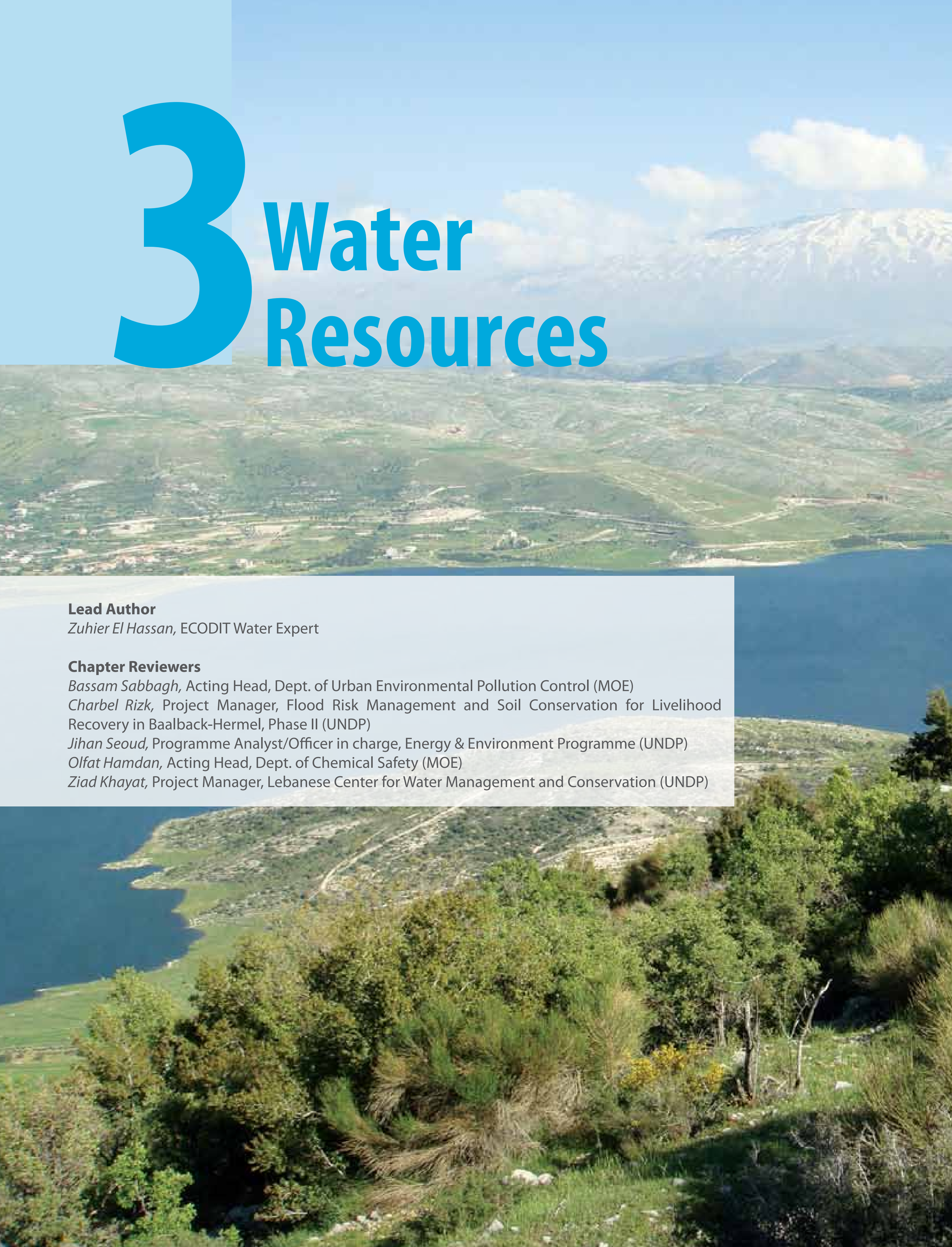
# Section II: State of the Environment

Chapter 3 **Water Resources**

Chapter 4 **Air Quality**

Chapter 5 **Biodiversity and Forests**

Chapter 6 **Land Resources**



# 3 Water Resources

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## ABBREVIATIONS & ACRONYMS

| | |
|---|---|
| a.s.l. | Above sea level |
| AFD | Agence Française pour le Développement |
| AUB | American University of Beirut |
| BOD | Biological Oxygen Demand |
| BOOT | Build-Own-Operate-Transfer |
| BOT | Build Operate Transfer |
| CAS | Central Administration of Statistics |
| CDR | Council for Development and Reconstruction |
| CNRS | National Council for Scientific Research |
| EU | European Union |
| GBA | Greater Beirut Area |
| GDP | Gross Domestic Product |
| GiZ | German International Cooperation |
| LRA | Litani River Authority |
| MOEW | Ministry of Energy and Water |
| MOPH | Ministry of Public Health |
| NGO | Non Governmental Organization |
| $NH_4$ | Ammonium |
| NLUMP | National Land Use Master Plan |
| $NO_3$ | Nitrate |
| NWSS | National Water Sector Strategy |
| $P_2O_5$ | Phosphorus Oxide |
| RHIA | Rafic Hariri International Airport |
| RWE | regional water establishments |
| STP | Sewage Treatment Plants |
| TDS | Total Dissolved Solids |
| TSE | Treated Sewage Effluent |
| TWA | Tripoli Water Establishment |
| UFW | Unaccounted for Water |
| USAID | United States Agency for International Development |
| WB | World Bank |

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Water is one of the most precious resources in Lebanon. Unsustainable water management practices, increasing water demand from all sectors, water pollution (see Box 3.1), and ineffective water governance are key obstacles facing Lebanon's water sector. Meeting the country's water demand over the medium and long-term poses a significant challenge to the Government of Lebanon.

This chapter describes the impacts of rapid population growth, urbanization, economic growth and climate change on water resources. It describes the current situation including the availability of water resources and sources of pollution, and then assesses key responses to water issues. Opportunities for improving the water sector are presented under the Outlook section.

**Box 3.1 What is *Water pollution*?**

Water pollution is the contamination of water bodies including lakes, rivers, seas and groundwater. It is a major global environmental concern and one of the leading worldwide causes of deaths and diseases. Around 20% of the world's population has no source of safe drinking water (UN 2010).

## 3.1 DRIVING FORCES

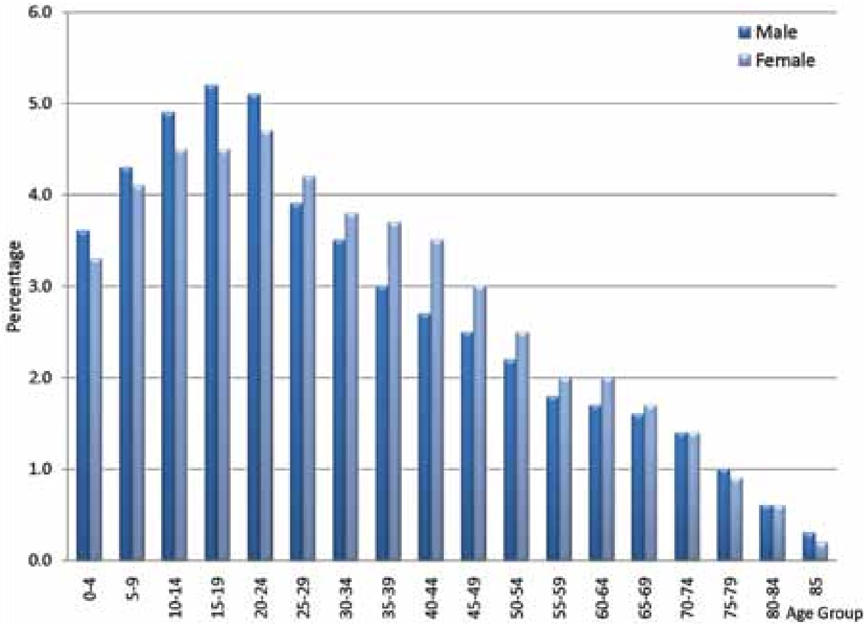
The driving forces affecting the quality and quantity of water resources in Lebanon are population growth and age structure, urbanization, economic growth and, more recently, climate change.

### 3.1.1 Population Growth

Population growth drives demand for water resources, energy, housing, transport, employment, and all other infrastructure. Although population impacts the environment and fragile ecosystems in many ways, population statistics in Lebanon remains unreliable at best. In assessing water resources, it is important to consider the total population in Lebanon (including refugees) and not just the resident population to capture the full impact on water resources. CAS records show that Lebanon's total population increased from about 4 million in 1996 to almost 4.2 million in 2007 –a net growth of about 170,000 people. This is not consistent with reported annual growth rates (1% to 2.5% depending on source), probably because of the concomitant rate of emigration. In 2006 alone, the number of people who left the country during and after the war, and did not return, was estimated at around 150,000.

An additional source of pressure on water resources is the age structure of Lebanon's population. Half of Lebanon's population is less than 29 years of age while 44 percent are under 25 years of age (Figure 3.1). Even if consumption rates stay constant, it can be expected that the number of new housing units will increase dramatically, from 843,600 in 2004 to 1,321,600 by 2030 (CDR-NLUMP, 2004). More housing means more networks and ancillary water infrastructure.

**Figure 3.1 Age sex structure of population**




*Source: CAS 2008*

For a more detailed analysis of the population distribution and growth rates, please refer to Chapter 1 (Section 1.3). Further pressure on water resources comes from tourism. According to the Ministry of Tourism website, 1.8 million visitors came to Lebanon in 2009. Whether they come for recreation, business or medical treatment, tourists consume more water than residents (400L/c/d for tourists compared to 150L/c/d for residents) but over a short time period.

### 3.1.2 Urbanization

Lebanon is a heavily urbanized country, with 88 percent of the population living in urban areas. This is the highest rate amongst Lebanon's neighbours including Syria (54.6%) and Jordan (78.5%). Additionally, 45 percent of Lebanon's population live in urban agglomerations of 1 million people or more, compared to 32 percent for Syria and 18 percent for Jordan (WB 2010a). See size and evolution of agglomerations in Table 3.1.

**Table 3.1 Resident population per size of agglomeration**

| Size of Agglomeration | 1970 | | 1997 | |
|---|---|---|---|---|
| Less than 1,000 inhabitants | 391,440 | 18.41% | 259,840 | 6.5% |
| 1,000 to 2,000 | 246,945 | 11.61% | 285,730 | 7.14% |
| 2,000 to 5,000 | 187,260 | 8.81% | 481,830 | 12.05% |
| 5,000 to 10,000 | 68,415 | 3.22% | 313,730 | 7.84% |
| 10,000 to 100,000 | 136,005 | 6.4% | 330,830 | 8.27% |
| More than 100,000 | 1,096,260 | 51.56% | 2,328,040 | 58.20% |
| **Total** | 2,126,325 | 100% | 4,000,000 | 100% |

*Source: Dar Al Handasah – IAURIF 2004*

Half of the country's urban population live in the Greater Beirut Area, GBA (WB 2009a). It is estimated that Lebanon's urban areas will grow by 10 square kilometres per year over the next 30 years (CDR-NLUMP, 2004). It should be noted that GBA comprises the city of Beirut and the southern and northern suburbs, which are the coastal part of Baabda caza, and coastal parts of the Metn caza. The cazas of Baabda and Metn are administratively part of Mount Lebanon.

This rate of urbanization has stressed water resources. As establishments have tried to meet growing demand in coastal cities, where the majority of Lebanese live, there has been an over reliance on pumping of wells and boreholes. This has resulted in a sever lowering of the water table in some aquifers, and salt water intrusion in coastal aquifers. The loss of coastal freshwater resources has led to shortages in supply of drinking water. The GBA, during the summer months, receives only three hours supply each day.

The growing urbanization has also resulted in the production of increased levels of untreated wastewater and solid waste, particularly in the coastal region. The cost of environmental degradation of random discharge of untreated sewage is estimated at 1 percent of GDP (WB 2010a). Lebanon's mountain public debt presents a formidable challenge for building, completing and operating wastewater collection and treatment systems to stop untreated effluent flowing into freshwater resources and coastal marine waters.

### 3.1.3 Economic Growth

Lebanon's economic development has been the main driver of urbanization in the country. During the 19th century Lebanon was largely an agrarian country. Throughout the 20th century the contribution of the services sector to overall economic growth, and to a lesser extent industry, increased in Beirut and the other major cities in Lebanon (Owen *et al.* 1998). Even after the Civil War, the contribution of the services sector to the economy continued its historical growth. The main drivers of this growth were construction (and reconstruction), tourism, and banking. Although the percent contribution of the agricultural sector to total GDP appears to be dropping (from 6 percent in 2005 to 5 percent in 2009 – see Table 3.2), the sector continues to be the largest water consumer in the country –about 60 percent of total freshwater goes for agriculture (WB 2010a).

**Table 3.2 Sector, value added (% GDP)**

| Sector | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|
| Agriculture | 6 | 7 | 7 | 5 | 5 |
| Industry | 21 | 20 | 22 | 21 | 18 |
| Services | 72 | 73 | 70 | 73 | 78 |

*Source: WB 2010a*

Lebanon is categorised as a high middle income country (WB 2009a). Lebanon's GDP per capita increased from $5,356 in 2005 to $8,157 in 2009. It is recognised that as per capita incomes improve, water consumption increases. In the NLUMP, the increase in domestic water consumption was related directly to population growth, estimated at 30 percent by 2030; as well as the growth in daily consumption for personal use, which was estimated to increase by 10 percent by 2030 (MOE-UNDP 2011). While the NLUMP looks at a number of growth scenarios, under the middle scenario, to meet domestic water demand in 2030, Lebanon will have to supply 420 million cubic metres per year compared to the 280 million cubic metres per year supplied by the water authorities in 2005 (MOE-UNDP 2011).

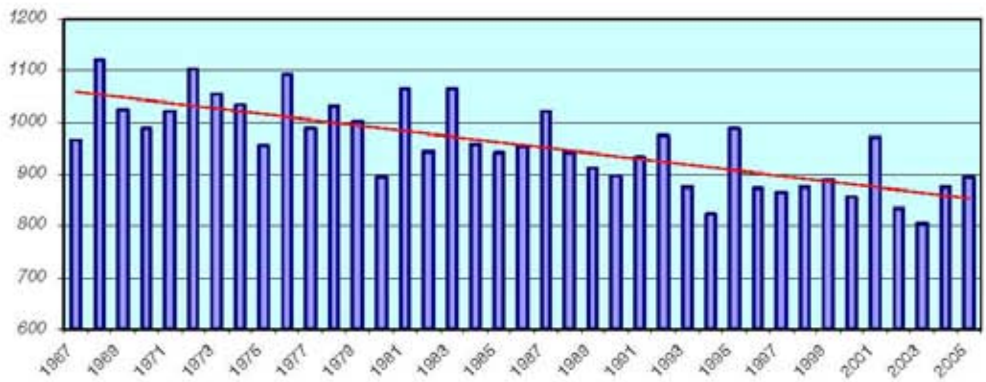
The WB estimates that as a result of this pattern of economic growth, agricultural demand on water resources will grow by one percent per year over the next 20 years, while domestic and industrial demands will grow by five percent per year. Industrial demand will triple due to the continued growth of tourism, while domestic demand will be driven by income and population growth (WB, 2009a).

### 3.1.4 Climate Change

Global warming will affect precipitation. This will be reflected in changes to "freshwater availability and quality, surface water runoff and groundwater recharge" (GEO 4, UNEP, 2007). Most of the studies dealing with this issue conclude that it is too early to discern a change in precipitation (MOE-UNDP 2011). The studies that have looked at the eastern Mediterranean region have revealed "…no detectable trend in precipitation or a major shift in the rainy season in the region over the last century" (MOE-UNDP 2011). Shaban, however, argues that Lebanon is witnessing signs of decreasing precipitation and increasing drought and desertification. Figure 3.2 shows a clear trend and a substantial decline in precipitation between 1966 and 2005. The study relied on data collected between 1966 and 1978, from 70 gauging stations distributed all over Lebanon, of with 66 percent are located in the western part of the country. For the period 1978-1997, the data was obtained from 11 gauge stations, while the number of stations after 1997 increased to 24 (Shaban 2009).


*Lebanon's snow cover is vital to the country's water cycle and to replenishing aquifers*

**Figure 3.2 Precipitation 1967 – 2005 (mm)**

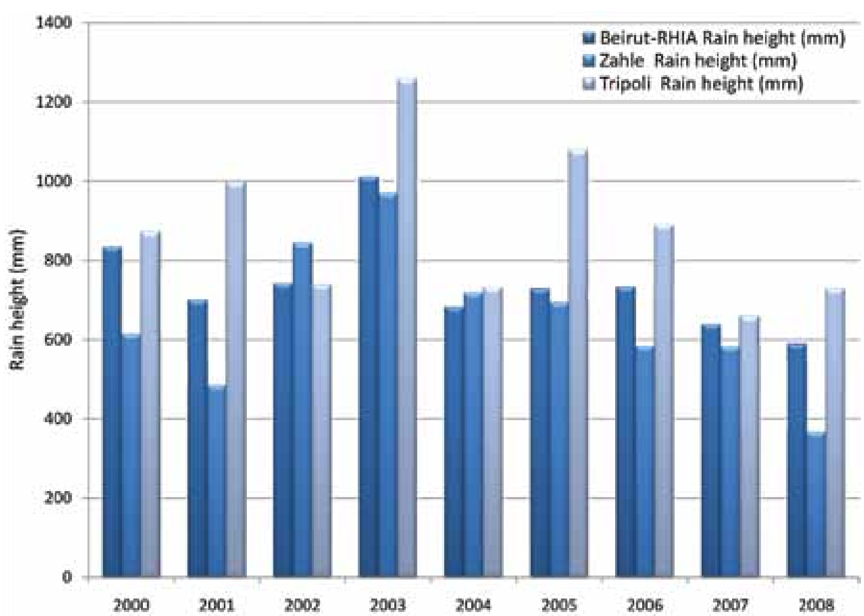



Source: Shaban 2009

In the last decade since the publication of the 2001 SOER, precipitation levels have been trending down. Because this is a very short time series, no conclusions can be drawn. The data in Figure 3.3 is presented for reference only.

*Another factor affecting water availability is the inter-annual variability in rainfall* in the drier inland regions of Lebanon. The coastal areas of Lebanon receive between 600 and 800 mm per year of rainfall, while the mountains receive between 1000 and 1400 mm per year. The inland Bekaa region receives between 200 and 600 mm per year while the south of Lebanon receives between 600 and 1000 mm per year. In the inland regions, it has been observed that inter-annual variability in mean rainfall ranges from less than 30 percent to over 200 percent, while in the coastal regions it ranges between 60 and 80 percent (MOE/ECODIT 2002). If, as most climate experts predict, the dry areas will become drier as the earth continues to warm up, the Litani River basin is going to see less rain in the future, which will have a substantial impact on water resources for irrigation because

**Figure 3.3 Rainfall series in Beirut, Tripoli (Coastal Lebanon) and Zahle (Inland) (2000-2008)**




Source: CAS 2009

the Litani River is the lifeline for agriculture in the Bekaa and South Lebanon.

*Snow coverage and density have been declining.* Lebanon's area is about 70-75 percent mountainous terrain. Historically, all the mountain regions were covered in snow at altitudes above 1,200 m during the winter. It should be noted that Lebanon does not have the capacity to measure the volume of snow cover with any degree of confidence, but some institutions such as the Regional Center for Water and Environment at USJ is conducting research related to snow cover and snowline. One of the most informative research papers related to snow was published in 2009 (Shaban 2009) according to which, before the 1990s, dense snow covered more than 2,000 $km^2$ of the mountains with an average of 2,280 $km^2$. The average dense snow cover has decreased to approximately 1,925 $Km^2$. Furthermore, the average time the dense snow remains before it starts to melt has decreased from an average of 110 days before 1990 to an average of 90 days after 1990.

As precipitation and snow coverage have decreased, *so have river flows in Lebanon*. The average yearly flow of Lebanon's rivers has decreased from 246 million $m^3$/year in 1965, to approximately 186 million $m^3$/year in 2005 (Shaban 2009). In the same period, average discharge from fresh water springs decreased from 104 million $m^3$/year to 49 million $m^3$/year. Equally, the surface area of the Qaroun Lake, the main lake in Lebanon, shrank from 5.14 $km^2$ (1965-1990) to 4.35 $km^2$ (1990-2005), equivalent to a 15 percent drop (Shaban 2009).

*Groundwater discharges have also declined.* The majority of the aquifers are karstic limestone formations categorised according to era of formation: Jurassic, Cenomanian, Turonian, Eocene, Miocene, Neogene. Shaban studied, for the period between 1987 and 2005, 193 Cenomanian wells in four regions, and 122 Jurassic wells in another four regions (see results in Tables 3.3 and 3.4). There is evidence of water table levels dropping. The Cenomanian and Jurassic aquifers in the Litani River basin (Bekaa) have dropped between 20 to 25m and 5 to 10m respectively. Furthermore, many wells and boreholes in the coastal cities have experienced irreversible saltwater intrusion.

Reduced precipitation, inter-annual variability, receding snow cover and declining groundwater discharge provide indisputable evidence of the impact of climate change on water resources. While it is difficult to predict future trends, the Second National Communication to the UNFCCC has developed projections of the impact of climate change on water resources availability (see Box 3.2).

**Box 3.2 Future Projections of Climate Change on Water Resource Availability**

Future projections are alarming. Lebanon's Second National Communication to the UNFCCC dealt with climate change in three periods: 1961 to 2000, 2025 to 2044, and 2080 to 2099. The report showed precipitation decreasing and losses due to evapo-transpiration increasing with global warming. If the temperature rise is 1C°, current total water resources estimated at between 2,800 $Mm^3$ and 4,700 $Mm^3$, will decrease by 250 $Mm^3$ per year. If the temperature rise is 2C°, resources will decrease by 450 $Mm^3$ per year.

The effect of global warming on snow, which is vital for water resources in Lebanon, is devastating. It is predicted that with a rise of 2C°, the snow cover in the mountain area above Ibrahim River will decrease by 50 percent. River flow patterns will be impacted greatly. River peak flow would shift from the end of April to the end of February. River flows would increase between December and February, and as snow melt decreases from April to June, river flows will dramatically decrease during periods of high demand for irrigation water.

Climate change is going to pose serious challenges for policy makers in Lebanon. The need to augment water resources to meet water sector demands and ecosystem maintenance and adaptability requirements will become urgent in the near and medium terms. Global warming is going to impact on all water resources, in terms of available volumes, the time of year they will peak and their quality.

*Source: MOE-UNDP 2011*

**Table 3.3 Cenomanian well discharge rates (L/S)**

| City | Amchit | | Beirut | | Nabatieh | | Zahle | |
|---|---|---|---|---|---|---|---|---|
| Year | 1984 | 2005 | 1984 | 2005 | 1984 | 2005 | 1984 | 2005 |
| Discharge | 29 | 20 | 28 | 14 | 30 | 21 | 34 | 26 |

*Source: Shaban 2009*

**Table 3.4 Jurassic well discharge rates (L/S)**

| City | Rachaya | | Ajaltoun | | Bikfaya | | Qobaiyat | |
|---|---|---|---|---|---|---|---|---|
| Year | 1987 | 2005 | 1987 | 2005 | 1987 | 2005 | 1987 | 2005 |
| Discharge | 30 | 23 | 30 | 24 | 34 | 25 | 30 | 26 |

*Source: Shaban 2009*

## 3.2 CURRENT SITUATION

Lebanon's water resources are under stress. Available water including rivers and springs, storage dams and groundwater (estimated at 2,000-2,700 million $m^3$ per year) exceed projected water demand (about 1,800 million $m^3$ in 2035) but widespread pollution and substandard water infrastructure are restricting the Government's ability to meet water demands in the future.

### 3.2.1 Water Resources Availability

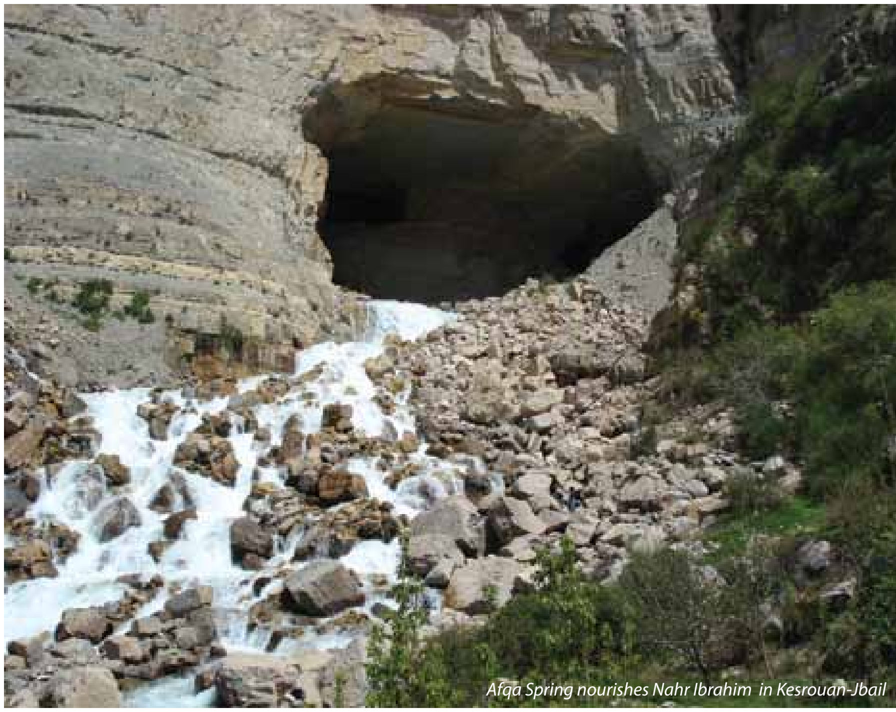
Some reports and studies put the average annual precipitation flows at 8.6 billion $m^3$ (MOE/ECODIT, 2002 & MOEW, 2010a). Other studies put it at 9.7 billion $m^3$ (CDR-NLUMP, 2004) of which one billion $m^3$ is due to snow (see Table 3.5). Most of these reports reference sources from the mid 1990s, while DAR –IAURIF use a source from 1989 (Mudallal 1989).

**Table 3.5 Annual available resources (Million cubic metres $Mm^3$)**

| *Source* | $Mm^{3(1)}$ | $Mm^{3(2)}$ | $Mm^{3(3)}$ | $Mm^{3(4)}$ |
|---|---|---|---|---|
| Precipitation* | 8,600 | 8,600 | 8,200 | 9,300 |
| Evapo-transpiration | (4,500) | (4,300) | (4,100) | (4,500) |
| **Losses** | **(1,400)** | **(1,700)** | **(1,333)** | **(2,400)** |
| -Rivers to neighbours | (700) | (670) | (648) | |
| -Groundwater | (700) | (1030) | (685) | |
| **Total Renewable Resources** | **2,700** | **2,600** | **2,767** | **2,400** |
| -Surface Water | 2,200 | | 2,200 | 2,000 |
| -Ground Water | 500 | | 567 | 400 |
| **Net Exploitable Resources** | **2,700** | **2,000** | **2,767** | **2,400** |

*Sources: 1) MOEW, 2010b, 2) MOE/ECODIT, 2002, 3) MOEW, 2010c and 4) Fawaz, 1992*

Note: Rain occurs for 90 to 100 days between October and April



*Afqa Spring nourishes Nahr Ibrahim in Kesrouan-Jbail*

Credit: ALES

*Underground lake inside Ain Lebne cave in Aaqoura (Mount Lebanon)*

The above data (Table 3.5) must be treated with caution because it is all based on measurements dating from the 1960s and 1970s. The case for setting up a modern and functional hydrometric network for measuring all hydrological parameters cannot be stated strongly enough. There is a pressing need to generate and consolidate continuous data relating to precipitation, river flows, soil infiltration and groundwater recharge, as well as losses to evaporation and evapo-transpiration. The undermining reality of all data on water resources is that Lebanon's four water establishments, combined, are currently exploiting less water resources than what is potentially exploitable (see Table 3.6).

**Table 3.6 Exploited resources according to source type (Mm³/year)**

| Source | BMLWE | NLWE | SLWE | BWE | Total |
|---|---|---|---|---|---|
| Surface water (springs) | 174 | 175 | 82 | 206 | **637** |
| Groundwater (wells ) | 198 | 163 | 141 | 193 | **695** |
| Storage (dams & lakes) | 15 | | 20 | 10 | **45** |
| **Total** | **387** | **387** | **243** | **409** | **1,377** |

Abbreviations: **BMLWE** Beirut and Mount Lebanon Water Establishment, **NLWE** North Lebanon Water Establishment, **SLWE** South Lebanon Water Establishment, and **BWE** Bekaa Water Establishment

*Source: MOEW 2010a*

Currently, water as defined by "present renewable resources per capita" in Lebanon is just over 1,100m³/capita/year, dangerously near the international benchmark of 1,000m³/capita/year, below which indicates water resources stress (WB 2009a). The MOEW puts the total renewable resources (drinking, industrial and irrigation) per capita per year at 926m³ and predicts it will drop to 839m³ by 2015 (MOEW 2010b).

*Rivers*

Lebanon has 16 perennial rivers and 23 seasonal rivers and total annual river flow is about 3,900 million m³, of which an estimated 700 million m³ flow into neighbouring countries. Seventy five percent of the flows occur between January and May, 16 percent between June and July and nine percent between August and October (Comair 2010). Accurate river flow data is hard to obtain in Lebanon, partially due to the impact of war and conflict on the country's river hydrometric systems and much of the data has been recycled over and over again. Monitoring river flows is the responsibility of the MOEW (Decree 5469 dated 07/09/1966) and is being carried out by the Litani River Authority (LRA). This report presents primary data obtained from LRA for two short time series, from 1971 to 1975 (five years) and from 2005 to 2009 (four years) (Table 3.7). Lebanon's highest river flows are Nahr el Litani, Nahr Ibrahim, and Nahr el Assi. Only two rivers do not discharge into the Mediterranean Sea (El Assi and Hasbani).

*Water Storage*

Lebanon has two dams, the Qaroun dam on the Litani River, and Chabrouh dam which captures rain runoff and runoff from Laban Spring. Their respective storage capacity is 220 million m³ and 8 million m³ (static storage capacity). Presently, only 30 million m³ is being utilised from the Qaroun Dam for water supply and irrigation and the rest is used to generate electricity. MOEW has a programme of building dams and lakes (discussed in Section 3.4.1). In many arid and semi-arid countries, most water supplied for domestic purposes comes from dams. Dams are built to secure supplies during the dry season or during periods of low rainfall. Paradoxically, by failing to build dams, Lebanon has ensured the variability of flow of its rivers which helps protect and maintain aquatic ecosystems that rely on the natural variability of river flows throughout the year.

*Springs*

Most of the surface water used to secure supply comes from captured spring sources. Lebanon has some 2,000 springs. Their total yearly yield exceeds 1,200 million m³, (MOEW, 2010b) however, less than 200 million m³ is available during the summer period. The total annual exploited volume is 637 million m³ (MOEW, 2010b). Lebanon also has a number of freshwater marine springs. Exploitation of these marine springs would present major technical challenges, leading to low cost effectiveness at the current stage. This resource could be considered on the long term when economic conditions become more favourable (MOEW 2010b).

*Groundwater*

Over 50 percent of irrigation water comes from underground wells and boreholes while 80 percent of potable water comes from groundwater sources. In addition, private wells have increased greatly in the last few years (see Tables 3.8 and 3.9). MOEW notes that this has been due to population growth, economic development and urban expansion (MOEW 2010b).

**Table 3.7 Flow data for 16 perennial rivers of Lebanon (1971-1975 and 2005-2009)**

| River name | River length (km) | Average Annual Vol | | Average Flow | | Maximum Flow | | Minimum Flow | |
|---|---|---|---|---|---|---|---|---|---|
| | | (71-75) Mm³ | (05-09) Mm³ | (71-75) m³/s | (05-09) m³/s | (71-75) m³/s | (05-09) m³/s | (71-75) m³/s | (05-09) m³/s |
| El Kabir | 58 | 259.20 | 283.86 | 9.07 | 9.13 | 48.47 | 190.80 | 1.52 | 1.42 |
| Ostuene | 44 | - | 46.96 | - | 1.59 | - | 6.89 | - | 0.00 |
| El Bared | 24 | 132.77 | 120.05 | 4.22 | 3.82 | 23.98 | 18.86 | 0.15 | 0.45 |
| Abou Ali | 45 | 148.60 | 206.57 | 4.62 | 6.58 | 25.23 | 32.53 | 0.56 | 1.11 |
| El Jaouz | 38 | 32.26 | 44.61 | 1.03 | 1.43 | 11.43 | 17.88 | 0.00 | 0.00 |
| **Ibrahim** | 30 | 208.55 | 329.16 | 6.63 | 10.49 | 65.52 | 79.11 | 0.14 | 0.25 |
| El Kalb | 38 | 154.08 | 189.32 | 4.90 | 6.07 | 29.34 | 66.95 | 0.23 | 0.00 |
| Beirut | 42 | 47.90 | 81.80 | 1.53 | 2.64 | 25.10 | 49.89 | 0.00 | 0.04 |
| Damour | 38 | - | 166.93 | - | 5.38 | - | 51.04 | - | 0.13 |
| El Awali | 48 | 393.70 | 252.88 | 12.54 | 8.05 | 51.66 | 32.17 | 1.89 | 1.61 |
| El Zahrani | 25 | 19.20 | 17.50 | 0.62 | 0.56 | 10.57 | 4.45 | 0.00 | 0.00 |
| **El Assi** | 46 | 326.40 | 275.54 | 11.03 | 8.70 | 13.84 | 12.36 | 8.78 | 5.99 |
| Al Qasmieh | - | 151.65 | 131.30 | 4.84 | 4.21 | 47.63 | 46.64 | 0.84 | 0.02 |
| **Litani** | 170 | - | 167.83 | - | 5.38 | - | 43.61 | - | 0.01 |
| Wazzani | - | - | 71.89 | - | 2.30 | - | 19.48 | - | 0.52 |
| Hasbani | 21 | 38.35 | 28.66 | 1.23 | 0.92 | 9.90 | 14.93 | 0.00 | 0.02 |

Notes:

(1) Al Qasmieh is part of the lower Litani River (downstream of the Qaroun Dam)

(2) River lengths are approximate

(3) 2005-2009 is a low rainfall period compared to other records

*Source: Data provided by LRA to ECODIT for 2010 SOER*

Aquifers are being over exploited and the data available from the MOEW supports the anecdotal evidence of wells drying up or increasing in salinity. According to MOEW records, there are more unlicensed private wells than there are licensed ones (22,500 versus 20,324). The regulation of these illegal wells is an ongoing concern, and undermines the Government's ability to control freshwater extraction from aquifers. Analysis of total yield shows that licensed private wells produce 29 percent of total abstraction, unlicensed wells 28 percent, and public wells 42 percent.

**Table 3.8 Annual yield of licensed private wells**

| Mohafazat | Number | Water Use (Mm³/year) | | | Total Yield (Mm³/year) |
|---|---|---|---|---|---|
| | | Domestic | Irrigation | Industry | |
| Beirut | 1,680 | 5.14 | 1.23 | 0.77 | 7.14 |
| Mt. Lebanon | 10,718, | 19.56 | 34.23 | 20.54 | 74.33 |
| Nth. Lebanon | 2,966 | 6.50 | 34.23 | 20.54 | 61.27 |
| Sth. Lebanon | 2,282 | 1.67 | 14.58 | 2.50 | 17.08 |
| Bekaa | 2,678 | 1.47 | 19.55 | 1.47 | 22.49 |
| Total | **20,324** | 32.67 | 103.82 | 45.82 | 182.31 |

*Source: MOEW 2010b*

**Table 3.9 Annual yield of illegal private wells**

| Mohafazat | Number | Water Use (Mm³/year) | | | Total Yield (Mm³/year) |
|---|---|---|---|---|---|
| | | Domestic | Irrigation | Industry | |
| Beirut | 1,500 | 4.65 | 1.10 | 0.69 | 6.44 |
| Mt. Lebanon | 4,500 | 8.21 | 14.37 | 8.62 | 31.2 |
| Nth. Lebanon | 7,000 | 15.33 | 19.16 | 12.78 | 47.27 |
| Sth. Lebanon | 5,000 | 15.51 | 31.94 | 5.48 | 52.93 |
| Bekaa | 4,500 | 2.46 | 32.85 | 2.46 | 37.77 |
| Total | **22,500** | 46.16 | 99.42 | 30.03 | 175.61 |

*Source: MOEW 2010b*

**Table 3.10 Annual yield of public wells (operated and maintained by Water Establishments)**

| Water Establishment | Number | Total Yield ($Mm^3$/year) |
|---|---|---|
| Beirut and Mount Lebanon | 138 | 76 |
| North Lebanon | 98 | 42 |
| South Lebanon | 269 | 87 |
| Bekaa | 135 | 55 |
| Total | 640 | 260 |

*Source: MOEW 2010b*

In an effort to update groundwater data, and with grant funding from the Italian Government to the tune of €1.7 million, the MOEW and UNDP will tender in 2011 the project *Groundwater Assessment and Database in Lebanon*. The project will update the last national groundwater assessment conducted in 1970 (UNDP in collaboration with the MOEW), considered comprehensive and accurate at the time. In particular, the project will (1) conduct a baseline assessment of available data and gaps through field surveys and hydrogeological reconnaissance, (2) design and implement a hydrogeological monitoring program of water quality and quantity, (3) create a an integrated database with remote access, and (4) assess groundwater resources using GIS, 3D flow model and groundwater basin budgets and safe yield prediction. The project will also identify potential sites for aquifer storage and recovery.

*Wetlands*

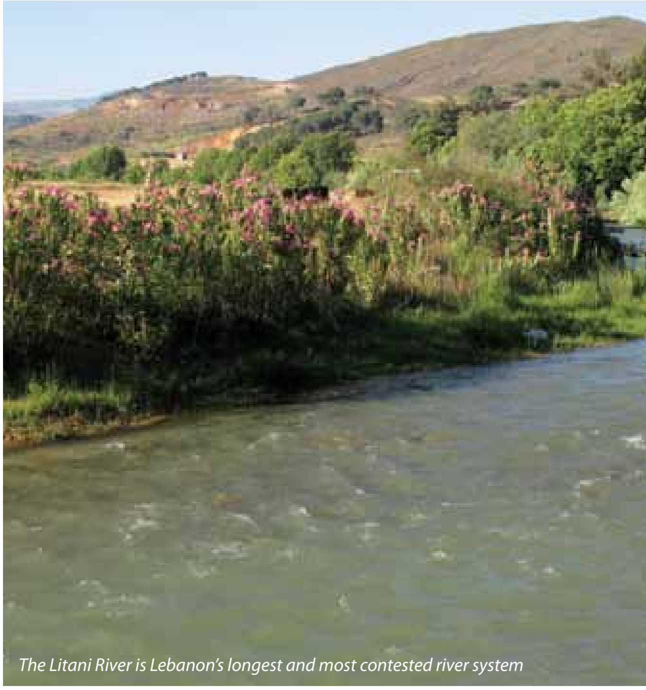
Wetlands are important ecosystems and water reservoirs. They are areas where water covers the soil, or is present either at or near the surface of the soil all year or for varying periods of time during the year. Water saturation determines how the soil develops and the types of plant and animal communities living in and on the soil. The most significant wetland in Lebanon is located in Ammiq, just north of the Qaroun Lake, on private land in the Bekaa Valley which is one of Lebanon's primary agricultural areas. Covering up to 250ha during the wet season, Ammiq Wetland supports a dynamic ecosystem and lies on one of the most important bird migration routes in the world. It is widely reported that these wetlands used to extend north to Zahle, before the advent of modern agricultural practices and large scale drainage schemes. Recognizing its importance, the MOE executed between 2002 and 2006 the project Conservation of Wetlands and Coastal Zones in the Mediterranean (MedWetCoast Project), which was funded by the French Global Environment Facility and managed by UNDP. Other wetlands in Lebanon include the Yammouneh Lake in north Bekaa (most of which was drained as part of large-scale irrigation schemes) and Hima Kfar Zabad in West Bekaa (which was the focus of a project for promoting sustainable agriculture, funded by EFL-GiZ and implemented by the Society for the Protection of Nature in Lebanon).

### 3.2.2 State of Water Resources

Rivers, springs and groundwater continue to be adversely impacted by raw sewage and other wastes, both domestic and industrial, being discharged without any regulation or control from establishments. While all the water resources are being impacted by bacteriological contamination, in the agricultural areas the runoff and infiltration of residues from fertilizers and pesticides is exposing them to further environmental degradation. Furthermore, runoff from urban areas may contain heavy metals and hydrocarbons which could impact the quality of receiving waters.

*Rivers and springs*

The majority of Lebanon's rivers have unacceptable levels of raw sewage contamination as reflected in the high levels of total coliform and E.Coli counts. The situation is identical in the coastal rivers and the inland rivers. The water quality data presented in Table 3.11 was consolidated from multiple sources to show the extent of pollution in the rivers and springs. In terms of biological contamination, the drinking water requirement is nil count per colony (Decree 1039/1999).



*The Litani River is Lebanon's longest and most contested river system*

**Table 3.11 Quality parameters for selected rivers in the dry season**

| River | $BOD_5$ (mg/L) | $NO_3$ (mg/L) | TDS (mg/L) | $SO_3$ (mg/L) | Total Coliform (c/100mL) | E. Coli (c/100mL) |
|---|---|---|---|---|---|---|
| Kabir | 14.4 | 3 | 270 | 20 | 900 | 20 |
| Bared | 28.2 | 2.8 | 225 | 28 | 610 | 17 |
| Abou Ali | 39.3 | 3.4 | 280 | 22 | 26,500 | 3,000 |
| Ibrahim | 62.8 | 1 | 150 | 8 | 3,500 | 200 |
| Antelias | 53.2 | 3 | 300 | 30 | 28,000 | 6,000 |
| Damour | 21.3 | 3 | 200 | 38 | 490 | 15 |
| Awali | 33.4 | 7 | 210 | 22 | 710 | 1 |
| Qasmieh | 22.5 | 5.5 | 250 | 21 | 80 | 0 |
| **Limit Value** | **Nil*** | **50*** | **600*** | **250*** | **500**** | **100**** |

Notes: Reported values are averages for period Jul-Aug-Sep 2004
* WHO (2006) standards for drinking water quality
**MOE Decision 52/1-1996: requirement for bathing water quality including sea, rivers and lakes
*Source: Houri et al. 2007*

Other studies have assessed water quality in particular rivers. See for example water data for Zahrani River (2006) and Kabir River (2001-2002) in Tables 3.12 and Table 3.13, respectively. The study of Kabir River and its tributaries and selected springs within its basin was based on 41 sampling points from its source right down to the Mediterranean Sea. The river constitutes the natural border between Lebanon and Syria. It was found to be heavily contaminated by raw sewage.

**Table 3.13 Bacteriological analysis of Kabir River (83 samples)**

| Parameter | Mean Value | Max. Value | Min Value | MOE Std* |
|---|---|---|---|---|
| Total Coliform (C/100 mL) | 540,091 | 26,999,800 | 0 | 500 |
| Feacal Coliform (C/100 mL) | 78,438 | 1,890,000 | 0 | 100 |

**MOE Decision 52/1-1996: requirement for bathing water quality including sea, rivers and lakes*
*Source: Hamze et al. 2005 (data from 2001-2002)*

The Upper Litani Basin (i.e., Litani River and tributaries, Qaroun Lake and Canal 900) has been the focus of many water quality sampling programs and assessment reports. USAID has been particularly active in funding these assessment and follow-on works. For example, in 2003, they financed the Water Quality Assessment of the Upper Litani River Basin and Lake Qaroun, followed by the Basin Management Advisory Services project (BAMAS, 2005-2007), and the Litani River Basin Management Support Program (LRBMS, 2009-2012). The LRBMS has made noteworthy strides towards building the capacities of the LRA in providing long-term water quality monitoring. In particular, the program tasked the American University of Beirut in 2010 to conduct a comprehensive water quality survey of the Upper Litani Basin in coordination with LRA (USAID, 2011). The objectives of the water quality survey were to update the water quality data generated in 2005 under BAMAS, and recommend interventions for improved practices and mitigation/control measures for the main sources and types of pollution. In total, AUB and LRA collected 149 samples over a period of 22 days (summer 2010) as follows:

**Table 3.12 Bacteriological analysis of Zahrani River**

| Parameter | Result | MOE Std* (C/100 mL) |
|---|---|---|
| Total Coliform (C/100 mL) | 500 | 500 |
| Feacal Colifrom (C/250 mL) | 350 | 100 |
| Feacal Streptococcus (C/250 mL) | 80 | 100 |

**MOE Decision 52/1-1996: requirement for bathing water quality including sea, rivers and lakes*
*Source: ELARD 2006*

| Sampling Location | Number of Samples |
|---|---|
| Litani River and its tributaries | 26 |
| Qaraoun Lake | 10 |
| Irrigation Canal 900 | 7 |
| Groundwater springs and wells | 43 |
| Sewage effluents from residential areas near the river | 12 |
| Industrial wastewater effluents discharging into the river | 7 |
| Agricultural soils bordering the river and irrigation canal | 36 |
| River and lake sediments | 8 |

Targeted surface and lake water results are summarized in Tables 3.14 and compared to previous results obtained in 2005. The 2010 sampling campaign shows a tenfold increase in BOD values in surface waters, compared to values in 2005. Sources of BOD into the Litani basin include the discharge of untreated sewage from homes and industries, as well as leachate from nearby municipal solid waste dump sites. TDS values and pH also increased (more alkaline). Microbiological load in the form of fecal coliform count were lower than in 2005 possibly because the sampling occurred during summer characterized by prolonged exposure to sunlight UV radiation. The results show a different trend for lake water. While TDS and pH increased, BOD load did not change markedly but fecal contamination increased tenfold. In terms of pollution from agricultural runoff, both surface and lake water showed a significant drop in phosphate and nitrate levels. The campaign also detected trace metals (arsenic, nickel, mercury and chromium) in river and lake sediment samples, reflecting and confirming continued exposure to industrial pollution.

**Table 3.14 Litani River Basin water quality**

| Indicator | BAMAS 2005 (summer) | | | LRBMS 2010 (summer) | | | Drinking Water Standard | |
|---|---|---|---|---|---|---|---|---|
| | Min | Mean | Max | Min | Mean | Max | LIB-NOR* | EPA |
| **Surface Waters** | | | | | | | | |
| TDS (mg/l) | 88 | 290.96 | 706 | 187 | 502 | 1979 | <500 | <500 |
| pH (pH units) | 6.57 | 7.09 | 7.68 | 7.27 | 7.93 | 8.66 | 6.5-8.5 | 6.5-8.5 |
| BOD (mg/l) | 2 | 48.46 | 624 | 2.50 | 547 | 2530 | NA | NA |
| Nitrates (mg/l as N) | 3 | 13.46 | 62 | 0.10 | 1.23 | 4.90 | 45* | <10 |
| Phosphates (mg/l) | 0 | 11.75 | 197 | 0 | 8.58 | 72 | NA | NA |
| Fecal Coliform (CFU/100ml) | 0 | 223,487 | 1,500,000 | 1 | 71.61 | 400 | 0 | 0 |
| Cadmium (mg/l) | NA | NA | NA | 0.005 | 0.01 | 0.079 | | <0.005 |
| **Lake Water** | | | | | | | | |
| TDS (mg/l) | 120 | 160 | 196 | 221 | 235 | 256 | <500 | <500 |
| pH (pH units) | 6.5 | 7 | 7.5 | 8.2 | 8.27 | 8.32 | 6.5-8.5 | 6.5-8.5 |
| BOD (mg/l) | <2 | 2.57 | 4 | 2.0 | 2.65 | 3.30 | NA | NA |
| Nitrates (mg/l as N) | 16 | 21 | 62 | 0.8 | 0.93 | 1.2 | 45* | <10 |
| Phosphates (mg/l) | 0.01 | 0.13 | 0.35 | 0 | 0.09 | 0.24 | NA | NA |
| Fecal Coliform (CFU/100ml) | 0 | 17 | 450 | 0 | 160 | 400 | 0 | 0 |
| Cadmium (mg/l) | NA | NA | NA | 0.0007 | 0.01 | 0.021 | | <0.005 |

*Note: Drinking water standard is LIBNOR NL1611999 in Decree 1039 (dated 02/08/1999)*

*Source: Based on USAID, 2011*

Not only is the Litani River suffering sewage contamination, fertilizers and pesticides used in the agriculturally rich Bekaa valley are flowing into the open watercourses and infiltrating into the groundwater. In addition to raw sewage, there are a number of uncontrolled dumpsites that produce leachate that seeps into rivers and aquifers. In the case of the Litani River, the Zahle dumpsite has been contained and transformed into a sanitary landfill; therefore at least one source of severe contamination has been stopped but many more remain. It should be noted that the Litani River and its tributaries has been the focus of many studies and testing campaigns but very little has been achieved so far to effectively control pollution sources.

In an effort to develop a sound business model for mitigating pollution into the Litani River, the MOE and UNDP commissioned the preparation of a Business Plan for Combating Pollution of the Qaraoun Lake (MOE/UNDP/ELARD, 2011). The analysis was used to determine the measures needed to alleviate pollution from various sources. The business plan examines the proposed responses to the identified pressures, and describes the enabling environment (institutional, legal and financial), as well as current and future initiatives for pollution abatement in the Litani basin.

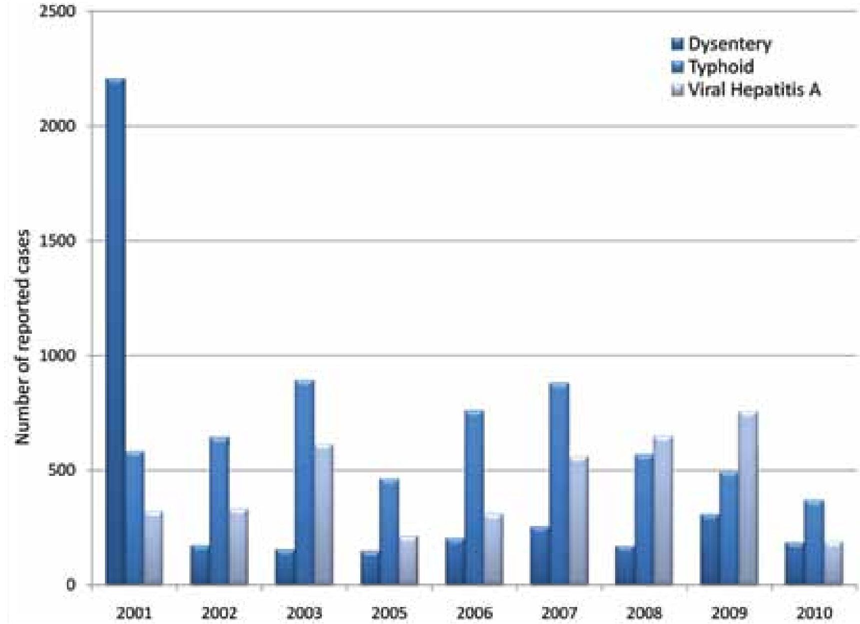
*Groundwater*

The majority of aquifers in Lebanon are karst limestone structures. Karst is a terrain with distinctive landforms and hydrology created from the dissolution of soluble rocks, principally limestone (USGS, 2010). Karst features are characterized by springs, caves, sinkholes, and a unique hydrogeology system. One of the drawbacks of the karst limestone aquifers is the high level of fissures and fractures in their formation, allowing ready transmission of pollutants from domestic and industrial waste discharges. They also allow transmission of diffuse sources (fertilizers and pesticides) and are prone to salt water intrusion.

Since the main sources of drinking water are wells and springs, it is reasonable to expect high incidences of waterborne diseases to reflect pollution stress in these sources. Over the last 10 years, waterborne diseases have been generally trending down although the number of reported cases of Hepatitis A spiked during the period 2006-2009. See overall trend for Hepatitis A, Dysentery and Typhoid in Figure 3.4 (data in 2004 not available). The highest number of reported cases for all three diseases was North Lebanon.


*Lebanese speleologist on an exploration of the underground river in the grotto of Jeita (candidate site for the new 7 wonders)*

**Figure 3.4 Number of reported cases of waterborne diseases in Lebanon (2001-2010)**




Source: MOPH 2010

Groundwater quality data is fragmented and not centralized. Some of these data are generated by EIA studies, development organizations and environmental research institutes, and relevant ministries in response to public health concerns or apparent disease outbreaks. There is an urgent need to consolidate such data into a centralized data system to appraise decision makers and municipal authorities as well as support future SOERs, EIAs and other environmental studies. As reported earlier, USAID has funded several water quality assessments in the Upper Litani Basin (2003, 2005 and 2010). According to the 2010 sampling campaign, TDS levels in groundwater were acceptable as compared to the Lebanese and EPA standards. Interestingly, only 16 percent of groundwater samples (compared to 35% in 2005) showed fecal contamination, an indication that the increased coverage of sewer systems in the Bekaa region has reduced the exposure of groundwater aquifers to progressive contamination and shifted the pollution to lake water. Nitrate levels in the groundwater remain high and very close to the permissible limit in drinking water in Lebanon (see Table 3.15).

Urban expansion, and the ever increasing need to irrigate crops as wet periods shorten, has led to an explosion in the use of wells in Lebanon. Aquifers that are over extracted can suffer increasing salinity, as evidenced by increased concentrations of sodium and chloride. In 2001, 31 samples from wells in the Bekaa Valley and the coastal zone showed elevated levels of sodium and chloride (El Fadel *et al.* 2000 *in* MOE/

**Table 3.15 Groundwater analysis in the Upper Litani Basin (2005 and 2010)**

| Indicator | BAMAS 2005 (summer) | | | LRBMS 2010 (summer) | | | Drinking Water Standard | |
|---|---|---|---|---|---|---|---|---|
| | Min | Mean | Max | Min | Mean | Max | LIBNOR* | EPA |
| TDS (mg/l) | NA | NA | NA | 170 | 385 | 863 | <500 | <500 |
| pH (pH units) | 6.54 | 6.9 | 7.22 | 6.98 | 7.76 | 8.72 | 6.5-8.5 | 6.5-8.5 |
| Nitrates (mg/l as N) | 3 | 48 | 171 | 0.2 | 6.7 | 41 | 45 | <10 |
| Phosphates (mg/l) | 0 | 0.3 | 12 | 0.1 | 1.2 | 6.43 | NA | NA |
| Fecal Coliform (CFU/100ml) | 0 | 42.8 | 400 | 0 | 39.2 | 400 | 0 | 0 |

*Note: Drinking water standard is LIBNOR NL1611999 in Decree 1039 (dated 2/8/1999)*

Source: USAID 2011

ECODIT 2002). In 2001, 21 recently completed wells in the Baalbeck region were sampled, and only seven had levels of chloride lower than the MOE standard of 25 mg/L (WB 2002). In 2006, 20 wells and springs were sampled in the West Bekaa, an area directly north of the Qaroun Lake, of which only three had chloride concentrations less than the MOE standard (Fidawi 2010). Generally, coastal wells are subject to severe salt water intrusion, and many are being put out of operation. This is confirmed by MOEW (Baroud, 2010), CDR, the water establishments, and a number of studies (Shaban, 2009). This situation is particularly acute in Beirut area.

*Coastal Marine Water*

Coastal waters in Lebanon receive untreated sewage from at least 53 major sewage outfalls (number of outfalls was reported in the 2001 SOER and has not been updated) spread along

Lebanon's 240 km coastline, of which 16 lie within the Beirut area. Coastal waters receive an estimated 162 $Mm^3$/year of untreated sewage (equivalent to 276,000 $m^3$/day), which is equivalent to 65 percent of the total sewage load in Lebanon. About 70 percent of Lebanon's population, plus hundreds of thousands of tourists each year contribute to this sewage stream. Although Lebanon has made progress in building Sewage Treatment Plant (STP) along the coast, none except for the Ghadir plant is operating at design capacity. *See overview of treatment plants in Section 3.4.2.* In addition to outfalls, rivers also carry upstream pollutants from various activities and sectors to the sea including agricultural runoff, and sewage. Houri (2007) estimated the extent of the pollution load coming from Lebanon's perennial rivers during the dry season (see Table 3.16).

**Table 3.16 Pollutant loading from coastal rivers in the dry season**

| *Parameters* | *BOD (g/s)* | *Nitrate (g/s)* | *Phosphate (g/s)* | *Sulfate (g/s)* | *E.COLI (CFU/s)* | *Coliform (CFU/S)* |
|---|---|---|---|---|---|---|
| Value | 664.5 | 69.3 | 6.17 | 479.1 | 16,708 | 114,889 |

Notes: g/s = Grams per second

*Source: Houri et al. 2007*

*Sewage outfall discharging into the sea near Antelias*

In addition to untreated sewage from cities and towns, coastal waters are also affected by large seafront dumpsites in Tripoli (still active but contained), Bourj Hammoud (closed but not rehabilitated), Beirut (closed and rehabilitated), Saida (active and causing severe environmental pollution) and Sour (active). *See analysis of dumpsites in Chapter 8 Solid Waste.* Additional pollution into coastal waters stems from coastline thermal power plants (Beddawi, Zouk, Jieh and Zahrani) and the overwhelming presence of heavy industries along the coast. The BOD load from industrial wastewater is estimated at 5,000 tonnes per year (WB, 2010b). As reported in the 2001 SOER, waters near industrial sites show high levels of the heavy metals Arsenic, Lead, Zinc and Chromium. The highest levels were found near the Dora industrial complex, due mainly to the significant tannery industry located there. Chromium levels may have dropped since because several tanneries have closed. Very little has been achieved insofar as treating industrial wastewater before discharge into the municipal streams, rivers and sea. *See current progress and pipeline initiatives related to industrial sewage treatment in Section 3.4.2.*

*Bathing Water*

Lebanon's public beaches are shrinking, partly due to infringements on the public maritime domain. Coastal erosion, mainly in north Lebanon, is also affecting beach quality and access. Bathing water is affected by several pollution streams mentioned earlier (sewage outfalls, thermal plants, industries, etc.) and therefore the need to monitor its quality is pronounced. The National Centre for Marine Sciences (NCMS), which is one of four subsidiary branches of the Lebanese National Centre for Scientific Research (see Chapter 2), runs several seawater quality monitoring programs. With funding from the World Health Organization, the NCMS profiled five public beaches in Lebanon (Heri in North Lebanon, Byblos in Mount Lebanon, Ramlet el Bayda in Beirut, Saida and Sour in South Lebanon). The analysis campaigns extended three years (January 2008-Decemebr 2010) during which the research team collected 136 samples from fixed sampling locations from all five beaches. The analysis covered physical, chemical, hydrological and microbiological parameters. Expectedly, the test results showed very high bacteriological contamination in Beirut and Saida, affected by sewage outfalls and dumpsites, but good bacteriological water quality in Heri, Byblos and Tyre. *See summary of test results in Table 3.17.*

**Table 3.17 Profile of five beaches in Lebanon**

| *Public Beaches* | *Heri Beach* | *Byblos Bahsa Beach* | *Ramlet-el-Bayda Beach* | *Saida Beach* | *Tyr Beach* |
|---|---|---|---|---|---|
| Length (m) | 700 | 250 | 1065 | 673 | 2030 |
| Depth (m) | 20 | 30 | 20-60 | 90 | 210 |
| Sewage outfalls | None | None | 2 outfalls | 2 outfalls | None |
| River discharge | Yes | No | No | No | Yes |
| Land uses and activities | Cement plant; beach resorts; agricultural fields | Beach resorts; main road; agricultural fields; public toilets (summer) | Beach resorts | Coastal highway; agricultural fields; open dumpsite nearby | Tyre Coastal Nature Reserve; beach resorts and kiosks; Rachidieh refugee camp; agricultural fields |
| Sampling period | Jan 2008-Dec 2010 | Jan 2008-Dec 2010 | Jan 2008-Dec 2010 | Nov 2009-Dec 2010 | Nov 2009-Dec 2010 |
| Number of Samples | 36 | 36 | 36 | 14 | 14 |
| Fecal coliform (CFU/100ml)<br>95th percentile<br>90th percentile | <br>19<br>11 | <br>13<br>9 | <br>55,742<br>22,182 | <br>19,455<br>10,475 | <br>78<br>41 |
| Fecal streptococci (CFU/100ml)<br>95th percentile<br>90th percentile | <br>137<br>77 | <br>132<br>73 | <br>45,123<br>19,342 | <br>3,525<br>2,189 | <br>194<br>109 |
| Bacteriological Water Quality | Good | Good | **Poor** | **Poor** | Good |
| Phosphate ($PO_4$) min-avg-max (µM/l) | 0.13-0.46-0.89 | 0.10-0.19-0.30 | 0.39-1.52-3.93 | 0.17-0.52-1.27 | 0.12-0.20-0.28 |
| Nitrate ($NO_3$) min-avg-max (µM/l) | 0.14-0.31-0.97 | 0.24-1.32-3.72 | 0.73-3.58-14.15 | 0.96-2.66-6.05 | 0.52-4.72-21.21 |
| Algae | No | No | - | Yes | No |

Note: MOE standard for fecal contamination in bathing water is 100 (CFU)/100ml (based on MOE Decision 52/1 of 1996)

*Source: National Centre for Marine Sciences, 2011*

### 3.2.3 Water Demand

*3.2.3.1 Current Water Demand*

Current demand estimates vary depending on source and assumptions. The most critical input parameters to estimating water demand include population, per capita water consumption, network efficiency, total irrigated area, irrigation consumption and industry demand. Table 3.18 shows three different demand estimates which range from 1,473 to 1,530 million $m^3$ per year. These demand estimates are compatible with currently exploited resources (Section 3.2.1.1).

Looking at the annual picture of demand and supply masks how dire the situation has become during the dry period. Table 3.19 shows demand and supply by sector during the four months from July to October. Depending on which source is used, the deficit ranges from 220 to 388 million $m^3$.

**Table 3.18 Estimates of current annual demand ($Mm^3$)**

| *Sector* | *2010*[1] | *2010*[2] | *2010*[3] |
|---|---|---|---|
| Domestic | 501 | 467 | 505 |
| Industrial | 150 | 163 | 158 |
| Agriculture | 900 | 900 | 810 |
| Total Demand | 1,515 | 1,530 | 1,473 |
| **Sources and assumptions:** | (1) Comair, 2010 | (2) WB, 2009a | (3) MOEW, 2010a |
| Population | 4.5 million | 4.2 million | 4.5 million |
| Per capita consumption | 200 L/d | 140 L/d | 180 L/d |
| Network efficiency | 70% | 65% | 52% |
| Irrigated area | 145,000 Ha | 103,000 Ha | 90,000 Ha |
| Irrigation consumption | 8,000 $m^3$/ha | 9,000 $m^3$/ha | 9,000 $m^3$/ha |
| Industry demand | 30% domestic | 35% domestic | 31% domestic |

**Table 3.19 Estimates of current demand during the period July-October ($Mm^3$)**

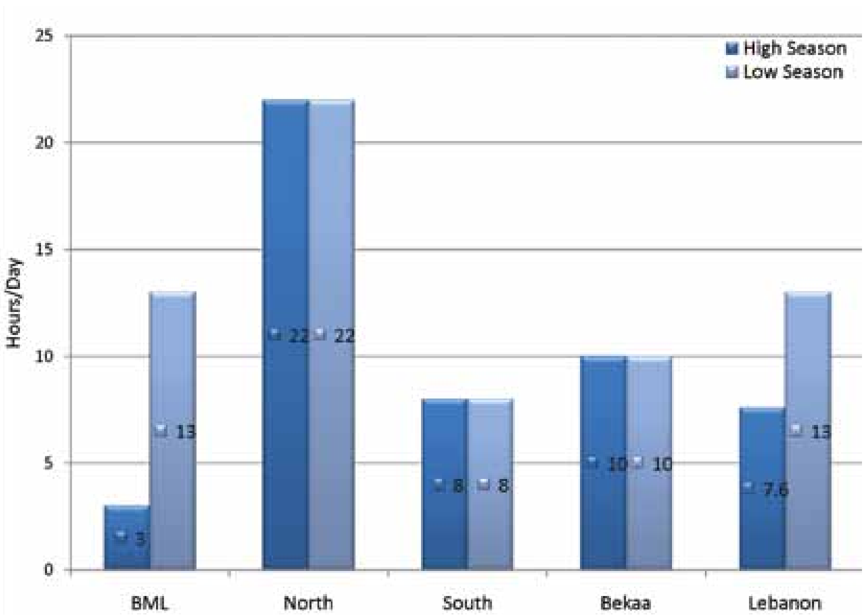
| Sector | 2010[1] | 2010[2] | 2010[3] |
|---|---|---|---|
| Domestic | 250 | 233 | 253 |
| Industrial | 60 | 65 | 63 |
| Agriculture | 675 | 765 | 567 |
| Total Demand | 985 | 1,063 | 883 |
| Total Supply | 765 | 675 | 650 |

Sources and notes:

(1) Comair 2010 (population for 2010).
(2) WB 2009a. Water needs: 0.5 x domestic + 0.4 x industrial + 0.85 x irrigation. Supply 0.45 x annual supply.
(3) MOEW 2010a (demand forecasts)

The data show that without any supply- and demand-side measures, such as augmenting existing exploitable resources, reducing network losses or improving efficiency, natural population growth alone will increase the prevalence of water deficits in the future. For potable water, the deficit between demand and supply has manifested itself in rationing of supply. The situation is particularly acute in Beirut and Mount Lebanon, where water supply drops from 13 hours during the wet season to only 3 hours during the dry season (see Figure 3.5). Summer rationing is less severe in other regions.

**Figure 3.5 Continuity of water supply by Water Establishment**




*Source: WB 2009a*

*Water rationing and intermittent supply encourages residents to buy water from private cisterns*

*3.2.3.2 Water Transmission and Distribution*

A consistent documentation of network assets is only available for the Beirut and Mount Lebanon WE. The other WEs only have records of transmission mains but not distribution networks. The total length of the documented network in BMLWE is 5,880 km of which 1,550 km account for large diameter transmission mains (MOEW 2010b). Table 3.20 shows the age of the existing water network in Beirut and Mount Lebanon; 26 percent of the transmission network and 23 percent of the distribution network were built after the year 2000.

**Table 3.20 Age of transmission and distribution water networks in Beirut and Mount Lebanon**

| Age (years) | Transmission (%) | Distribution (%) |
|---|---|---|
| <10 | 26 | 23 |
| 10-20 | 15 | 15 |
| 20-30 | 6 | 11 |
| 30-40 | 15 | 8 |
| 40-50 | 16 | 5 |
| >50 | 5 | 2 |
| Unknown | 17 | 36 |

*Source: MOEW 2010b*

Water supply network coverage varies among Water Establishments between 62 and 87 percent. According to CAS, almost 85 percent of buildings in 2004 were connected to water networks but at least 7 percent were equipped with private water wells (CAS 2006). *See connection rates for all cazas in **Annex 1**.* The resulting coverage at national level is therefore higher than the 75 percent MENA average (e.g., Syria 60%; Qatar 70%; Jordan 98%) but much lower than the 100 percent best practice threshold (e.g., Bahrain 100%). However, around 50 percent of the transmission and distribution pipelines require special attention given their age and the limited maintenance activities and surveillance (MOEW 2010b). Intermittent water supply has economic repercussions on households –see analysis of connection rates and household budget that goes to water in Box 3.3.

**Box 3.3 Socio-economic costs of intermittent water supply**

Water rationing is not the only problem affecting water supply. When the connection rate for drinking water per water establishment is factored into the water situation, it becomes evident that many Lebanese do not rely on the public water supply networks for their drinking water needs. Records show that about 22 percent of households (and 18% of the population) are not connected to public water supply systems (see Figures 1 and 2). Yet, over 70 percent of total household expenditure on water goes to private suppliers of water, distributed as follows: 35 percent water gallons (18L containers), 21 percent water tankers, and 16 percent small water bottles (see Figure 3).

Figure 1 Household connection rates

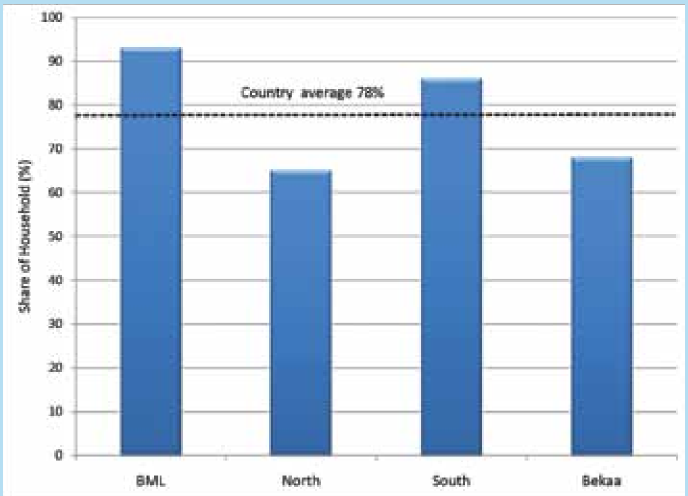



Figure 2 Population connected by Water Establishment

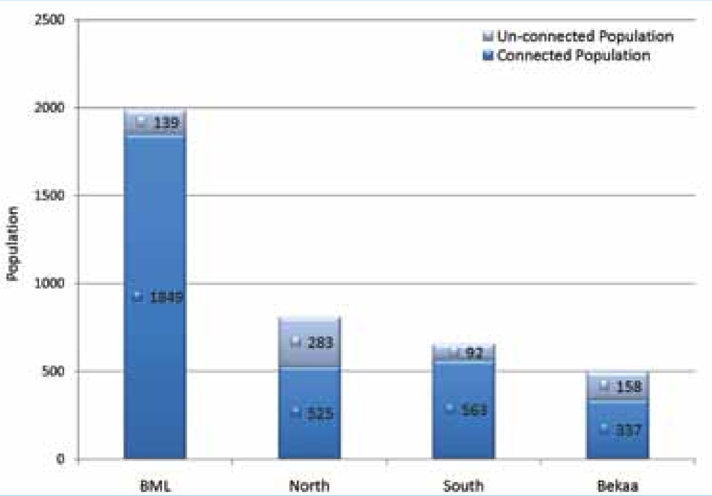
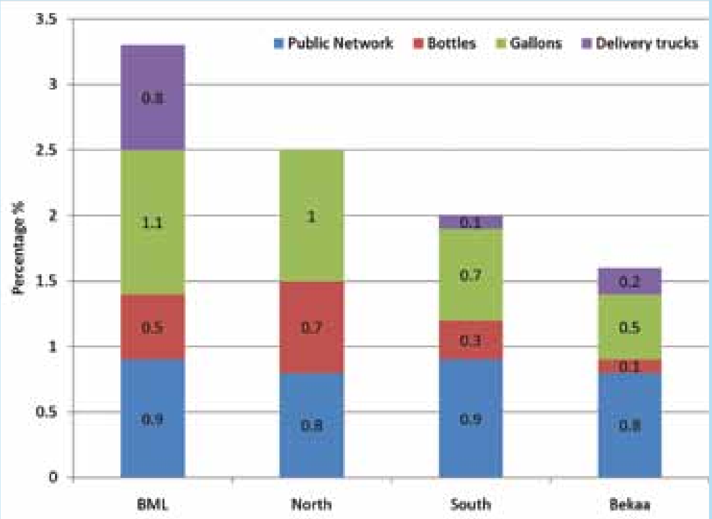



Figure 3 Percentage share of household budget that goes to water by WE & water source




Despite the stress water resources are under, current demand is not being met by public resources, and the community is bearing significant additional costs with private provision of drinking water. From a public health perspective, not all the private providers of water are regulated strictly, and so the risk to public health is real. Moreover, the social and economic impact on the community, particularly the lower socio-economic groups, is quite severe. The unit price of public water supply ranges from \$0.3 to \$0.8 /m³ (depending on the region), compared to \$3 to \$6 /m³ for water tankers and \$400 to \$500 /m³ for small bottles.

The annual cost to the community, above the water charges that are paid to the water establishments, is \$307 million or 1.3 percent of annual GDP. This is higher than the total annual expenditure in the sector (including O&M), which is estimated at 0.5 percent of GDP. So, the Government has the scope to invest in the sector on the condition that it secures sufficient supplies and of quality that would win the confidence of the community.

*Source: Based on WB 2009a*

*3.2.3.3 Projected Water Demand*

Lebanon has entered into a period of water stress whereby its total exploited resources (about 1,500 million $m^3$) do not meet current annual demand, and that projected demand after 2020 will start exceeding exploitable renewable resources of 2,000 to 2,500 million $m^3$. This is the projection of the World Bank (Table 3.21). The projections of the MOEW are more optimistic (Table 3.22 and Table 3.23).

**Table 3.21 Annual water demand 2010 -2030 $Mm^3$ and share of total**

| Sector | 2010 | | 2020 | | 2030 | |
|---|---|---|---|---|---|---|
| Domestic | 467 | 31% | 767 | 37% | 1258 | 44% |
| Industrial | 163 | 11% | 268 | 13% | 440 | 16% |
| Irrigation | 900 | 58% | 1020 | 50% | 1120 | 40% |
| Total | **1,530** | **100%** | **2,055** | **100%** | **2,818** | **100%** |

**Assumptions**: *Annual population growth* 2.5%; *Per capita water consumption* 140 L/d; *Network Losses* 35%; *Irrigated area* growing from 90,000 Ha to 140,000 Ha in 2030; *Irrigation demand* decreasing from 9,000 $m^3$/Ha to 8,000 $m^3$/Ha; Industrial demand equals 35% of domestic demand.

*Source: WB 2009a*

**Table 3.22 Annual water demand in Mm3 by sector (2010 -2035)**

| Sector | 2010 | 2015 | 2020 | 2025 | 2030 | 2035 |
|---|---|---|---|---|---|---|
| Domestic | 505 | 460 | 427 | 467 | 512 | 562 |
| Industrial | 152 | 138 | 128 | 140 | 154 | 169 |
| Tourism | 6 | 8 | 10 | 13 | 16 | 21 |
| Irrigation | 810 | 877 | 935 | 983 | 1,021 | 1,050 |
| Total | **1,473** | **1,483** | **1,500** | **1,603** | **1,703** | **1,802** |

**Assumptions**: *Annual population growth* 1.75% starting at 4.425 million,; *Per capita water consumption* 180 L/d urban and 160 L/d rural; *Network Losses* 48% in 2010, 30% in 2020, 20% in 2035; *Irrigated area* growing from 90,000 Ha to 150,000 Ha in 2035; *Irrigation demand* decreasing from 9,000 $m^3$/Ha to 7,000 $m^3$/Ha in 2035; Industrial demand equals 30% of domestic demand; *Tourist consumption* 400/L/d; *Consumption growth* 1% per annum. *Water conservation measures* 3L/c/d.

*Source: MOEW 2010a*

**Table 3.23 Annual water demand in Mm3 by Water Establishment (2010 -2035)**

| Sector | 2010 | 2015 | 2020 | 2025 | 2030 | 2035 |
|---|---|---|---|---|---|---|
| BML | 373 | 373 | 374 | 407 | 443 | 482 |
| Nth Lebanon | 351 | 354 | 358 | 381 | 403 | 424 |
| Sth Lebanon | 256 | 242 | 234 | 251 | 268 | 285 |
| Bekaa | 493 | 513 | 533 | 563 | 589 | 612 |
| Total | **1,473** | **1,483** | **1,500** | **1,603** | **1,703** | **1,802** |

*Source: MOEW 2010a*

### 3.2.4 Wastewater Generation

Wastewater generation from households and industries is affecting water resource quality almost everywhere in Lebanon. While data on industrial wastewater networks and flows is scant and fragmented, the CAS produced in 1996-1997 data on household wastewater connections and updated these data in 2004. According to CAS, only 52 percent of buildings were connected to sewage networks in 2004 and therefore at least 48 percent rely on sceptic tanks most of which are permeable or are deliberately drained to prevent overflow. Nationwide, the highest rate of sewage connection was recorded in Beirut (96%), followed by Tripoli and Baabda (each 91%) and Zahle (83%). The lowest connection rates were in Batroun (1%), followed by Bent Jbeyl (4%) and Jbail (10%). *See connection rates for all cazas in **Annex 1**.* Table 3.24 shows the approximate domestic sewage loads discharged into the sea and water courses.

**Table 3.24 Estimated domestic wastewater generation**

| Mohafaza | Population | Domestic WW $Mm^3$/ year | BOD Load (tonnes/ year) |
|---|---|---|---|
| Beirut | 361,366 | 25.1 | 10,040 |
| Mount Lb | 1,484,474 | 93.8 | 37,525 |
| North Lb | 763,712 | 50.2 | 20,092 |
| Bekaa | 489,865 | 33.6 | 13,428 |
| South Lb | 416,842 | 29.4 | 11,751 |
| Nabatiyah | 242,876 | 17.1 | 6,854 |
| **Total** | **3,759,135** | **249.2** | **99,690** |

Notes: Based on 2007 population

*Source: WB, 2010b*

Pollutant levels in treated wastewater must comply with MOE standards stipulated in Decision 8/1 (dated 30/01/2001) before discharge into public sewers, surface water and/or the sea. Industrial wastewater, estimated at 43 million $m^3$ per year, is even more problematic because they contain an array of inorganic pollutants which can be toxic to ecosystems and biota. Industrial wastewater is very diverse from phosphogypsum slurry discharged into the sea to Olive Mill Wastewater from approximately 492 surveyed olive mills discharged into public sewers and streams during the olive pressing season. Lebanon is a signatory to the Barcelona Convention and its amendments including the Protocol for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources (also known as the LBS Protocol). In response to the LBS Protocol, the MOE prepared in 2005 a Sectoral Plan for the Reduction of Pollution of the Mediterranean Sea from Land Based Sources.

## 3.3 KEY ACTORS, LAWS AND REGULATIONS

The following section describes key regulations and policy issues related to the water sector. Each legal text cited here is also listed chronologically at the end of the chapter. For a more complete analysis of environmental legislation related to water and environment, please refer to Chapter 8 of SELDAS (EU/UOB/MOE/ELARD, 2005). To review environmental jurisprudence cases related to water, wastewater and sea water in Lebanon and other similar countries, please refer to Chapter 8 of SEEL (MOJ/MOE/UNDP, 2010).

### 3.3.1 Legal and Institutional Framework for Water and Wastewater

The institutional framework for the water sector in Lebanon is characterised by a myriad of ministries, water establishments, public agencies, municipalities, etc. Key actors in the water sector often duplicate each other's work, other times complement each other, always operating through weak links of communication and responsibility, which have led to a lack of policy focus, with no *one* institution taking the effective lead of the sector. Table 3.25 shows a simplified allocation of responsibilities in the water and wastewater sectors.

The following sections attempt to show how the crowded institutional framework and policy environment is impacting on the management of water resources.

*Ministry of Energy and Water*

The Ministry of Energy and Water (MOEW) is responsible for the water sector under Law 221 dated 26 May 2000. According to Article 2 of this law, the Ministry has the following responsibilities:

1) Monitor, control and measure water resources, and determine needs and use of water resources
2) Monitor the quality of water resources and set relevant quality standards for water resources
3) Establish public plans for the utilisation and distribution of water resources, as well as prepare the master-plan for water and wastewater to be endorsed by the COM through the MOEW
4) Design, build and put into operation major water facilities such as dams, mountain lakes, underground conveyors, river stream correction works and water supply networks and the like
5) Implement artificial recharge of groundwater when required and regulate the volumes of groundwater extracted
6) Protect water resources from pollution and waste by issuing laws, rules and regulations and their application and enforcement
7) License wells and all water extraction from rivers and public water resources according to applicable laws and regulations
8) Conduct continuous hydrological, geological and hydro-geological research, study, data gathering and mapping pertaining to the water sector
9) Provide tutelage and oversight of all public institutions working in the working sector according to Law 221 and the laws governing these institutions
10) Enhance the operational performance of regional water establishments and monitor their performance according to approved benchmarks
11) Set the standards and benchmarks the RWE's will need to abide by in their design and operation of water supply, irrigation and wastewater systems
12) Conduct all land expropriations for MOEW and RWE's in conformity with existing laws
13) Provide advice in the licensing of mines and quarries when such mines and quarries impact on water resources
14) Conduct public outreach to inform them of water related issues and ways of conserving water.

**Table 3.25 Key players and responsibilities in the water and wastewater sectors**

| *Function* | *MOEW* | *RWEs* | *LRA* | *CDR* | *MOE* | *MOPH* | *Other* |
|---|---|---|---|---|---|---|---|
| Planning | X | X | | X | | | |
| Licensing and permitting (inc. EIAs) | X | | | | X | | X |
| Capital Investment | X | X | | X | | | X |
| Infrastructure construction | X | X | | X | | | X |
| Operation & maintenance | X | X | | | | | |
| Financing (national) | X | X | | X | | | |
| Financing (external funding) | X | | | X | | | |
| Regulations and guidelines | X | | | | X | X | |
| Water quality / quantity monitoring | X | | X | | X | | |
| Hydro-power plants | X | | X | | | | |

Notes: "Other" includes Council for the South, Municipalities, other ministries and agencies

Law 221/2000 was amended by Laws 241 (dated 7/08/2000) and 337 (dated 14/12/2001). These laws were promulgated to reform the water sector and clearly define the roles of MOEW and regional water establishments (RWEs), and the relationship governing them. The Law however does not explicitly grant MOEW or any other public institution the responsibility or power to *set policy*. The MOEW by its powers can *formulate* policy and provide *policy advice* to the Government of the day, but it does not have exclusive power of policy setting in the water sector.

It should be noted that MOEW has to function in a legal environment that still has laws from the 19th and early 20th centuries in currency. For example, Law 144 of 10/6/1925 defined water resources as "public domain", and surface water is still governed by this law. A code law from 26/5/1926 provides for special privileges as access rights that allowed them to be registered as private property (MSC 2005). These were and remain tradable articles to this day. The Irrigation Code of 11/2/1913 still regulates the use of irrigation water (MSC 2005).

The Ministry has been active in leading the implementation of the institutional changes introduced by Law 221/2000. Over the course of 2010, MOEW developed a National Water Sector Strategy (NWSS). During the preparation of this strategy, three separate documents were issued: (1) *NWSS Baseline* that provides a general overview of the water sector (September 2010); (2) *NWSS Baseline Supply/Demand Forecasts* that presents projections of how planned resource augmentation and other projects will meet future demand as estimated by NWSS authors (November 2010); and (3) *NWSS Baseline Sector Enabling Environment and 2011–2015 Investment Plan* (December 2010). This last document is centred on five pillars summarized in Box 3.4.

**Box 3.4 The five pillars of the NWSS Investment Plan**

1) Institutional and Organisational Initiatives. This pillar's main thrust is the completion of the institutional reforms defined under Law 221/2000
2) Financial and Commercial Initiatives. This pillar aims at improving the financial performance of the sector through setting more rational tariffs, facilitating private sector participation in the sector, improving institutional performance
3) Legal and Regulatory Initiatives. This pillar aims at enacting the draft Water Code, provide the legal framework for the NWSS initiatives,
4) Environmental Concerns. This pillar will mainstream environmental concerns into the water sector such as: protection of water resources and recharge zones, flood mitigation, institutionalize Strategic Environmental Assessment in the planning cycle.
5) Investment Plan 2011 – 2015. Capital Investment $5,086 million distributed as follows: $1,134m for resource augmentation, $1,394m for water supply networks, $343m for irrigation, $2,160m for wastewater systems, and $55m for enabling initiatives. Operation and maintenance $732m million distributed as follows: $552m for water supply, $104m for irrigation, and $77m for wastewater.

*Regional Water Establishments*

Law 221/2001 and its amendments created four Regional Water Establishments (RWEs): Beirut and Mount Lebanon Water Establishment; North Lebanon Water Establishment; South Lebanon Water Establishment; and Bekaa Water Establishment. Lebanon had 21 water establishments and over 200 local water committees, mainly active in irrigation, before Law 221 was approved. Under Clause 4 of Law 221, the RWEs were given the following responsibilities:

i. Plan, build, operate and maintain potable and irrigation water transmission and distribution networks
ii. Plan, build, operate and maintain sewage treatment plants (STP's) and networks
iii. Ensure the quality of water supplied to their communities
iv. Recommend tariffs for water, irrigation and wastewater (based on prevailing socio-economic conditions)
v. Oversee works, studies, and operation and maintenance of by private service providers

The RWE's were given autonomy and control of their human resources, as they were freed of the regulatory oversight of the Civil Service Board, which is responsible for recruitment into the civil service (Clause 6 of Law 221). Financially, the RWE are subject to Government audit periodically, and their administrative activities are subject to the Government's administrative regulator (Central Inspectorate). They have the power to recommend tariff structure and rates to MOEW, but not set them.

Law 221/2000 stipulated a 2-year transitional phase for full incorporation of the local water committees, as well as all the implementation of the other sector wide reforms associated with the Law. Unfortunately, the by-laws or regulatory decrees making the Laws effective were not issued till December 2005. Few of the reforms behind the Law have come to fruition. Many of the local committees, which are mainly active in operating potable and irrigation networks, have yet to be incorporated into the corresponding RWE.

*Litani River Authority*
The Litani River Authority (LRA) was established in 1954 (Law dated 04/08/1954) with the responsibility of managing the Litani River Basin. In particular, the LRA would (1) plan and operate all potable, irrigation and hydro-electrical schemes associated with the Litani River, (2) measure all surface flows throughout the country, (3) establish and operate hydroelectric power plants on the Litani River.

In 1962 it was given the power to develop and operate all water systems connected to the Litani River and Awali Rivers in the area of Lebanon between the Beirut Damascus Highway and its international border in the south. Clause 7 of Law 221 affirmed that irrigation water schemes tied to the Litani River would remain under the control of the LRA. Although Law 221 should have had an impact on the LRA, it still operates as it has for the last 30 years. Its operations are within the Bekaa Water Establishment and South Lebanon Water Establishment area, yet no perceivable change has been recorded in LRA operations or those of the recently established establishments.

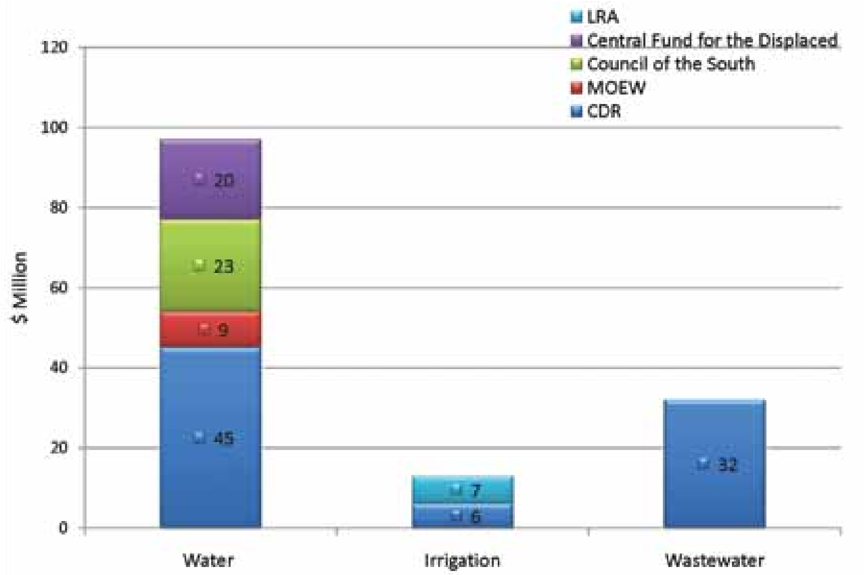
*Council for Development and Reconstruction*
CDR was created in 1977 (Legislative Decree No. 5 of 1977) to replace the-then defunct Ministry of Planning. CDR has the responsibility to prepare national sector plans in coordination with the different line ministries. CDR is empowered to seek international funding for these plans and then manage their execution. As different projects are completed, the ownership of facilities and assets built are in principle handed over to the respective line ministries or establishments for management and operation.

CDR has led Lebanon's capital spending in the water sector. Such capital spending has included building water supply systems throughout Lebanon, the rehabilitation and construction of water treatment facilities, rehabilitation and construction of transmission and distribution networks, finally to construction of house connections. Furthermore, it is expected that by 2015, all the major Lebanese coastal cities will have sewage treatment plants in operation. Equally, a large number of inland wastewater systems including sewage treatment plants will come into operation. Figure 3.6 shows capital expenditure in the water, irrigation and


*Lebanon has five Water Establishments including the Beirut and Mount Lebanon Water Establishment*

wastewater sectors by several agencies. CDR is by far the largest expenditure in the water and wastewater sectors, while the LRA is largest expenditure in the irrigation sector.

**Figure 3.6 Annual capital expenditure in the water sector by agency (1994-2008)**



*Source: WB 2009a*

*Ministry of Environment*
The Ministry of Environment is responsible for controlling pollution and regulating all activities that impact the environment. Its remit is wide. The ministry has several legal avenues for controlling pollution, including prevention. For example, the draft EIA decree (approval eminent) requires that all sewage treatment plants undergo full Environmental Impact Assessment studies. The ministry has set standards for treated wastewater discharged into sewers and surface waters (Decision 8/1 dated 30/1/2001). Although MOE's policing role has been absent due to shortages in human resources and funding, the recent push to setup an environmental police force is promising and will help detect and control pollution (for more details, see Chapter 2 on environmental governance).

At the river level, the ministry has designated eight rivers (Ibrahim, Jaouz, Damour, Kalb, Beirut, Awali, Arka and Assi) as natural sites and under its protection –see full list in Chapter 6. Although the ministry lacks the personnel and resources to protect rivers and riverbanks from unlicensed developments and authorized discharge, it has prepared environmental conditions for construction permits located within river banks (MOE Decision 90/1 dated 17/10/2000).

*Ministry of Public Health*
The Ministry of Public Health has the responsibility of maintaining health standards in the community. In relation to water resources, it monitors drinking water to ensure compliance with local and international standards. The Ministry monitors the incidence of waterborne diseases and publishes related epidemiological data.

*Other Agencies*
The Ministry of Agriculture is another important stakeholder in the water sector. According to Legislative-Decree 31 (dated 18/01/1955 and its amendments), the ministry studies irrigation projects and provides technical supervision during implementation. The ministry regulates also the distribution of irrigation water and ways to use it and monitors the implementation of these regulations. In practice, the role of the MOA has been marginalized, primarily because funding for large-scale irrigation schemes has come from international development organizations and lending instruments, and therefore the design and implementation of irrigation projects has primarily been the responsibility of the CDR. The MOA has however maintained some influence and control over small-scale irrigation projects including hill lakes and hill ponds through the Green Plan.

The Council for the South is very active in building water supply systems in the south and West Bekaa regions (expenditure peaked during the period 1992-2008). These systems all rely on boreholes for the supply source. Separately, the Central Fund for the Displaced, which is responsible for rehabilitating and building water supply systems in the villages of Chouf, Baabda and Aley, has contributed substantially to expenditure during the last 15 years in building water supply wells.

It should be noted that the Council for the South and the Central Fund for the Displaced have a lot of autonomy in terms of the decisions they take and the projects they execute. They inform MOEW and the RWE, and attempts at coordination are made, but coordination remains informal.

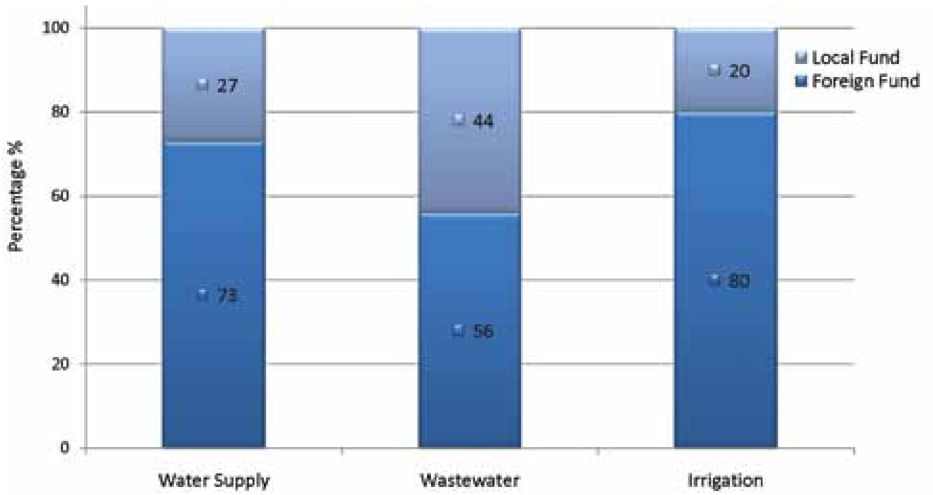
Traditionally, sewage networks have been the responsibility of the municipalities. Law 221/2000 is ambiguous on the issue of sewer lines, and there is a view that the rehabilitation and condition of sewer lines remains the responsibility of the municipality. Further confusion is caused by one of the provisions in the municipal law related to municipal taxes. Municipalities levy tax on the rental value of residential and commercial units, as well as a tax on sidewalks and sewers. The Arabic word is *majareh* which is not the same as sewers (in Arabic *majareer*). While the RWE are not yet equipped to take possession of the STP's and other sophisticated facilities, the municipalities are totally ill equipped to operate and maintain the expanding sewage networks that are coming into operation. So while collection networks are expanding, institutionally, their operation and maintenance is uncertain. It should be noted that the municipalities continue to build or upgrade sewer lines separately from MOEW, RWE and CDR.

### 3.3.2 Other Players and Stakeholders

*Foreign Funding Agencies*
Most of the capital investment in the water supply, wastewater and irrigation sectors has come from foreign funding agencies (see Figure 3.7). Foreign funding is usually provided and administered by the CDR.

The largest funders in the water sector in decreasing order of importance include the World Bank (almost 20% of total spending), the European Investment Fund and the Kuwait Fund for Arab Economic Development. In the wastewater sector, the top three funders are the European Investment Bank (35% of total spending), the Islamic Development Bank, and Japan. It is important to note here that local funding in the wastewater sector is mostly limited to networks and other civil works but not STPs. In the irrigation sector, the top funders are the World Bank (almost 80%) and the Arab Fund for Economic and Social Development (almost 20%).

**Figure 3.7 Investment source of funding in water, wastewater and irrigation sectors**




*Source: WB 2009a*

In addition to funding capital investments, several funding agencies (particularly the EU, USAID, AFD and GiZ) have been involved in funding institutional capacity building and policy type projects. The World Bank has played a leading role in driving the policy debate and reform in the water sector since the early 1990s, followed by USAID and GTZ.

Paradoxically, this myriad of funding agencies may have reinforced the fragmentation of government agencies working in the water sector. For example, while the World Bank has tended to work through CDR, USAID worked directly with the municipalities for many years by funding the construction of small-scale STPs in the south and the Bekaa without any coordination with MOEW or CDR. (USAID subsequently adopted a different approach in the wastewater sector and is currently funding the construction of four medium-sized STPs in the Litani basin, in close coordination with MOEW and the LRA). USAID has also funded the *Lebanon Water Policy Initiative* (2002-2007), which is an institutional capacity building project in close coordination with MOEW, followed by the *Lebanon Water and Wastewater Sector Support* project (2009-2013), which is assisting all four Water Establishments attain financial and operational sustainability. The French Development Agency has worked with MOEW to develop a draft Water Code, and GiZ is working with the Beirut and Mount Lebanon WE in trying to improve the establishment's capacity to operate water supply and wastewater systems.

*Academic Sector*

A number of universities are active in water research, most notably the American University of Beirut (Water Resources Centre), the Notre Dame University (Water Energy and Environment Research Centre) and Saint-Joseph University (Regional Centre for Water and Environment). A lot of the environmental quality data used in this report comes from articles and research published by academics and researchers. In addition to their research and data, the universities are offering water resource and environmental studies as majors (see details of majors in Chapter 2). This will allow water resource professionals to come into the sector with greater awareness of the environmental challenges facing the sector.

*Private water providers*

Most households pay a sizeable share of total water spending to private providers, including bottled water, gallons, bulk tanker water or private well operations. It is inevitable, with such a significant share of the drinking water market, that the bottled water companies have real influence with the Government and have interests that they actively and effectively defend. In fact, leading bottling companies are setting up new bottling plants.

*The Community (End Consumers)*

While some reports have described the environmental NGOs working at the grassroots level (EMWATER, 2004), community involvement in water matters is muted. The World Bank deals with this issue at length, and concludes that since the community has no avenue to hold the public water providers to account for the quality of service delivery, the community has resorted to private providers. The proliferation of private providers is not going to help the Government in regulating water extraction and thus minimise further degradation of water resources.

### 3.3.3 Multilateral Environmental Agreements

Lebanon is a signatory to several multilateral environmental agreements related to reducing pollution into the Mediterranean Sea (Convention for the Protection of the Mediterranean Sea against Pollution-Barcelona, ratified by the GOL in 1977 and the Protocol for the Protection of the Mediterranean Sea against Pollution from Land-based Sources-Athens, ratified in 1994); spill prevention (International Convention for the Prevention of Pollution from Ships-London, ratified in 1983); as well as the protection of wetlands (Convention on Wetlands of International Importance-Ramsar, ratified in 1999). See targeted list of MEA ratified by the GOL in Annex 2 in Chapter 2.

### 3.3.4 Policy Formulation and Development

Under the legal framework governing the water sector, there are no explicit policy development and formulation powers given to the MOEW, or any other public agency or institution. The absence of an official government policy governing the water sector has plagued the sector for decades. The only clear policy initiative to date, backed up with legislation and regulations, has been Law 221/2000 and its derivatives. The law addresses the institutional setup of the sector but the impact has yet to be felt due to the following:

- Investment planning and execution has not been handed over to the RWE but remain with MOEW and CDR;
- Local irrigation committees remain responsible for operating irrigation networks;
- Project execution remains with MOEW, the CDR, the Council for the South, the Fund for the Displaced and the LRA;
- RWEs are still ill equipped and poorly staffed to coordinate and take over the projects once they are completed on the scale required; and
- The regulatory framework to police and impose standards and benchmarks, technically, fiscally and environmentally are either nonexistent or ineffectual. For example, the uncontrolled extraction of groundwater continues unabated; domestic and industrial discharges are rampant throughout the country.

If and when the National Water Sector Strategy is formally approved by the Council of Ministers, many of the issues raised above will be resolved. By putting the sector on a rational footing, and mainstreaming environmental concerns, and incorporating more recent initiatives (e.g., the Water Code, MOEW 10-Year Plan and CDR wastewater program), the NWSS has the potential to reduce and perhaps eliminate institutional overlap and inefficiencies within the sector.

Capitalizing on the formulation of the NWSS, UNDP launched in 2010 the Lebanese Centre for Water Management and Conservation (LCWMC) to provide policy support to the MOEW to optimize water resource use through an integrated approach to water management. The centre will initially (1) help update groundwater resources data nationwide by establishing a groundwater database and water library at the MOEW (see Section 3.2.1) and (2) raise awareness on the importance of water and its conservation. The long-term objective of the LCWMC is to promote sustainable water management and assist in the implementation of selected initiatives under the National Water Sector Strategy. The centre will seek funding from different development organizations and will have the flexibility to accommodate and coordinate several projects.

## 3.4 SELECTED RESPONSES TO WATER ISSUES

Faced with mounting water-related challenges, political uncertainties and security issues, Lebanon has invested in expanding existing water supply networks, providing wastewater collection and treatment systems, developing additional water resources, building the institutions to manage this infrastructure, and improving service delivery. Overall progress however has been predictably slow.

### 3.4.1 Increasing Water Resources: Dams and Lakes

It has been apparent since the mid 1990s that Lebanon's water supply sector is facing real problems in terms meeting long term demand. Accordingly, the MOEW developed a 10-Year Plan to build dams and lakes in the late 1990s. Under the Plan, 17 proposed dams would add approximately 650 million cubic metres per year to the stock of available renewable freshwater resources (Comair, 2010). Dams and lakes envisioned under the Plan were mainly for drinking water, and to a lesser extent irrigation.

The 10-Year Plan was slated to be substantially completed by 2010. To date, only the Chabrouh Dam in the upper Kesrouan has been completed (see details and lessons learned in Box 3.5). Very little progress has been made towards the construction of the remaining dams including (numbers in parentheses show total storage capacity by region):

- **North**: Noura el Tahta, Qarqaf, Bared, Iaal, El Mseilah, and Dar Beachtar (205 million $m^3$)
- **Mount Lebanon**: Janneh, Boqaata, Aazzounieh, and Damour (109 million $m^3$)
- **North Bekaa**: Aassi, Younine, and Massa (52 million $m^3$)
- **South Lebanon** : Ibl Es Saqi, Bisri, and Khardaleh (290 million $m^3$)

MOEW has estimated that the total cost of building the dams and lakes is $2.6 billion (MOEW 2010a). As discussed in Box 3.4 on the five pillars of the NWSS, the Ministry is proposing the expenditure of $1,134 million between 2011 and 2015 for resource augmentation. The main components of this program are dams and lakes proposed under the MOEW's 10-Year Plan and augmentation projects to be executed by CDR. In particular, the NWSS listed five dams and hill lakes including Brissa in Dinnieh (under construction), Boqaata in Kesrouan (ready for construction), Janneh in Jbail (detailed design) and Rahwe in Batroun (preliminary design). Once the Government approves the NWSS, it is envisaged more funding, both local and foreign, will be mobilised to complete the projects needed up to year 2015. The NWSS (Initiative 12) also aims to produce the final version of the long-awaited Water Code, which is expected to be discussed by the COM and transferred to Parliament for final approval and implementation.

*Bisri Dam and Awali-Beirut Conveyor*

The case for augmenting water resources cannot be more pronounced than in the GBA, an agglomeration of 1.8 million people. Currently receiving most of its water from the area of Jeita (though the Dbayeh treatment plant), MOEW and CDR have started to implement two large-scale projects that will help overcome the projected deficits in greater Beirut; the Bisri Dam, and the Awali-Beirut Conveyor. The GBA is already experiencing very severe water rationing in summer and drinking water demand is set to increase by at least 13 percent over the next 20 years based on the most optimistic assumptions (see demand in Table 3.26 and projected deficit in Table 3.27).

**Box 3.5 Lessons learned from Chabrouh Dam**

Located in Faraya (Kesrouan) 40 Km from Beirut, the Chabrouh Dam helped solve the chronic water shortage in the upper Kesrouan region. With a static storage capacity of 8 million $m^3$ and a dynamic storage capacity of 15 million $m^3$ (and a total cost of about $60 million), the dam is expected to meet drinking water demand until 2025. Designed to deliver 60,000 $m^3$ per day, today the dam reservoir delivers only 35,000 $m^3$ pending completion of remaining water networks in the upper Kesrouan region. The construction of this hydraulic infrastructure took about five years (August 2002 - October 2007). No EIA was submitted to the MOE for review and approval.

Location: Chabrouh Dam and Basin are located on the eastern flank of the Qana Plateau (total basin area is 12 $km^2$). The Qana Plateau is an 8 $Km^2$ semi-isolated plateau in Mount Lebanon; it rises from approximately 1600m a.s.l. and reaches a maximum elevation of 1945m a.s.l. It is circular in shape with a relatively flat top and steeply sloping sides. The base of Chabrouh Dam is located at an elevation of 1555m a.s.l. The dam's crest height is 63m, its length is 470m and width is 100m.

Investigations: Examination of Chabrouh Dam site started in the 1970's; Majdaleni (1977) argued that the presence of karst rocks in Chabrouh valley will make building such a structure and retaining the water in the basin quite difficult. In 2006, Bou Jaoude showed that the nature of the karstic terrain in the Qana plateau and the height of the water in the basin might lead to channeling of the water from the Chabrouh basin into the surrounding springs (Bou Jaoude, 2006). Leaks of up to 200 l/s were observed around the western abutments of the dam on the Qana Plateau side due to the geological formation of the area. In 2009, detailed surface geology of the Qana plateau revealed that the area is dissected by NW-SE dip-slip faults (Bou Jaoude *et al.* 2009). Hydrographs of three major springs (Hadid, Qana and Terrache) show clear karstic characteristics. A major increase in the flow of the studied springs has been documented suggesting that leaking from the Chabrouh dam basin is occurring towards those springs (Bou Jaoude *et al.* 2009).

Conclusion: Despite technical challenges, budget overruns, construction delays (linked to budgetary constraints and political wrangling), and now growing evidence of leaks (which even if unplanned help replenish aquifers), the dam represents today a much-needed water reservoir for the upper Kesrouane region and should serve as a case study for future dam projects in the country.

*Source: adapted from (Comair 2010), (Majdaleni 1977) and (Bou Jaoude et al. 2006, 2009)*

*View of Chabrouh Dam in Kesrouan, the only dam completed based on the 10-Year Plan of the MOEW*

**Table 3.26 Low demand scenario for GBA**

| Year | Population | Domestic Consumption | Non Domestic Consumption | Total consumption | Unaccounted For Water | | Total Demand |
|---|---|---|---|---|---|---|---|
| | | $m^3/d$ | $m^3/d$ | $m^3/d$ | %total | $m^3/d$ | $m^3/d$ |
| 2010 | 1,700,000 | 255,000 | 76,500 | 331,500 | 30 | 99,450 | 430,950 |
| 2015 | 1,787,161 | 268,074 | 80,422 | 348,496 | 25 | 87,124 | 435,620 |
| 2020 | 1,878,791 | 281,819 | 84,546 | 366,364 | 20 | 73,273 | 439,637 |
| 2025 | 1,975,118 | 296,268 | 88,880 | 385,148 | 20 | 77,030 | 462,178 |
| 2030 | 2,076,385 | 311,458 | 93,437 | 404,895 | 20 | 80,979 | 485,874 |

**Assumptions:** *Population growth rate* of 1%; *Domestic Consumption* 150 l/c/d; *Non domestic consumption* 30% of per capita consumption.

*Source: WB, 2009a*

**Table 3.27 Projected deficit for GBA**

| Year | Total Demand (From Table 3.23) | Available Resources | Deficit |
|---|---|---|---|
| | $m^3/d$ | $m^3/d$ | $m^3/d$ |
| 2010 | 430,950 | 271,000 | -159,950 |
| 2015 | 435,620 | 271,000 | -164,620 |
| 2020 | 439,637 | 271,000 | -168,637 |
| 2025 | 462,178 | 271,000 | -191,178 |
| 2030 | 485,874 | 271,000 | -214,874 |

*Source: Available resources from Montgomery Watson 2001*

*Hill lakes in Kfar Selouan provide much needed water for mountain agriculture*

The Awali-Beirut Conveyor will transfer water from the Litani River basin to Beirut. Currently, water is diverted away from the Qaroun Lake through a series of hydroelectric plants and tunnels and residual water ends in the Awali River (Bisri) before reaching the sea. The Awali-Beirut Conveyor will allow some of this water to be taken and transferred to greater Beirut. During the dry season, the conveyor will supply water under gravity to the GBA at the rate of 250,000 $m^3$/day (3 $m^3$/s). This will meet the needs of GBA in the short to medium terms. Over the long-term, the Bisri Dam will supply an additional 500,000 $m^3$/day (6 $m^3$/s), also through the Awali-Beirut Conveyor.

Both projects are now funded by the World Bank and the Islamic Development Bank. It should be noted that these projects were anticipated by Presidential Decree 14522 (May 1970) which allocated water from the Litani and Awali (Bisri) River catchments to different regions of Lebanon.

### 3.4.2 Protection of Water Resources: Wastewater Systems

Although projects to augment water resources (particularly dams and lakes) are proceeding slowly, a significant number of sewage plants and systems will become operational in the next five years. In total, seven treatment plants were completed since the 2001 SOER (Tripoli, Chekka, Batroun, Jbail, Nabi Younes, West Bekaa and Nabatieh) but have yet to go online pending the completion of the corresponding networks. Only two coastal treatment plants are currently operational (Ghadir and Saida) but both plants provide preliminary treatment as the effluent is discharged into the Mediterranean Sea through dedicated sea outfalls.

At CDR, there are two programmes that deal directly with the protection of water resources and coastal waters: (1) Inland Water Resources Protection Programme, and (2) Coastal Pollution Control Programme. Considering the importance of the Litani River for agriculture and drinking water, there is sub programme for the protection of the Litani River basin. With significant international funding, CDR has been implementing Lebanon's wastewater master plan and USAID has in recent years lent support to implementing specific investments foreseen in the plan, in and around the Litani River. A complete and up-to-date list of sewage treatments plants (coastal, inland, and Litani) is presented in Table 3.28 and illustrated in ***Map 2.***

**Table 3.28 Status of Lebanon's sewage treatment plants**

| Location (RWE) | Population Served | Capacity $m^3/d$ | Process | Status |
|---|---|---|---|---|
| **Main Coastal STPs** | | | | |
| Ghadir (BML) | 250,000 | 50,000 | PT | Operating. An expansion planned to add 850,000 people. |
| Jbail (BML) | 50,000 | 9,000 | B | STP complete. Networks completion in 2011 |
| Jieh (BML) | 88,000 | 11,900 | B | Complete |
| Tabarja (BML) | 505,000 | 70,000 | B | Planned |
| Bourj Hammoud (BML) | 2,200,000 | 330,000 | PT | Planned |
| Saida (Sth L) | 390,000 | 55,000 | PT | Operational |
| Sour (Sth L) | 200,000 | 45,000 | AS | Under construction |
| Batroun (Nth L) | 30,000 | 4,100 | EAAS | Complete. Networks under construction |
| Chekka (Nth L) | 15,600 | 1,750 | EAAS | Complete. Networks under construction |
| Tripoli (Nth L) | 1,000,000 | 135,000 | AS | Complete. Operational mid 2011. |
| Abdeh (Nth L) | 185,000 | 30,000 | AS | Planned |
| **Main Inland STPs** | | | | |
| Barouk (BML) | 12,000 | 1,000 | AS | Planned |
| Nabeh al Safa (BML) | 30,000 | 3,000 | AS | Planned |
| Hrajel (BML) | 37,000 | 6,000 | AS | Planned |
| Nabatieh (Sth L) | 100,000 | 9,000 | EAAS | Complete. Awaiting completion of network. |
| **Litani Basin (Bekaa)** | | | | |
| Baalbeck | 89,000 | 12,000 | AS | Complete. Awaiting completion of network |
| Zahleh | 120,000 | 18,000 | TF | Ongoing |
| Joub Janine | 77,000 | 10,500 | EAAS | Ongoing |
| Saghbine | 4,100 | 530 | EAAS | Ongoing |
| Labwa | 53,000 | 7,000 | AS | Planned |
| Majdel Anjar | 275,000 | 44,500 | AS | Planned |
| Tibnin el Tahta | 100,000 | 25,000 | AS | Planned |
| Aitanit | 37,500 | 5,000 | TF | Operational |
| Fourzol | 7,400 | 1,000 | TF | Operational |
| Chmistar | 13,200 | 1,800 | TF | Ongoing |
| Ablah | 14,630 | 2,000 | TF | Ongoing |

**AS** Activated Sludge, **B** Biofiltration, **EAAS** Extended Aeration Activated Sludge, **TF** Trickling Filter, **PT** Pre Treatment

*Source: CDR, 2010 (Main Coastal and Main Inland) and WB, 2010 (Litani Basin)*

As part the Country Environmental Analysis report for Lebanon, the World Bank estimated the cost of upgrading pre-treatment plants to secondary (Saida and Ghadir) and 10 other coastal treatment plants from secondary to tertiary (WB 2010). Tertiary treatment would present new opportunities for water reuse but would cost the GOL an estimated $45 million in capital expenditure and $61 million in O&M costs per year.

Building on these efforts, the MOEW has recently prepared and published a Strategy for the Wastewater Sector. Although not yet officially endorsed, the strategy has defined ambitious targets for wastewater collection, treatment and reuse over the short-to-medium term (2011-2015) and the long-term (2016-2020). Pertinent sector targets (2011-2020) include increasing wastewater collection and treatment from the current 60 and 8 percent respectively, to 80 percent in 2015, and 95 percent in 2020; pre-treatment of all industrial wastewater by 2020; increase the reuse of treated effluent from the current zero percent to 20 percent in 2015, and 50 percent in 2020; and full recovery of all O&M costs by 2020. Achieving these targets is based on five strategic initiatives:

1) An integrated and prioritized investment program for wastewater collection, treatment and reuse (e.g., completing networks and plants, regional wastewater master planning)

2) Legal, regulatory and policy measures (e.g., bylaws for WEs, guidelines for small-scale plants)
3) Institutional measures (e.g., asset evaluation and progress transfer to WEs, capacity building for WEs related to operation and maintenance, and for MOEW to strengthen oversight)
4) Financial measures (e.g., cost recovery mechanisms based on the polluter-pays-principle)
5) Private sector participation (e.g., testing alternative models for private sector participation and strengthening WE capacity in contract preparation and oversight).

It is expected that within the next 10 years, the wastewater master plan will be almost complete. By then, at least 80 percent of Lebanon's population would be served by wastewater systems. Sound operation and maintenance of these facilities however will depend on many factors such as achieving minimum inflow requirements while preventing the inflow of industrial wastewater connected to public sewers. Industrial wastewater characteristics differ vastly from domestic wastewater characteristics and can easily overload and impair the treatment process.

In an effort to incentivize industries to comply with discharge standards for public sewers, the Environment Fund for Lebanon selected nine pollution abatement projects as part of its Second Call for Proposals (August 2010), with grant funding from GiZ. The projects will co-finance up to 50 percent of the total cost of cleaner production measures and the construction of treatment units for industrial wastewater in industries located in Kesrouan and the Litani Basin. The selected enterprises include pulp and paper, food and beverages, metals products and textile industries. Total capital expenditure by the EFL-GiZ program will be €1.2 million.

### 3.4.3 Improving Service Delivery: Public Private Partnerships

Only Beirut and Mount Lebanon WE is not financially reliant on the Government for help. The other water establishments cannot cover their power needs, nor pay salaries or invest in capital investment. It must be noted, the reliance on pumping from aquifers, has meant power is the biggest expenditure on the RWE books. As a result, the World Bank has argued that spending on operation and maintenance has been well below what was required to ensure efficient operation of networks that have come into operation the last 15 years (World Bank, ERP, 2009a). Added to this, the RWE have not been able to hire suitable staff to operate supply systems. This will be compounded in the next few years as wastewater systems become operational and are handed over to the RWE, who are incapable of managing these systems. In an effort to address the underperformance of RWEs and improve service delivery, the GOL has been seeking private sector participation to support service delivery. *See for example Ondeo contract in Box 3.6.*

There are several other service contracts ongoing. For example, the Bekaa WE has relegated the operation and maintenance of its water supply network and the Baalbeck STP to a Lebanese company. This contract is funded by the World Bank and it still ongoing. MOEW also operates and maintains a number of water pumping stations on behalf of the RWE. Considering the inability of the RWE to take over the STP that will be coming into operation over the next few years, the ongoing wastewater construction contracts have provision for three to five year operation and maintenance periods after the construction phase. They also include provision for the private operators to train the RWE staff to operate and maintain wastewater treatment plants.

One of the pillars of the NWSS is to encourage private sector participation in the operations of the water sector. The NWSS recommends that while RWE efficiencies are low and tariffs have not been rationalised, management contracts could be feasible for operations of water and wastewater systems. Once the water sector performance improves and matures, more advanced forms of private sector participation in the form of lease, concession or divestiture arrangements could be considered.

## 3.5 EMERGING ISSUES AND OUTLOOK

Key emerging issues include options for augmenting water resources, and new approaches for water management including integrated water resource management, water demand management, protection of water recharge zones and protection from flood plains.

**Box 3.6 Ondeo Management Contract in support of North Lebanon WE**

In December 2002 a management contract was signed with the French water company Ondeo. Funded by AFD, the management contract allowed Ondeo to take over the management of Tripoli Water Establishment (TWE) for a period of four years. The scope of the contract allowed for the transfer of the staff to Ondeo. Contract objectives included:

1) Increase level of supply
2) Guarantee water quality
3) Cost recovery for operation and maintenance
4) Installation of water meters
5) Staff training
6) Installation of management information systems covering customer services, accounting, asset management, maintenance management

On the whole, the contract was successful. Service was increased to 22 hours every day. The water meters funded under the contract were installed, as were all the management information systems. Unaccounted for water (UFW) was reduced from 65 percent to around 40 percent. However, cost recovery was not achieved, nor was the collection rate improved despite the improvement in the billing rates (CDR, 2010). Regarding UFW, the work of Ondeo showed that the physical losses in the networks are not the main contributors to UFW. As part of improving service delivery, the contract provided for a leakage detection and repair programme throughout Tripoli. The leakage detection part of the programme did not show the same extent of leakage as had been envisaged and allowed for in the contract. It is worth noting that service levels remain at the same level as they were during the term of the contract, which reflects the enduring effect of the contract.

During the term of the contract, the relationship between the management of TWA and Ondeo was difficult, and required attention from CDR to keep the contract from failing. This was due to the fact that no legal framework existed to allow Ondeo to truly run the Establishment autonomously in order to meet the objectives the contract set. The main lesson learned from the contract is the need to establish the legislation to allow delegation of management of water authorities to private operators for the term of management contracts. If the Government can establish suitable legislation, all the parties to the contract can proceed with clarity. The lack of clarity in relation to the roles and responsibilities of parties was a major impediment during the execution of the Ondeo contract.

### 3.5.1 Other Water Resource Augmentation Options

*3.5.1.1 Treated Sewage Effluent*

There are no regulations or laws or official policy in place which allow or even encourage the possible reuse of Treated Sewage Effluent (TSE) or treated sludge. As was detailed above, over the next 10 years, at least 10 STPs will come into operation along the coast, as well as up to twenty smaller plants inland. As a result, there will be significant volumes of TSE generated that will either be suitable directly for reuse or will require further polishing for reuse in irrigation and groundwater recharge. A number of studies have investigated the availability of treated effluent and sludge and reuse options. According to CDR's master plan in 2003, the projected quantity of treated sludge will grow from 334 t/d in 2010 to 426 t/d in 2020 (WB, 2010). The study suggested very limited reuse of the treated sludge in agriculture and recommended incineration. With regards to treated effluent sludge, the outlook is more positive. It is projected that by the year 2020, TSE could meet:

- 30% of irrigation demand in south Lebanon
- 50% of irrigation demand in North Lebanon
- 13% of irrigation demand in the Bekaa (the biggest user of irrigation water)

The only project that actually has a component for effluent wastewater is the Baalbeck Water and Wastewater Project. The project will equip the plant with an off take point for farmers to access the TSE and the treated sludge. The Baalbeck plant is expected to produce TSE and sludge suitable for irrigation however the plant experienced significant delays first because the wastewater networks were not complete and, more recently, because the plant is not receiving the minimum required inflow to ensure good operation (farmers are tapping raw sewage upstream of the plant for irrigation). It is clear however that treated effluent will become an attractive source of alternative irrigation water in the future. As precipitation rates decrease and population increases, the volume of TSE relative to freshwater resources are going to increase. It is a resource Lebanon should not ignore. Guidelines for the reuse of treated effluent are being developed by FAO and the relevant ministries (Agriculture, Environment and Public Health).

*3.5.1.2 Rainwater Harvesting*

While MOEW's 10-Year Plan aims to create dams on Lebanon's perennial rivers, it also relies heavily on capturing seasonal water running in the many rivers that dry up during summer. In contrast to dams, rainwater harvesting aims more at creating reservoirs at the municipal and

*Wastewater Treatment Plant in Saida*

household level. Additionally, storm water drains can be diverted into open or closed reservoirs to create brown or grey water resources for municipal irrigation of green spaces. This water can be polished to make it suitable for irrigation of public parks, median strips and other public green spaces.

At the household level, there are public programmes in different parts of the world where governments are subsidizing or incentivising citizens in cities to install water tanks to capture water flowing off their roofs. The collected water can be used to water house gardens, and wash building staircases and cars. In fact, until the 1970s, water was commonly harvested in the rural areas of Lebanon. Water running off roofs was diverted to underground reservoirs. The water was used for drinking and irrigation of gardens and vegetable patches. Some villages had communal schemes whereby rain was diverted through open channels to large underground reservoirs. The water was then rationed to villagers. Considering the extent of household expenditure on private water resources, creating small scale schemes described above, could help reduce expenditures on private water. At the same time, it would enable households to take greater responsibility for the quality of their water and their consumption. Good housekeeping such as using double-flush toilets and aerators should also become mandatory as part of a national plumbing code.

*3.5.1.3 Aquifer Recharge*

The MOEW 10-Year Plan does not only look for surface water storage to augment existing resources, it calls for the use of TSE for artificial recharge of aquifers, particularly coastal aquifers as many STP's will come into operation along the coast in the next few years. The Plan estimates that 300 $Mm^3$/year could be added to existing resources (Comair, 2010). The MOEW has started to study this measure, and it is investigating pilot projects near Beirut, Tripoli and Baalbeck.

*3.5.1.4 Metering, Leakage Detection and Repair Programmes*

Metering is a priority and necessary to conserve water. Water in Lebanon at the household level is rarely metered. Installation of meters is ongoing in Tripoli, Baalbeck, Beirut and Saida. Further metering programmes are either under consideration or ongoing in all the RWE. All calculations of demand are based on design consumption rates, and not real data from RWE. Metering will help produce more accurate data on water consumption.

Metering and associated billing are powerful demand management tools, that should not be ignored. Once the consumer pays principle is adopted by RWE, consumption will drop to reflect real consumption levels. The current orifice type gauges which are supposed to allow one cubic metre a day per connection are no longer appropriate to manage demand or water supply. More tellingly, once RWE start to obtain reliable data on the effective demand, supply system investments can be rationalised. With regards to UFW, it is important that RWE ascertain the volumes of water lost in the networks. The building of dams and more storage facilities is going to be wasteful if huge volumes of the additional resources are going to be lost in network leaks. Repair of network losses is a more economically efficient way of augmenting resources than building dams.

### 3.5.2 Potential New Approaches

*3.5.2.1 Integrated Water Resources Management*

One of the main ways of managing water resources is at the river basin level (GEO 4, UNEP, 2007). At the core of Integrated Water Resources Management (IWRM) is to integrate all those activities that affect water resources within a river basin into a single framework.

> "…… integrated water resources planning and management are facilitated by policies, laws, strategies, and plans that are multi-sectoral, based on the allocation of water for all uses; protection of water quality and control of pollution; protection and restoration of lake basins, watersheds, groundwater aquifers, and wetlands; and control and management of invasive species (WB 2009b)"

Management of the sector in Lebanon is very much fragmented. The management model has not proved its effectiveness. Perhaps devolution to the river basin level would bring decision makers closer to the users and the community in general. In the Litani River Basin, the need to integrate, water supply, sewage, irrigation, land use, industry waste, agricultural practices, and tariff policy together is overwhelming. Irrigation in the Bekaa and south Lebanon is dependent on the health of the Litani River. Beirut's drinking water under the Awali Beirut Conveyor Project also depends on the quality of the Litani River water. Communities within the Litani Basin place enormous environmental loads on the River.

Although IWRM is referred to in the 10-Year Plan and NWSS, there is not enough devolution to the regional water authorities to facilitate integrated basin level management. Under both Law 221/2001 and NWSS, strategic planning at the basin level is in the hands of MOEW. Under an effective IWRM policy, basin level water authorities would be created and fully empowered to operate autonomously. No legal framework yet exists in Lebanon to bring this about. The approach remains top down, centralised decision making.

*3.5.2.2 Environmental Water*

The concept Environmental water should be considered if Lebanon is indeed going to go ahead and build all the dams proposed under the MOEW 10 Year Plan. Environmental water is broadly defined as any water that achieves ecological benefits (Hamstead, 2007). It can be split into two categories: planned and adaptive environmental water. Planned environmental water is the water committed to the environment by rules, regulations or laws. This can be achieved either by placing limits on extraction of water from river or ground water systems or by allocating mandatory flows in river and groundwater systems. Adaptive environmental water is the water committed to the environment as part of water access licenses (NSW SOER 2009).

Lebanon's groundwater reservoirs are seriously stressed. By setting environmental water levels, the GOL can ensure that (1) sustainable volumes of water remain in rivers or groundwater reservoirs to sustain ecosystems, and (2) natural flow patterns are maintained so they are compatible with the ecological processes and environmental needs within rivers and aquifers. Groundwater health affects many ecosystems including terrestrial vegetation, wetland ecosystems, river systems, aquifer and cave ecosystems, and terrestrial fauna. See more details in Chapter 5.

The MOEW is striving to regulate the drilling of new boreholes and the GOL should provide all the backing needed to control illegal boreholes as failure will have community wide consequences. Just as a real and effective implementation of IRWM should be considered, both MOE and MOEW should consider incorporating the concept of environmental water into water sector planning and operations. There is a need to retain sufficient environmental flows in ecosystems to allow them to continue providing environmental products and services that sustainable development demands and have the adaptability required to cope with increasing environmental stresses.

*3.5.2.3 Demand Management*

Along with the adoption of IWRM as the management model, and incorporation of the concept of environmental water into water resources planning and regulation, the Water Establishments need to pursue aggressive demand management measures. This includes physical measures such as:

- Introducing water metering to all sectors (domestic, industrial and irrigation)
- Mandating water saving devices in the construction sector (e.g., Lebanese Building Code)
- Working with the agricultural sector to promote efficient irrigation technology

These measures will have to be part of public information campaigns that help the community appreciate the seriousness of the stresses water resources face in Lebanon.

Proper tariff structures for water use are another important tool in demand management. It has the added advantage of allowing Water Establishments to recover their costs. As stated earlier, water meter installation programs are ongoing in most of the country. Under Initiatives 9 and 10 of the NWSS, consumption-based tariff are proposed for water supply, irrigation and wastewater. The use of meter based tariffs, particularly for domestic and irrigation water, has been shown internationally to reduce demand wherever it is introduced.

The World Bank has studied tariffs in Lebanon extensively. The Bank believes the existing block tariff "does not provide incentives for neither demand management or irrigation improvements, nor does it provide commercial incentives for Water authorities to reduce water losses and increase water production" (WB-PER, 2009, p 40). The introduction of a proper tariff for water has been under discussion for the last 15 years, but no real progress has occurred.

*3.5.2.4 Protection of Water Recharge Zones*

While the Inland Water Resources Protection Program (discussed in Section 3.4.2) is part of the actions required to protect recharge zones, the programme could be better targeted. The wastewater treatment plants and sewage networks under the program aim at protecting springs and rivers from untreated effluent. They do not cover entire aquifer recharge zones, which remain poorly defined and are impacted by industrial and agricultural waste. A number of studies such as the NLUMP (2004) and the MSC Environment (2005) have identified vulnerable recharge zones and the protection of recharges zones in general was incorporated in the NWSS (Initiative 15). Mainstreaming and enforcing the SEA (program and policy level) and the EIA (project level) process in all construction sectors would help prevent and/or minimize the degradation of recharge zones. Using the EPIK method to assess vulnerable karst formations would also help control pollution (see description of EPIK in Chapter 6).

*3.5.2.5 Flood Plain Protection*

In 2005, the National Land Use Master Plan identified areas prone to flooding and organized these areas into three zones:

1) Areas subject to shallow water table, in particular the agriculturally rich plain of Bekaa and Akkar (Lebanon's main agricultural regions);
2) Areas prone to river flooding; and
3) Areas prone to sea water flooding.

The Master Plan also noted the growth of urban centres in a number of flood plain areas and made several recommendations to mitigate flood risk: restriction of real estate developments, clearing of water courses and removal of unauthorised obstructions, combating deforestation, and enforcing the maintenance of 80 percent of all land with gardens, lawns and orchards. The need for action for flood plain protection was also taken up in the NWSS (Initiative 15) per the following recommendations:

- Establish flood plain zones
- Establish integrated flood management plans
- Study the use of flood water for groundwater recharge
- Combat desertification.

As was discussed in Section 3.1.2 the rate of urbanization in Lebanon is increasing and it infringing on natural water courses. In the rural areas, open water channels that historically allowed water to flow unrestricted into larger water courses, are being paved or are being built in. Forests and green areas are also decreasing in size, in turn restricting water retention and infiltration.

As part of post-war recovery efforts and reform initiatives, the Government of Spain through the

Lebanon Recovery Fund financed a $6.6 million project for Flood Risk Management and Water Harvesting for Livelihood Recovery in Baalback-Hermel (Phase I and II). The project targeted war- and poverty-affected areas in the region of Baalback-Hermel by introducing improved land management practices such as flood risk reduction and improved access to irrigation water. Managed by UNDP, Phase I of the project (targeting Aarsal and Fakhe) established a flood risk management plan covering an area of 94Km² that includes (1) the construction of stone walls and membrane-lined reservoirs to collect unused water from springs, rainfall and snow melts to prevent runoff water from reaching villages and farms, (2) the restoration of land cover to reduce soil erosion and (3) installation of efficient irrigation networks. This phase also organized public awareness campaigns on flood risk management and trained target municipalities on the maintenance of flood management structures. Phase II (still underway) aims at expanding the flood risk management plan to cover new and larger watershed areas (about 200Km²) and reduce damages and risks caused by floods affecting the village of Ras Baalback and its surroundings.

*3.5.2.6 Environmental Data and Indicators*

There are many indicators used in relation to water supply. However, there are a number of indicators that are pertinent to the environmental state of water resources. ***Annex 2*** presents a candidate list of proposed indicators that should be monitored and measured in future SOER's, and availability of the data commented on. It is important that a protocol be set up and funded by GOL to enable the relevant ministries and public institutions to monitor these indicators, which should be made available to the Ministry of Environment to monitor the state of the environment, and supply valuable information to go into the periodic state of the environment reports. This will require a budget for the different ministries, RWE and other agencies to collect data on water resources, by constructing a hydrometric network to measure river flows, spring and well discharges, quality of all water resources, including marine waters, etc. The budget for such a network is insignificant compared to the cost of building a dam or any of the other major projects the Government is planning to build.

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| نوع النص | الرقم | التاريخ | عنوان النص |
|---|---|---|---|
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| قرار وزير البيئة | ١/٩٠ | ٢٠٠٢/٠٣/٠٤ | الشروط البيئية لرخص إنشاء و/أو استثمار مصانع المطاط |
| قرار وزير البيئة | ١/١٥ | ٢٠٠٢/٠٣/٠٤ | الشروط البيئية لرخص إنشاء و/أو استثمار مصانع الزجاج |
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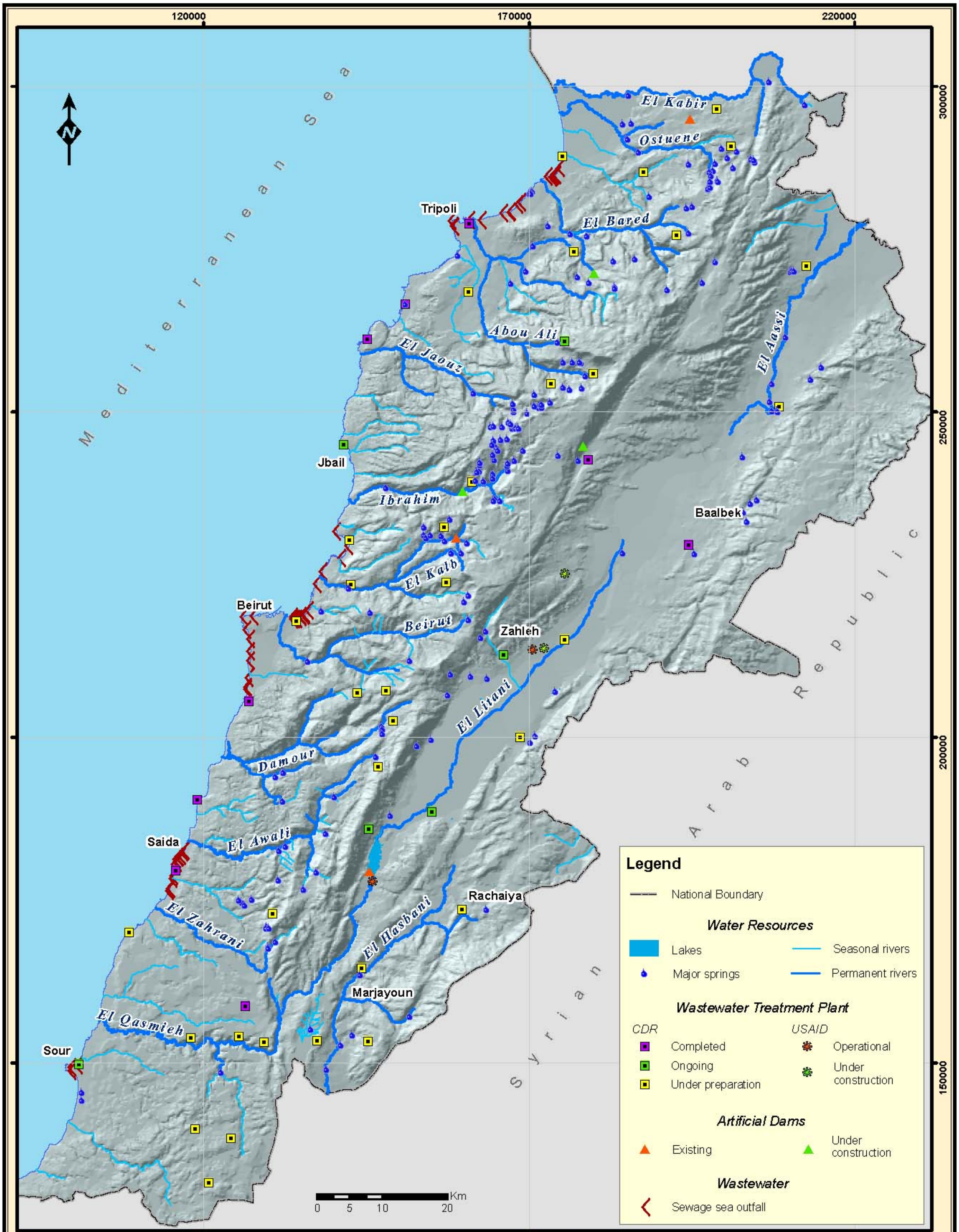


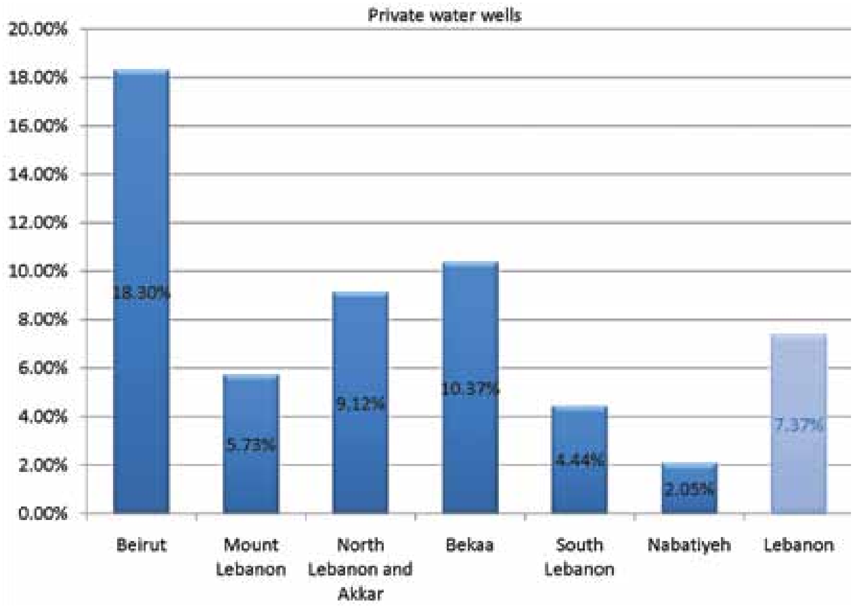

State & Trends of the Lebanese Environment
Chapter 3 - Water Resources

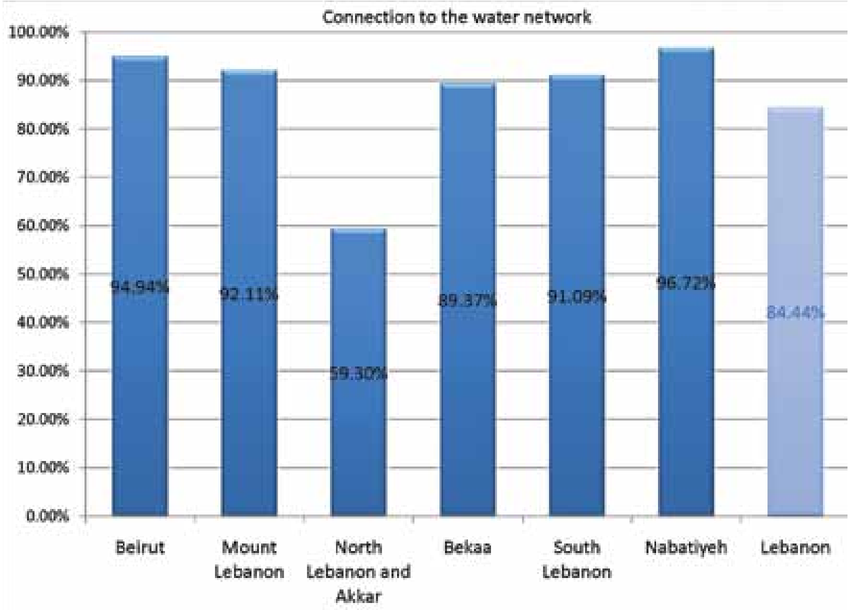
**Map 2 - Water Resources and Major Water and Wastewater Infrastructure**

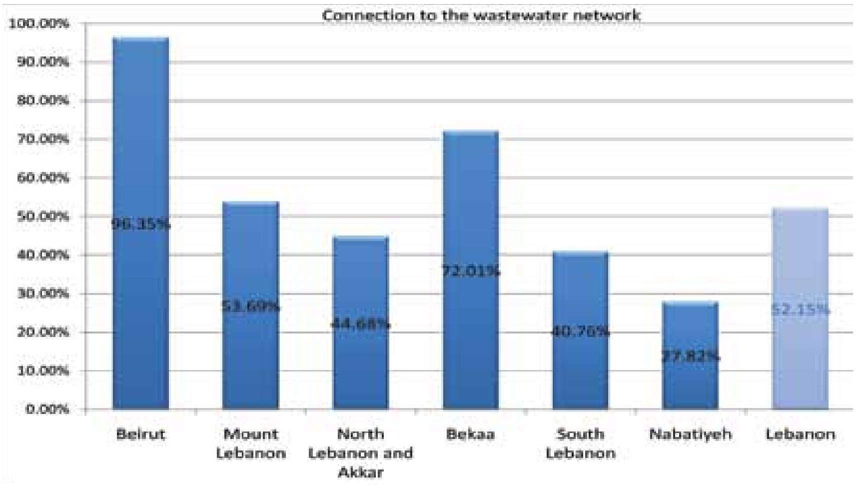
# ANNEX 1 WATER AND WASTEWATER BUILDING EQUIPMENT IN LEBANON

| Mohafaza/Caza | Well | | Water Network | | Sewage Network | | Unknown |
|---|---|---|---|---|---|---|---|
| | Yes | No | Yes | No | Yes | No | |
| **Beirut** | 3,163 | 14,118 | 16,407 | 874 | 16,651 | 630 | 1,055 |
| Baabda | 4,710 | 29,342 | 28,326 | 5,726 | 31,021 | 3,031 | 2,134 |
| Metn | 1,051 | 36,082 | 36,230 | 903 | 21,112 | 16,021 | 1,514 |
| Kesrouan | 508 | 23,576 | 23,657 | 427 | 5,772 | 18,312 | 789 |
| Jbail | 63 | 15,235 | 13,631 | 1,667 | 1,460 | 13,838 | 484 |
| **North Mount-Lebanon** | **6,332** | **104,235** | **101,844** | **8,723** | **59,365** | **51,202** | **4,921** |
| Tripoli | 1,772 | 8,045 | 8,700 | 1,117 | 8,956 | 861 | 533 |
| Koura | 1,040 | 9,577 | 8,281 | 2,336 | 3,030 | 7,587 | 1,144 |
| Zghorta | 623 | 9,734 | 8,077 | 2,280 | 7,675 | 2,682 | 961 |
| Batroun | 252 | 9,310 | 8,682 | 880 | 86 | 9,476 | 1,127 |
| Aakkar | 4,914 | 40,564 | 19,227 | 26,251 | 15,919 | 29,559 | 1,153 |
| Bcharreh | 4 | 4,436 | 1,331 | 3,109 | 731 | 3,709 | 222 |
| Minieh-Dennieh | 1,007 | 14,076 | 8,173 | 6,910 | 10,679 | 4,404 | 459 |
| **North Lebanon and Akkar** | **9,612** | **95,742** | **62,471** | **42,883** | **47,076** | **58,278** | **5,599** |
| Zahleh | 2,819 | 22,492 | 22,188 | 3,123 | 20,911 | 4,400 | 1,312 |
| West Bekaa | 843 | 12,561 | 12,726 | 678 | 9,989 | 3,415 | 1,148 |
| Baalbeck | 6,209 | 40,343 | 41,005 | 5,547 | 32,006 | 14,546 | 2,988 |
| Hermel | 168 | 7,220 | 6,392 | 996 | 5,706 | 1,682 | 142 |
| Rachaya | 278 | 6,550 | 6,600 | 228 | 3,029 | 3,799 | 307 |
| **Bekaa** | **10,317** | **89,166** | **88,911** | **10,572** | **71,641** | **27,842** | **5,897** |
| Saida | 1,180 | 24,101 | 23,595 | 1,686 | 14,227 | 11,054 | 1,476 |
| Tyre | 1,609 | 29,604 | 27,440 | 3,773 | 8,389 | 22,824 | 1,939 |
| Jezine | 13 | 6,670 | 6,515 | 168 | 3,135 | 3,548 | 965 |
| **South Lebanon** | **2,802** | **60,375** | **57,550** | **5,627** | **25,751** | **37,426** | **4,380** |
| Nabatieh | 352 | 22,631 | 22,349 | 634 | 8,469 | 14,514 | 1,814 |
| Bent Jbeyl | 245 | 15,566 | 15,112 | 699 | 670 | 15,141 | 1,445 |
| Marjaayoun | 573 | 11,931 | 12,163 | 341 | 2,019 | 10,485 | 1,065 |
| Hasbaya | 14 | 6,340 | 6,138 | 216 | 4,883 | 1,471 | 825 |
| **Nabatiyeh** | **1,184** | **56,468** | **55,762** | **1,890** | **16,041** | **41,611** | **5,149** |
| **Lebanon** | **33,410** | **420,104** | **382,945** | **70,569** | **236,525** | **216,989** | **27,001** |

*Source: CAS 2006 (data from 2004)*


Private water wells
20.00%
18.00%
16.00%
14.00%
12.00%
10.00%
8.00%
6.00%
4.00%
2.00%
0.00%
18.30%
5.73%
9.12%
10.37%
4.44%
2.05%
7.37%
Beirut
Mount Lebanon
North Lebanon and Akkar
Bekaa
South Lebanon
Nabatiyeh
Lebanon


Connection to the water network
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
94.94%
92.11%
59.30%
89.37%
91.09%
96.72%
84.44%
Beirut
Mount Lebanon
North Lebanon and Akkar
Bekaa
South Lebanon
Nabatiyeh
Lebanon


Connection to the wastewater network
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
96.35%
53.69%
44.68%
72.01%
40.76%
27.82%
52.15%
Beirut
Mount Lebanon
North Lebanon and Akkar
Bekaa
South Lebanon
Nabatiyeh
Lebanon

## ANNEX 2 PROPOSED LONG-TERM WATER INDICATORS FOR LEBANON

### Water Availability and Extraction

| Indicator | Trend | Data availability |
|---|---|---|
| **Available water supply** | | |
| Storage | | |
| Springs | | |
| Groundwater | | |
| **Extraction levels** | | |
| Storage | | |
| Springs | | |
| Groundwater | | |

### Water Consumption

| Indicator | Trend | Data availability |
|---|---|---|
| **Pattern of Consumption**[1] | | |
| Agriculture | | |
| Industry | | |
| Hotels | | |
| Public institutions | | |
| Households | | |
| Electricity | | |
| Others | | |

Measured nationally and by mohafaza

### Surface water quality

| Indicator | Trend | Data availability |
|---|---|---|
| **Rivers & springs** | | |
| Annual flow volume | | |
| Salinity | | |
| BOD loads | | |
| E.Coli & T. Coliform | | |
| Nitrates | | |

### Ground Water Quality

| Indicator | Trend | Data availability |
|---|---|---|
| **Groundwater** | | |
| Groundwater quality | | |

### Sea Water Quality

| Indicator | Trend | Data availability |
|---|---|---|
| **Coastal Waters** | | |
| Quality at selected sites | | |
| Frequency of algal bloom | | |