Lebanon, crosses the southern border and flows south toward Palestine forming one of the tributaries of the Jordan River. It presents great possibilities for irrigation.

5. All the remaining major coastal rivers: The majority of the Lebanese rivers (13) spring up on the western slope of "Mount Lebanon" and flow west toward the Mediterranean Sea (Ostuene, Aaraqa, El Bared, Abou Ali, El Jaouz, Ibrahim, El Kalb, Beirut, Damour, Awali, Saitani, El Zahrani, Abou Assouad).

All the remaining watercourses are small and are located in-between scattered and isolated catchments with no noticeable surface stream flow, like the endorheic catchment areas (water bodies, that don't flow to the sea) and isolated coastal 'pockets'.

Major River Basins of Lebanon



Source: El-Fadel *et al.*, 2000a

Figure 4.1: Major River Basins of Lebanon

While most rivers reach their peak flow during the months of March and April, some may reach their maximum flow later in the year, such as the El Assi River, which peaks in July. Minimum flows are usually registered during the months of September and October. The maximum and minimum flows of the 17 perennial rivers are shown in Table 4.2.

For more information on the rivers (name, lengths, river catchment's area, etc.) refer to http://www.emwis-lb.org/EN/Context/Characteristics%20of%20the%20rivers.htm).

Table 4.2: Flow Data for the Perennial Rivers of Lebanon

Flow Data for the Perennial Rivers of Lebanon

River name	*Length (km)*	*Flow in Mm³*			
		Annual	*Average*	*Max*	*Min*
El Kabir	58	190	6.02	13.9	1.8
Ostuene	44	65	2.07	4.01	0.8
Aaraqa	27	59	2.06	6.27	0.8
El Bared	24	282	8.94	15.2	2.7
Abou Ali	45	262	15.17	37.3	1.6
El Jaouz	38	76	2.40	6.18	0.4
Ibrahim	30	508	16.1	27.6	1.9
El Kalb	38	254	8.04	18.1	2.4
Beirut	42	101	2.59	10	0.1
Damour	38	307	13.8	32.7	0.6
El Awali	48	299	9.71	26.2	3.9
Saitani	22	14	0.73	1.3	0
El Zahrani	25	38	1.59	3.4	0.3
Abou Assouad	15	11	0.35	NA	NA
Litani	170	793	12.5	30.8	4.3
El Aassi	46	480	16.4	20.9	11.5
Hasbani	21	151	4.8	11.3	1.6

Source: Various including Al Hajjar, 1997; CD&M, 1982; Acra and Inglessis, 1978

4.1.5 Water Storage - Dams

In Lebanon, the unevenly distributed precipitation throughout the year and the fact that several parts of the country have zero rainfall during the summer months between May and September/October, call for storage measures as to provide water during the dry periods. But until today only one large water storage facility exists between the mountainous range and the coastline, and most floodwater is lost into the Mediterranean Sea.

Public authorities and the private sector have developed hundreds of small earth and concrete storage pounds, with a maximum per unit capacity of 0.2 million m³. During the period 1964-1992 a total of 3.5 million m³ of earth pounds and 0.35 million m³ of concrete pounds has been built. Three hillside stock ponds were constructed in the early 1970s for a total storage capacity of about 1.8 million m³.

In the year 2000, the Ministry of Energy and Water established a ten-year plan for constructing a set of dams on the entire national territory to confront the water shortage that Lebanese experts forecast to emerge by the year 2015.

However, geologic formations (fractured karstic rocks) often preclude the feasibility of constructing conventional larger dams in Lebanon. To date, the only constructed reservoir dam created the Qaroun Lake and was built in 1964 on the Litani River in the Bekaa Plain about 800 m above sea level for power generation and irrigation purposes. It has a storage capacity of 220 million m^3 and an effective storage of 160 million m^3. Despite plans to construct up to 30 new dam systems in Lebanon, only four proposed dams are currently being explored / executed.

Table 4.3: Proposed Dams under Study or Execution

Proposed dam location	*Design Capacity (Mm^3)*	*Status of Implementation*
Nour el Tahta/ El Kebir River	40	Preliminary agreement between Lebanon and Syria concluded
Khardali/Litani River	85	Preliminary designs are being drafted
Bisri/Awali River	106	Detailed designs are underway
Massa-Yahfoufa/ Yanta River	8	Feasibility study completed. Financing pending.

Source: Proceedings of the third Hariri Foundation Alumni Association conference in Beirut: Water in Lebanon and the Middle East. The Reality of Water in Lebanon. Beirut, 18 April 2001 (in Arabic). Conference sponsored by the MEW.

The Bisri dam on the Awali River is currently at the final design stage, features a storage capacity of 106 million m^3 and is intended mainly for supplying water to Greater Beirut. The Khardali dam on the middle reach of the Litani River, with a planned storage capacity of 85 million m^3, has been postponed at the preliminary design stage in view of the prevailing adverse security situation in the southern border region.

4.2 Water Quality

In Lebanon the water quality is adversely affected by industrial, agricultural and domestic wastewaters. Leaching of pesticides and fertilizers from agriculture causes ground and surface water pollution. Industrial activity releases a wide range of chemical effluents into watercourses, especially surface and coastal waters. It is difficult to accurately estimate the pollution loads into water bodies from various economic sectors. Not only are data on effluent generation from industries scant and poorly monitored, but there is also insufficient data on effluent disposal routes (i.e., direct discharge on land or into nearby water courses and the Mediterranean Sea, indirect discharge into sewer networks, with or without pre-treatment) [18].

Quality of Groundwater

The prevalence of fissured limestone formations in Lebanon facilitates the seepage of liquid wastes into groundwater. Point sources of pollution include the discharge of domestic and industrial solid and liquid wastes, as well as routine or accidental spills (e.g., leaking underground storage tanks). Diffuse sources of pollution include mainly agrochemicals (pesticide residues and fertilizers) and seawater intrusion (water salinization).

Quality of Surface Water

Several studies show that some of Lebanon's rivers are highly polluted. For example, high concentrations of BOD_5 as well as fecal and total coliforms, and high Nitrate levels were measured. High BOD_5 levels and coliform counts indicate that untreated domestic sewage is directly discharged into water bodies. High nitrate levels reflect the additional presence of diffuse sources of pollution, such as fertilizers from riverbank agriculture.

Surface water quality data are available from sporadic sampling activities conducted by various institutions. Such data highlight spatial variations but do not account for temporal variations. Temporal variations in river quality would require continuous sampling and monitoring events– something Lebanon does not have.

Open dumping also impacts surface water quality. Unlike controlled landfills, which are equipped with basal lining systems to intercept leachate, open dumps release leachate directly into the environment. Leachate will seep into groundwater or runoff into nearby watercourses.

Quality of Coastal Waters

Marine waters receive contaminated surface water from river outlets, raw or partially treated domestic and industrial wastewater from the coastal zone, agricultural run-off from coastal agriculture, leachate and drifting waste from seafront dumps, hydrocarbons from accidental or routine oil spills, and ballast water dumped illegally.

Some 2.3 million people live in the coastal zone. They release approximately 950,000 m^3 of wastewater a day, most of it ending up in the sea [13]. Currently, there are about 53 wastewater outfalls along the coast [8]. Coastal waters are also affected by countless beachfront resorts and numerous reclamation and sea embankment projects. Of the 10 coastal areas monitored by the National Center for Marine Sciences, only one station (Batroun) was deemed fit for swimming based on the concentration of fecal coliforms. All other nine areas exceeded the WHO fecal coliform standard for recreation waters.

4.3 Water Consumption and Future Demand

It is not possible to determine the accurate annual Lebanese water consumption. Present consumption and future water demands vary because of different assumptions used in the estimation process, particularly in terms of available land for agriculture, average consumption per hectare, annual population growth, average per capita consumption, and future industrialization potential.

It is widely reported that **current annual water consumption** is around **1,400 million m^3**. But demand forecasts are conflicting, ranging from 1,897 million m^3 to 3,300 million m^3 [3] for the year 2010. However, there is a general consensus that there will be a deficit in the quantities of water required within the next 10 to 15 years (see Figure 4.2).

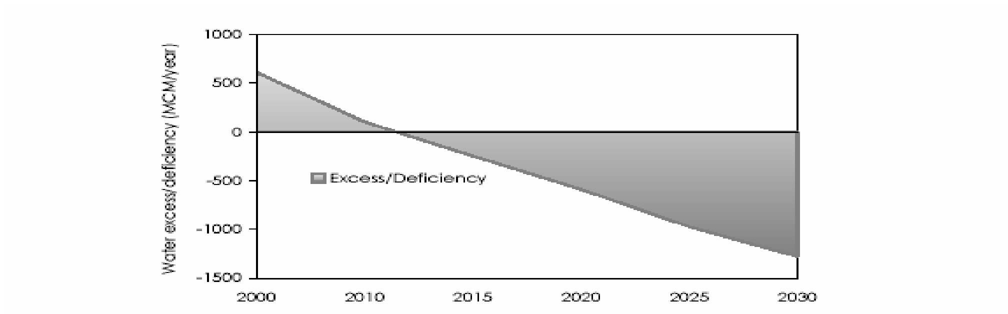


Figure 4.2: Projected water demand in Lebanon between 2000 and 2030

Water consumption in Lebanon is divided among three principal sectors: agriculture, industry and domestic use. As shown in Figure 4.3, agriculture, with a share of around 70 %, is by far the largest consumer of water in Lebanon (as elsewhere in the region), followed by domestic (20 %) and industrial uses (10 %).

Other activities that demand additional water include the generation of hydroelectricity (power plants), recreation (water parks and sports), and aquaculture. Moreover, tourism exerts extra stress on the demand especially in the summer season.

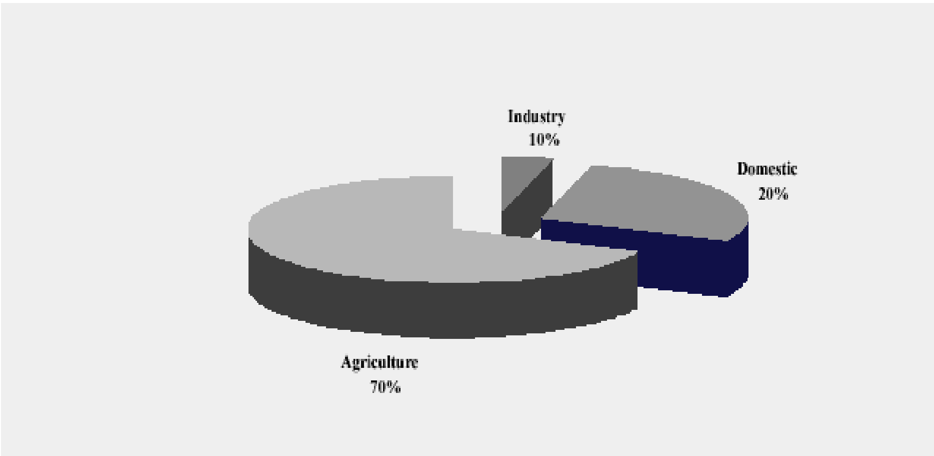


Figure 4.3: Water consumption in Lebanon by sector

The average **water supply delivery rate** in Lebanon is approximately 120 liters per capita per day (l/c/d); delivery rates may vary from 100 (e.g., Baalbeck and Qoubayat) to 200 l/c/d (Beirut and Kesrouane). It is very difficult to determine the actual breakdown of water consumption, as a large share of water in public distribution systems is lost through system leakages. The losses in the distribution systems can amount to as much as 50 % of the supply. Thus, the real water supply may reach less than 64 l/c/d in some areas. In addition, private water wells also supply a great deal of water. Most private wells are unlicensed and therefore not monitored.

4.4 Water Supply Management

4.4.1 Water Treatment Plants

In Lebanon 15 water treatment plants are in operation. The locations and supply capacities of these plants are shown in Table 4.4. The plants extract and treat water from surface water and/or groundwater.

Table 4.4: Distribution and Flow Capacities of Water Treatment Plants in Lebanon

Distribution and Flow Capacity of Water Treatment Plants in Lebanon

Region	*Water Board*	*Plant Location/Name*	*Capacity (m^3/d)*	
			1995/a	2001/b
Greater Beirut	Beirut	Dbaiye	230,000	430,000
	Ain El Delbe	Dachonieh	50,000	50,000
		Hazmieh	50,000	50,000
North	Tripoli	Haab	40,000	40,000
	Nabaa el ghar	Kousba	5,000	16,000
	Batroun	Nabaa Delleh	3,500	12,000
Mount Lebanon	Metn	El Marj lake	3,500	3,500
		Jeita	16,000	17,000
	Jbeil	Nahr Ibrahim	4,000	16,000
South	Saida	Nabaa Kfarwa	8,500	8,500
	Nabaa el-Tasse	Nabaa Azzibeh	4,000	4,000
	Sour	El Bass	6,000	12,000
		Ras el Ain	13,500	15,000
	Jabal Amel	Taybeh /c	8,000	8,000
Bekaa	Zahle	Berdawni	10,000	10,000
Total	**12 authorities**	**15 plants**	**452,000**	**692,000**

a/ Source: METAP/ERM, 1995

b/ Source: *Pers Comm* El Hassan Z, CDR/Water supply specialist

c/ A new plant with a design capacity of 25,000 m^3/day is under preparation

4.4.2 Potable Water Quality

Regional water authorities are responsible for procuring, treating and distributing potable water to households. Water is either chlorinated directly at the source (bore holes and springs) or treated at a centralized water treatment plant. However, potable water quality may then deteriorate during distribution (cross contamination by wastewater network, rusting water conduits, etc.). Thus, when end-users receive potable water, in some cases it may not be safe for consumption, potentially leading to incidences of gastro-intestinal diseases (e.g. diarrhea, dysentery) and other infectious diseases (e.g. typhoid, hepatitis). It is therefore advisable to boil drinking water or to purchase bottled water.

4.4.3 Water Pricing

The regional water authorities are empowered by law (Law 221) to set and collect water tariffs for domestic and agricultural use. Subscription fees for domestic water supply vary among water boards. During the year 2001, tariffs ranged from LBP 65,000 (48 EUR) per year (e.g., Bsharre, Dinniyeh) to LBP 231,000 (169 EUR) per year (e.g., Beirut, Metn) for a 1 m^3/day gauge subscription. Differences are partly due to water availability and distribution costs as gravity distribution is cheapest, while distribution by pumping is far more expensive. In Beirut and the Metn area, where water tariffs are highest, water is transported long distances and/or pumped from deep wells. In

Bsharre and Dinniyeh, where water tariffs are lowest, water is available from springs and delivered by gravity. Table 4.5 presents the evolution of water tariffs between 1996 and 2000 for the Beirut and Dinniyeh water boards.

Table 4.5: Evolution of water tariffs between 1996 and 2000 for select regions (in LBP for an annual subscription of 1m^3/day)

Region	*Year*					% Increase (1996-2000)
	1996	*1997*	*1998*	*1999*	*2000*	
Akkar	100,000	100,000	134,100	134,000	160,100	60
Baalbeck-Hermel	110,000	132,000	132,000	132,000	132,000	20
Barouk	110,000	110,000	121,000	152,000	152,000	38
Beirut	158,400	158,400	182,160	200,500	230,500	46
Bsharre	65,000	65,000	65,000	65,000	65,000	0
Dinniyeh	75,000	75,000	75,000	75,000	75,000	0
Metn	127,100	152,800	180,600	210,100	231,100	82
Saida	99,000	115,000	147,000	148,000	148,000	49
Tripoli	132,000	132,000	132,000	132,000	165,000	25

Source: Data compiled and supplied to ECODIT by Jaber B, MoEW

Most households incur additional expenses to meet their water consumption. Assuming households with a 1 m^3/day gauge subscription actually receive and consume this amount of water per day; such households would be paying the equivalent of US$ 0.12-0.42 per m^3 of water. In fact, most households end up paying much more on a per cubic meter basis for two main reasons:

- Frequent and periodic water shortages (some areas report receiving water only a few hours per day) and
- Users need to buy water from private haulers, at costs typically around $ 5-10 (US) per m^3.

As long as water meters are not installed, the price of water will remain unaffected by actual water consumption and people will pay the same amount regardless of the quantity of water actually delivered/ consumed. Users have no incentives to conserve water and wastage is much more common.

4.4.4 Water Distribution Systems

According to the CAS Census of Buildings and Establishment almost 80 % of the buildings are connected to water supply networks (see Table 4.6). However, many of the households that are connected to the distribution network also rely heavily on extracting water from artesian wells.

Table 4.6: Percentage of housings with connection to the water network

Regions	**% of housings connected to the water network**	**% of housings connected to the sewage network**
Beirut	95.1	98.3
Beirut suburbs	77.3	89.3
Remaining Mount Lebanon	89.2	33.9
North Lebanon	67.6	53.5
South Lebanon	79.0	42.1
Nabatiyeh	90.4	23.8
Bekaa	70.8	41.1
Average	**79.9**	**58.5**

Source: CAS 1998

The connections to water and sewage networks show the supremacy of Beirut and its suburbs over the other Mohafazas, including Mount Lebanon. Beirut has the highest rates of connection to water (95.1 %) and sewage (98.3 %) networks. Beirut suburbs have more problems related to access to water (rates drop to 77.3 %) rather than problems related to the sewage network (89.3 %). The situation is drastically reversed in Mount Lebanon where we find the lowest rate of connection to the sewage network (33.9 %), well behind the North (53.5 %), the South (42.1 %) and the Bekaa (41.1 %), where the situation is also not propitious. Access to the water network is better in Mount Lebanon (89.2 %). The South has a high access rate to water (79 %), followed by the Bekaa (70.8 %) and by the North (67.6 %).

Distribution Network Status

Despite recent governmental efforts to improve the water supply network, the distribution system is highly inefficient with losses reaching up to 50 % of the supply. This is due to old piping systems, losses in bends and fittings, lack of maintenance, evaporation, outlet losses, and others. Moreover, the network does not cover the entire Lebanese territory. Many regions are still deprived and receive no water from the network.

4.4.5 Privatization of the Water Supply Sector

The Lebanese government has been advocating private sector participation in many sectors including water, but many factors hinder this participation such as lack of written policies and action plans, an inadequate legal framework, and unclear procedures for creating and sustaining public-private partnerships. In the absence of an overall strategy, the government is pursuing a piecemeal approach, moving ahead with a management contract with a private operator in the city of Tripoli and considering other arrangements supported by the World Bank in Baalbeck. As these isolated efforts increase, different donors may encourage different or contradictory approaches. Private sector efforts grow, in part, out of recognition of the weak performance, inadequate staffing, and poor resources of the regional water authorities, but a clear and broadly accepted understanding of the operational partnership among the regional authorities and the private operators has yet to emerge and should probably be an early step in the overall process. [18]

4.5 Pressures Exerted on the Water Sector

The water sector in Lebanon is subjected to many environmental stresses related to agricultural, industrial and other sectors as shown in Table 4.7.

Table 4.7: Potential environmental stresses on water resources[5]

Potential Environmental Stresses on Water Resources

Economic Activity	*Source of Impact*	*Evidence of Stress*
Agriculture	Excessive use of surface and groundwater for irrigation	Seasonal water shortages
	Excessive application of agrochemicals	Possible contamination of groundwater from pesticides and nitrates
Industry	Discharge of liquid waste	Contamination of rivers and coastal waters
	Uncontrolled disposal of solid waste	Possible contamination of rivers and groundwater from leachate seepage
Transport	Use of leaded gasoline	Lead in rivers and coastal waters especially after storms
	Disposal of waste oils	Waste oil dispersal in rivers, wells and coastal waters
	Disposal of ballast water	Oil slick and tar balls on shores
Energy	Hydropower	Intermittent drying of river beds during summer
	Thermal pollution stations	Discharge of cooling water leads to thermal pollution of costal waters in the vicinity of thermal plants, disturbing marine ecology
Human Settlement	Uncontrolled sewage disposal and no monitoring of septic tanks	Bacterial contamination of ground and surface water
	Excessive use of ground water resources for domestic supply	Seawater intrusion in coastal areas

Source: Adapted from METAP/ERM, 1995

In the following some of the environmental stresses and pressures on the Lebanese water sector will be explained in more detail.

4.5.1 Agricultural Sector

Agriculture in Lebanon is increasingly shifting to irrigated production. Irrigation water in Lebanon's agriculture is provided from both surface and groundwater in almost equal proportions. Although there is no data on water wells, the number of farms that have private water wells is believed to be increasing rapidly to satisfy the growing need for irrigation water. Furthermore, the seasonal discrepancy between the precipitation period (winter) and the period of maximum demand for irrigation water (dry summer) has consistently led to excessive and uncontrolled withdrawal of groundwater. Uncontrolled construction of bore wells and inappropriate water abstraction from wells have led to a significant draw-down of the water table in many regions and ultimately caused saltwater intrusion along the coastal plains. Saltwater intrusion poses a significant threat to the quality of fresh water in coastal areas, particularly in some locations where seawater has actually intruded several kilometers inland into coastal aquifers.

[5] Please note that for the transport sector, the use of leaded gasoline has been stopped in recent years. The damage caused by years of usage has not been treated yet.

Another concern with the expansion of irrigated agriculture is the high dependence on gravity irrigation that accounts for 64 % of the total irrigated land and is the predominant method of irrigation with surface water. When compared to sprinkler and drip irrigation, gravity irrigation has higher water losses, due to low system efficiencies and high evaporation losses. While efficiency of gravity irrigation could be significantly improved using optimal water and crop management schemes, the majority of farmers in Lebanon lack basic agricultural training and environmental awareness.

In addition, some agricultural practices have also contributed to a diminishing water quality. Excessive fertilizer utilization in some areas has led to nitrate leakage, which has been detected in elevated concentrations in ground waters. Furthermore, the uncontrolled application of pesticides is leading to the contamination of surface and groundwater.

4.5.2 Industrial Sector

The pressure exerted by the industrial sector on the water sector is mainly related to pollution. Most industries in Lebanon discharge industrial waste into the groundwater or the surface water. Two main categories of industrial pollution can be identified:

1. Surface and subsurface disposal of liquid effluents laden with organic chemicals and heavy metals, which find their way through the highly porous and fractured bedrock into the groundwater.
2. Leaky underground gasoline storage tanks and the uncontrolled surface dumping of waste oils and petroleum by-products and residues.

Furthermore, the industrial sector receives almost 70 % of its water needs from groundwater. This is exerting extra pressure on the water resources of Lebanon.

4.5.3 Population Expansion

The population in Lebanon is expanding at an average annual growth rate of 1.5 %. This expansion of the population is exerting serious stress on the water sector since the population growth is not being coupled with parallel projects in the water sector. Thus the expansion of the water sector has not been able to cope with the expansion of the population, which has exerted pressure on the water network.

4.5.4 Tourism Sector

The tourism sector in Lebanon flourishes in the summer season. The summer in Lebanon is dry and no precipitation is recorded during this season. The water used to support the highly active tourism sector is mostly drawn from wells. This is posing significant pressure on the water supply and is causing fluctuation in the groundwater table.

5 Wastewater Management

Wastewater management is one of the greatest challenges of Lebanon. Most towns and villages lack wastewater infrastructure except for the traditional household sanitary pits or the method of draining wastewater into boreholes in bedrock which in turn eventually reaches the groundwater. Many groundwater resources are already contaminated with fecal matter. The entire central coastline and the regions around the major cities in the north and south (with few exceptional areas) have lost their recreational potential because they are continuously receiving municipal and industrial wastewater. The Bekaa valley is also plagued with similar environmental problems. The problem is aggravated here as surface and groundwater additionally take on agricultural wastes.

While significant improvements are being made to the sewer network, little has been achieved in terms of wastewater treatment. Raw sewers are considered the number one priority for remedial action due to their multiple negative impacts on the environment leading to significant economic and health costs. Currently, a detailed planning for wastewater treatment exists. The plan calls for connecting nearly 80 % of the population to major sewage treatment plants by 2020. At present only one large-scale pre-treatment plant is operating south of Beirut. It only involves preliminary and primary treatment. Afterwards the effluent is released into the Mediterranean Sea. Lebanon is in the process of implementing temporary solutions for the metropolitan areas, but still lacks any integrated management for water and wastewater and villages and mountainous regions are left without any wastewater treatment facilities.

5.1 Wastewater Flows

5.1.1 Domestic Wastewater

Lebanon generated an estimated 249 million m^3 of **domestic wastewater** in 2001 (0.68 million m^3 per day), with a total Biological Oxygen Demand (BOD) load of 99,960 tons [18].

Table 5.1: Estimates of domestic wastewater generation at Mohafaza level (2001)

Mohafaza	Wastewater Flow (1000 m^3/day)	Wastewater BOD Load (Tons per year)
Beirut	68.8	10,040
Mount Lebanon	257.0	37,525
North	137.6	20,092
Bekaa	92.0	13,428
South	80.5	11,751
Nabatiyeh	47.0	6,854
TOTAL	**683.0**	**99,690**

Source: ECODIT

Domestic wastewater flow is related to water supply. The average water supply delivery rate is approximately 120 liters per capita per day (l/c/d). A lot of water is additionally supplied from private water wells and ultimately ends up in the sewage flow. Whereas the Lebanese State of the Environment Report from 1995 calculated sewage flow using a mean sewage generation rate of 120 liters per capita per day, the State of the Environment Report from 2001 uses a mean generation rate of 160 l/c/d which reflects significant improvements that have been achieved in the water supply sector since 1995.

5.1.2 Industrial Wastewater

Industries generate an estimated 43 million m^3 of wastewater per year (117,800 m^3 per day). The composition and BOD load of industrial wastewater is difficult to estimate due to the lack of industrial water statistics. Nevertheless, several estimates report that the total BOD load produced by industries is almost 5,000 tons per year.

It is estimated that the Mohafaza Mount Lebanon generates over two-thirds of the national industrial wastewater flow and has the highest proportion of industrial wastewaters in its overall wastewater stream (21 %). These estimates were derived based on industry employment statistics and an approximation of water consumption rates for several key industrial branches.

Several studies and audits have focused on selected industrial branches. For example, it was estimated that tanneries discharge around 40 tons of chromium into the Mediterranean Sea each year. A fertilizer company in Selaata /Chekka produces a significant amount of phosphogypsum (about 950 tons per day), currently discharged in slurry form into the sea [20]. The plant is also estimated to discharge about 0.7 tons of cadmium, 2 tons of lead, and 2 tons of nickel per year into the sea [19].

Other regional studies were also conducted recently in support of planned pollution control activities for the coastal zone [12] and the Litani watershed [17], but none of these studies has produced reliable estimates of the quantities of industrial wastewaters generated in the targeted regions or of the associated pollutant loads. Ultimately, most industrial wastewater is discharged into the environment with little or no prior treatment, either directly into rivers and streams or through sewer networks. Discharge of industrial effluents with a high BOD load or heavy metal contents into the sewer network could affect the operation of planned wastewater treatment plants.

Table 5.2: Industrial wastewater generation estimated for 1994 and projected for 2020

Mohafaza	*Industrial Wastewater Generation Estimate for 1994*		*Industrial Wastewater Generation Projection for 2020*	
	Quantity (m^3/d)	*Percent of total wastewater stream*	*Quantity (m^3/d)*	*Percent of total wastewater stream*
Beirut	2,754	3	2,754	1
Bekaa	5,279	10	42,159	23
Mount Lebanon	43,914	21	107,584	17
Nabatiyeh	698	3	1,479	2
North Lebanon	6,084	6	34,378	11
South Lebanon	2,391	6	3,269	3
Total	**61,120**	**12%**	**191,623**	**12%**

Source: MoE/Dar Al-Handasah, 1996

5.2 Wastewater Collection

According to the CAS Census of Buildings and Establishment in 1998 less than 60 % of the buildings are connected to sewage networks (see Table 5.3).

Table 5.3: Percentage of housing connected to the sewage network

Mohafaza	**% of housing connected to the sewage network**
Beirut	98.3
Beirut suburbs	89.3
Remaining Mount Lebanon	33.9
North Lebanon	53.5
South Lebanon	42.1
Nabatiyeh	23.8
Bekaa	41.1
Average	**58.5**

Source: CAS 1998

Connections to sewage networks show the supremacy of Beirut and its suburbs over the other Mohafazas, including Mount Lebanon. Beirut has the highest rate of connection to sewage (98.3 %) networks followed by Beirut suburbs with 89.3 % of the buildings connected to sewage networks. The situation is drastically reversed in Mount Lebanon where we find the lowest rate of connection to the sewage network (33.9 %), well behind the North (53.5 %), the South (42.1 %) and the Bekaa (41.1 %).

Since 1998, widespread developments to wastewater works have been realized which have most probably improved the wastewater collection capacity and networks. The current span of buildings connected to sewer networks is not known. However, it is assumed that it is higher than that in 1998.

5.2.1 Urban Systems

As mentioned before, with 98.3 % **Beirut** has the highest rate of connection to sewage networks. To protect the coastline from Metn to Aley the following wastewater collection lines in Beirut are planned and the construction is in progress:

- Southern Collectors: Wastewater collected from the southern regions of Beirut and its suburbs (Manara area and Naameh) will be conveyed by the Carlton -Ghadir -

Naameh collector to the **Ghadir** wastewater treatment plant where a preliminary and primary wastewater treatment plant already exists. The two southern collectors are about 9 km long and will serve an estimated population of 784,000.

- Northern Collectors: Wastewater from Beirut as well as from parts of the Cazas of Metn, Baabda, and Aley is collected and transported via sewer networks to **Dora**. Two more sewer lines are connected to the Dora collector: one from the Manara area in Ras Beirut and the other one from Dbaye. Together, these northern collectors extend over about 17 km and are designed for a future population of 891,000 people [10]. Although work on the northern coastal collectors was completed in 2001, the collectors will remain out of operation until the proposed Dora wastewater treatment plant is constructed. In the meantime, the recently built collectors will require repair and routine maintenance works.

The collectors and plants (design capacity for 1.68 million people) for the greater Beirut area are shown in Figure 5.1.

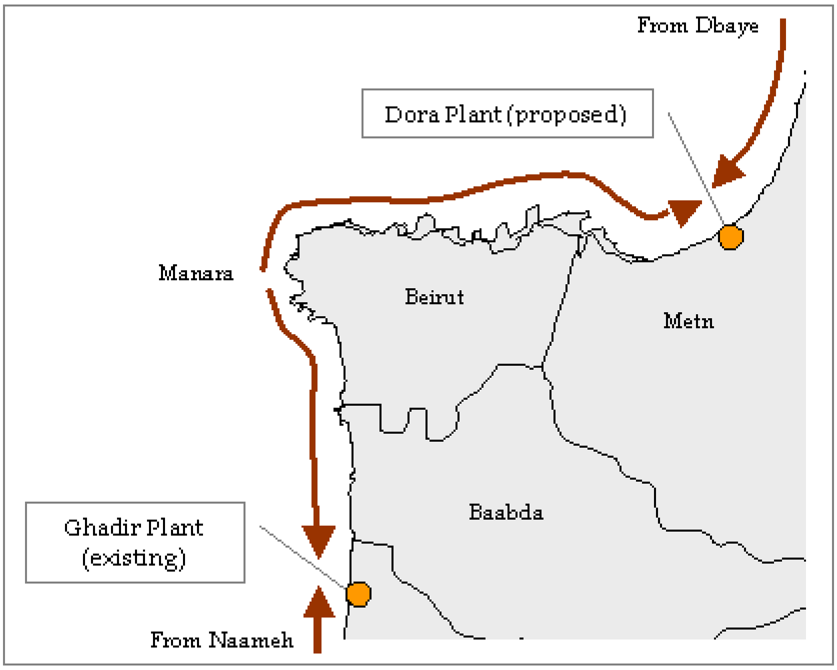


Figure 5.1: Wastewater collection and treatment scheme for Beirut

Wastewater collectors are under execution in the cities Akkar, Beddawi, Laboue, and Baalbeck. Moreover, wastewater collection systems are under preparation for major coastal cities including Tripoli, Jounieh / Kesrouane, Saida and Tyre.

All the above-mentioned collectors will remain idle unless they are connected to treatment plants. Currently, many plants are planned but no funding has been secured to construct them. The only functional plant is the Ghadir wastewater treatment plant.

5.2.2 Rural Systems

Rural systems in Lebanon are limited to cesspools and septic tanks. Moreover, some rural communities do not employ any treatment methods and simply release raw sewage into the environment (ground, rivers, wells, streams, ocean, etc.). In recent years some projects promoting small-scale, decentralized wastewater treatment in rural areas have been implemented (for project examples see chapter 5.3).

5.3 Wastewater Treatment

The only large-scale wastewater treatment plant currently in operation is the **Ghadir** plant, located south of Beirut. The Ghadir plant provides only preliminary and primary treatment (i.e. grit and scum removal). Its construction began in 1974 but was interrupted during the civil war. The plant finally opened for operation in November 1997.

After preliminary and primary treatment the effluent is piped offshore and released into the Mediterranean Sea. Many upgrades have been proposed to extend the range of this plant to secondary treatment. However, no action has been taken to date. The operation and maintenance contracts of the plant have been awarded to the private sector.

There are also several small community-level wastewater treatment plants that have become operational in recent years (see chapter 5.6).

Upgrading the Ghadir wastewater treatment plant

A feasibility study for expanding and upgrading the Ghadir wastewater treatment plant was undertaken to determine the most suitable and cost-effective treatment alternatives [7]. Initial project screening indicated that the plant should be located on land gained from the sea opposite the existing preliminary wastewater treatment facility. Specifically, the study then examined two technical alternatives:

- Activated sludge process with primary treatment; and
- Activated sludge process with anaerobic pre-treatment.

This first alternative would need to reclaim a lot of area from the sea and the total project cost was estimated at US$ 168 million for a capacity of 1.3 million people-equivalents. Land reclamation works alone were evaluated at more than US$ 25 million. The study found that the second alternative was more feasible as it could be implemented in several stages, requires less offshore land reclamation, produces less sludge and would be self-sufficient in terms of energy (biogas generation would provide sufficient energy for on-site uses). This alternative would cost an estimated US$ 52 million to serve one million people-equivalents and an additional US$ 52 million to be upgraded with an aerobic treatment system.

To further minimize costs and eliminate the need to reclaim land offshore, a sub-alternative was then elaborated. This sub-alternative would eliminate the activated sludge process altogether and thereby comprise only anaerobic treatment and a sea outfall, while still fulfilling environmental obligations under the Mediterranean Action Plan (MAP). The first stage of implementation (up to one million people-equivalents) would cost an estimated US$ 52 million. The plant could then be upgraded to serve 1.3, 1.6 and 1.8 million people-equivalents, respectively, in three additional stages. By the end of the third stage, the plant would have incurred additional costs worth a total of US$ 32 million. Land reclamation would be required during the third and fourth phases only. Using this alternative, the final cost of treating wastewater was estimated at 12 cents per m³, down from 33 cents and 20 cents for the first and second alternatives, respectively.

5.4 Wastewater Discharge

In the absence of wastewater treatment plants, effluents from coastal agglomerations are discharged into the sea while effluents from inland communities are disposed in rivers, streams, on open land or underground. While the number of sea outfalls has been surveyed, there is no information on the state of these outfalls (i.e., length, dimensions, loading volume, etc.).There are approximately 53 outfalls along the coast (see Figure 5.2), 16 of which are located between Dbayeh (North of Beirut) and Ghadir (South of Beirut). Most outfalls extend only a couple of meters or terminate at the surface of the water (i.e. no submersed outfall and therefore no effective dilution of wastewater).

The Ghadir outfall is a submersed pipeline at 1,200 mm in diameter which extends 2.6 km into the Mediterranean Sea. The outlet point is approximately 60 meters deep thereby achieving some dilution of the disposed wastewater [6]. Table 5.4 presents the average flow rates and BOD levels of wastewater pumped through the outfall [1].

Table 5.4: Average flow rate and BOD_5 of wastewater through the Ghadir sea outfall

Month	*Flow Rate (m^3/day)*	*BOD_5 (mg/l)*
June, 2000	24,419	371
July, 2000	30,348	527
August, 2000	39,247	494
September, 2000	41,612	418
October, 2000	41,000	445
November, 2000	40,967	411
Average	**36,266**	**444**

Source: CDR/Subal, 2000

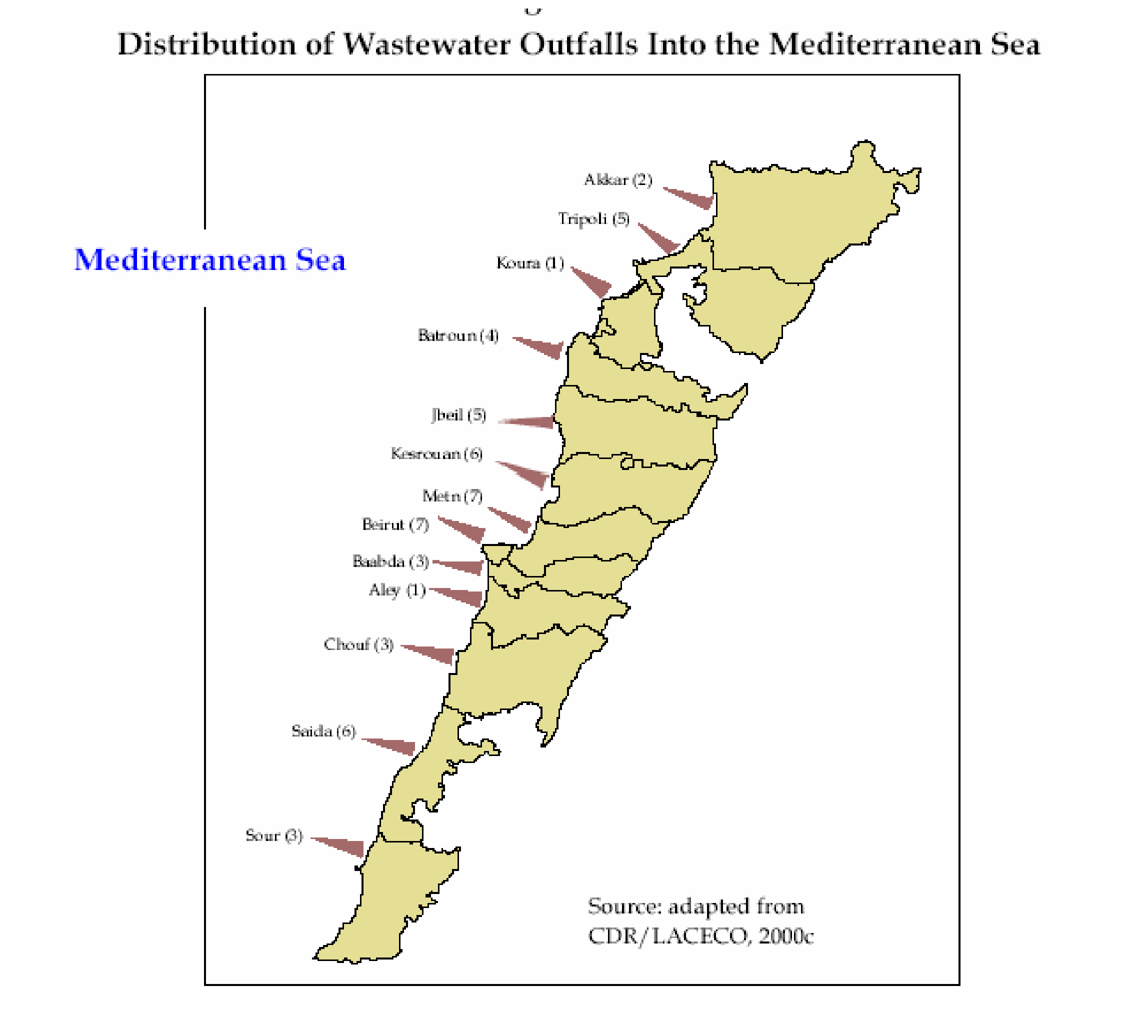


Figure 5.2: Distribution of wastewater outfalls into the Mediterranean Sea

5.5 Governmental Plans and Projects in Wastewater Management

The plans of the Lebanese government in the wastewater sector are based on two fundamental considerations: first, compliance with the provisions of the Convention for Protecting the Mediterranean from Pollution; and second, protection of inland water resources from pollution. Consequently, the objectives of the plan require treatment of wastewater in all regions of Lebanon. To implement these objectives the National Emergency Rehabilitation Program (NERP) launched two major programs:

- **Coastal Pollution Control Program (CPCP)**: The CPCP represents Lebanon's commitment to fulfilling the requirements of the Barcelona Convention and its protocols. Despite the cancellation in the late nineties of the World Bank loan to fund wastewater management works in Saida, Sour, and Kesrouane, CPCP is proceeding with alternative funding from various sources.
- **Water Resources Protection Program (WRPP)**: Work under the WRPP includes the rehabilitation of water treatment plants and water sources (springs and wells), as well as the rehabilitation and construction of transmission and distribution networks.

The total value of studies and contracts in the wastewater sector to date amounts to US$ 363 million. Currently 7 wastewater treatment plants are under construction in Saida, Chekka, Batroun, Jbeil, the Chouf coastal area, Baalbeck and Nabatiyeh. 18 wastewater treatment plants are under preparation and have secured funding, and 10 have secured no funding to date (see Annex E) [18]. According to CDR, wastewater management works are hampered by lack of funds. Sources of funding are diverse and include the Italian Protocol, French Protocol, European Investment Bank (EIB), Japan, Islamic Development Bank (IDB), International Bank for Reconstruction and Development (IBRD), and the Lebanese government.

5.5.1 Achievements to Date

Emergency rehabilitation of wastewater sewer networks: This project covered the rehabilitation and extension of wastewater networks in all regions of Lebanon for a total cost of US$ 24 million. It comprised the rehabilitation of the two wastewater pumping stations in Al-Mina/Tripoli and in Jounieh, and the rehabilitation and construction of 820 kilometers of sewer networks.

Construction of Ghadir wastewater pre-treatment plant: The construction and equipping of the wastewater pre-treatment plant serving the southern suburbs of Greater Beirut and the rehabilitation of the associated sea outfall have been completed. This plant was the first wastewater treatment plant in Lebanon. Its construction began in 1974 but was interrupted during the civil war. It began operating in November 1997. Its operation and maintenance contracts have been awarded to the private sector.

5.5.2 Projects in Progress

Beirut coastal wastewater collectors' project: This project aims to protect the coastline from Metn to Aley. Wastewater will be collected from the northern regions of Beirut and its suburbs from Dbayeh to Manara and conveyed to Dora. Wastewater collected from the southern regions of Beirut and its suburbs will be conveyed by the Carlton-Ghadir-Naameh collector to the Ghadir wastewater pre-treatment plant. Work on the northern component commenced in 1997 and are now complete with costs at US$ 46 million. The Islamic Development Bank provided the necessary funding for the construction of the Carlton-Ghadir-Naameh collector which commenced during the second half of 2001. The cost of this component of the project amounts to about US$ 10.5 million, of which 15 % has now been completed.

Maintenance and development of wastewater and storm water sewer networks in the main cities: This project includes the maintenance and repair of wastewater and storm water sewer networks in the main cities and aims to limit overflow and prevent problems resulting from the malfunction of existing networks. The work includes cleaning of the existing wastewater and storm water sewer networks, in addition to the installation of pipes, fittings and fixtures necessary to improve the efficacy of the networks. The project covers Greater Beirut with its northern and southern suburbs, Tripoli, Zahleh, Jounieh, Saida, Sour and Nabatieh with their suburbs. The project is being carried out in coordination with the Ministry of the Interior and Municipalities. Work started in 1997.

Protection of the coastline from pollution: Lebanon has signed several conventions and agreements for the Protection of the Mediterranean Sea from pollution, which include the Barcelona Convention and the Genoa Declaration. These agreements underline the necessity of treating wastewater before discharging it to the sea in cities and towns with populations that exceed 100,000. Many projects have been prepared for the construction of wastewater collector networks and treatment plants in the coastal regions of Lebanon. On this level: A **treatment plant** and wastewater collector project was commenced **in Saida** during the second half of 2001. The cost for this is US$ 9.5 million which is being funded by the Japanese Bank for International Cooperation (JBIC). The ratio of the work that has been performed has reached 30 %. Similarly, contracts were awarded for the construction of **wastewater treatment plants in Chekka** (11.3 million EUR), **Batroun** (7.2 million EUR), **Jbeil** (8.8 million EUR), the **Chouf** coastal areas (13.1 million EUR), **Nabatieh** (8.5 million EUR). Financing of the construction of these plants was made available through the French Protocol. Performance of work started during 2002. A contract was awarded for the construction of a **wastewater treatment plant in Tripoli** (70 million EUR) which was funded by the European Investment Bank (EIB). The project for the rehabilitation of the infrastructure in Beirut is underway with financing from the Arab Fund for Economic and Social Development (AFESD). The total cost of this project is about US$ 11.3 million. The ratio of work that has been performed was almost 5 % by the end of 2002.

Protection of water resources from pollution: A study was undertaken in 1994 to update the wastewater sector master plan which was originally prepared during 1982. This study identified priority areas for the construction of new wastewater treatment plants to protect water resources from pollution. To accomplish this, financing was secured for the collection and treatment plants in the main inland towns (Zahleh, Baalbeck, Nabatieh, etc.) and in towns close to water resources and springs (Laboue, Qaraoun Lake, Anjar, Hermel, Michmich, Bcharre, Bakhoun, Jbaa, Hasbaya, Chakra, Hrajel and Kartaba). Construction of a wastewater treatment plant in Baalbeck started in the summer of 2000 with the World Bank financing and is now complete. The World Bank approved a US$ 43.53 million loan to the Government of Lebanon to upgrade water supply and wastewater collection and treatment in Baalbeck. The **Baalbeck Water and Wastewater Project (BWWP)** aims to expand the coverage of water supply and wastewater collection in nearby communities by strengthening the efficiency of local water authorities and involving the private sector in the operation and maintenance of water and wastewater facilities. The BWWP will focus on optimizing investments in the sector by increasing the water supply, distribution and wastewater collection coverage and providing service connections in the towns of Baalbeck and Nabi Chit – particularly in poor neighborhoods. **The project will also promote water conservation by introducing customer water metering and subscriber payment for water and wastewater services.** The construction of a **wastewater treatment plant in Zahle**, which is being funded by the Italian Protocol, commenced in 2003.

5.5.3 Projects in Preparation

Protection of the coastline from pollution: The Ministry of Energy and Water conducted a full study for the Akkar Caza that proposed the construction of a wastewater treatment plant on the coast at Abdeh. Also, detailed designs and tender documents are now ready for the construction of wastewater treatment plants in the coastal areas of Kesrouan and Sour Caza. CDR is seeking funding for the Kesrouan wastewater treatment plant from the Japan Bank for International Cooperation (JBIC) and for the Sour plant from the European Investment Bank (EIB). A tender will be launched for the Dora Wastewater Treatment Plant (north of Beirut), which specifies that the contractor should provide funding for both the design and construction of the plant. A feasibility study has been completed for the extension of the wastewater pre-treatment plant at Ghadir (south of Beirut) to add a secondary wastewater treatment plant to it. While CDR has already secured about US$ 15 million from KfW (German Development Bank) to cover part of the costs of this extension, it has started negotiations with the Islamic Development Bank (IDB) and the EIB to secure the needed extra funding. CDR is actively seeking to secure funding for the Greater Beirut wastewater treatment project from the IDB and the EIB. This project involves the construction of the sewerage networks to collect and convey the sewerage from the north and south of Greater Beirut to Dora and Ghadir wastewater treatment plants respectively. EIB expressed interest in funding the construction of the main collectors in the north and south of Greater Beirut, worth approximately US$ 52 million, while CDR has proposed to IDB the funding of US$ 80 million worth of the sewerage networks for the south of Greater Beirut.

Protection of water resources from pollution: The Ministry of Energy and Water and CDR identified about 20 wastewater schemes located near water resources (springs, rivers, lakes, etc.) in the inland areas of Lebanon. Detailed design has been completed for many of these systems that mostly fall within existing financing agreement (Italian Protocol, Islamic Development Bank). Special attention is being paid to the west Bekaa, Qaraoun Lake and Litani River areas, where the degree of water pollution necessitates urgent action to install wastewater collection and treatment facilities in order to secure a swift reduction in the degree of water pollution and contamination. It is expected that in the second half of 2003, the construction of two wastewater treatment plants and associated networks in Jib Jennine and Soughbine will start. The detailed designs and tender documents are about to be completed and it is expected that tenders will be issued in mid 2003. The total cost of these works is estimated at US$ 27 million and will be financed by a loan from the IDB. As part of the Baalbeck water and wastewater treatment plant, CDR will launch a tender for the construction of 148 kilometres of sewerage networks in Baalbeck and surrounding areas. The detailed design and tender documents are ready and the World Bank expressed its willingness to fund the project at a cost of about US$ 16 million. Funding may be secured by August 2003. [11]

5.6 Municipal Initiatives in Wastewater Management

Delays in wastewater works in several regions in the country have prompted several municipalities and local communities to make their own arrangements to improve wastewater collection and treatment. One example is the inauguration of a small wastewater treatment plant in Hammana (May 2001) in Mount Lebanon. The plant uses a combination of extended aeration and activated sludge treatment technologies. It is designed to serve 8,000 people and can be expanded to serve 12,000 people in the future. The Hammana WWTP was constructed before the war but was destroyed in

1976 before starting operations. The Pontifical Mission in Lebanon and USAID have co-financed its rehabilitation. USAID also funded other small-scale wastewater treatment plants including one plant in Jabbouleh, Baalbeck region, and one in Bchetfine, Chouf region (see textbox below). Several of these plants provide secondary treatment resulting in water that is suitable for irrigation. [18]

Table 5.5: Examples of small-scale wastewater treatment plants, funded by USAID

Area	*Village*	*NGO*	*Cost (US$)*	*Beneficiaries*
Bekaa	Jabbouleh	CHF	74,000	NA
Dennieh	Markibta	Pontifical Mission	113,000	260 families
Akkar	Qobayat	Pontifical Mission	195,000	NA
	Charbila	Mercy Corps	80,000	5,759 families
	Bqerzla	Mercy Corps	23,811	330 families
	Akkar el Atika	YMCA	80,000	NA
	Koss Akkar	YMCA	143,000	NA
Baabda	Himmana	Pontifical Mission	168,000	1,400 families
	Kornayel	Pontifical Mission	NA	NA
Chouf	Bchetfine	Creative Associates	350,000	240 families
Marjaayoun	Borj el Moulouk	Pontifical Mission	185,000	NA
	Marj el Zouhour	YMCA	130,000	NA
Hasbaya	Wazzani	Mercy Corps	31,677	NA
Total	**13 WWTPs**		**1,573,488**	

Source: Data supplied to ECODIT by USAID Lebanon Mission, August 2001; note: Costs include community contributions, which may reach 40 % of the total - NA: Not Available

Project example: Bchetfine Wastewater Network and Treatment Facility

The citizens of Bchetfine are represented by a committee formed of all government and non-government institutions in the village. This committee was very involved in all decision making, implementing and funding aspects of the network and treatment facility, identified by its members as the number one village priority. Residents were diverting the sewage into the storm water channels that flow into the Safa River threatening surface and groundwater. The government's master plan for the entire district previewed construction of a costly wastewater treatment plant by 2025. Rather than wait decades, local residents, on their own, contracted a preliminary engineering study for their village and then requested the Creative Associates International Inc. (CAII) cluster program for help. The village committee coordinating with the CAII team decided on a 5.5 km network, a 950 m secondary network, and a treatment plant for 3,500 people. The villagers committed to excavating, backfilling and asphalting the whole network. The village's 40 % contribution to the plant, and their dedication to getting the job done, produced a model sewer system along with the needed sewage facility. The project has been completed and is benefiting approximately 380 families who have access to a sewer system for the first time. CAII also provided extensive hands on technical and administrative training for the committee and municipality, which has now taken over the operations and maintenance of the plant. It has also raised citizens' awareness to what can be achieved through professional and transparent public projects. During a regular inspection visit by CAII's field coordinator to the town hall, she was unable to get through due to long lines formed by locals who were voluntarily coming in to pay their share of the community contribution to the project - or what could be otherwise characterized as a local tax.

Selected USAID Activities in Lebanon in the Wastewater Sector

- Wastewater management in Maaser El Chouf (Mount Lebanon): wastewater collection, wastewater treatment, plant operation, treated wastewater and sludge management.
- Physical infrastructure for wastewater management in Bekaa, Nabatiyyeh and South Lebanon: 9 wastewater treatment centers involving 11 villages
- Human liquid waste treatment in Hasbaya (Nabatiyyeh): Establish low cost, low maintenance treatment plants based on a proven technology: anaerobic digestion (Screens, anaerobic digesters, sedimentation tank, aerobic bacterial bed, sand filtration, gas collector). Proposed interventions are designed to protect potable water sources, watersheds, and important ecological and environmental ground-water bodies, such as Hasbani and Ouazzani rivers.

Activities of MECTAT (Middle East Center for the Transfer of Appropriate Technology) in the Wastewater Sector

- Establishment of a low cost wastewater treatment plant in Wazzani village in South Lebanon (2000-2001)
- Grey water treatment and reuse in six towns of West Bekaa, with IDRC from Canada (2002-2005): The water of 30 households in total is treated in small treatment plants and research is carried out on reuse in agriculture (mainly on socio-economic aspects).
- Training of local managers in construction of waterless/odorless latrines in protected areas (1998)
- Training workshop on solid waste and wastewater management in Lebanon (1996-1998)
- Production and dissemination of do-it-yourself booklets on different subjects including sanitary latrines

5.7 Management of Sewage Sludge

In the coming few years, Lebanon will face a new waste management problem: What to do with sludge generated from wastewater treatment plants? The bulk of the suspended solids which entering a wastewater treatment plant and the waste solids generated from the biological treatment must be handled as sludge at some point in the treatment process. The character and amount of the solids depend on the number and type of industries within the community, the degree to which their wastes are pre-treated before discharge to the public sewers, and to some extent, the primary and secondary processes employed within the treatment plant [23].

Sewage sludge contains microorganisms that may contribute to the transmission of disease, as well as organic and inorganic contaminants that may be hazardous or toxic to humans or have detrimental effects on the environment in general. Therefore sewage sludge should be conditioned before final disposal. Conditioning could include aerobic and anaerobic sludge digestion, composting, chemical addition, and heat treatment. These processes will improve the chemical and physical characteristics of sludge (i.e., reduce impermeability) and may also reduce total mass of solids. To date, while wastewater treatment plants envisioned for Lebanon will provide secondary treatment technology, it is unknown what type of sludge conditioning will be afforded.

In anticipation of future wastewater treatment plants, a master plan for sludge management is currently being drafted [9]. The preliminary report indicates that treatment plants will either generate digested sludge at the rate of 35-49 g/person/day, or undigested sludge at the rate of 63 g/person/day. For the GBA (Ghadir and Dora wastewater treatment plants), this would be equivalent to about 113 tons of sludge per day. The study is also examining available options for sludge reuse and application as a soil conditioner. For example, digested sludge could be used in agriculture and silviculture (forest seedling production), provided the sludge meets minimum quality standards such as permissible heavy metal content. [18]

6 Water Reuse

The main objective of the EMWater Project is to encourage reuse-oriented wastewater management. Therefore draft policy guidelines for efficient wastewater treatment and reuse will be elaborated which shall support the further elaboration of water laws, standards, legislation and policies in the Mediterranean partner countries. New water resources shall be developed by using treated wastewater as a source for the expanding water demands in the region.

The policy guidelines will suggest different reuse purposes and evaluate different technologies and their costs. Quality standards for different agriculture applications will be developed recognizing health risks and integrating environmental aspects, regional and international experience, as well as institutional aspects.

Treated wastewater shall be reused whenever appropriate. Today, technically proven wastewater treatment and purification processes exist to produce water of almost any quality desired. The contaminants in reclaimed wastewater that are of public health significance consist of biological and chemical agents. In the planning and implementation of wastewater reclamation and reuse, the intended water reuse applications dictate the extent of wastewater treatment required. Possible applications are:

- Irrigation in agriculture (plants not eaten by humans; plants eaten cooked; plants eaten uncooked) or for landscaping (with direct contact; without direct contact)
- Groundwater recharge
- Industrial reuse
- Human reuse (usable water; drinking water)

Advantages of wastewater reuse

The reuse of wastewater reduces the demand on freshwater sources. Additionally the technology may diminish the volume of wastewater discharged, resulting in a beneficial impact on the aquatic environment. Capital costs are low to medium, for most systems, and are recoverable in a short time; this excludes systems designed for direct reuse of sewage water. Operation and maintenance are relatively simple except in direct reuse systems, where more extensive technology and quality control are required. The provision of nutrient-rich wastewaters can increase agricultural production.

Disadvantages of wastewater reuse

Reuse of wastewater may be seasonal in nature, resulting in the overloading of treatment and disposal facilities during the rainy season; if the wet season is of long duration and/or high intensity, the seasonal discharge of raw wastewaters may occur. Health problems, such as water-borne diseases and skin irritations, may occur if people come into direct contact with reused wastewater. In some cases, reuse of wastewater is not economically feasible because of the requirement for an additional distribution system. The reuse of reclaimed wastewater may not be culturally or religiously accepted in some societies. These circumstances have to be analyzed carefully before a reuse orientated system is implemented.

6.1 Types of Reuse

Treated wastewater usage depends on several factors (supply and demand, treatment requirements, storage, distribution system, associated environmental and health risks, cultural acceptance). Treated wastewater can be reused for different applications, e.g. agriculture, industry, households or groundwater recharge. Most common is the reuse in agriculture.

6.1.1 Agricultural Reuse

In the Mediterranean basin, wastewater has been used as a source of irrigation for centuries. In addition to providing a low cost water source, the use of treated wastewater for irrigation in agriculture combines three advantages. First, using the fertilizing properties of the water eliminates part of the demand for synthetic fertilizers and contributes to decrease levels of nutrient in receiving waters (rivers, sea, ocean, lakes). Second, the practice increases the available agricultural water and third, it may eliminate the need for expensive tertiary treatment.

However, wastewater is often associated with environmental and health risks. As a consequence, its acceptability to replace other water resources for irrigation is highly dependent on whether the health risks and environmental impacts entailed are acceptable.

Because crop water requirements vary with climatic conditions, the need for supplemental irrigation will vary from month to month through the year. This seasonal variation is a function of rainfall, temperature, crop type, and stage of plant growth, and other factors depending on the method of irrigation being used. The supplier of reclaimed water must quantify these seasonal demands, as well as any fluctuation in the reclaimed water supply, to assure that the demand for irrigation water is met. To assess the feasibility of reuse, the supplier of reclaimed water must be able to reasonably estimate irrigation demands and reclaimed water supplies.

The constituents of concern in using reclaimed water for agricultural irrigation are salinity, sodium, trace elements, excessive chlorine residual, and nutrients. The most important nutrients to a crop's needs are nitrogen, phosphorus, potassium, zinc, boron and sulfur. Reclaimed water usually contains enough of these nutrients to supply a large portion of a crop's needs.

The types and concentrations of constituents in reclaimed wastewater depend upon the municipal water supply, the influent waste streams (i.e., domestic and industrial contributions), amount and composition of infiltration in the wastewater collection system, the wastewater treatment processes, and the type of storage facilities.

6.1.2 Groundwater Recharge

The purposes of groundwater recharge using reclaimed water include the establishment of saltwater intrusion barriers in coastal aquifers, the augmentation of potable or non-potable aquifers, the storage of reclaimed water for future reuse, and the control or prevention of ground subsidence.

Infiltration and percolation of reclaimed water take advantage of the subsoil's' natural ability for biodegradation and filtration, thus providing additional in situ treatment of the wastewater and additional treatment reliability to the overall wastewater management system. The treatment achieved in the subsurface environment may eliminate the need for costly advanced wastewater treatment processes, depending on the method of recharge, hydro geological conditions, requirements of the downstream users, and other factors. Additionally groundwater recharge helps provide a loss of identity between reclaimed water and groundwater. This loss of identity has a positive psychological impact where reuse is contemplated and is an important factor in making reclaimed water acceptable for a wide variety of uses, including potable water supply augmentation.

Methods of Groundwater Recharge are riverbank or dune filtration, surface spreading, or direct injection. Recharge via riverbank or sand dune filtration is practiced in Europe as a means of indirect potable reuse. Surface spreading is a direct method of recharge whereby the water moves from the land surface to the aquifer by infiltration and percolation through the soil matrix. Direct injection involves the pumping of reclaimed water directly into the groundwater zone, which is usually a well-confined aquifer. Direct injection is used where groundwater is deep or where hydro geological conditions are not conducive to surface spreading. Direct injection is also an effective method for creating barriers against saltwater intrusion in coastal areas. Direct injection requires water of higher quality than surface spreading because of the absence of soil matrix treatment used by surface spreading.

The risk of groundwater recharge, that has to be considered, is the possibility of aquifer contamination. Aquifer remediation is difficult, expensive, and may take years to accomplish. Many criteria specify the quality of the reclaimed water, the groundwater, and the aquifer material that have to be taken into consideration prior to construction and operation recharge systems. These include possible chemical reactions between the reclaimed water and the groundwater, iron precipitation, ionic reactions, biochemical changes, temperature differences, and viscosity changes.

6.1.3 Industrial Reuse

Industrial reuse represents a significant potential market for reclaimed water. Reclaimed water is ideal for many industries where processes do not require water of potable quality. Also, industries are often located near populated areas where centralized wastewater treatment facilities already generate an available source of reclaimed water. Reclaimed water for industrial reuse may be derived from in-plant recycling of industrial wastewaters and/or municipal water reclamation facilities. Recycling within an industrial plant is usually an integral part of the industrial process and must be developed on a case-by-case basis. Industries, such as steel mills, breweries, electronics, and many others, treat and recycle their own wastewater either to conserve water or to meet or avoid stringent regulatory standards for effluent discharges.

Cooling water is currently the predominant industrial reuse application. In most industries, cooling creates the single largest demand for water within a plant. Worldwide, the majority of industrial plants using reclaimed water for cooling are utility power stations. Other reuse applications are the recycling of boiler-feed water or process water, and the use of reclaimed water for irrigation and maintenance of plant ground.

6.2 Regional Experiences in Water Reuse

Water reuse in agriculture is common throughout the Middle East and North Africa. Water reuse can be planned through specifically designed projects to treat, store, convey and distribute treated wastewater for irrigation. Examples of planned reuse can be found in Egypt and Tunisia. Reuse can also be unplanned, usually after discharge into open watercourses. This is the case in Jordan, where wastewater is treated to some extent, and in Morocco, where most of the wastewater is untreated, as well as in Algeria, West Bank and Gaza, Syria, and Yemen. In most countries of the region, wastewater treatment plants are not operated and maintained adequately, making wastewater unsuitable for unrestricted irrigation even where it has passed through a treatment plant. Wherever available, farmers prefer to rely on freshwater, which is usually very cheap. But if no other source of water is available, farmers throughout the region use wastewater for irrigation.

The benefits of promoting wastewater reuse as a means of supplementing water resources have been recognized by many countries. In some of them such as Egypt, Tunisia, Jordan, Malta, Cyprus and Spain, several projects are already in operation or under planning. Other countries, such as Greece, France and Italy are seriously considering wastewater reuse and reclamation.

6.3 Water Reuse Potential in Lebanon

In 1991, the quantity of treated wastewater was roughly estimated at 4 million m^3, the quantity reused at 2 million m^3, for some informal irrigation. Some illegal irrigation from untreated wastewater is practiced in Lebanon [4], but no water reuse technology is currently used in Lebanon on a wide scale.

Regarding to information of the Ministry of Agriculture (MoA) in Lebanon the reuse of treated wastewater in agriculture for consumables is not encouraged and will most likely be rejected by the market because there is no cultural acceptance. No law prohibiting wastewater reuse for agriculture currently exists but it is not probable that permits will be granted to irrigate consumables with treated water. Irrigation of tree plantations could be an option but the impact on groundwater has to be assessed and the water has to be disinfected to ensure the absence of pathogens.

In the following textbox a project example for greywater treatment and reuse in Lebanon is presented.

Greywater Treatment and Reuse in West Bekaa

Research institution: MECTAT
Funding: International Development Research Center (IDRC), Canada
Duration: 2002-2005

At present, most wastewater in the West Bekaa area is released untreated into the environment or captured in septic tanks, which frequently leak, causing soil and groundwater contamination. Recycling greywater for use in urban agriculture could have a significant positive effect on water access, economic and social conditions, and the environment.

Within the course of this project a system for greywater treatment and use in home gardens in five towns in the West Bekaa region is tested. Initially, it involves the implementation of greywater treatment systems using trickle filters in 30 homes.

Specific objectives
- Increase greywater recovery and make it more convenient and safe to handle.
- Minimize environmental impacts associated with greywater reuse and ascertain whether greywater treatment is necessary and cost-effective.
- Improve gardening and horticulture practices.
- Identify and incorporate relevant socio-economic (including gender) issues related to greywater reuse.
- Strengthen local capacity to safely and efficiently reuse greywater.
- Promote changes in policies to encourage greater greywater reuse in Lebanon.
- Establish regional cooperation with similar on-going greywater projects in order to exchange information and expertise.

In the Mediterranean countries water reuse for irrigation is the most common form of reuse. Therefore, more information on the agricultural sector in Lebanon and the irrigation systems will be given in the following to assess the reuse potential in Lebanon.

Another reuse option in Lebanon might be the recharge of groundwater with reclaimed wastewater to prevent or, respectively, to stop saltwater intrusion into the groundwater aquifers.

6.3.1 Area under Cultivation

In 1999, 248,000 hectares of land were cultivated (24 % of the Lebanese territory), of which 42 % were irrigated (104,009 hectares) and 2 % were under greenhouse production [16]. An additional 53,137 hectares were fallow lands abandoned for more than five years. Almost 42 % of the exploitable agricultural land is located in the Bekaa, an area which also accounts for 52 % of the total irrigated land (see Figure 6.1).

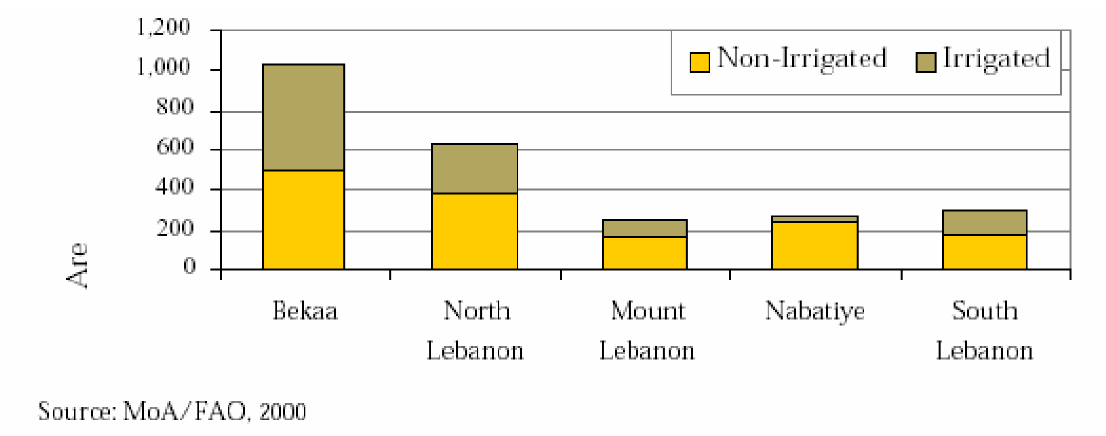


Figure 6.1: Irrigated and Non-Irrigated Land by Mohafaza (are = km^2)

6.3.2 Crops Production

Lebanon produces crops in five major categories: cereals, fruits (not including olives), olives, industrial crops (e.g. sugar beets, tobacco), and vegetables. Fruit and olive trees account for 45 % of the total cultivated area, and have increased by about 23,000 ha in the past 10 years.

6.3.3 Agricultural Water Consumption and Demand

The agricultural sector is with 70 % by far the largest consumer of available water resources in Lebanon, consuming around 980 million m³ per year. The main sources of irrigation water are the Litani River and the Litani-Awali complex of water resources. While the total land area under cultivation has remained fairly constant during the past decades, irrigated lands have more than doubled, from 40,775 hectares in 1961 to 104,009 hectares in 1999 [16] putting more and more pressure on limited water resources. The increase of irrigation reflects the intensification of agricultural practices (i.e. producing more per unit area). Moreover, the gradual substitution of traditional and wild cultivars with new crop varieties constitutes an added pressure on water resources. This is due to the fact that, compared to traditional crops, new imported varieties usually consume more water and are more drought sensitive.

6.3.4 Irrigation Systems

Irrigation water for Lebanon's agriculture is provided from both surface and groundwater. As can be observed in Figure 6.2, irrigation water is almost equally supplied from surface water and well water (48 and 52 % respectively). Although there are no data on water wells, the number of farms that have private water wells is believed to be increasing rapidly to satisfy the increasing need for irrigation water.

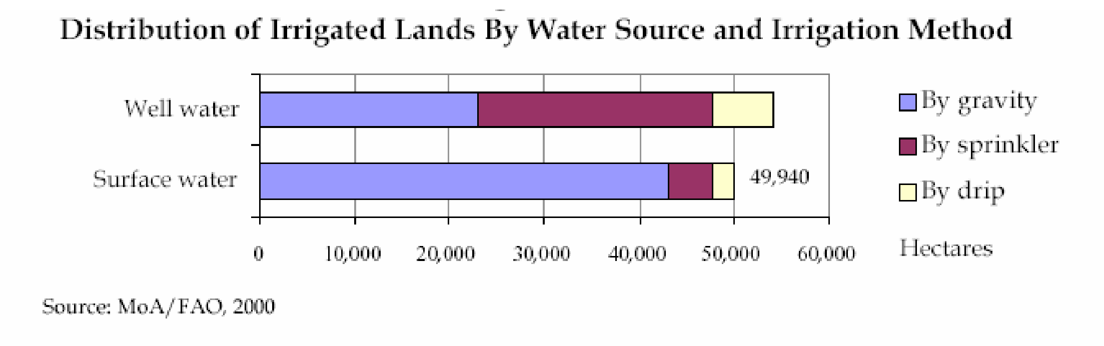


Figure 6.2: Distribution of irrigated land by water source and irrigation method

Irrigated agriculture depends highly on gravity irrigation which accounts for 64 % of the total irrigated land and is the predominant method of irrigation using surface water. When compared to sprinkler and drip irrigation, gravity irrigation has higher water losses due to low system efficiencies and high evaporation losses. While efficiency of gravity irrigation could be significantly improved using optimal water and crop management schemes, the majority of farmers in Lebanon lack basic agricultural training and environmental awareness.

Furthermore, the seasonal discrepancy between the precipitation period (winter) and the period of maximum demand for irrigation water (dry summer) has consistently led to excessive and uncontrolled withdrawal of groundwater. These water withdrawals have led to severe lowering of the water table as previously mentioned and ultimately caused saltwater intrusion along the coastal plains. Saltwater intrusion poses a significant threat to the quality of fresh water in coastal areas, particularly as in some locations seawater has actually intruded several kilometers inland into coastal aquifers.

6.3.5 Irrigation Costs

Within governmental irrigation systems, irrigation water is charged at a flat rate per planted area, except in the modern pressurized irrigation schemes of the Litani River Authority in South Bekaa and Saida-Jezzine where volumetric metering is provided. At present, for the Qasmieh-Ras El Ain coastal scheme, water charges are fixed at US$ 260/ha for farmers who irrigate by gravity extracting water directly from the canal. In the Danneyeh scheme and the Akkar scheme, in the north, water charges range from US$ 30 to 125/ha.

Estimates of operation and maintenance costs are US$ 40/ha per year for small schemes with gravity surface irrigation. Medium schemes cost from US$ 100/ha per year for gravity surface irrigation to US$ 600/ha per year for private wells. Large schemes cost from $US 400/ha per year for private pumping in rivers to US$ 600/ha per year for tube wells.

The average cost for irrigation development ranges from US$ 2,500/ha for small schemes, US$ 3,750/ha for medium schemes and between US$ 4,000 and 7,000/ha for large schemes.

6.3.6 Trends in Irrigation Management

The development of potential future irrigation aims at increasing the actual area to the potential soil and water ceiling of 177,500 ha, concentrated mainly in South Lebanon, the Bekaa Plain and the northern coastal areas (Akkar). The irrigation potential in Lebanon is linked to the physical mobilization of water and to the rehabilitation and modernization of irrigation infrastructures. An increase in the irrigated area can be achieved from surface water resources by means of the construction of storage dams and interregional transfers, for example the Khardali dam over the middle Litani river (now postponed) and the 'Canal 800' conveyor for the irrigation of 15,000 ha in South Lebanon. With a total capacity of 873 million m^3, more than 83 sites for possible dam construction have already been prospected and are recommended for further investigation (compare chapter 4.1.5).

7 Public Awareness Program for Wastewater Management and Water Reuse

One of the main objectives of the EMWater Project is to increase public awareness in the field of efficient management of wastewater and reuse in the four Mediterranean partner countries. The project will only be successful when people understand and accept the necessity of proper wastewater management, in particular for the protection of drinking water, and the advantages of reclaimed water reuse to ensure safe fresh water resources. Therefore, public awareness programs will be conducted in the course of the whole project implementation using different media.

7.1 Planned Activities within the EMWater Project

To enhance public awareness the following activities will be realized within the EMWater Project:

- Publication of articles about the project activities in diverse local and regional newspapers, professional and scientific magazines and international journals,
- Dissemination of information by means of other media, like radio and a project website,
- Design of a project brochure and a media information set,
- Production of the video “Water Environment”,
- Construction of wastewater treatment demonstration plants where people can see how wastewater treatment functions, looks and smells,
- At the end of the project the outcome will be summarized in the manual “Innovative Solutions in Wastewater Management”.

Additionally, the local and regional training programs will educate professionals and multipliers (train the trainer courses) in the Mediterranean partner countries. This will promote public awareness in the long run by raising awareness about the need for public awareness among managers and decision makers in the field of wastewater treatment and reuse.

In addition to local and regional training programs computer based training sessions will also be given. The outcomes will reach a broader range of people and may increase cooperation between technicians and managers related to wastewater treatment and reuse in the Mediterranean partner countries providing excellent opportunities for exchanging experience and know-how.

7.2 Development of a Public Awareness Program

The improvement of the wastewater management and water reuse practices requires specific public awareness strategies. The strategies should focus on inter-sectoral and multi-disciplinary approaches. They have to take into consideration target group’s priorities, knowledge, specific behaviors and inhibiting factors. Behaviors with respect to wastewater management and water reuse practices involve at the community level changes of a broad range of current practices. In order to facilitate the change in these practices, it is necessary not only to provide knowledge and skills to people and to reinforce and monitor their behaviors locally, but also to establish regional and national systems of supply and maintenance of materials and equipment. Thus, a public awareness program for wastewater management and reuse must not only focus on individuals but it must also involve public authorities and decision makers. To develop public awareness programs the modified Triple A framework (Assessment – Analysis – Action) can be used[6].The approach of this method is shown in the following textbox.

- **Assessment**
  - Establish or reactivate an inter-sectoral working group or team
  - Review status of ongoing activities in the water and wastewater sector
  - Identify missing information
- Communication **Analysis**
  - Problem analysis
  - Behavior analysis
  - Participant analysis (beneficiaries, secondary program participants, partners and allies)
  - Channel analysis (participants, communication capacity, rules for channel selection)
  - Communication objectives
  - Developing strategies and activities
  - Monitoring and evaluation indicators
- Program design
  - Design strategy
  - Message design and development
- **Action**
  - Carry out Training and Capacity-Building
  - Carrying out Communication Activities
  - Carrying out Supportive Supervision
  - Monitoring Communication Activities and Behavior Change
  - Evaluating Communication Program during Follow-up Period

As a first step in implementing a public awareness program on wastewater management and water reuse in Lebanon, the Lebanese situation as relates to this sector has been assessed by the University of Balamand.

7.3 Assessment in Lebanon

7.3.1 Survey Conducted by the University of Balamand

A preliminary survey conducted by the University of Balamand throughout the country has shown increasing positive public attitudes towards wastewater treatment. The survey indicated that all involved municipalities, the Ministry of Environment and NGOs encourage and support any effort being invested to increase the familiarity of the public in issues of proper management of wastewater. It was agreed that without public acceptance, it would be difficult for any municipality to site, finance, construct and

[6] The modified Triple A framework is described in more detail in “A Manual on Communication for Water Supply and Environmental Sanitation Programs”, Water, Environment and Sanitation Technical Guidelines Series - No. 7, UNICEF, 1999, http://www.unicef.org/wes/com_e.pdf

operate wastewater treatment plants. Some of the NGOs that are actively involved (although limited in number) in the wastewater management sector have stressed that many of the precious water resources have been depleted and the quality has deteriorated due to the lack of proper wastewater management studies.

7.3.2 Status of Ongoing NGO Activities Dealing with Wastewater Management

The list of all known NGOs in Lebanon was reviewed by the University of Balamand, and all those involved in activities dealing with environmental issues were contacted. Most of the NGOs clarified that they were not directly involved with the wastewater management problems. Some did studies but nothing was adequately documented or implemented, and only two of the NGOs, YMCA and Mercy Corps, were found to be actively involved in programs aiming at public education in the field of proper management of wastewater and its impact on the environment. Their work is based on campaigns for school children and has concentrated on the issue of waste disposal in toilettes.

7.3.3 How to Approach Public Education and Outreach

The key issues of concern in constructing wastewater treatment plants are the facility site, the quality of recycled water and its specific use, environmental impacts, safety of operation and protection of public health, construction impacts, customers' acceptance of products produced with recycled water, the cost and the financing. Thus, any educational program should address these specific issues and should have the public at large as the ultimate target. It's more likely to have a positive attitude from the public towards such treatment facilities if educational and awareness programs precede the construction of any plant in unsewered communities and if people in the community participate in decision-making.

Additionally people need to be informed about alternatives to central, large-scale wastewater treatment plants, like decentralized small-scale treatment facilities, wetlands or ecological sanitation concepts. Only well informed citizens can decided which technology is appropriate for their situation. The same applies to the topic of water reuse.

It may be efficient to reach the public by means of:

- Media
- Elected officials
- Schools
- Community leaders

The essential elements to be used in an educational program should include:

- Written materials (brochures, fact sheets, websites)
- Community outreach (school programs, presentation for affected communities)
- Media (press releases)
- Television and radio
- Video and slide presentations.

7.3.4 Lebanese Media

The media plays a pivotal role in disseminating environmental information and promoting awareness. Although it has become more involved and proactive in recent years, environmental programming continues to lack sufficient technical and funding support. Since the summer of 2001, at least five local **newspapers** (three Arabic, one English, and one French) have run regular features and articles on the environment and an additional four newspapers have provided intermittent coverage (see Table 7.1). At least four local newspapers are available daily on the Internet (Al Moustaqbal, Al Nahar, The Daily Star, and L'Orient le Jour). Local, university and regional newspapers are also providing increasing environmental coverage and usually benefit from a dedicated audience. For example, between 1997 and 1998, the Green Forum (association of environmental NGOs) published a monthly environmental newspaper that was widely distributed free of charge.

Table 7.1: Environmental Coverage by Lebanese Newspapers

Environmental Coverage by Lebanese Newspapers

Newspaper	*Format*	*Rubric Name*	*Frequency*	*Since*
Al-Nahar	Page	Environment & Culture	Daily	1997
Orient le jour	Section	--	2-3/week	1997
Al-Mostakbal	Page	Environment & Science	Daily	2000
Hayat	NA	--	NA	NA
Daily Star	Section	Investigated Report	2-3/week	NA
Al-Diyar	Page	Our Environment (suspended in 2001)	weekly	2000
Al-Kifah Al-Arabi	Page	Municipalities & Environment	Floating	1997
Al-Safir	Page	Environment	weekly	1998

Source: ECODIT survey, 2001

Environment & Development magazine, published in Beirut, is the only pan-Arab **environmental magazine**. Launched in June 1996 as a bi-monthly publication, it became a monthly magazine in January 2000 and is available on newsstands all over the Arab region, with a circulation of 28,000 in 22 countries. The magazine is a combination of current environmental topics, global issues, nature and environmental lobbying.

In addition to the written press, **television** is airing more and more environmental programs. Several stations run regular documentaries and live debates on environmental issues. High-level officials and senior staff of the MoE, prominent individuals and lawyers, and environmental associations are frequently hosted by TV shows. **Radio** Stations have experienced a similar rise in environmental programs and host regular talk shows on various green issues. This is a remarkable shift compared to the situation only 10 years ago when the environment was rarely seen as a priority or as material for readers and viewers. [18]

8 Pilot Plant Study

8.1 Location

The wastewater treatment plant proposed at the University of Balamand shall be located at the lowest point within the UOB campus. This will facilitate the transfer of the sewage to the plant.

8.2 Processes

8.2.1 Main Sewage Treatment Plant

- Screen and Collection Channel
- Balance Tank
- Activation Tank
- Clarification Tank
- Chlorination Tank
- Sludge Holding

8.2.2 Tertiary Treatment Equipment

- Feed/backwash Booster Pump
- Sand Filter
- Activated Carbon Filter
- Treated Water Storage Tank
- Irrigation Booster Pressure System

8.3 Scope of work

The sewage treatment plant proposed is the extended aeration type designed for treating domestic sewage. The complete system includes all the necessary equipment for efficient plant operation and basically consists of the aeration zone, settlement chamber.

In addition, a tertiary treatment plant is being provided consisting of a chlorination zone, feed / backwash pump, sand filter, activated carbon filter and final storage water tank where treated water is used for irrigation.

The treatment program will be defined as follows:

- Pollution to be treated not to exceed a maximum volumetric load equal to 0.36 kg BOD/m^3/day.
- Transfer the necessary quantity of oxygen to the water to be treated by means of an aeration device for the cellular synthesis of bacteria endogenous breathing.
- Keeping the system into a massif load area, specific to extended aeration, between 0.07 and 0.12.

- Achievement of important mineralization of organic substances, thus satisfying the biological demand of oxygen.
- Physical separation of solid and liquid phases by means of clarification with re-injection of decanted sludge into the activation cell.
- Periodical sludge discharge in order to de-concentrate the system, and therefore, to dehydrate the discharged sludge.
- Storage of the biologically treated water in an equalization tank (acting also as a contact tank for the chlorination).
- Chlorination of the biologically treated water in order to achieve the sterilization of the water and make it safe for reuse.
- A simple control of sludge concentration allows a manipulation conform to the principle of the biological treatment.
- Extra sludge is lifted in a truck by means of the recycling pump (or the truck pump).
- The biologically treated water is now safe enough to be discharged in the underground water table or in the surface river.
- Filtration of the biologically treated and chlorinated water through multimedia filters followed by activated carbon filtration in order to remove the excess of chlorine thus making the effluent suitable for irrigation.

The above mentioned processes are still being proposed and have not yet been decided upon. However they can be taken as suggested processes for the proposed plant. Further processes shall be considered and perhaps implemented.

9 Conclusions

Considering the information that has been collected for this country study, the following conclusions can be drawn in order to guide the implementation of the EMWater Project in Lebanon:

- **Legal and institutional framework**
  There is no comprehensive environmental law but specific issues are addressed in sector laws and regulations. The Ministry of Environment has drafted an Environmental Framework Law, a Framework Law for Protected Areas and a Decree for Environmental Impact Assessment (EIA). Lebanon has enacted minimum standards to assure the quality of drinking water and regulate the discharge of wastewater but they are not fully enforced. Guidelines for wastewater treatment or water reuse do not exist. Therefore, the development of wastewater treatment and water reuse guidelines is an important task for improving water management in Lebanon. High ranking officials should be included in the development processes of these guidelines as early as possible. This could be done within a workshop for decision-makers.

- **Water resources and water sector**
  Considering the predicted deficit of water within the next 10-15 years, water management must be improved in Lebanon.
  - One important task is the proper maintenance and repair of inefficient water distribution networks to reduce high water losses which currently reach up to 50 %.
  - Another option for reducing water consumption is the installation of water meters and the pricing of water depending on the actual consumption for domestic, industrial and agricultural use. Additionally, illegal connections must be detected and prevented.
  - Further measures include licensing and monitoring of private water wells. Much of the water for domestic, industrial and agricultural consumption is supplied from private water wells. Most private wells are unlicensed and therefore not monitored. The uncontrolled construction of wells and the inappropriate water abstraction have led to excessive and uncontrolled withdrawal of groundwater. Moreover, the number of farms that have private water wells is expected to increase rapidly in the future to satisfy the growing demand for irrigation water.
  - The usage of alternative water resources should be considered for example for irrigation purposes in the agricultural sector or for groundwater recharge with reclaimed wastewater to prevent or, respectively, to stop saltwater intrusion into the groundwater aquifers.

  Raising public awareness for water issues and water saving are activities that must accompany all other measures undertaken to improve water management. Here the EMWater Project can contribute by informing and educating people and experts via training courses and awareness campaigns.

- **Wastewater management**

  As most Lebanese municipalities still lack the human and financial resources, environmental awareness, management capabilities, and/or political commitment necessary to implement wastewater management in an environmentally sound manner, training of municipal decision-makers and professionals will be required to improve the overall effectiveness and environmental performance of Lebanese municipalities. Training courses that will be implemented within the EMWater Project can play an important role in this regard. The construction of a pilot plant offers the opportunity to adapt technologies to local conditions. Additionally, the plant will be used for demonstration and education purposes.

  One issue that should be considered is the generation of sewage sludge: The planned wastewater treatment plants in Lebanon will generate large quantities of sewage sludge that will require adequate management to prevent environmental problems. The management of sewage sludge, its treatment and reuse should therefore be included in the EMWater pilot plant concept from the outset.

- **Reuse of reclaimed wastewater**

  In Lebanon currently no water reuse technology is applied on a large scale. The reuse of treated wastewater in agriculture is not encouraged and there is no cultural acceptance. Irrigation water in Lebanon's agriculture sector is provided from surface and groundwater. In governmental irrigation systems, irrigation water is charged at a flat rate per planted area, except in some modern pressurized irrigation schemes where volumetric metering is provided.

  Considering the forecasted water deficit the efficiency of water usage must be improved, and the use of reclaimed wastewater should be integrated in Lebanese wastewater management concepts. The EMWater Project will promote this process by demonstrating safe wastewater reuse. To secure environmentally sound usage of treated effluent, it is essential to create general understanding and sensitivity among all parties. Public awareness programs, guidance documents and manuals for beneficiaries and stakeholders must be promoted.

Consequently, one main objective in Lebanon within the EMWater Project will be to raise public awareness related to water and wastewater issues. Training courses will be conducted. With the aid of an appropriate pilot plant technology, the successful treatment of wastewater, proper handling of sewage sludge and suitable reuse of reclaimed wastewater will be demonstrated and taught. The transfer of technologies and know-how will also be facilitated.

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11 Annex

Annex A: Contact Details

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Annex B: Standard Values for the Quality of Drinking Water

Parameter	Units	Standard Value	Maximum Accepted Value
Total coliforms	number/100 ml	0	0
Fecal streptococcus	number/100 ml	0	0
Fecal coliforms	number/100 ml	0	0
Sulfate reducing bacteria	number/20 ml	1	1
Thermo tolerant coliforms	number/100 ml	0	0
Salmonella	number/5 liters	0	0
Pathogenic staphylococci	number/100 ml	0	0
Bacteriophages	number/50 ml	0	0
Enter viruses	number/10 liters	0	0
Temperature	° C	12	25
pH	pH units	6.5<pH >8.5	9
Conductivity	mS/cm at 20°C	400	400
Nitrate	mg/l	5	50
Chloride	mg/l	25	200
Sulfates	mg/l	25	250
Sodium	mg/l	20	150
Potassium	mg/l	10	12
Magnesium	mg/l	30	50
Calcium	mg/l	100	100
Total Aluminum	mg/l	0,05	0,2
Dry Residues	mg/l at 180°C	1500	1500

Annex C: Environmental Limit Values (ELV) for Wastewater Discharge

Environmental Limit Values (ELV) for Wastewater Discharged into the Sea

In the following tables, column 1 shows the regulated pollution parameters, column 2 gives the emission limit values for existing facilities, and column 3 gives data for new facilities. Emission limits values of column 2 will automatically expire when the Barcelona LBS protocol is ratified by the Republic of Lebanon. In this case, the limit values of column 3 become automatically valid for all kinds of facilities.

The outlet of the pipeline for coastal outfalls, its length, and depth should be designed according to:

- Seabed data
    - Seabed levels
    - Seabed soils
    - Seabed stability or movements
- Environmental data
    - Wind speed frequencies and direction
    - Local topography and effects on currents, winds, and waves
    - Shipping, dredging, fishing, shell-fishery, bathing, and other activities
- Effluent data
- Receiving water characteristics
    - Time for bacteria to die (T90)
    - Horizontal and lateral dispersion coefficients
    - Vertical dispersion coefficient
    - Temperature, salinity, and density profiles.

1	2	3
Parameter	**ELV for existing facilities**	**ELV for new facilities**
pH	5-9	6-9
Temperature	35°C	35°C
BOD_5 mgO_2/L	100	25
COD mgO_2/L	250	125
Total Phosphorus mgP/L	16	10
Total Nitrogen mgN/L [1]	40	30
Suspended Solids mg/L	200	60
AOX	5	5
Detergents mg/L	3	3
Coliform Bacteria 37°C in 100 ml [2]	2,000	2,000
Salmonellae	Absence	Absence
Hydrocarbons mg/L	20	20
Phenol index mg/L	0.3	0.3
Oil and Grease mg/L	30	30
Total Organic Carbon (TOC) mg/L	75	75
Ammonia (NH_4^+) mg/L	10	10
Silver (Ag) mg/L	0.1	0.1
Aluminum (Al) mg/L	10	10
Arsenic (As) mg/L	0.1	0.1
Barium (Ba) mg/L	10	2
Cadmium (Cd) mg/L	0.2	0.2

Cobalt (Co) mg/L	0.5	0.5
Chromium total (Cr) mg/L	2	2
Hexavalent Chromium (Cr^{VI}) mg/L	0.5	0.5
Copper total (Cu) mg/L	1.5	1.5
Iron total (Fe) mg/L	5	5
Mercury total (Hg) mg/L	0.05	0.05
Manganese (Mn) mg/L	1	1
Nickel total (Ni) mg/L	2	0.5
Lead total (Pb) mg/L	0.5	0.5
Antimony (Sb) mg/L	0.3	0.3
Tin total (Sn) mg/L	2	2
Zinc total (Zn) mg/L	10	5
Active Cl_2 mg/L	1	1
Cyanides (CN^-) mg/L	0.1	0.1
Fluoride (F^-) mg/L	25	25
Nitrate (NO_3) mg/L	90	90
Phosphate (PO_4^{3-}) mg/L	5	5
Sulfate (SO_4^{2-}) mg/L	1,000	1,000
Sulfide (S^{2-}) mg/L	5	1

[1] Sum of Kjeldahl-N (organic N+ NH_3), NO_3-N, NO_2-N
[2] For dischargers in close distance to bathing water a stricter ELV could be necessary.

Environmental Limit Values (ELV) for Wastewater Discharged into Surface Water

Surface water is defined as inland water permanently or temporarily flowing in beds or flowing quickly from springs. A minimum flow of 0.1 m^3/s needs to be guaranteed when discharging.

1	2	3
Parameter	**ELV for existing facilities**	**ELV for new facilities**
pH	5-9	6-9
Temperature	30°C	30°C
BOD_5 mgO_2/L	100	25
COD mgO_2/L	250	125
Total Phosphorus mgP/L	16	10
Total Nitrogen mgN/L [3]	40	30
Suspended Solids mg/L	200	60
AOX	5	5
Detergents mg/L	3	3
Coliform Bacteria 37°C in 100 ml [4]	2,000	2,000
Salmonellae	Absence	Absence
Hydrocarbons mg/L	20	20
Phenol index mg/L	0.3	0.3
Oil and Grease mg/L	30	30
Total Organic Carbon (TOC) mg/L	75	75
Ammonia (NH_4^+) mg/L	10	10
Silver (Ag) mg/L	0.1	0.1
Aluminum (Al) mg/L	10	10
Arsenic (As) mg/L	0.1	0.1
Barium (Ba) mg/L	2	2
Cadmium (Cd) mg/L	0.2	0.2
Cobalt (Co) mg/L	0.5	0.5
Chromium total (Cr) mg/L	2	2
Hexavalent Chromium (Cr^{VI}) mg/L	0.5	0.2
Copper total (Cu) mg/L	1.5	0.5
Iron total (Fe) mg/L	5	5
Mercury total (Hg) mg/L	0.05	0.05
Manganese (Mn) mg/L	1	1
Nickel total (Ni) mg/L	2	0.5
Lead total (Pb) mg/L	0.5	0.5
Antimony (Sb) mg/L	0.3	0.3
Tin total (Sn) mg/L	2	2
Zinc total (Zn) mg/L	5	5
Active Cl_2 mg/L	1	1
Cyanides (CN^-) mg/L	0.1	0.1
Fluoride (F^-) mg/L	25	25
Nitrate (NO_3) mg/L	90	90
Phosphate (PO_4^{3-}) mg/L	5	5
Sulfate (SO_4^{2-}) mg/L	1,000	1,000
Sulfide (S^{2-}) mg/L	1	1

[3] Sum of Kjeldahl-N (organic N+ NH_3), NO_3-N, NO_2-N

[4] For dischargers in close distance to bathing water a stricter ELV could be necessary

Environmental Limit Values (ELV) for Wastewater Discharged into Sewerage System

Dischargers can agree on divergent emission limit values for discharging wastewater to the sewerage system with the operator of the sewage treatment plant as long as the respective emission limit values are kept at the outlet of the sewage treatment plant.

Parameter	ELV for existing facilities	ELV for new facilities
pH	6-9	6-9
Temperature	35°C	35°C
BOD_5 mgO_2/L [5]	125	125
COD mgO_2/L [6]	500	500
Total Phosphorus mgP/L [7]	10	10
Total Nitrogen mgN/L [8]	60	60
Suspended Solids mg/L	600	600
AOX	5	5
Salmonellae	Absence	Absence
Hydrocarbons mg/L	20	20
Phenol index mg/L	5	5
Oil and Grease mg/L	50	50
Total Organic Carbon (TOC) mg/L	750	750
Ammonia (NH_4^+) mg/L [9]	-	-
Silver (Ag) mg/L	0.1	0.1
Aluminum (Al) mg/L	10	10
Arsenic (As) mg/L	0.1	0.1
Barium (Ba) mg/L	2	2
Cadmium (Cd) mg/L	0.2	0.2
Cobalt (Co) mg/L	1	1
Chromium total (Cr) mg/L	2	2
Hexavalent Chromium (Cr^{VI}) mg/L	0.2	0.2
Copper total (Cu) mg/L [10]	1	1
Iron total (Fe) mg/L	5	5
Mercury total (Hg) mg/L	0.05	0.05
Manganese (Mn) mg/L	1	1
Nickel total (Ni) mg/L [11]	2	2
Lead total (Pb) mg/L [12]	1	1
Antimony (Sb) mg/L	0.3	0.3
Tin total (Sn) mg/L	2	2
Zinc total (Zn) mg/L [13]	10	10
Cyanides (CN^-) mg/L	1	1
Fluoride (F^-) mg/L	15	15
Nitrate (NO_3) mg/L [14]	-	-
Phosphate (PO_4^{3-}) mg/L [15]	-	-
Sulfate (SO_4^{2-}) mg/L	1,000	1,000
Sulfide (S^{2-}) mg/L	1	1

5 Assuming an outlet concentration of 25 mg/L and a cleaning capacity of 80%
6 Assuming an outlet concentration of 125 mg/L and a cleaning capacity of 75%
7 Assuming an outlet concentration of 2 mg/L and a cleaning capacity of 80%
8 Assuming connection to a biological wastewater treatment plant. Performance of wastewater treatment plant related to the concentration in the inflow: 70-80%, ELV at outlet: 15 mg/L N
9 Assuming connection to a biological wastewater treatment plant. Performance of wastewater treatment plant related to the concentration in the inflow: 70-80%, ELV at outlet: 15 mg/L N
10 ELV of 0.5 mg/L must be kept at the WWTP outlet
11 ELV of 0.5 mg/L must be kept at the WWTP outlet
12 ELV of 0.5 mg/L must be kept at the WWTP outlet
13 ELV of 5 mg/L must be kept at the WWTP outlet
14 ELV for total nitrogen has to be kept
15 ELV for total phosphorus has to be kept

Annex D: Environment and Development Indicators Related to Water, Wastewater or Irrigation Published by LEDO

Ref. No.	Indicator	Unit	Concerned Institution
53	Sea water quality	Quantity per volume and quality classes	Ministry of Environment Ministry of Energy & Water Ministry of Public Health National Council for Scientific Research
54	Industrial releases into water	Tons/day	Ministry of Environment Ministry of Energy & Water Ministry of Public Health
55	Share of distributed water not conforming to quality standards	% of total water distribution units or % of total population	Water Authorities Ministry of Environment Ministry of Energy & Water Ministry of Public Health
56	Water global quality index	mg/l or % of samples complying with standards	Water Authorities Ministry of Environment Ministry of Energy & Water Ministry of Public Health National Marine Research Center
57	Groundwater quality index	mg/l or % of samples complying with standards	Water Authorities Ministry of Environment Ministry of Energy & Water Ministry of Public Health National Marine Research Center
58	Surface water quality index	mg/l or % of samples complying with standards	Water Authorities Ministry of Environment Ministry of Energy & Water Ministry of Public Health National Marine Research Center
59	Share of collected & treated wastewater by the public sewerage system	%	Water Authorities, Municipalities Ministry of Environment Ministry of Energy & Water Ministry of Public Health
60	Amount of wastewater collected by sector (industry /domestic)	%	Water Authorities, Municipalities Ministry of Environment Ministry of Energy & Water Ministry of Public Health
61	Amount of wastewater treated by sector (industry /domestic)	%	Water Authorities, Municipalities Ministry of Environment Ministry of Energy & Water Ministry of Public Health
62	Area irrigated with treated/untreated sewage	% of total irrigated area	Ministry of Agriculture Municipalities Ministry of Environment Ministry of Energy & Water Ministry of Public Health

Source: http://www.moe.gov.lb/ledo/indicators3.html

Annex E: Current Status of Wastewater Treatment Plants

Caza	*Location/Name*	*Implementation Status*		
		Under Execution	Under Preparation	No Funding Secured
Akkar	Jebrayal			X
	Abdeh			X
	Michmich		X	
Minieh-Dinnieh	Bakhoun		X	
Tripoli	Tripoli		X	
Becharre	Becharre			X
	Hasroun			X
Koura	Amioun			X
Batroun	Chikka	X		
	Batroun	X		
Jbeil	Jbeil	X		
	Kartaba		X	
Kesrouane	Khanchara			X
	Harajel		X	
	Kesrouane/Tabarja			X
Metn	Dora			X
Aley	Ghadir			X
Chouf	Chouf coastal area	X		
	Mazraat el Chouf		X	
South	Saida	X		
	Sour			X
Hermel	Hermel		X	
Baalbeck	Laboue		X	
	Yammouneh		X	
	Baalbeck	X		
Zahle	Zahle		X	
	Aanjar		X	
West Bekaa	Jib Jinnine/Deir Tahnich		X	
	Karoun		X	
	Sohmor/Yohmor		X	
Hasbaya	Hasbaya		X	
Nabatiyeh	Jbaa		X	
	Nabatiyeh	X		
Bint Jbeil	Shakra		X	
	Bint Jbeil		X	

(Source: Adapted from CDR, 2001)